THE MANY TRANSFORMATIONS OF THE UNIVERSITY OF ILLINOIS OBSERVATORY ANNEX

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Abstract: The University of Illinois Observatory acquired a second-hand 30-inch Brashear reflector in 1912 with the intent of dedicating it to photoelectric photometry. A small observatory annex was built adjacent to the main observatory. This smaller observatory and its telescope underwent multiple transitions and instrument changes over the next 70 years, reflecting the research interests of Joel Stebbins and Robert H. Baker. The story of this observatory telescope illustrates changes in astronomical instrumentation and research over the course of the twentieth century.

Key words: photoelectric photometer, Joel Stebbins, Robert H. Baker, Bart Bok, star counts, University of Illinois Observatory, John Brashear, photography

1 INTRODUCTION

The goal of preserving astronomical heritage is to illustrate how our understanding and interpretation of the sky has changed over time. Historic sites and artifacts present an opportunity to engage the general public in the activities and stories of practicing scientists so that they may better understand how astronomy progresses as a science. The conservation and preservation of astronomical heritage takes many forms and presents some unique challenges. The identification of physical structures such as an observatory for preservation can be complicated when the label 'observatory' applies to a site consisting of multiple instruments and buildings. As Donnelly noted, the concept of an observatory as a single building was dominant until the last quarter of the nineteenth century when advances in instrument size and specialization resulted in the need for separate buildings.

> An 'observatory' can therefore no longer be defined as a single building, but rather as an enterprise which may be housed in one building or several. (Donnelly, 1973: 146).

The University of Illinois Observatory was constructed in 1896 and consisted of a single brick building, housing four transit telescopes, a classroom and office, and a 12-inch (30.5-cm) Warner & Swasey equatorial refractor as the primary instrument. The south yard behind the Observatory was home to several brick piers for surveying instruments, a shed for a 6-inch (15.2-cm) reflector, and a small dome for a 4-inch (10.2-cm) equatorial. In 1914, a new observatory was built for a purpose-built reflector. Considered part of the University of Illinois Observatory, it was locally referenced as either the annex or the south observatory.

This paper illustrates the multiple transformations of the observatory annex and its telescope, demonstrating a long history of adaptation from commercial to scientific purposes, variable stars to galactic structure, and photoelectric photometry to photographic research surveys. Tangible instruments and special-built observatories are often adapted and altered over time to different scientific purposes. As illustrated by this observatory, once the scientific purpose of the instrument or telescope has been satisfied, it is often forgotten. The significance of this telescope goes beyond the astronomical research conducted. The remaining artifacts from this telescope and forgotten observatory help tell the stories of the associated astronomers and their professional lives. The story of the observatory annex begins a decade before its construction in a private laboratory.

2 PEOPLE AND PLACES

2.1 Elmer Gates

The origin of the telescope that is the focus of this paper is with an unusual man. Psychologist, scientist, and inventor, Elmer Gates (1859–1923) was a person of many interests and talents with 43 patents to his name. His primary interest was in psychology, and his most recognized invention was the education toy consisting of a box with different shaped holes cut in it so that you can place similarly shaped blocks into it. He developed the largest private laboratory in the United States located in Chevy Chase, Maryland, and financed his investigations by commercial inventions. Unfortunately, he could get lost within the inventive process, neglecting the business side of his work. Many of his major inventions came with debt, forcing the need for more financing and inventions. It was one of these efforts that created the need for the telescope:

> In March 1903, a deal was made giving him $12,500 to develop his methods related to diamonds (improved Moissan process and an X-ray separation process), and he took up making synthetic rubies, and making large rubies from small natural ones. First he had John A. Brashears [sic] of the Allegheny Observatory near Pittsburgh make a solar

> focus, a 30-inch [76.2-cm] reflector of 20-inch [50.8-cm] focus, which after several corrections produced a solar image 0.17 inches in diameter, which Gates considered very good. On December 18 a ruby was melted by sunlight alone. (Gates, 1971: 253–254).

The John Brashear Company's catalog (1906) suggests a price of $7500 for a 30-inch reflector with setting circles and a clock drive. Gates' telescope was a special order designed to be a solar furnace. The primary mirror directed the light to a secondary mirror that then focused the light to a small crucible between the primary and

Figure 1: Photograph of the 30-inch as solar furnace in the laboratory of Elmer Gates circa1906 (image used with the permission of Elmer Gates.com.).

secondary mirrors. The mount was similar to the Keeler 30-inch reflector built in 1906 that can still be found at the Allegheny Observatory, although the solar furnace lacked setting circles and substituted a fork mount for the declination axis. After the initial efforts melting rubies, Gates abandoned the solar furnace in favor of a gas pressure furnace. It was also suggested that there were experiments melting platinum (New reflecting telescope, 1914). The telescope as a solar furnace is shown in Figure 1. By 1908, Gates was heavily in debt and sold the contents of the Chevy Chase Laboratory. Gates' assistant, Charles W. Draper, obtained the telescope, perhaps as financial compensation. While Gates' laboratory was in decline, research carried out by Joel Stebbins (1878–1966; Whitford, 1978) was in it ascendancy.

2.2 Joel Stebbins

The second incarnation of the telescope is associated with Joel Stebbins and photoelectric photometry. Stebbins arrived at the University of Illinois Observatory fresh out of his Ph.D. program at the University of California and Lick Observatory. The University of Illinois Observatory was equipped with a modest 12-inch Brashear refractor and was conceived and constructed as a teaching facility. The Observatory was part of the Department of Mathematics, and Stebbins taught both astronomy and mathematics. Why would an able, ambitious astronomer leave the mountain top center of astronomical research for the flat plains of Illinois? Lankford (1997) recounts Stebbins' decision based in part on the experiences of his mentor and Lick Observatory's director W.W. Campbell (1862–1938). Stebbins preferred a more stable and permanent university position, the social setting of a campus compared to an isolated mountain observatory, and finally the independence and control a modest university observatory would provide, compared to a major research facility. Stebbins later commented:

> One doesn't have to go to a place where there is a large observatory to find something to do. I have found conditions here in Urbana more favorable to my work than anywhere else. At the large observatories there is always something the matter. (Professor Joel Stebbins …, 1916).

2.2.1 A Photometric Telescope

After his arrival in the fall of 1903, Stebbins began to take advantage of the existing equipment and initiated a research program measuring the brightness of double stars with a visual polarizing photometer.

Frustrated with the visual polarizing photometer, he approached physics instructor F.C. Brown (1881–1968), who experimented with selenium cells. They soon constructed an electric photometer based on a selenium cell. Brown left Illinois in 1907 but continued to work with Stebbins, returning for the summers of 1908 and 1909, assisting with the development of the selenium photometer. By 1909, the selenium photometer had been improved to the point that 2nd magnitude stars were detectable, resulting in his seminal work on Algol. Stebbins (1911) struggled to improve the sensitivity of the selenium cells, even attempting to use liquid nitrogen in 1911. In order to continue his research on spectroscopic and eclipsing variable stars, Stebbins required either a new technological innovation or a larger telescope. He expressed his dilemma to the University President:

> At present we are continuing this work, but because of the moderate size of our instrument, the observations are limited to bright stars. If a larger telescope were available, we could reach much fainter objects, and the possibilities of discovery would be much increased. The highest optical excellence in a telescope is not

> necessary for this work, and it would be possible for us to use an instrument which would be worthless for some kinds of observation. (Stebbins, 1911c).

Stebbins pursued two avenues: seeking a larger instrument and improving the photometer's detector. He once again turned to the Physics Department and found Jacob Kunz (1874–1938; Stebbins, 1939). Instead of the selenium cell, Kunz worked with photoelectric cells. One of Kunz's graduate students, J.G. Kemp, found that a potassium-hydrogen photoelectric cell had 200 times the sensitivity of the selenium cell (Kemp, 1913). Encouraged by the results with the photocells, Kunz and another Illinois physicist, W.F. Schulz, made the first photoelectric measurements at Illinois of Capella in December 1912.

2.2.2 The Battle for Tenure

By 1911 Stebbins was not satisfied with his rate of advancement at the University (Lankford, 1997). In the previous eight years, he had a successful research agenda supported by grants, a consistent University budget, a Teaching Assistant, an undergraduate Research Assistant, and increased enrollment in the astronomy classes approaching 125 students. Stebbins articulated that he found the salary and conditions acceptable at Illinois and felt the Observatory was given solid support, but he had been passed over for promotion in spite of his contributions to both teaching and his pioneering selenium cell research. As he told his Lick Observatory mentor, W.W. Campbell,

> I am rather sorry that I did not have the offer of a position elsewhere, for it so happened that the men who spoke of leaving were the fortunate ones this time. (Stebbins, 1911a).

Stebbins met with University President Edmund James (1855–1925), concerning the future of astronomy at Illinois and his position. James was not encouraging, so Stebbins went in search of an outside offer, first approaching his former Lick Observatory associate W.J. Hussey at the University of Michigan's Detroit Observatory and then the University of Missouri in the spring of 1911. Campbell moved behind the scenes; and in April 1912 Stebbins was invited to the University of Virginia for an interview (Alderman, 1912). The efforts gave Stebbins a stronger hand in negotiating with the University of Illinois and as Stebbins noted:

> This Virginia opening has had a good effect upon the authorities here, for they have agreed to purchase the 30-inch short focus reflector from Mr. Chas. W. Draper of Washington, and also they will give me the rank of professor at $3,000 per annum. (Stebbins, 1912a).

At the 7 June 1912 Board of Trustees (1912 meeting, funds were provided for a large reflecting telescope; Stebbins was granted a sabbatical for the 1912–1913 academic year; and he was promoted to Professor. His only concession was agreeing that astronomy was to remain a division of the Department of Mathematics and not an independent department. Stebbins was relieved since he did not want to leave Illinois; and in a letter dated 19 June 1912 to Dean Edgar Townsend he stated: "I had a fine day in Charlottesville but Illinois with the new reflector seems the place for me. The instrument is even better than I expected." (Stebbins, 1912b).

Figure 2: The 30-inch in the mechanical workshop at the University of Illinois circa 1913 (courtesy: University of Illinois Department of Astronomy).

The month following the Trustees meeting, the telescope was purchased for $1500. According to letters in the Illinois Archives, this was one-third of the original cost of the instrument. The telescope was inspected by Wisconsin's Professor Comstock (1855–1934) and by the staff at the U.S. Naval Observatory in Washington before the sale was finalized. Once the telescope arrived in Urbana, it was slightly modified by the University's machine shop so that a detector was located at mirror's prime focus. The telescope is shown in Figure 2. A four-inch finder scope was also added.

Construction on the new observatory began in the spring of 1914. Designed by university architect James White, it was a two-story building with a twin shutter 15-foot wooden dome.

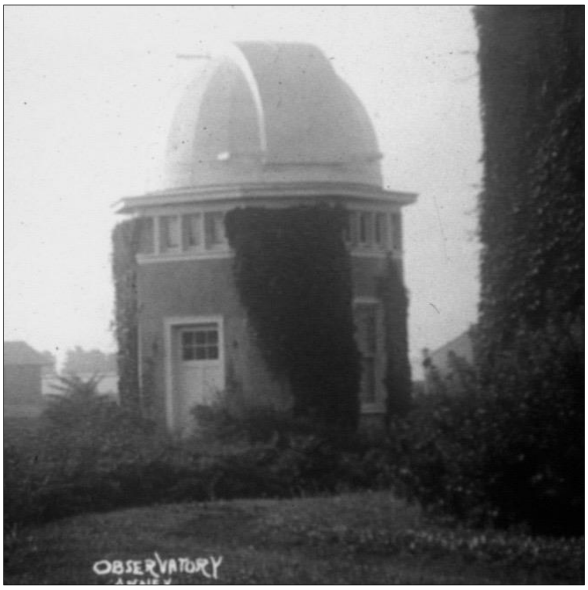

Figure 3: The Observatory annex circa 1917. The University of Illinois Observatory is in the fore ground on the right side of the photograph.

The tower was of wooden construction in the shape of an octagon with a stucco finish. The main entrance was on the north side, facing the main Observatory. The first floor was dominated by the brick telescope pier and stairs that wrapped around the pier. The structure was adapted to photometry with the addition of a battery room on the first floor and a source for dry air pumped into the photometer. Called the 'observatory annex', it was located south and east of the main Observatory (Figure 3). The telescope was in place by April 1915.

Figure 4: Electrical test equipment mounted on the right ascension axis and connected to a detector at the primary focus. Dates to circa 1917 (courtesy: University of Illinois Department of Astronomy).

The new telescope arrived with an interesting association. The 27 September 1913 article "Purchase new telescope" in the student newspaper *Daily Illini* claimed the University had purchased a second-hand telescope and "… the telescope was part of the apparatus with which experiments to photographing the human aura were conducted." Thus began the association between the telescope and observing the flight of human souls, a story that persisted for decades. Robert H. Baker (1928: 86) later recalled "… another story is that he [Gates] expected to observe the flight of souls." The origin of the story might be a 1906 press story that misrepresented one of Gates' experiments on the transparency of an animal body to certain electrical frequencies, claiming he saw the soul of a dying rat.

After his return from sabbatical in 1913, Stebbins abandoned his variable star research using the selenium cell photometer and began using the more sensitive photoelectric cells on the 12-inch refractor. Although the photoelectric photometer was proving to be a productive research instrument, Stebbins did not completely abandon the selenium cells. The new 30-inch reflector was reserved for testing new technologies and the 12-inch refractor for astronomical research. His correspondence with F.C. Brown and photographic evidence (Figure 4) illustrate the 30-inch reflector was used as a test bed for improving the selenium cell. The crucible of the solar furnace was replaced with a detector. Stebbins' collaboration with Brown included a paid visit to Urbana in April 1916. During the summer of 1919, Stebbins' Assistant Dr Elmer Dershem (1881–1965) wrote F.C. Brown, comparing the results of the selenium cells with recent tests of dyscrasite cells:

> I think that it might be possible that for our use a dyscrasite cell in a clear glass bulb instead of a red glass one would work better, since in this case we are not concerned with the necessity of eliminating visible light. However, as I do not know anything as to the sensibility of dyscrasite to violet light, I can only suggest this. (Dershem, 1919).

Dershem also rebuilt the photoelectric photometer being used for research on the 12-inch refractor. There is no evidence that the 30-inch telescope was used after Dershem left Illinois to become an Assistant Professor of Physics at the University of California Berkeley in 1919. Stebbins continued using the 12-inch refractor for photoelectric photometric research and directing C.C. Wylie's dissertation before leaving for the University of Wisconsin in 1922. One of Stebbins' final acts before departing Illinois was to establish Astronomy as an independent Department within the College of Liberal Arts and Science.

2.3 Robert Horace Baker

The third and fourth incarnations of the University of Illinois telescope are associated with Robert Horace Baker (1883–1964) and mark a change from photometric detectors to photographic detectors. Robert Baker was among the short-list of astronomers recommended by Stebbins (1922) in a letter to Dean Babcock as the new Observatory Director and Professor of Astronomy.[1] Baker had completed his Ph.D. at the University of Pittsburgh and worked at Allegheny Observatory under Director Frank Schlesinger (1871–1943; Brouwer, 1945) on spectroscopic binary stars. After graduation he was Director at the University of Missouri's Law Observatory where he continued his work on variable stars, employing a visual photometer and extrafocal photography. Stebbins had cited Baker's work on both spectroscopic binary stars and eclipsing binaries.

Baker was well positioned to continue Stebbins' photometric observations. After being selected as the new Director at Illinois in the spring of 1923, Baker spent the 1922–1923 academic year as a Martin Kellogg Fellow at Lick Observatory. Baker worked with his former student, Edith E. Cummings (b. 1894), using a photoelectric photometer based on Stebbins' photometer, built by Dr Elmer Dershem. Once in Urbana, Baker had a photoelectric photometer built based on the Lick Observatory photometer using the local experts in the Physics Department. In addition, Stebbins' student C.C. Wylie remained at Illinois until 1925. Baker (1926) began a program of variable star observing using the 12-inch refractor.

2.3.1 Photometry

Baker picked up Stebbins' photometric research program but had a challenge: what to do with the 30-inch reflector. The campus site was no longer suitable because of campus growth, the bright night sky, and the

> … 30-inch mirror had a focal length of only 20 inches and such necessarily imperfect definetion that is was not the easiest matter to distinguish between a star and the moon. (Baker, 1928: 86).

Thus began the telescope's third incarnation and the Observatory's first move.

Baker was able to secure funding from the University by the spring of 1924 to move the Observatory annex and have the telescope rebuilt. A new mirror was ordered from the Spencer Lens Company of New York. The new primary mirror was 30 inches in diameter, 4 inches thick with a 4-inch hole in the center. The secondary mirror was 7 inches (17.8 cm) in diameter and could be moved back and forth to achieve focus. Both were made of borosilicate crown glass figured by John E. Mellish (1886–1970; Williams, 1997). The new focal length of the primary was 75 inches (1.9 meters), yielding a focal ratio for the Cassegrain system of 12. The small size of the dome limited the tube assembly to 6 feet. The quality of the new optics permitted photometry and photography to be undertaken.

With the new optics and longer focal length, the telescope mount needed to be modified (Baker, 1928). In order to save money, the modifications were done on campus by the University's machine shops (Telescope built by local men, 1927). Six brass rods supported the secondary mirror in its new position. Black canvas wrapped the tube assembly. Focus was achieved by racking the secondary along the optic axis of the primary. Slow motion controls and clamps were added, as were long counter-balance weight rods. The clock drive was also modified to handle the extra load.

The 30-inch reflector observatory's new site was on the south side of Florida Avenue, about a quarter mile south of the main Observatory. The old 2-storey domed structure was moved in July 1924 to the new site. The location had darker skies, courtesy of Mt Hope cemetery to the north and agricultural fields to the south. The new location likely perpetuated the telescope's association with ghosts as younger astronomers retold the tale as they walked through the cemetery on their way to a night's work.

The rebuilt telescope (Figure 5) was complemented by a new photometer also built by the J.B. Hayes Company of Urbana who had assisted Stebbins with his photometers. The new photometer featured two cells and electrometers side by side, patterned after the Lick Observatory's electrometers. The intention was to study the light and color variations of Cepheid variables. Light could be diverted to either side. The cells were manufactured by the Cooper-Hewitt Company but filled by Kunz. Kunz's photoelectric cells dominated early astronomical photometry because their sensitivity exceeded that of commercially available photoelectric cells. The new photometer used a hybrid of commercial cells modified by Kunz. After Kunz's death, commercial photocells had improved in sensitivity and dominated astronomical photometers. The entire photometer, weighing 136 kg, could easily be removed, but seldom was, since the telescope was used exclusively for photometry.

Once the reflector was completed by the end of 1927,[2] research using the 12-inch refractor was discontinued; and the 30-inch reflector became the primary research instrument. As the new photometer was used more, it was found not

Figure 5: The rebuilt 30-inch telescope with dual channel photoelectric photometer attached. Circa 1928 (courtesy: University of Illinois Department of Astronomy).

not to perform as well as hoped. To improve its performance, a single quartz photocell by Kunz replaced the two Copper-Hewitt-Kunz cells. The dual electrometer was replaced by a smaller Lindemann electrometer. The astronomer records the time it takes for the electrometer needle to move ten scale divisions. In order for two stars to be compared, they must be nearly the same brightness. Stebbins typically used shade glasses and filters to reduce one star's brightness in a known quantity. In the rebuilt photometer, Baker followed the example of the Lick photometer and employed a sector box with rotating sector disks to reduce the brightness by the desired amount.

The photometer was used in routine observations of suspected variable stars but resulted in no research publications and only two theses. Sidney Jacob Walck (1904?–1970?) earned his Master of Arts degree in 1930 for his thesis *Photoelectric Photometry in Astronomy*, and Robert B. Arnold earned his Masters in 1931 for *The Design and Use of a Photoelectric Photometer for Astronomical Research*. In Arnold's thesis, there were data related to γ Eridani. In addition, he experimented with measuring the color index of the star directly using the photometer. The photocell had a maximum sensitivity in the blue. By adding a yellow filter, the sensitivity matched the human eye. The difference, multiplied by a correcting factor, yielded the color index. In practice, a blue filter was used. Arnold also noted Stebbins' photometric work on B class stars and color excess, the difference between the measured color index and the true color index. Color excess is an indication of the absorbing material in the path of starlight, a factor that influenced Baker's future work on star counts.

With the start of the Depression, the University cut salaries and research funds. Baker's salary dropped from $5000 to $4350, and his Departmental budget from $1000 to $200 a year. He lost an Assistant and any graduate students after 1933. As Hearnshaw (1993) noted, successful photometry during this period required collaboration with physicists; and Baker was not connected to the Illinois Physics Department as well as Stebbins had been. With little budget and technical support, Baker's research interest turned away from photometry in the 1930s. No research publications based on data from the photometer were published. Instead, as the reflector was stagnant, Baker was busy at the typewriter, producing a series of influential astronomy books. The textbook *Astronomy* was first published in 1930 followed by *An Introduction to Astronomy* in 1934, both dominating the introductory astronomy textbook market for decades. *The Universe Unfolding* was published in 1932 as part of the Century of Progress series. Additional books for the general public included *When the Stars Come Out* printed in 1934 and *Introducing the Constellations* in 1937.

The only noteworthy use of the new photometer was the opening of the Chicago Century of Progress World's Fair. Havlik (2006) recounts the use of Arcturus and photometers to open the exposition. The night of the grand public opening, undergraduate student Harry E. Crull assisted Baker at the photometer (Figure 6). At a quarter past nine o'clock on the evening of 27 May 1933, the telescopes at Yerkes, Harvard, Allegheny and the University of Illinois, with photocells attached, were pointed at Arcturus. The local newspaper recounted the event in the following manner:

> But in Urbana, just south of the University cemetery, a yellow star, zero in magnitude, shone down on a silent observatory. Forty years ago the star on its congratulatory message on the Columbian exposition; its message arrived last night in time to touch off another and greater exposition. A star had been called upon to come to earth and light a fair. And cosmos had responded without hesitation through the University observatory. (Lieberman, 1933).

2.3.2 Star Counting

Not finding much success with the photoelectric photometer, Baker's research interest returned to photography. In 1931–1932 and again in 1938–1939, he took a sabbatical leave, serving as Research Associate at Harvard. It was at this time he befriended and joined the research of Bart Bok (1906–1983; Grapham, Wade and Price, 1994), who was beginning his Star Counting Circuit. Bok's circuit involved the counting of stars over the entire course of the Milky Way, in order to achieve an understanding of the distribution of stars in the Galaxy and to measure the amount of obscuration present. Bok (1937) described this pioneering work in *The Distribution of Stars in Space*.

Even though photographs had been taken at the prime focus of the 30-inch (Bell Brothers …, 1936), it was not suited for such work. Baker contacted the J.W. Fecker Company about adapting the telescope for photographic work by converting it to a Schmidt starting in 1938, even discussing the possibility of using the original Brashear mirror (Baker, 1938). Fecker estimated the cost at $4680. Unfortunately, the University was able to provide only half of the needed money. Fecker proposed either a 5-inch (12.7-cm) or 4-inch Ross-Fecker refractor camera for under $2000. Baker chose the 4-inch Ross-Fecker because it had the same focal length and scale as the 4-inch Ross-Lundin camera at the Oak Ridge Station he used at Harvard during his 1938 sabbatical (Baker, 1939; Kiefer and Baker, 1941).

The optical tube assembly of the 30-inch reflector was dismounted, and the 4-inch Ross-Fecker camera put in its place in the fall of 1939. Ross-Fecker cameras were typically sold with a German Equatorial mount, but this camera was adapted to the yoke of the Brashear equatorial mount. The instrument (Figure 7) was an f/7 and held 8 ×10 inch glass plates. Each plate covered 9.4 × 4.4° of sky, and the scale of the plates was 290" per millimeter. The first photographs were taken in October 1939. Although the new camera was operational, Baker continued to correspond with Fecker, discussing a Schmidt camera made from regrinding the Mellish mirror and adding a 22-inch (55.9-cm) corrector plate. His hopes for a new larger photo-

Figure 6: University publicity photograph of Robert Baker and student Harry Crull recreating the opening of the Chicago Worlds Fair on 27 May 1933. Note that the photoelectric photometer has been rebuilt into a single channel instrument using a Lindemann electrometer (courtesy: University of Illinois Department of Astronomy).

Figure 7: The Ross-Fecker camera with 4-inch guiding scope (courtesy: University of Illinois Department of Astronomy).

graphic instrument never materialized. The new camera, however served as a catalyst for a new research and was the beginning of the fourth incarnation, resulting in the most productive research output.

Baker did little to popularize astronomy on campus and the undergraduate courses, prefering to teach the smaller upper level courses. In addition to an introductory course on descriptive astronomy, he taught the upper level 'Geodetic Astronomy' in the fall and 'Observational Astronomy' in the spring, as well as a graduate course in celestial mechanics and occasionally graduate courses in stellar astronomy or astrophysics. Undergraduate physicist Robert G. Tull (b. 1929) remembers taking an astronomy class with only three students (personal communication 16 December 2015). It was from those upper level courses that he recruited students for his star counting research.

Star counting research begins with a wide-angle camera recording stars down to the 15th magnitude on glass photographic plates. Investigators then count how many stars per square degree are brighter than 9th magnitude, 10th magnitude, and so on down to the 15th magnitude (Figure 8). Published magnitude scales provide a reference for the brighter stars. A magnitude scale, consisting of a series of eleven images of the same star with different exposure times, forms a geometric progression allowing unknown magnitudes to be estimated to a tenth of a magnitude. Assuming stars are evenly distributed in the Galaxy, differences in the density are the result of absorbing matter. The analysis is based on the measured star counts represented in the succession of magnitudes and on published color excesses and nebulae counts (Calvert, 1951).

Baker and Bok's correspondence, preserved at the Harvard Archives, shows frequent interaction and personal visits. Photographic plates, drafts of papers, as well as students, moved back

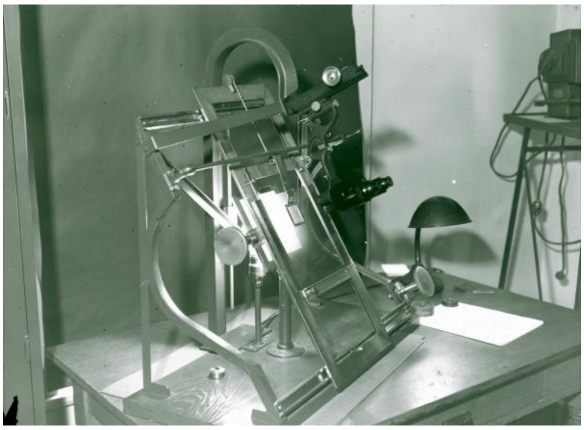

Figure 8: A Fecker plate counting machine purchased in 1939 and used to analyze the plates (courtesy: University of Illinois Department of Astronomy).

and forth between Cambridge and Urbana. Baker's connection to Bok provided valuable feedback for their work, as well as training for his undergraduate students. David Heeschen's (1926–2012; Hogg, 2014) paper on the Milky Way in Perseus used counts by undergraduates Allan Sandage (1926–2010; Devorkin, 2011) and T.J. McNamara. Allan Sandage learned the skills that he credits with making him an astronomer:

> He [Sandage] majored in physics and mathematics but he also minored in philosophy, and took a celestial mechanics course from Robert H. Baker. He volunteered to work at the observatory, learning the art and craft of calibrating photographic plates so that magnitudes could be transferred and intercompared from plate to plate, an experience that he later realized prepared him well for his life career and also introduced him into Bart Bok's "star counting" circuit based at Harvard. In consequence, when Bok visited Illinois sometime in 1947, he invited Sandage to work at Harvard in their summer school at the Agassiz Station mapping Milky Way fields. (DeVorkin, 2011; paragraph 4).

During the research life of the instrument, Baker recruited a number of graduate students mostly from mathematics. Lois Kiefer (1915–2009) earned her Ph.D. in mathematics for her work on radial analysis of the structure of the Milky Way in Auriga. Elaine Vivian Nantkes (1919–2008) earned a Master of Science in Mathematics in 1944, working on Cassiopeia and Cepheus and remained as a Visiting Lecturer in Astronomy until 1948. Ralph Lowell Calvert (1951) completed his mathematics Ph.D., completing an analysis of galactic structure in the direction of Aquila. David Heeschen earned his Master's for his work on Perseus in 1951. Mathematics instructor Dickran Erkiletian, Jr. (1913–1997) worked with Baker on Auriga, starting in 1940. Although not directly involved in star counting, Ray Langebartel (1921–2011), Illinois mathematics graduate, spent time at the Stockholm Observatory and then worked with Baker, eventually assuming the position of interim Department Chair after Baker retired at the end of the 1951 spring term.

Baker and his students published seven papers in the *Astrophysical Journal* on the analysis of the Milky Way in Cassiopeia (Baker and Nantkes, 1944), Ophiuchus, Sagittarius (Baker and Kiefer, 1942), Auriga (Kiefer and Baker, 1941), Aquila (Baker, 1941; Calvert, 1951), Cepheus (Nantkes and Baker, 1948) and Perseus (Heeschen, 1951). Baker also contributed plates of Monoceros for work by Bok and Jean Rendall.[3] This was the principal astronomical research done at the University of Illinois from 1939 until 1951. Unfortunately, the impact of the long years devoted to the tedious star counting was never fully realized. By 1951, Bok realized that radio astronomy held the key to mapping the galactic structure and quickly abandoned star counting (Bahcall, 1986). Bok comforted Baker in a 1952 letter:

> I do not agree with your rather gloomy outlook upon the value of the Illinois analyses of stellar distribution. The basic material of the star count is certainly sound and should continue to find many uses in years to come.

2.4 The McVittie Years

The days of the one-person Astronomy Department drew to a close with the retirement of Robert Baker in 1951. The University considered closing the Department but instead hired British cosmologist George C. McVittie (1904–1988; MacCallum, 1989). McVittie arrived in 1952, as both the Astronomy Department Chair and the Director of the University of Illinois Observatory. During his tenure, the enterprise of astronomical research became associated not with the Observatory but with the Department. McVittie grew the Department by adding faculty and addressed the lack of modern research facilities by expanding into the emerging area of radio astronomy, resulting in the construction of the Vermillion River Radio Observatory in 1962.

No longer suited for a growing modern astronomy department, the Ross-Fecker camera became a teaching tool. Members of the newly-formed University of Illinois Astronomical Society began using the telescope for personal use about 1954. McVittie allowed the student group to use the telescope in return for cleaning the facility and assisting at public open houses at the campus Observatory. Soon enrollment in both the undergraduate and graduate program grew to the point that a course in instrumentation was offered. The Ross-Fecker camera became an important portion of that class. Still lacking a large optical instrument, Raymond White Jr. (1933–2004; Liebert, 2004) was the last to use the Ross-Fecker camera for research. His 1967 dissertation investigated the density distribution of RR Lyrae variable stars.

Campus growth once again impacted the use of the Ross-Fecker camera. The nearby construction of Assembly Hall starting in 1959 resulted in road expansion and new parking lot lights, reducing the effectiveness of the camera. Once it was possible to take 90-minute exposures, but after the new parking lot was constructed the film fogged after only fifteen minutes. The observatory dome and the Ross-Fecker Camera were removed in 1965 when Florida Avenue was widened. The telescope was reassembled in 1968 at the University's new Prairie Observatory site near Oakland, Illinois, adjacent to Walnut Point State Park. The principal research instrument at the Prairie Observatory was a 1-m (39.37-in) Cassegrain, but the Ross-Fecker camera was used for instruction and was housed in a new independent building. Over the next 17-year period, there was an average of 38 plates taken per year, in addition to the undocumented photographs by members of the Astronomical Society. The last recorded plate was taken in October 1980 as part of the instrumentation course. With the 1-m telescope removed to Mount Laguna in 1981, vandals soon descended on the site, and the Ross-Fecker camera optics and finder scope were stolen and the mount damaged in 1983.

3 CONCLUSION

The University of Illinois Observatory remains on campus and continues in its role as a teaching facility while the Department of Astronomy has its own campus office building. What remains of the observatory annex and its telescope after more than a century of modifications and four moves? The 30-inch Brashear mirror, the tube assembly, photoelectric equipment and the Ross-Fecker camera have been lost. The Mellish 30-inch mirror remains for storytelling and is on display in the University of Illinois Observatory. The logbooks and the collection of over 2000 photographic glass plates are now located in the Yerkes Observatory Photographic Plate Collection.

The original Brashear telescope mount built for Gates and the 1914 twin-shutter dome still survive and remain functional. The 15-foot dome is all that remains of the observatory building and was acquired by the Champaign Urbana Astronomical Society in 1991 and moved back to Champaign County where it now sits at a dark sky site. Inside the dome is a 16-inch (40.6-cm) reflector, mounted to the original Brashear equatorial head and polar axis. That telescope is currently being rebuilt and modified (see Figure 9) so that it will continue to follow the stars.

4 NOTES

1. Stebbins recommended Keivin Burns from Allegheny Observatory, W.D. MacMillan from the University of Chicago, W.H. Wright from Lick Observatory, and as a bold and costly recommendation, A.S. Eddington from Cambridge, England. He mentioned that both MacMillan and Eddington were mathematical astronomers and would not need equipment.
2. Personal tragedy struck Robert H. Baker when his wife Rose died of pneumonia on 2 February 1925. His two children, Ralph and Ruth, were sent to live with her family in Washington State. Baker married Mary Howe (1900–1965) in June 1926. A Vassar College class of 1922 graduate, Howe had worked as an Assistant at Lick Observatory where she met Baker during his Kellogg Fellowship. She was the daughter of Louis McHenry Howe, long-time friend and chief advisor to President Franklin D. Roosevelt. Roosevelt was the godfather of Baker and Howe's only child, Robert Baker (1927–1983).
3. There is an unexplained 5-year gap in the plate collection between the dates of November 1942 and July 1947. This corresponds with a gap in the correspondence between Bok and Baker, stretching between January 1943 and November 1948.

Figure 9: The Brashear equatorial head and polar axis in November 2017 as it undergoes modification for a 16-inch telescope (photograph used with the permission of David Leake).

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