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10. REFERENCES

The following abbreviation is used:

SA = Mary Lea Shane Archives, University of California at Santa Cruz

Abbot, C.G., 1900. A preliminary statement of the results of the Smithsonian Observatory eclipse expedition. *Astrophysical Journal*, 12, 69-76.

Abbot, C.G., 1908a. A bolometric study of the solar corona. *Lick Observatory University of California Bulletin No. 132*. Berkeley, University Press, 5, 15-20.

Abbot, C.G., 1908b. A bolometric study of the solar corona. *Publications of the Astronomical Society of the Pacific,* 20, 119, 86-90.

Abbot, C.G., 1908c. 519-520. Probable nature of the corona. *Popular Astronomy*, 16, 519-520.

Abbot, C.G., 1911. *The Sun*. New York, Appleton.

Abbot, C.G., 1920. Observations of the total solar eclipse of May 29, 1919. *Astrophysical Journal,* 51, 1-3.

Abbot, C.G., 1929. *The Sun*. New York, Appleton.

Abbot, C.P., and Brackett, F.P., 1923. Introduction. *Annals of the Astrophysical Observatory of the Smithsonian Institution*, 4, 1-5.

Aitken, R.G., 1908. Latitude and longitude of the observing station, and the eclipse contact times. *Lick Observatory Bulletin,* 5, 6.

Aitken, R.G., 1917. A total eclipse of the Sun. *Publications of the Astronomical Society of the Pacific*, 29, 25-40. Adolfo Stahl Lecture delivered in San Francisco on January 12, 1917.

Aiken, R.G., 1923. Edward Emerson Barnard, 1857-1923. *Publications of the Astronomical Society of the Pacific,* 35, 87-94.

Aitken, R.G., 1928a. Appointments to fellowships in the Lick Observatory. *Publications of the Astronomical Society of the Pacific,* 35, 252-254.

Aitken, R.G., 1928b. The Lick Observatory forty years after. *Publications of the Astronomical Society of the Pacific,* 40, 151-163.

Aitken, R.G., 1929. The Lick Observatory-Crocker expedition to observe the solar eclipse of April 28, 1930. *Publications of the Astronomical Society of the Pacific,* 41, 281-282.

Aitken, R.G., 1930. The total eclipse on April, 1930. *Astronomical Society of the Pacific Leaflets,* 1, 109-112.

Aitken, R.G., 1932a. The Lick Observatory-Crocker expedition to Fryburg, Maine. *Publications of the Astronomical Society of the Pacific,* 44, 317-318.

Aitken, R.G., 1932b. The Lick Observatory-Crocker expedition to observe the total eclipse of the Sun on August 31, 1932. *Publications of the Astronomical Society of the Pacific,* 44, 122.

Aitken, R.G., 1933a. Notes on the progress of astronomy in the year 1932-1933. *Publications of the Astronomical Society of the Pacific,* 45, 127-137.

Aitken, R.G., 1933b. The use of astronomy. *Astronomical Society of the Pacific Leaflets,* 2, 33-36.

Andrews, L.B., and Whipple, F.L., 1932. The Harvard eclipse expeditions of 1932. *Popular Astronomy*, 40, 530-531.

Arrhenius, S., 1904a. On the physical nature of the solar corona. *Astrophysical Journal*, 20, 224-230.

Arrhenius, S., 1904b. On the physical nature of the solar corona. *Lick observatory Bulletin, no. 58*, 188-191.

Baily, S.I., 1931. *The History and Work of the Harvard Observatory 1839 to 1927*. McGraw-Hill.

Ball, R.S., 1893. *The Story of the Sun*. London, Cassell.

Barnard, E.E., 1889. *Reports on the Observations of the Total Eclipse of the Sun of January 1, 1889*: Report on the Photographic Operations by Mr. E.E. Barnard. Contributions of the Lick Observatory, No. 1. 56-75.

Barnard, E.E., 1892. Letter to Holden, no date. SA, microfilm, v32, 409-413.

Barnard, E.E., 1908. Some of the results of astronomical photography pertaining specially to the work with a portrait lens. *Popular Astronomy*, 16, 286-298.

Barnard, E.E., 1909a. Suggestions in respect to photographing comets with special reference to Halley's Comet. *Popular Astronomy*, 17, 597-609.

Barnard, E.E., 1909b. Letter to Campbell, dated 9 February. SA, Barnard File.

Barnard, E.E., 1913. *Photographs of the Milky Way and of Comets Made with the Six-Inch Willard Lens and Crocker Telescope During the years 1892 to 1895*. Publications of the Lick Observatory, Volume 11, Sacramento, State Printers, 1-46.

Barnard, E.E., 1919a. On the varnishing of astronomical negatives. *Popular Astronomy*, 27, 524.

Barnard, E.E., 1919b. On the varnishing of astronomical negatives. *Popular Astronomy*, 27, 487-489.

Barnard, E.E., 1923. Photographing the Sky. *Journal of the Royal Astronomical Society of Canada*, 17, 177-196.

Barnard, J.M., and Schaeberle, E.E., 1890. Simple method for pointing a photographic telescope during a long exposure. *Publications of the Astronomical Society of the Pacific*, 2, 259.

Barnes, V.M., 1923. Two eclipse expeditions of 1918. *Publications of the Pomona Astronomical Society*, 8, 29-31.

Becker, B.J., 2001. Visionary memories: William Huggins and the origins of astrophysics. *Journal for the History of Astronomy*, 32, 43-62.

Bigelow, F.H., 1889. *The solar corona, discussed by spherical harmonics. By Frank H. Bigelow*. Washington, Smithsonian Institution Publication 691, 1-22.

Bigelow, F.H., 1890. The law of the solar corona. *Publications of the Astronomical Society of the Pacific*, 34-39.

Bigelow, F.H., 1891a. The extension of the corona, and the details of its structure. *The Observatory*, 14, 50-52.

Bigelow, F.H., 1891b. The law of solar corona. *Publications of the Astronomical Society of the Pacific*, 3, 34-39.

Bigelow, F.H., 1906a. The Sun as magnetized sphere. *Popular Astronomy*, 14, 37-42.

Bigelow, F.H., 1906b. The Sun as magnetized sphere. *Popular Astronomy*, 14, 463-468.

Bigelow, F.H., 1918. *A Treatise on the Sun's Radiation and Other Solar Phenomena*. New York, John Whiley & Sons.

Bracher, K., 1992. Echoes of the past. *Mercury*, 21, 6, 191-192.

Bracher, K., 1997. Crowning the Sun. *Mercury*, 26, 3, 7.

Bracher, K., 2001. A Solar Eclipse in Sumatra. *Mercury*, 30, 6.

Brackett, F.P., 1930. The Pomona College eclipse expedition. *Publications of the Astronomical Society of the Pacific*, 42, 149-151.

Brashear, J.A., 1890. Letter to Brashear, dated 14 February. SA, Brashear Letter File.

Brashear, J.A., 1891. Letter to Holden, dated 13 December. SA, Brashear Letter File.

Brashear, J.A., 1895a. Letter to Campbell, dated 1 June. SA, Brashear Letter File.

Brashear, J.A., 1895b. Letter to Holden, dated 17 November. SA, Brashear Letter File.

Brashear, J.A., 1895c. Letter to Holden, dated December. SA, Brashear Letter File.

Brashear, J.A., 1896a. Letter to Holden, dated 20 April. SA, Brashear Letter File.

Brashear, J.A., 1896b. Letter to Holden, dated 4 May. SA, Brashear Letter File.

Brashear, J.A., 1897a. Letter to Holden, dated 22 September. SA, Brashear Letter Files.

Brashear, J.A., 1897b. Letter to Schaeberle, dated 11 October. SA, Brashear Letter Files.

Brashear, J.A., 1898. Letter to Keeler, dated 25 July. SA, Brashear Letter Files.

Brashear, J.A., 1924. *John A. Brashear: The Autobiography of a Man who Loved the Stars*. The American Society of Mechanical Engineers, New York. Cambridge, Riverside Press.

Brown, S.J., 1900. Preliminary results of the United States Naval Observatory eclipse expeditons. *Astrophysical Journal*, 12, 58-78.

Burckhalter, C., 1889. No title. 1889 September 28 meeting of the Astronomical Society of the Pacific, v12, 429-431.

Burckhalter, C., 1898. A general account of the Chabot Observatory-Pierson eclipse expedition to India. *Publications of the Astronomical Society of the Pacific*, 10, 203-212.

Burman, R.R., and Jeffery, P.M., 1990. Wallal – the 1922 eclipse expedition. *Astronomical Society of Australia. Proceedings*, 8.3, 312-313.

Burnham, S.W., and Schaeberle, J.M., 1889. *Reports on the Observations of the Total Eclipse of the Sun. II. Report of S.W. Burnham and J.M. Schaeberle*. Contributions of the Lick Observatory, No 1, Sacramento, State Printers.

Burnham, S.W., and Schaeberle, J.M., 1891. *II. Report of S.W. Burnham and J.M. Schaeberle: Total solar eclipse of December 21-22, 1889*. Contributions of the Lick Observatory, No 2, 22-46.

Campbell, E.B., Undated diary. *In the Shadow of the Moon: India, January 22, 1898.* SA. 1898 Eclipse file, 1-200.

Campbell, W.W., 1893a. Experiments in photographing the corona. *Publications of the Astronomical Society of the Pacific*, 5, 173.

Campbell, W.W., 1893b. Photographing the corona without an eclipse. *Publications of the Astronomical Society of the Pacific*, 5, 101.

Campbell, W.W., 1893c. The French eclipse expedition to Senegal. *Publications of the Astronomical Society of the Pacific*, 5, 180.

Campbell, W.W., 1894. Cloud observations on the island of Yezo, Japan with reference to the solar eclipse of 1896, August 9. *Publications of the Astronomical Society of the Pacific*, 6, 218-220.

Campbell, W.W., 1895a. On photographing the solar corona without an eclipse. *Publications of the Astronomical Society of the Pacific*, 7, 62.

Campbell, W.W., 1895b. The periodicity of the Sun-spots. *Publications of the Astronomical Society of the Pacific*, 7, 64.

Campbell, W.W., 1895c. Address of the retiring president of the society, at the seventh annual meeting (A.S.P.) March 30, 1895 A.S.P. *Publications of the Astronomical Society of the Pacific*, 7, 81-88.

Campbell, W.W., 1897a. Letter to Schaeberle, dated 9 August. SA, microfilm, v59, 348.

Campbell, W.W., 1897b. Letter to Schaeberle, dated 29 September. SA, microfilm, v59, 242.

Campbell, W.W., 1897c. Unpublished document, dated 25 March. SA, microfilm, v59, 249-250.

Campbell, W.W., 1898a. A general account of the Lick Observatory-Crocker Eclipse Expedition to India. *Publications of the Astronomical Society of the Pacific*, 10, 127-140.

Campbell, W.W., 1898b. Memo to Burckhalter, dated 17 May. SA, Campbell Letter File.

Campbell, W.W., 1899a. The wave-length of the green coronal line, and other data resulting from an attempt to determine the law of rotation of the solar corona. *Astrophysical Journal*, 10, 186-192.

Campbell, W.W., 1899b. Letter to Ormond Stone, dated 6 December. SA, microfilm vol Y, 71-82.

Campbell, W.W., 1900a. Observations of the second and third contacts at the solar eclipse of 1898 January 22, in India. *Astronomical Journal*, 20, 144-145.

Campbell, W.W., 1900b. Some spectrographic results obtained at the Indian eclipse by the Lick Observatory-Crocker Expedition. *Astrophysical Journal*, 11, 226-233.

Campbell, W.W., 1900c. James Edward Keeler. *Publications of the Astronomical Society of the Pacific*, 12, 139-145.

Campbell, W.W., 1900d. Letter to Keeler, dated 31 May. SA, Campbell Letter File.

Campbell, W.W., 1900e. Letter to Keeler, dated 2 June. SA, Campbell Letter File.

Campbell, W.W., 1900f. Letter to Keeler, dated 4 June. SA, Campbell Letter File.

Campbell, W.W., 1900g. Letter to Keeler, dated 05 June. SA, Campbell Letter File.

Campbell, W.W., 1900h. Letter to Keeler, dated 16 June. SA, Campbell Letter File.

Campbell, W.W., 1900i. Letter to President Wheeler of the University of California, dated 19 December. SA, microfilm, v28, 66-72

Campbell, W.W., 1900j. Letter to Leuschner, Director of the Student's Observatory UC Berkeley, dated 01 October. SA, microfilm, v28, 80.

Campbell, W.W., 1900k. Letter to Leuschner, dated September. SA, microfilm, v28, 150.

Campbell, W.W., 1900l. Letter to A. Carnegie, dated 1 November. SA, Microfilm, v28, 256.

Campbell, W.W., 1900m. Letter to President Wheeler, University of California, dated 19 December. SA, microfilm, v28, 1-2.

Campbell, W.W., 1901a. Letter to S.A. Mitchell, Columbia University, dated 14 January. SA, Campbell letter file, 27.

Campbell, W.W., 1901b. Letter to Perrine, dated 15 February. SA, microfilm, v28, 281.

Campbell, W.W., 1901c. Letter to G.E. Hale, dated 24 January. SA, microfilm v28, 89.

Campbell, W.W., 1901d. Letter to Pickering at Harvard College Observatory, dated 12 October. SA, microfilm v30, 429.

Campbell, W.W., 1901e. Letter to President Wheeler, University of California, dated 1 October. SA, microfilm v30.

Campbell, W.W., 1901f. Letter to Northern Insurance Company, dated 12 October. SA, v30, 433.

Campbell, W.W., 1901g. Letter to A. Fowler, dated 10 March. SA microfilm v29, copybook V71.

Campbell, W.W., 1901h. Letter to A. Fowler, dated 5 April. SA microfilm v29, copybook V71, 179-180.

Campbell, W.W., 1901i. Letter to Newcomb, dated 9 September. SA, microfilm, v30, 481.

Campbell, W.W., 1901j. Letter to R. Wood at John Hopkins University, dated 10 October. SA, microfilm, v30II, 30

Campbell, W.W., 1901k. Letter to J.O. Hirchfelder, dated 13 March. SA, microfilm, v29, 25.

Campbell, W.W., 1901l. Letter to Hursch and Kaiser, dated 14 September. SA, microfilm, v30.

Campbell, W.W., 1901m. Letter to Bakewell, University of California, dated 6 November, v30II, 120.

Campbell, W.W., 1901n. Letter to McKowne, Acting Secretary, board of Regents, University of California, dated 1 February. SA, microfilm, v28, 156.

Campbell, W.W., 1901o. Letter to President Wheeler, President of the University of California, dated 19 April. SA, microfilm, v29, 326.

Campbell, W.W., 1901p. Letter to G.E. Hale, dated December. SA, microfilm, v30.

Campbell, W.W., 1901q. Letter to G.E. Hale, dated 14 August. SA, microfilm, v30, 65.

Campbell, W.W., 1901r. Letter to Carnegie, dated 14 September. SA, microfilm, v30, 278.

Campbell, W.W., 1901s. Letter to Burckhalter, dated 2 November. SA, microfilm, v30II, 97-98.

Campbell, W.W., 1901t. Letter to General Barnes, Chairman of the Lick Observatory Committee, dated 17 June. SA, microfilm, v29II, 231.

Campbell, W.W., 1902a. Letter to Christie, the Astronomer Royal, Greenwich, dated 2 February. SA, v31II, 386.

Campbell, W.W., 1902b. Letter to Lockyer, dated 27 February. SA, microfilm, v31, 52-53.

Campbell, W.W., 1902c. Annual report, dated June. SA, microfilm, v32.

Campbell, W.W., 1902d. Letter to Bigelow, dated 26 June. SA, microfilm, v32, 166-167.

Campbell, W.W., 1902e. Letter to Ress, dated 27 February. SA, microfilm, v31II, 47-48.

Campbell, W.W., 1902f. Letter to President Wheeler, University of California, dated 17 May. SA, microfilm, v32II, 228-229.

Campbell, W.W., 1902g. Letter to President Wheeler, University of California, dated 15 February. SA, microfilm, v31, 44-46.

Campbell, W.W., 1902h. Letter to President Wheeler, University of California, dated 12 December. SA, microfilm, v33I, 18.

Campbell, W.W., 1902i. Letter to President Wheeler, University of California, dated 25 January. SA, microfilm, v31I, 198.

Campbell, W.W., 1902j. Letter to President Stanford, Stanford University, dated 21 March. SA, microfilm, v31, 125.

Campbell, W.W., 1902k. Letter to G.C. Perkins, United States Senator, dated 20 March. SA, v31, 128.

Campbell, W.W., 1902l. Letter to President Wheeler, University of California, dated 27 July. SA, microfilm, v31I, 403.

Campbell, W.W., 1902m. Letter to J.A. Parkhurst, Yerkes Observatory, dated 20 May. SA, microfilm, v32, 437.

Campbell, W.W., 1902n. Letter to President Wheeler, University of California, dated 17 July. SA, microfilm, v331I, 371.

Campbell, W.W., 1903a. Letter to Barnard, dated 25 March. SA, microfilm, v33, 56.

Campbell, W.W., 1903b. Letter to Hussey quoting Hale, dated 24 April. SA, microfilm, v33, 306.

Campbell, W.W., 1904a. The Crocker Eclipse Expeditions in 1905. *Astrophysical Journal*, 20, 235-236.

Campbell, W.W., 1904b. The total eclipse of August 30, 1905. *Popular Science Monthly*, 97-108.

Campbell, W.W., 1904c. The Crocker eclipse expeditions in 1905. *Lick Observatory University of California Bulletin No. 59*. Berkeley, University Press, 3, 1-2.

Campbell, W.W., 1904d. Expedition budget sheet, undated. SA, Campbell letter file.

Campbell, W.W., 1904e. Letter to A. Shuster, no date. SA, copybook V82, 478-479.

Campbell, W.W., 1904f. Letter to A. Shuster, dated 31 May. SA, copybook V84.

Campbell, W.W., 1904g. Letter to W.W. Law, Esq., Yonkers, New York, dated 17 May. SA, microfilm-copybook v84, 70-71.

Campbell, W.W., 1905a. Station coordinates and contact-times for the eclipse of August 30, 1905. *Lick Observatory University of California Bulletin*. Berkeley, University Press, 4, 118-120.

Campbell, W.W., 1905b. Letter to Macgregor, General of Newfoundland, dated 6 February. SA, Campbell letter file.

Campbell, W.W., 1905c. Letter to Macgregor, General of Newfoundland, dated 14 February. SA, Campbell letter file.

Campbell, W.W., 1907a. The Lick Observatory Crocker Eclipse Expedition of 1905. *Chronicle* IX:1, University of California at Berkeley, University Press, June (1907).

Campbell, W.W., 1907b. The solar corona. *Publications of the Astronomical Society of the Pacific*, 19, 71-79.

Campbell, W.W., 1907c. Plans for observing the total eclipse of January, 1908. *Publications of the Astronomical Society of the Pacific*, 19, 167-168.

Campbell, W.W., 1908a. Coronal photographs with the Floyd camera. *Lick Observatory University of California Bulletin No. 18*. Berkeley, University Press, 5, 7-8.

Campbell, W.W., 1908b. The Crocker Eclipse Expedition of 1908 from the Lick Observatory, University of California. *Publications of the Astronomical Society of the Pacific*, 20, 63-85.

Campbell, W.W., 1908c. Flint Island corona. *Publications of the Astronomical Society of the Pacific*, 20, 232-234.

Campbell, W.W., 1908d. The spectrum of the Sun's edge with the moving-plate spectrograph. *Lick Observatory University of California Bulletin No. 131*. Berkeley, University Press, 5, 10.

Campbell, W.W., 1908e. Coronal photographs with the forty-foot camera. *Lick Observatory University of California Bulletin No. 18*. Berkeley, University Press, 5, 8-9.

Campbell, W.W., 1908f. Observations of the total solar eclipse, dated August 17. SA, Campbell letter file, 288-293.

Campbell, W.W., 1910a. Sir William Huggins, K.C.B., O.M. *Publications of the Astronomical Society of the Pacific*, 22 149-162.

Campbell, W.W., 1910b. Report of Lick Observatory. *Publications of the Astronomical Society of the Pacific*, 22, 216-241.

Campbell, W.W., 1910c. Appointment of Dr. ABLRECHT. *Publications of the Astronomical Society of the Pacific*, 22, 100.

Campbell, W.W., 1910d. Memorial to Professor Keeler. *Publications of the Astronomical Society of the Pacific*, 22, 189.

Campbell, W.W., 1912. Biennial report of the director of Lick Observatory. *Publications of the Astronomical Society of the Pacific*, 24, 237-249.

Campbell, W.W., 1914. Edward Singleton Holden, Sc.D, LL.D., LITT.D. *Publications of the Astronomical Society of the Pacific*, 26, 77-87.

Campbell, W.W., 1918a. The total eclipse of June 8, 1918. *Lick Observatory University of California Bulletin No. 317*. Berkeley, University Press, 10, 1-3.

Campbell, W.W., 1918b. The Crocker Eclipse Expedition, 1918. *Publications of the Astronomical Society of the Pacific*, 30, 195-198.

Campbell, W.W., 1918c. The Crocker Eclipse Expedition from the Lick Observatory, University of California, June 8, 1918. *Publications of the Astronomical Society of the Pacific*, 30, 219-240.

Campbell, W.W., 1918d. The Lick Observatory eclipse instruments. *Popular Astronomy*, 26, 356-

Campbell, W.W., 1918e. The Lick Observatory eclipse instruments. *Publications of the Astronomical Society of the Pacific*, 30, 171-174.

Campbell, W.W., 1918f. The return of eclipse instruments from Russia. *Publications of the Astronomical Society of the Pacific*, 30, 177, 312.

Campbell, W.W., 1919a. Solar eclipse notes. *Publications of the Astronomical Society of the Pacific*, 31, 113-116.

Campbell, W.W., 1919b. The Crocker Eclipse Expedition from the Lick Observatory, June 8, 1918. Some eclipse problems. Unpublished paper read before the American Philosophical Society on April 25, 1919, 1-23.

Campbell, W.W., 1920. Volume XIII, Publications of the Lick Observatory. *Publications of the Astronomical Society of the Pacific*, 32, 67.

Campbell, W.W., 1921a. The total solar eclipse of September 10, 1922. *Publications of the Astronomical Society of the Pacific*, 33, 254-255.

Campbell, W.W., 1921b. The total solar eclipse of September 10, 1923. *Publications of the Astronomical Society of the Pacific*, 33, 255-257.

Campbell, W.W., 1922a. Notes on the Crocker Eclipse expedition to Australia. *Publications of the Astronomical Society of the Pacific*, 34, 171-172.

Campbell, W.W., 1922b. The total eclipse of September 21, 1922. *Publications of the Astronomical Society of the Pacific*, 33, 254-258.

Campbell, W.W., 1922c. The total eclipse of September 21, 1922. *Publications of the Astronomical Society of the Pacific*, 34, 121-125.

Campbell, W.W., 1922d. The total eclipse of September 21, 1922. *Journal of the Royal Astronomical Society of Canada*, 16, 186-190.

Campbell, W.W., 1922e. Personal notes. Campbell, W. W., 1921. *Publications of the Astronomical Society of the Pacific*, 34, 172-173.

Campbell, W.W., 1923a. The total eclipse of September 21, 1922. *Publications of the Astronomical Society of the Pacific,* 35, 11-44.

Campbell, W.W., 1923b. Conditions apparently existing in the solar corona. *Popular Astronomy*, 31, 642-643.

Campbell, W.W., 1923c. Search for intramercurial bodies. *Publications of the Astronomical Society of the Pacific*, 35, 214-216.

Campbell, W.W., 1930. Letter to Col. Van Horn, dated 07 February. SA, 1930 eclipse file.

Campbell, W.W., and Albrecht, S., 1908a. The coronal spectrum. *Lick Observatory University of California Bulletin No. 131*. Berkeley, University Press, 5, 13-14.

Campbell, W.W., and Albrecht, S., 1908b. The coronal spectrum as observed at the Flint Island eclipse. *Publications of the Astronomical Society of the Pacific*, 20, 168-171.

Campbell, W.W., and Albrecht, S., 1908c. A disturbed region in the corona of January 3, 1908. *Lick Observatory University of California Bulletin No. 136*. Berkeley, University Press, 5, 36-37.

Campbell, W.W., and Albrecht, S., 1908d. *Lick Observatory University of California Bulletin No. 18*. Berkeley, University Press, 5, 7-9.

Campbell, W.W., and Albrecht, S., 1908e. A disturbed region in the corona of January 3, 1908. *Publications of the Astronomical Society of the Pacific* 20, 232-233.

Campbell, W.W., Albrecht, S., and Tucker, R. H., 1908. A disturbed region in the corona of January 3, 1908. *Lick Observatory University of California Bulletin No. 136*. Berkeley, University Press, 5, 36-37.

Campbell, W.W., Aitken, R.G., Perrine, C.D., Albrecht, S., and Lewis, E.P., 1908. The Crocker Eclipse Expedition of 1908. *Lick Observatory University of California Bulletin No. 131*. Berkeley, University Press, 5, 1-14.

Campbell, W.W., and Curtis, H.D., 1914. The Lick Observatory-Crocker Eclipse Expedition to Brovary, Russia. *Publications of the Astronomical Society of the Pacific*, 26, 224-237.

Campbell, W.W., Lewis, E.P., and Wright, W.H., 1919. The total eclipse of June 8, 1918. *Lick Observatory University of California Bulletin No. 117(118), 318*. Berkeley, University Press, 10, 1-14.

Campbell, W.W., and Moore, J.H., 1918a. Bright-line spectrum of the corona. *Publications of the Astronomical Society of the Pacific*, 30, 349-351.

Campbell, W.W., and Moore, J.H., 1918b. The wave-length of the green coronium line. *Publications of the Astronomical Society of the Pacific*, 30, 348-349.

Campbell, W.W., and Moore, J.H., 1918c. The spectrum of the solar corona. *Lick Observatory University of California Bulletin*. Berkeley, University Press, 10, 8-14.

Campbell, W.W., and Perrine, C.D., 1900. The Crocker Expedition to observe the total eclipse of May 28, 1900. *Publications of the Astronomical Society of the Pacific*, 12, 175-184.

Campbell, W.W., and Perrine, C.D., 1905a. The results of efforts to determine motion within the solar corona. *Lick Observatory University of California Bulletin*. Berkeley, University Press, 4, 121.

Campbell, W.W., and Perrine, C.D., 1905b. Note on a disturbed region in the corona of August 30, 1905. *Lick Observatory University of California Bulletin*. Berkeley, University Press, 4, 122.

Campbell, W.W., and Perrine, C.D., 1906. The Lick Observatory-Crocker Eclipse Expedition to Spain. *Publications of the Astronomical Society of the Pacific*, 18, 13-36.

Campbell, W.W., and Perrine, C.D., 1907a. Note on a disturbed region in the corona of August 30, 1905. *Lick Observatory University of California Bulletin No. 115*. Berkeley, University Press, 3, 122.

Campbell, W.W., and Perrine, C.D., 1907b. The results of an effort to determine motion within the solar corona. *Publications of the Astronomical Society of the Pacific*, 19, 160-161.

Campbell, W.W., and Perrine, C.D., 1907c. The results of an effort to determine motion within the solar corona. *Lick Observatory University of California Bulletin No. 115*. Berkeley, University Press, 3, 121.

Campbell, W.W., and Perrine, C.D., 1907d. Note on a disturbed region in the corona of August 30, 1905. *Publications of the Astronomical Society of the Pacific*, 19, 161-163.

Campbell, W.W., Lewis, E.P., and Wright, W.H., 1919. The total solar eclipse of June8, 1918. *Lick Observatory Bulletin, No. 317, 318*, 1-14.

Campbell, W.W., and Trumpler, R.J., 1923a. Observations on the Deflection of Light in Passing Through the Sun's Gravitational Field. *Lick Observatory University of California Bulletin No. 346*. Berkeley, University Press, 11, 41-54.

Campbell, W.W., and Trumpler, R.J., 1923b. Search for intramercurial bodies. *Publications of the Astronomical Society of the Pacific*, 35, 214-216.

Campbell, W.W., and Trumpler, R.J., 1928. Observations made with a pair of five-foot cameras on the light-deflections in the Sun's gravitational field at the total solar eclipse of September 21, 1922. *Lick Observatory University of California Bulletin No. 397*. Berkeley, University Press, 13, 130-160.

Carver, R.T., 1915. Address upon the presentation of the Bruce Gold Medal to Dr. W. W. Campbell. *Publications of the Astronomical Society of the Pacific*, 27, 153-160.

Chambers, G.F., 1902. The *Story of Eclipses*. New York, McClure, Phillips.

Chant, C.A., 1922. The eclipse expedition to Australia-from Auckland to Port Hedland. *Journal of the Royal Astronomical Society of Canada*, 16, 281-283.

Christie, W.H.M., and Dyson, F.W., 1900. Expedition to Ovar, Portugal, preliminary report: Total solar eclipse of 1900 May 28. *Monthly Notices of the Royal Astronomical Society*, 60, 392-402.

Christie, W.H.M., Hills, E.H., and Turner, H.H., 1897. 1896 August 9, report on the expedition to Japan. *Monthly Notices of the Royal Astronomical Society*, 57, 95-111.

Clerke, A.M., 1902. *A Popular History of Astronomy*. London, Adam and Charles Black.

Clerke, A.M., 1903. *Problems in Astrophysics*. London, Adam and Charles Black.

Clerke, A.M., 1908. *A Popular History of Astronomy*. London, Adam and Charles Black.

Cliver, E.W., 1989. Was the eclipse comet of 1893 a disconnected coronal mass ejection? *Solar Physics*, 122, 319-333.

Collins, J.R., 1932. The Royal Astronomical Society of Canada's expedition to observe the total eclipse of the Sun, August 31, 1932. *Journal of the Royal Astronomical Society of Canada*, 26, 425-436.

Common, A.A., 1893. Preliminary report of the Joint Solar Eclipse Committee of the Royal Society, the Royal Astronomical Society, and the Solar Physics Committee on the Observations of the solar eclipse of 1893 April 16. *Monthly Notices of the Royal Astronomical Society*, 53, 472-473.

Comstock, G.C., 1900. The Astronomical and Astrophysical Society of America. *Science*, 12, 171-191 174.

Cooke, W.W., 1923. The total solar eclipse of 1922 September 21. *Monthly Notices of the Royal Astronomical Society*, 83, 511-51.

Copeland, R., 1900. Expedition to Santa Pola, Spain, preliminary report: Total solar eclipse of 1900 May 28. *Monthly Notices of the Royal Astronomical Society*, 63, 385-4391.

Crawford, R.T., 1915. Address upon the presentation of the Bruce Gold Medal to Dr. W. W. Campbell. *Publications of the Astronomical Society of the Pacific*, 27, 153-160.

Crelinsten, J., 2006. *Einstein's Jury, the Race to Test Relativity*. New Jersey, Princeton University Press.

Curtis, H.D., 1901. The U. S. Naval Observatory eclipse expedition to Sumatra. *Publications of the Astronomical Society of the Pacific*, 13, 205-213.

Curtis, H.D., 1902. On the limits of unaided vision. *Lick Observatory University of California Bulletin No. 38*. Berkeley, University Press, 2, 67-69.

Curtis, H.D., 1904. A brief review of recent progress in solar physics. *Publications of the Astronomical Society of the Pacific*, 16, 133-140.

Curtis, H.D., 1905. The Lick Observatory-Crocker Eclipse Expedition to Labrador. *Publications of the Astronomical Society of the Pacific*, 17, 173-181.

Curtis, H.D., 1918. Note on the result of the search for an intra-Mercurial planet, eclipse of June 8, 1918. *Publications of the Astronomical Society of the Pacific*, 31, 234-235.

Curtiss, R.H., 1926. William Joseph Hussey. *Popular Astronomy*, 34, 605-612.

Davidson, C.R., and Jackson, J., 1932. *Monthly Notices of the Royal Astronomical Society*, 39, 3-8.

De La Rue, W., 1860. Photographs of the solar eclipse of 18 July, 1860. *Monthly Notices of the Royal Astronomical Society*, 21, 177-178.

Demiansky, M., and Pasachoff, J.M., 1984, Coelostat and Heliostat – Theory of Alignment. *Solar Physics*, 93, 211-217.

Dick, S.J., 2007. *Sky and Ocean Joined. The U.S. Naval Observatory 1830-2000*. Cambridge, Cambridge University Press.

Dodwell, G.E., and Davidson, C.R., 1924. Determination of the deflection of light by the sun's gravitational field from observations made at Cordillo Downs, South Australia, during the total eclipse of 1922 September 21. *Monthly Notices of the Royal Astronomical Society*, 84, 385-4391. 150-162.

Douglas, A.V., 1952. *The Life of Aruthur Stanley Eddington*. Ontario, Thomas Nelson and Sons, Ltd.

Duncan, J.C., 1930. *Astronomy*. London, Harper and Brothers Publishers.

Dyson, F. and Woolley, R., 1937. *Eclipses of the Sun and Moon*. Oxford, Clarendon Press.

Eddy, J.A., 1970. The Schaeberle 40 foot camera. Unpublished paper, submitted to the *Journal for the History of Astronomy*. Sponsored by the National Science Foundation and the High Altitude Observatory of the National Center for Atmospheric Research. SA. Eclipse Files.

Eddy, J.A., 1971. The Schaeberle 40-ft Camera of the Lick Observatory. *Journal for the History of Astronomy*, 2, 1-22.

Eddy, J.A., 1973. Observation of a possible sheet in the corona. *Solar Physics*, 30, 385-394.

Eddy, J.A., and Goff, J., 1971. An atlas of the white light corona (abstract). *Bulletin of the American Astronomical Society*, 3, 262.

Everett, A., 1893. The total eclipse. *The Observatory*, 16, 200-201.

Galligan, F.A., 1930. Letter to Aitken from Curtiss-Wright Flying Service, dated 7 February, SA, Aitken Letter File.

Golub, L., and Pasachoff, J.M., 1997. *The Solar Corona*. 2nd ed. 2007. Cambridge, Cambridge, Mass, University Press.

Golub, L., and Pasachoff, J.M. 2001. *Nearest Star, The Surprising Science of Our Sun*. Cambridge, Mass, Harvard University Press.

Grant, R., 1852. *History of Physical Astronomy from the Earliest Ages to the Middle of the Nineteenth Century*. London, Henry G. Bohn., 1-624.

Guillemen, A., 1872. *The Sun. London*. Richard Bentley, New Burlington St.

Gustafson, J.R., 1988. Pioneering astronomy at Lick Observatory. *Astronomy*, 16, 7-15.

Hale, G.E., 1897. Letter to Campbell, dated 25 March. SA, Hale letter file.

Hale, G.E., 1900. The Yerkes Observatory of the University of Chicago, Bulletin No. 14, Observations of the Total Solar Eclipse of May 28, 1900, at Wadesboro, N. C., *Astrophysical Journal*, 23, 80-89.

Hale, G.E., 1906. Some tests of the Snow Telescope. *Astrophysical Journal*, 23, 6-10.

Hale, G.E., 1907. A vertical coelostat telescope. *Astrophysical Journal*, 25, 68-74.

Hale, G.E., 1908a. On the probable existence of a magnetic field in Sun-spots. *Contributions from the Mount Wilson Observatory No. 30,* Carnegie Institution of Washington, 30, 1-29.

Hale, G.E., 1908b. Preliminary note on the rotation of the Sun as determined from the motions of the Hydrogen flocculi. *Astrophysical Journal*, 27, 219-229.

Hale, G.E., 1908c. Solar Vortices. *Contributions from the Mt. Wilson Observatory, No. 26*, Carnegie Institution of Washington, 26, 1-17.

Hale, G.E., 1908d. The Zeeman effect in the Sun. *Publications of the Astronomical Society of the Pacific*, 20, 287-343.

Hale, G.E., 1908e. Solar Vortices. *Astrophysical Journal*, 28,100-116.

Hale, G.E., 1909a. Solar vortices and magnetic fields. *The Observatory*, 32, 311-315.

Hale, G.E., 1909b. Note on the magnetic field in Sun-spots. *Publications of the Astronomical Society of the Pacific*, 21, 205-208.

Hale, G.E., 1912. A Sun-spot hypothesis. *Publications of the Astronomical Society of the Pacific*, 24, 226-227.

Hale, G.E., 1913. Preliminary results of an attempt to detect the general magnetic field of the Sun. *Astrophysical Journal*, 38, 27-98.

Hale, G.E., 1919. The magnetic polarity of Sun-spots. *Astrophysical Journal*, 49, 153-178.

Hale, G.E., 1935. Sir Arthur Schuster. *Astrophysical Journal*, 81, 97-106.

Hale, G.E., and Adams, W.S., 1909. Photography of the "flash" spectrum without an eclipse. *Astrophysical Journal*, 30, 222-230.

Hale, G.E., and Nicholson, S.B., 1925. The law of Sun-spot polarity. *Astrophysical Journal*, 62, 270-300.

Hale, G.E., Seares, F.H., van Maanen, A., and Ellerman, F., 1918. The general magnetic field of the Sun. Apparent variation of field-strength with level in the solar atmosphere. *Astrophysical Journal*, 47, 206-254.

Hammond, J.C., 1919. The Naval Observatory eclipse expedition, June 8, 1918. *Popular Astronomy*, 27, 1-6.

Hastings, C.S., 1883. On the variation in the focal length of an objective with change of temperature. *Astronomische Nachrichten*, 105, 69-72.

Holden, E.S., 1886. Letter to the Editor. *Astronomische Nachrichten*, 113, 49.

Holden, E.S., 1887. VIII. *Description of the Astronomical Instruments*. Publications of the Lick Observatory 1. 59-77.

Holden, E.S., 1888a. The Lick Observatory. *Astronomische Nachrichten*, 119, 303.

Holden, E.S., 1888b. The total solar eclipse of 1889, January 1, in California: probable meteorological conditions at that time. *Monthly Notices of the Royal Astronomical Society*, 48, 302-307.

Holden, E.S., 1889a. Letter to Burnham and Schaeberle, dated 26 July. SA, Holden letter file, 1-16.

Holden, E.S., 1889b. Reports on the observations of the total eclipse of the Sun of January 1, 1889. *Contributions of Lick Observatory*, 1, 1-210.

Holden, E.S., 1889c. *On the photographs of the corona at the solar eclipse of 1889*. London, Spottiswoode & co., printers, 1889.

Holden, E.S., 1889d. On the solar eclipse of January 1, 1889. *The Observatory*, 12, 130-134.

Holden, E.S., 1889e. The work of an astronomical society. *Publications of the Astronomical Society of the Pacific*, 1, 9-22.

Holden, E.S., 1889f. On the photographs of the corona at the solar eclipse of 1889, January 1. *Monthly Notices of the Royal Astronomical Society*, 49, 343-351.

Holden, E.S., 1889g. The corona of 1889 Jan. 1. *The Observatory*, 12, 221.

Holden, E.S., 1889h. Letter to Burnham and Schaeberle, dated 26 July. SA, Holden Letter File.

Holden, E.S., 1889i. Examination of stellar photographs. *Publications of the Astronomical Society of the Pacific*, 1, 75-76.

Holden, E.S., 1889j. Note on the corona of Jan 1, 1889. *Publications of the Astronomical Society of the Pacific*, 1, 76-77.

Holden, E.S., 1889k. Letter to Burnham and Schaeberle, dated 17 October. SA, Holden microfilm 353.

Holden, E.S., 1889m. *Suggestions for Observing the Total Eclipse of the Sun on January 1, 1889*. Sacramento, University of California, State Printers, 1-21.

Holden, E.S., 1890a. Letter to Schaeberle, dated 16 October. SA, Schaeberle, microfilm, v17, 340-344.

Holden, E.S., 1890b. Letter to Schaeberle, dated 28 October. SA, Schaeberle, microfilm, v17.

Holden, E.S., 1890c. Address of the retiring President of the second annual meeting (March 29, 1890). *Publications of the Astronomical Society of the Pacific*, 2, 50-54.

Holden, E.S., 1890d. Eclipse of December 21, 1889. *Publications of the Astronomical Society of the Pacific*, 2, 93-97.

Holden, E.S., 1890e. Photometry of the corona of December, 1889. *Publications of the Astronomical Society of the Pacific*, 2, 69-70.

Holden, E.S., 1890f. Reports of the two solar eclipses of 1889. *Publications of the Astronomical Society of the Pacific*, 2, 134.

Holden, E.S., 1890g. Letter to C.F. Crocker, dated February. SA, December 1889 Eclipse Folder.

Holden, E.S., 1890h. Astronomical photography at the Lick Observatory. *Publications of the Astronomical Society of the Pacific*, 2, 152-159.

Holden, E.S., 1890i. Letter to Burnham and Schaeberle, dated 16 October. SA, microfilm, v17, 340-344.

Holden, E.S., 1890j. Letter to Burnham and Schaeberle, dated 20 October. SA, microfilm, v17.

Holden, E.S., 1890k. Scientific Visitors to the Lick Observatory. *Publications of the Astronomical Society of the Pacific*, 2, 194.

Holden, E.S., 1890l. Absorption of the photographic rays of light in the Earth's Atmosphere [by Dr. J. Scheiner]. *Publications of the Astronomical Society of the Pacific*, 2, 250-251.

Holden, E.S., 1890m. Letter to M.H. Phelps, Esq., dated 19 March. SA, microfilm, v13, 83-88.

Holden, E.S., 1891a. I. *Total Solar Eclipse of December, 1889*: I. Introduction by Edward S. Holden. Contributions of the Lick Observatory, 2-21.

Holden, E.S., 1891b. Letter to Burnham and Schaeberle, dated June. SA microfilm, v22, 86.

Holden, E.S., 1891c. Letter to Campbell, dated 13 June. SA microfilm, v22, 148.

Holden, E.S., 1891d. Letter to Campbell, dated 14 May. SA microfilm, v21, 322.

Holden, E.S., 189le. *Catalogue of the Library of the Lick Observatory of the University of California*. Contributions of the Lick Observatory, No. 2, 1-121.

Holden, E.S., 1891f. Books wanted in the Library of the Lick Observatory. *Publications of the Astronomical Society of the Pacific*, 3, 143.

Holden, E.S., 1891g. Duplicated in the Library of the Lick Observatory. *Publications of the Astronomical Society of the Pacific*, 3, 142-143.

Holden, E.S., 1891h. Letter to Martin Kellogg, President of the Academic Senate, University of California, dated 21 April. SA, microfilm, v21, 132.

Holden, E.S., 1892a. Note on the early history of the Lick Observatory. *Publications of the Astronomical Society of the Pacific* 4, 139-151.

Holden, E.S., 1892b. Total Solar Eclipse of April, 1893. Lick Observatory Expedition to Chile. *Publications of the Astronomical Society of the Pacific*, 4Q.153.

Holden, E.S., 1892c. Letter and 1993 eclipse orders to Schaeberle, dated 1 December. SA, Schaeberle Letter File, 8-13.

Holden, E.S., 1892d. Letter to Schaeberle, dated 1 December. SA, Holden 1892 copybook.

Holden, E.S., 1892e. A graduate school of astronomy at Mount Hamilton. *Publications of the Astronomical Society of the Pacific*, 4, 184.

Holden, E.S., 1893. Schaeberle's work - His observations in Chile have been successful. *San Jose Daily Mercury*, April 18.

Holden, E.S., 1894a. The eclipse comet of April 16, 1893. *Publications of the Astronomical Society of the Pacific*, 6, 295.

Holden, E.S., 1894b. The Lick Observatory Eclipse Expedition of January, 1889, December, 1889, and April, 1893. *Publications of the Astronomical Society of the Pacific*, 6, 245-254.

Holden, E.S., 1894. Theory of photographic photometry. *Publications of the Astronomical Society of the Pacific*, 6, 67-68.

Holden, E.S., 1895. Photographs of the Sun at Mt. Hamilton. *Publications of the Astronomical Society of the Pacific*, 7, 30.

Holden, E.S., 1896a. Telescope for eclipse Aug. 1896. *Publications of the Astronomical Society of the Pacific,* 8, 91.

Holden, E.S., 1896b. *Lick Observatory to Observe the Total Solar Eclipse of August, 1896, in Japan. Publications of the Astronomical Society of the Pacific*, 8, 30-31.

Holden, E.S., 1896c. A cipher-code for astronomical messages. *Publications of the Astronomical Society of the Pacific*, 8, 109-133.

Holden, E.S., 1896d. Telescope making for observing the eclipse of August, 1896. *Publications of the Astronomical Society of the Pacific*, 8, 91.

Holden, E.S., 1896e. Letter to the University of California, Board of Regents, dated 4 April. SA, microfilm, v51, 491.

Holden, E.S., 1897a. Letter to Maunder, dated 21 June. SA, microfilm v58, 466.

Holden, E.S., 1897b. Letter to R.S. Ball, President of the Royal Astronomical Society, dated 24 June. SA, microfilm v58, 485.

Holden, E.S., 1897c. Letter to C. Burckhalter at the Chabot Observatory, dated 25 August. SA, v59, 480-481.

Holden, E.S., 1897d. Letter to the University of California, Board of Regents, dated 5 January. SA, microfilm, v56, 91.

Holden, E.S., 1897e. Letter to staff, dated, 12 July. SA, microfilm, v59, 120.

Holden, E.S., 1897f. Letter to Brashear, dated 16 July. SA, microfilm, v59, 169-170.

Hufbauer, K., 1993. *Exploring the Sun: Solar Science since Galileo*. Baltimore, Johns Hopkins University Press.

Huggins, M.L., 1882. Astronomical drawing. *The Observatory*, 5, 358-362.

Huggins, W., 1868. On a possible method of viewing the red flames without an eclipse. *Notices of the Royal Astronomical Society*, 29, 4-5.

Huggins, W., 1869. Note on Mr. De La Rue's paper, "On some attempts to render the luminous prominences visible without the use of the spectroscope." *Notices of the Royal Astronomical Society*, 30, 36-37.

Huggins, W., 1883. On a method of photographing the solar corona without an eclipse. *Astronomical Register*, 21, 38-38.

Huggins, W., 1885a. Photographing the corona. *The Observatory*, 8, 376-377.

Huggins, W., 1885b. The solar corona. *The Observatory,* 8, 153-159.

Huggins, W., 1900. A suggested explanation of the solar corona. *The Astrophysical Journal*, 12, 279-280.

Hussey, W.J., 1895. Latent image of exposed dry plates. *Publications of the Astronomical Society of the Pacific*, 7, 102-103.

Hussey, W.J., 1897. Astronomy and astronomers in their relations to the public. *Publications of the Astronomical Society of the Pacific*, 9, 53-64.

Hussey, W.J., 1906. The Lick Observatory-Crocker Eclipse Expedition to Egypt. *Publications of the Astronomical Society of the Pacific*, 18, 37-45.

Hussey, W.J., 1924. John Martin Schaeberle. *Publications of the Astronomical Society of the Pacific*, 36, 309-312.

Janssen, M., 1872. Notes, [letter to French Academy of Sciences, dated 18 December, 1871]. *Nature*, 5 249.

Jeffery, P.M., Burman, R.R., and Budge, J.R., 1989. Wallal: the total solar eclipse of 1922 September 21. In Blair, D.G., and Buckingham, M.J. (eds.). *The Fifth Marcel Grossman Meeting on Recent Developments in Theoretical and Experimental Gereral Relativity* … Singapore, World Scientific. 1343-1350.

Keeler, J.A., 1889. *Reports on the Observations of the Total Eclipse of the Sun January 1, 1889*: Report of the Mr. J.E. Keeler, chief of party. Contributions of the Lick Observatory. No. 1. Sacramento, State Printers, 31-55.

Keeler, J.A., 1900a. Letter to W.S. Sproule Esq., dated 19 March. SA, microfilm, v27, 236.

Keeler, J.A., 1900b. Letter to Langley, dated 1 February. SA, microfilm, v27 110.

Keeler, J.A., 1900c. Letter to Campbell, dated 7 March. SA, microfilm, v 27, 205

Keeler, J.A., 1900d. Letter ot Hirsch and Kaiser, dated 19 February. SA, microfilm, v27, 138.

Keeler, J.A., 1909. Photographs of Nebulae and Clusters, Made With the Crossley Reflector. *Publications of the Lick Observatory, 8*, Sacramento, University of California Publications.

Kevies, D.J., 1968. Guide to the microfilm edition of The George Ellery Hale Papers 1882-1937 at the Mount Wilson and Palomar Observatories Library Pasadena, California. *Carnegie Institution of Washington and the California Institute of Technology 1968*, 1-47

King, E.S., 1926. Efficiency of early and recent photographic plates. *35th Meeting of the American Astronomical Society*, 239-240.

Klickitat County Historical Society, 1978. Sunday, 1918 – the day when Goldendale was center of national attention. *Klickitat Heritage*, 4, 1-8.

Langley, S.P., 1900. A preliminary account of the solar eclipse of May 28, 1900, as observed by the Smithsonian Expedition. *Science*, 11, 974-980.

Lankford, J., 1983. Photography and the long-focus visual refractor: Three American case studies, 1885-1914. *Journal for the History of Astronomy*, 14, 77-91.

Leuschner, A.O., 1889. *Reports on the Observations of the Total Eclipse of the Sun of January 1, 1889*: Report of photometric observations, by Mr. A.O. Leuschner. Contributions of the Lick Observatory, Sacramento, State Printers, 81-103.

Leuschner, A.O., 1890. Determination of the relation between the exposure-time and the consequent blackening of a photographic film. *Publications of the Astronomical Society of the Pacific*, 2, 7-14.

Lewis, E.P., 1908. Spectrum of the corona and the second flash. *Lick Observatory University of California Bulletin No. 131*. University Press, Berkeley 5, 10-12.

Lewis, E.P., 1918. The coronal and flash spectra. *Lick Observatory University of California Bulletin.* University Press, Berkeley 10, 3-5.

Lewis, E.P., 1923. Address of the retiring President of the Society. *Publications of the Astronomical Society of the Pacific*, 35, 2-10.

Lippmann, M.G., 1895. The coelostat. *The Observatory*, 18, 301-303.

Lockyer, N.J., 1874. *Solar Physics*. London, Macmillan.

Lockyer, N.J., 1887. *The Chemistry of the Sun*. London, Macmillan.

Lockyer, N.J., 1896. The total solar eclipse of the Sun, April 16th, 1893. Report and discussion of the observations relating to solar physics. *Philosophical Transactions of the Royal Astronomical Society of London*, A187, 551-618.

Lockyer, N.J., 1900. Expedition to Santa Pola, Spain, preliminary report: Total solar eclipse of 1900 May 1 28. *Monthly Notices of the Royal Astronomical Society*, 630, 337-368.

Lockyer, W.J.S., 1903. 481-483. On a probable relationship between the solar prominences and corona. *Monthly Notices of the Royal Astronomical Society*, 63, 481-480.

Macgregory, W., 1905a. letter to Campbell, dated 6 January. SA, Campbell Letter File.

Macgregory, W., 1905b. Letter to Campbell, dated 28 January. SA, Campbell Letter File.

Malville, K., 2009. Correspondence email on non-LTE calculations.

Malville, K., 2009. Correspondence email with Campbell paper production chart.

Mary Lea Shane Archives of the Lick Observatory, Santa Cruz, University of California, McHenry Library, Special Collections, lick@cats.ucsc.edu

Maunder, E.W., 1899. *The Total Indian Eclipse, 1898, Report of the Expeditions Organized by the British Astronomical Association to Observe the Total Solar Eclipse of 1898 January 22.* British Astronomical Association, London, Hazell, Watson, and Viney.

Maunder, E.W., 1900. *The Total Solar Eclipse of May 1900*. British Astronomical Association, Knowledge Office, Witherby, London.

Maunder, E.W., 1901. The comet and the eclipse. *The Observatory*, 24, 372-376.

McClean, F.K., 1908. *Report of the Solar Eclipse Expedition to Flint Island January 3, 1908. Being an account of the Observations made by the Expedition under the Leadership of F.K. McClean.* Suffolk, Richard Clay and Sons, Limited.

McDowell, J.H., 1898. Letter to Keeler, dated 25 July. SA, Keeler Letter File.

Meadows, A.J., 1970. *Early Solar Physics.* Oxford, Pergamon Press.

Mees, C.E., 1926. The color sensitivity of photographic materials. *35th Meeting of the American Astronomical Society*, 240-241.

Menzel, D.H., 1928a. A study of the flash spectrum. *Popular Astronomy*, 36, 601-602.

Menzel, D.H., 1928b. Structure of the solar chromosphere. *Popular Astronomy*, 36, 602-

Menzel, D.H., 1929. Progress of Astronomy. *Publications of the Astronomical Society of the Pacific*, 41, 224-231.

Menzel, D.H., 1930. The deviation of stellar atmospheres from thermodynamic equilibrium. *Publications of the Astronomical Society of the Pacific*, 42, 113-117.

Menzel, D.H., 1931a. Pressures at the base of the chromosphere: a critical study of Milne's theories. *Monthly Notices of the Royal Astronomical Society*, 91, 628-652.

Menzel, D.H., 1931b. *Solar Chromosphere – Halley's Comet. A Study of the Solar Chromosphere Based upon Photographs of the Flash Spectrum taken by Dr. William Wallace Campbell., Director of the Lick Observatory, at the Total Eclipses of the Sun in 1898, 1900, 1905, and 1908.* Publications of the Lick Observatory Vol. XVII, Berkeley, University of California Press.

Menzel, D.H., 1932. Crocker Eclipse expedition to Fryeburg, Maine: Report on the jumping-film spectrographs. *Publications of the Astronomical Society of the Pacific*, 44, 356-358.

Menzel, D.H., and Cillie, G.G. 1937. Hydrogen emission in the chromosphere. *Astrophysical Journal*, 85, 88-106.

Metcalf, J., 1914. Review of Publications of the Lick-Observatory, Volume XI. *Publications of the Astronomical Society of the Pacific*, 26, 242-244.

Miller, J.A., 1911a. The position of certain coronal streams on the assumption that the corona is a mechanical product. *Astrophysical Journal*, 33, 303-329.

Miller, J.A., 1911b. The position of certain coronal streams on the assumption that the corona is a mechanical product. *Publications of the Sproul Observatory*, 1, 1-27.

Miller, J.A., 1918. The William C. Sproul eclipse expedition. *Popular Astronomy*, 26, 481-483.

Miller, J.A., 1919. The Sproul Observatory eclipse expedition, June 8, 1918. Coronal arches and streamers. *Proceedings of the American Philosophical Society*, 58 272-281.

Miller, J.A., 1932. Eclipse reports, Sproul Observatory expedition at Derby, Vermont. *Popular Astronomy*, 40, 477-478.

Miller, J.A., and Marriott, R.W., 1925a. Motion in the sun's atmosphere (abstract). *Popular Astronomy*, 33, 298-300.

Milne, B.A., 1921a. Ionization in stellar atmospheres. *The Observatory*, 44, 262-269.

Milne, B.A., 1921b. Spectroscopy astronomical, radiative equilibrium and spectral distribution. *Monthly Notices of the Royal Astronomical Society*, 81, 375-388.

Misch, A., 2008. The pleasures of the the vault. *Journal of Astronomical History and Heritage*, 11, 22-24.

Mitchell S.A., 1923. *Eclipses of the Sun*. New York, Columbia University Press.

Mitchell S.A., 1932. *Eclipses of the Sun*. New York, Columbia University Press.

Mitchell S.A., 1951. *Eclipses of the Sun*. New York, Columbia University Press.

Mitchell S.A., 1969. *Eclipses of the Sun*. New York, Greenwood Press.

Moore, J.H., 1921. Sun-spots and terrestrial magnetic storms. *Publications of the Astronomical Society of the Pacific*, 33, 171.

Moore, J.H., 1923a. The coronal spectrum of September 21, 1922. *Publications of the Astronomical Society of the Pacific*, 35, 59-61.

Moore, J.H., 1923b. Spectroscopic evidence of radial motion in the outer corona. *Publications of the Astronomical Society of the Pacific*, 35, 333-336.

Moore, J.H., 1927. Exum Percival Lewis, 1863-1926. *Publications of the Astronomical Society of the Pacific*, 39, 83-87.

Moore, J.H., 1929a. A source book in astronomy (Shapley and Howarth). *Publications of the Astronomical Society of the Pacific*, 41, 109-112.

Moore, J.H., 1929b. The total eclipse of the Sun, April 28, 1930. *Publications of the Astronomical Society of the Pacific*, 41, 340-343.

Moore, J.H., 1930a. Ralph Hamilton Curtiss, 1880-1929. *Publications of the Astronomical Society of the Pacific*, 42, 37-40.

Moore, J.H., 1930b. The Crocker Eclipse Expedition of the Lick Observatory to Camptonville, California, April 28, 1930. *Publications of the Astronomical Society of the Pacific*, 42, 131-140.

Moore, J.H., 1932. Crocker Eclipse Expedition to Fryeburg, Maine, the Lick Observatory. *Publications of the Astronomical Society of the Pacific*, 44, 341-360.

Moore, J.H., 1933a. The solar corona. *Astronomical Society of the Pacific Leaflets* 2, 13-16.

Moore, J.H., 1933b. Spectroscopic evidence of radial motion in the corona. *Publications of the Astronomical Society of the Pacific*, 45, 147-149.

Moore, J.H., 1934. The Fraunhofer spectrum of the solar corona. *Publications of the Astronomical Society of the Pacific*, 46, 298-300.

Moore, J.H., 1938. Fifty years of research at the Lick Observatory. *Publications of the Astronomical Society of the Pacific*, 50, 189-203.

Moore, J.H., 1939. William Wallace Campbell, 1862-1938. *Astrophysical Journal*, 89, 143-151.

Moore, J.H., and Menzel, D.H., 1930. The Green Line at the eclipse of April 28, 1930. *Publications of the Astronomical Society of the Pacific*, 42, 182-184.

Newcomb, S., and Holden, E.S., 1880. *Astronomy*. New York, Henry Holt.

Nicholson, J.W., 1910. Radiation, the pressure of, on reflecting spherical particles. *Monthly Notices of the Royal Astronomical Society*, 70, 544-565.

Nicholson, J.W., 1911. Sun, corona, on the constitution of the solar corona I: Protofluorine. *Monthly Notices of the Royal Astronomical Society*, 72, 39-150.

Nicholson, J.W., 1912a. Sun, corona, on the constitution of the solar corona II. *Monthly Notices of the Royal Astronomical Society*, 72, 677-692.

Nicholson, J.W., 1912b. Sun, corona, on the constitution of the solar corona III. *Monthly Notices of the Royal Astronomical Society*, 72, 729-730.

Norman, D., 1938. The development of astronomical photography. *Osiris*, 5, 560-794.

O'Meara, S.J., 2005. The secret corona. *Sky and Telescope*, 109, 75-76.

Orchiston, W., 1989. Astrophysics and the evolution of twentieth century Australian astronomy. *Search*, 20, 198-302.

Orchiston, W., Chen, K.-Yu., Lee, E.-H., and Ahn, Y.-S., 2006, British observations of the 1868 total solar eclipse from Guntoor, India. *Proceedings of the Fifth International Conference on Oriental Astronomy*. Chiang Mai, Chiang Mai University. 23-34

Osterbrock, D.E., 1979. Lick Observatory solar eclipse expeditions. *The Astronomy Quarterly*, 3, 67-79.

Osterbrock, D.E., 1984a. *James E. Keeler: Pioneer American Astrophysicist and the Early Development of American Astrophysics.* Cambridge, Cambridge University Press.

Osterbrock, D.E., 1984b. The rise and fall of Edward S. Holden: Part 1. *Journal for the History of Astronomy*, 15, 81-127.

Osterbrock, D.E., 1984c. The rise and fall of Edward S. Holden: Part 2. *Journal for the History of Astronomy*, 15, 151-176.

Osterbrock, D.E., 1986. Stranger in a strange land–Donald H. Menzel–first theoretical astrophysicist on the Lick Observatory staff. *Bulletin of the American Astronomical Society*, 98, 1112.

Osterbrock, D.E., 1990. Leuschner, Armin and the Berkeley Astronomical Department. *Astronomy Quarterly*, 7, 95-115.

Osterbrock, D.E., 2002a. Young Don Menzel's amazing adventures at Lick Observatory. *Journal for the History of Astronomy*, 33, 95-118.

Osterbrock, D. E., 2002b. *James E. Keeler: Pioneer American Astrophysicist*. Cambridge University Press, Cambridge, UK.

Osterbrock, D.E., and Cruikshank, D.P., 1983. J. E. Keeler's discovery of a gap in the outer part of the A ring. *Icarus*, 53, 165-173.

Osterbrock, D.E., Gustafson, J.R., and Unruh, W.J.S., 1988. *Eye on the Sky: Lick Observation's First Century*. Berkeley, University of California Press.

Pang, A.S.-K., 1994. Victorian observing practices, printing technology, and representations of the solar corona, (1): The 1860's and 1870's. *Journal for the History of Astronomy*, 25, 249-273.

Pang, A.S.-K., 1995. Victorian observing practices, printing technology, and representations of the solar corona, (2): The age of photomechanical reproduction. *Journal for the History of Astronomy* 26, 63-75.

Pang, A.S.-K., 1997. 'Stars should henceforth register themselves': astrophotography at the early Lick Observatory. *British Journal of the History of Science*, 30, 177-202.

Pang, A.S.-K., 2002. *Empire and the Sun, Victorian Solar Eclipse Expeditions*. Stanford, Standford University Press.

Pasachoff, J.M., 1998. Williams College's Hopkins Observatory: the oldest extant observatory in the United States. *Journal of Astronomical History and Heritage*, 1, 61-78.

Pasachoff, J.M., 2001a. Solar-eclipse science still going strong. *Sky and Telescope*, 101(2), 40-47.

Pasachoff, J.M., 2001b. Early eclipse science. *Sky and Telescope*, 101(2), 46.

Pasachoff, J.M., 2002. Menzel and eclipses. *Journal for the History of Astronomy*, 33, 139-156.

Pasachoff, J.M., and Livingston, W.C., 1984. Coelostat and heliostat: I. Alignment and use for eclipse and other field purposes. *Applied Optics*, 23, 2803-2808.

Pearson, J.C. and Orchiston, W., 2008. The 40-foot solar eclipse camera of the Lick Observatory. *Journal of Astronomical History and Heritage*, 11, 25-37.

Perrine, C.D., 1895. Change in the latent image of an exposed dry plate. *Publications of the Astronomical Society of the Pacific*, 7, 76.

Perrine, C.D., 1900a. Preliminary report of observations of the total solar eclipse of 1901, May 17-18. *Lick Observatory University of California Bulletin No. 9.* Berkeley, University Press, 1, 58-63.

Perrine, C.D., 1900b. Origin of a disturbed region observed in the corona of 1901. *Lick Observatory University of California Bulletin No. 18.* Berkeley, University Press, 1, 151-152.

Perrine, C.D., 1900c. Results of the search for an intra-mercurial planet at the total solar eclipse of 1901, May 18. *Lick Observatory University of California Bulletin No. 18.* Berkeley, University Press, 1, 183-187.

Perrine, C.D., 1901a. Preliminary report of observations of the total solar eclipse of 1901, May 17-18. *Astrophysical Journal*, 14, 349-359.

Perrine, C.D., 1901b. Preliminary report of observations of the total solar eclipse of 1901, May 17-18. *Lick Observatory University of California Bulletin No. 9.* Berkeley, University Press, 1, 58-63.

Perrine, C.D., 1901c. The Lick Observatory-Crocker Expedition to observe the total solar eclipse of 1901, May 17-18. *Publications of the Astronomical Society of the Pacific*, 13, 187-204.

Perrine, C.D., 1901d. Bulletin No. 9 – Preliminary report of the observations of the total solar eclipse of 1901, May 17-18. *Lick Observatory Bulletin*, 1, 58-63.

Perrine, C.D., 1902a. Origin of a disturbed region observed in the corona of 1901, May 17-18. *Lick Observatory University of California Bulletin No. 18.* Berkeley, University Press, 2, 151-152.

Perrine, C.D., 1902b. Results of the search for an intra-mercurial planet at the total eclipse of 1901, May 18. *Lick Observatory University of California Bulletin No. 24.* Berkeley, University Press, 183-187.

Perrine, C.D., 1902c. Origin of a disturbed region observed in the corona of 1901, May 17-18. *Astrophysical Journal*, 15, 147-149.

Perrine, C.D., 1904. Some total solar eclipse problems. *Astrophysical Journal*, 20, 331-337.

Perrine, C.D., 1905. Results of the search for an intramercurial planet at the total solar eclipse of August 30, 1905. *Lick Observatory University of California Bulletin No. 115*. Berkeley, University Press, 4, 115-117.

Perrine, C.D., 1908a. Observations of the corona for polarization effects. *Lick Observatory University of California Bulletin No. 131*. Berkeley, University Press, 5, 13.

Perrine, C.D., 1908b. Photometric observations of the corona. *Lick Observatory University of California Bulletin No. 131*. Berkeley, University Press, 5, 7.

Perrine, C.D., 1908c. Some results of attempts to determine the total brightnesses of the coronas of August 30, 1905 and January 3, 1908. *Lick Observatory University of California Bulletin No. 153*. Berkeley, University Press, 5, 98-99.

Perrine, C.D., 1908d. The search for intramercurial bodies at the total solar eclipse of January 3, 1908. *Lick Observatory University of California Bulletin No. 152*. Berkeley, University Press, 5, 95-97.

Perrine, C.D., 1908e . Search for intramercurial bodies. *Lick Observatory University of California Bulletin No. 131*. Berkeley, University Press, 9.

Perrine, C.D., 1909a. The search for intramercurial bodies at the total solar eclipse of January 3, 1908. *Lick Observatory University of California Bulletin No. 152*. Berkeley, University Press, 5, 95-99.

Perrine, C.D., 1909b. The brightness of the corona on January 3, 1908. *Publications of the Astronomical Society of the Pacific,* 21, 34-37.

Perrine, C.D., 1909c. Some results of attempts to determine the total brightnesses of the coronas of August 30, 1905 and January 3, 1908. *Lick Observatory University of California Bulletin No. 152*. Berkeley, University Press, 5, 98-99.

Perrine, C.D., 1918. The nature of the Sun's corona. *The Observatory*, 41, 253-255.

Petit, E. 1926. Ultra-violet solar radiation and its variations. *35th Meeting of the American Astronomical Society*, 241-242.

Pickering, E.C., 1883. Astronomical photography. *The Observatory*, 6, 149-150.

Pickering, E.C., 1900. Observations of the total eclipse of May 28, 1900, by the Harvard Observatory Expedition. *Astrophysicaal Journal*, 12, 94-95.

Pickering, E.C., 1900b. Measurement of photographic instensities. *Harvard College Observatory Circular*, 50, 1-5.

Pickering, W.H., and Pickering, E.C., 1895. Investigations in astronomical photography. *Annals of Harvard College Observatory*, 32, 1-115.

Pitman, J.H., 1941. Quaker astronomer - John A. Miller. *The Sky*, 5, Cover, 3-5.

Poynting, J.H., 1903a. Radiation pressure. *Proceedings of the physical society of London*, 19, 475-490.

Poynting, J.H., 1903b. Radiation in the solar system: its effect on small bodies. *Monthly Notices of the Royal Astronomical Society*, 64, 265-266.

Poynting, J.H., 1904. Radiation in the solar system: Its effect on temperature and its pressure on small bodies. *Philosphical Transactions of the Royal Society of London. Series A*, 202, 525, 535-539.

Poynting, J.H., 1907. Some astronomical consequences of the pressure of light. *Popular Astronomy*, 15, 626-629.

Poynting, J.H., 1908. Some astronomical consequences of the pressure of light. *The Observatory*, 31, 55-57.

Pritchett, H.S., 1891. The solar corona of January, 1889, from the photographs. *Publications of the Astronomical Society of the Pacific*, 3, 154-162.

Proctor, R.A., 1869a. A new theory of the Milky Way. *Monthly Notices of the Royal Astronomical Society*, 30, 50-56.

Proctor, R.A., 1869b. Correspondence - Mr. Proctor's theory of the zodiacal light. *Astronomical Register*, 7, 218-219.

Proctor, R.A., 1870. Notes on the solar corona and the zodiacal light; with suggestions respecting observations to be made on the total solar eclipse of December 24, 1870. *Monthly Notices of the Royal Astronomical Society*, 30, 138-149.

Proctor, R.A., 1871a. *The Sun: Ruler, Fire, Light, and Life of the Planetary System.* London, Longmans, Green.

Proctor, R.A., 1871b. Oudemann's theory of coronal radiation. *Monthly Notices of the Royal Astronomical Society*, 31, 71-73.

Proctor, R.A., 1871e. Theoretical considerations on the corona. *Monthly Notices of the Royal Astronomical Society*, 31, 184-194.

Proctor, R.A., 1871f. Theoretical considerations on the corona. *Monthly Notices of the Royal Astronomical Society*, 31, 254-262.

Proctor, R.A., 1872. *Essays on Astronomy*. London, Longmans, Green. New York, Scribner, Welford, and Armstrong.

Proctor, R.A., 1873. On the expulsion theory of the solar corona, comets, &c. *Monthly Notices of the Royal Astronomical Society*, 33, 536-539.

Proctor, R.A., 1876. *The Sun: Ruler, Light, and Life of the Planetary System*. London, Longmans, Green.

Ranyard, A.C., 1879. The solar corona. *Memoirs of the Royal Astronomical Society*, XLI, 1-791.

Ress, A., (ed.), 1822. *Cyclopedia or Universal Dictionary of Arts, Sciences, and Literature*. Samuel F. Bradford, and Murray, Fairman, and Co., XXXVI, unpaged.

Rolston, W.E., 1908. The Lick Observatory – Crocker Eclipse Expedition, January, 1908. *Nature*, 79, 70-72).

Rooney, J., 1890. Report of the expedition to the Salut Isles to observe the eclipse of Dec. 22, 1889. *Monthly Notices of the Royal Astronomical Society*, 50, 274-283.

Ross, F.E., 1920. Image contraction and distortion on photographic plates. *Astrophysical Journal*, 52, 98-112.

Russell, H.N., 1932. Note on Milne's theory of stellar structure. *Monthly Notices of the Royal Astronomical Society*, 92, 831-835.

Russell, H.N., and Stewart, J.Q., 1924. Pressures at the Sun's surface. *Astrophysical Journal*, 59, 197-209.

Schaeberle, J.M., 1890a. A mechanical theory of the solar corona. *Publications of the Astronomical Society of the Pacific*, 2, 68-70.

Schaeberle, J.M., 1890b. The solar corona. *Publications of the Astronomical Society of the Pacific*, 2, 260.

Schaeberle, J.M., 1890c. A mechanical theory of the solar corona. *Monthly Notices of the Royal Astronomical Society*, 50, 373.

Schaeberle, J.M., 1891a. Some physical phenomena involved in the mechanical theory of the corona. *Publications of the Astronomical Society of the Pacific*, 3, 71-73.

Schaeberle, J.M., 1891b. III. A mechanical theory of the solar corona by J.M. Schaeberle. *Contributions of the Lick Observatory*, 2. 47-103.

Schaeberle, J.M., 1893b. Preliminary note on the corona of April 16, 1893, observed in Chile. *Publications of the Astronomical Society of the Pacific*, 5, 139-143.

Schaeberle, J.M., 1893c. The Dallmeyer lens of the eclipse expedition. *Publications of the Astronomical Society of the Pacific*, 5, 230.

Schaeberle, J.M., 1894a. The inner corona of April 16, 1893. *Publications of the Astronomical Society of the Pacific*, 6, 113.

Schaeberle, J.M., 1894b. The coronal comet of April 16, 1893. *Publications of the Astronomical Society of the Pacific*, 6, 237-237.

Schaeberle, J. M., 1894c. A comet in the corona of 1893 April 16. *Astronomical Journal*, 14, 46.

Schaeberle, J.M., 1894d. Illustrations of the Lick Observatory station in Chile. *Publications of the Astronomical Society of the Pacific*, 6, 290-292.

Schaeberle, J.M., 1895. *Report of the Total Eclipse of the Sun, observed at Mina Bronces, Chile, on April 16, 1893.* Contributions From the Lick Observatory No. 4. Regents of the University of California, State Printing. 1895.

Schaeberle, J.M., 1897. Letter to Campbell, dated 15 October. SA, Campbell letter file 292-298.

Schaeberle, J.M., 1897a. Letter to Brashear, dated 30 September. SA, Schaeberle Letter File, 241.

Schaeberle, J.M., 1897b. On a fundamental optical imperfection of the parabolic reflecting telescope. *Astronomische Nachrichten*, 144, 377-380.

Schaeberle, J.M., 1897c. On a fundamental optical defect in the images formed by a parabolic reflector. *Astronomical Journal*, 18, 35-38.

Schaeberle, J.M., 1898a. Solar eclipse expedition of the Lick Observatory. *Astronomical Journal*, 18, 152.

Schaeberle, J.M., 1898b. General theory of the aberration in the focal plane of a parabolic reflector. *Astronomical Journal*, 19, 17-21.

Schaeberle, J.M., and Barnard, J.M., 1890. Simple method for pointing a photographic telescope during a long exposure. *Publications of the Astronomical Society of the Pacific*, 2, 259.

Scheiner, J., 1900. A suggested explanation of the solar corona. *Astrophysical Journal*, 12, 25-29.

Schuster, A., 1879. On the polarization of the Solar Corona. *Monthly Notices of the Royal Astronomical Society*, 40, 35-57.

Schwarzschild, K, and Villiger, W., 1906. On the distribution of brightness of the ultra-violet light on the Sun's Disk. *Astrophysical Journal*, 23, 284-306.

Shane, C.D., 1932a. Crocker Eclipse Expedition to Fryeburg, Maine: Report on the application of the interferometer to the observation of the green coronal Line. *Publications of the Astronomical Society of the Pacific*, 44, 358-360.

Shane, C.D., 1932b. The photometry of lines in the solar spectrum. *Lick Observatory University of California Bulletin No. 449*. Berkeley, University Press, 16, 76-89.

Shane, M.L., 1971. The Archives of Lick Observatory. *Journal for the History of Astronomy*, 2, 51-53.

Sheppard, S.E., 1926. Nature of photographic sensitivity. *35th Meeting of the American Astronomical Society*, 245-246.

Siemens, C.W., 1883. *On the Conservation of Solar Energy; a Collection of Papers and Discussions*. London, Macmillan and co.

Slipher, V.M., 1918. The Lowell Observatory solar eclipse expedition. *Popular Astronomy*, 26, 462-465.

Slipher, W.M., 1922. The spectrum of the corona as observed by the expedition from Lowell Observatory at the total eclipse of June 8, 1918. *Astrophysical Journal*, 73-83.

Smith, H.W., 1902. Photographic work of the eclipse expedition from the Massachusetts Institute of Technology. *Astrophysical Journal*, 15, 199-206.

Stephenson, F.R., 1997. *Historical Eclipses and Earth's Rotation*. Cambridge, Cambridge University Press.

Störmer, C., 1914. Part VI – On solar vortices. *Transactions of the International Union for Cooperation in Solar Research*, 4, 208-213.

Störmer, C., 1916. Researches on solar vortices. *Astrophysical Journal*, 43, 347-402.

Stratton, F.J.M., 1932. Total eclipse of the sun, 1932 August 31: Report of the expedition from the Solar Physics Observatory, Cambridge. *Monthly Notices of the Royal Astronomical Society*, 93, 9-16.

Sydney Observatory, 1923. *The Total Eclipse of the Sun, 1922 September 21*. Sydney, Alfred James Kent, 1-13.

Taylor, A., 1890. The total solar eclipse of December 21-22, 1889. *The Observatory*, 13, 349-351.

Taylor, A., 1893. Eclipse photography. *The Observatory*, 61, 95-98.

Tenn, J.S., 1992. Wallace Campbell: the twelfth Bruce Medalist. *Mercury*, 21, 62-65.

Todd, D.P., 1889. Photographs of the corona taken during the total eclipse of the Sun, January 1, 1889. *Smithsonian Institution Publication No. 2,* Washington, 1889.

Todd, D.P., 1890. Totality of the eclipse of December 22, 1889. *Monthly Notices of the Royal Astronomical Society*, 50, 380-384.

Todd, D.P., 1897a. Automatic photography of the corona. *Astrophysical Journal*, 5, 318-324.

Todd, D.P., 1897b. *A New Astronomy*. New York, American Book Company.

Turner, H.H., 1889a. Eclipse committee of the Royal Astronomical Society, Report October 3, 1889 drawn up by H. H. Turner, Secretary of the Committee. *Monthly Notices of the Royal Astronomical Society*, 50, 2-8.

Turner, H.H., 1889b. The total solar eclipse of 1889 January 1. *The Observatory*, 12, 106-109.

Turner, H.H., 1889c. The total solar eclipse of Dec.21. *The Observatory*, 12, 395-398.

Turner, H.H., 1890. Report of the eclipse committee, March 14, 1890. *Monthly Notices of the Royal Astronomical Society*, 50, 265-272.

Turner, H.H., 1893. Total solar eclipses. *The Observatory,* 6, 289-290.

Turner, H.H., 1896. Some notes on the adjustment of the coelostat. *Monthly Notices of the Royal Astronomical Society*, 56, 408-423.

Turner, H.H., 1901. On mechanically compensating the rotation of the field of a siderostat. *Monthly Notices of the Royal Astronomical Society,* 61, 122-129.

Turner, H.H., 1904. Mirrors, long-focus, note on the use of, for eclipse work. *Monthly Notices of the Royal Astronomical Society*, 64, 189-192.

Turner, H.H., 1906. Studying the corona of the Sun. *Popular Astronomy*, 14, 548-557.

Turner, H.H., and Dyson, F.W., 1900a. Expedition to Bouzareah, Algiers, preliminary report: Total solar eclipse of 1900 May 28. *Monthly Notices of the Royal Astronomical Society*, 60, 13.

Turner, H.H., and Dyson, F.W., 1900b. Expedition to Bouzareah, Algiers, preliminary report: total eclipse of 1900 May 28. *Monthly Notices of the Royal Astronomical Society*, 60, 349-368.

Turner, H.H., and Newall, H.F., 1900. Total solar eclipse of 1900 (May 28). Preliminary report on the observations made at Bauzareah (in the grounds of the Algiers Observatory). *Proceeding of the Royal Society of London*, 67, 346-369.

Upton, W., Rotch, A.L, and Pickering, E.C., 1889. Meterorological and other observations made at Willow, California, in connections with the total solar eclipse of January 1, 1889. *Annals of the Astronomical Observatory of Harvard College*, 29, 1-35.

Van de Sande Bakhuyen, H.G., 1901. Report of the committee for the organization of the observations of the solar eclipse on May 18th, 1901. *Koninklijke Nederlandsche Akademie van Wetenschappen Proceedings*, 3, 529-543.

Van Horn, R.O., 1930. Letter to the Commanding General, Hdq. 9th Corps Area, Prsidio, SF, dated 10 February. SA, 1930 eclipse file.

Vose, J.M., 1827. *A System of Astronomy, on the Principles of Copernicus*. Concord, Jacob Moore.

Wesley, W.H., 1889. The corona of 1889, December 22. *The Observatory,* 13, 105-107.

Whitesell, P.S., 2003. Detroit Observatory: nineteenth-century training ground for astronomers. *Journal of Astronomical History and Heritage*, 6, 90-92.

Wolf, M., 1893. The change of sensitiveness of dry plates. *Publications of the Astronomical Society of the Pacific*, 5, 182-183.

Wood R.W., 1901. The nature of the solar corona. *Astrophysical Journal*, 13, 68-79.

Wood, R.W., 1908. Polarized fluorescence of metallic vapors and the solar corona. *Astrophysical Journal*, 28, 75-78.

Wright, W.H., 1923. The Lick Observatory-Crocker eclipse expedition to Ensenada, lower California, September 10, 1923 (with notes). *Publications of the Astronomical Society of the Pacific*, 35, 275-289.

Wright, W.H., 1930. Photographs of the partially eclipsed Sun made at Mount Hamilton on April 28, 1930. *Publications of the Astronomical Society of the Pacific*, 42, 145-148.

Wright, W.H., 1932. Crocker Eclipse Expeditions to Fryeburg, Maine, August 31, 1932 with Report on the photography of the corona. *Publications of the Astronomical Society of the Pacific*, 44, 352-357.

Young, C.A., (ed.), 1887. *The Sun*. New York, Appleton.

Young, C.A., 1895a. *The Sun*. Ohio, Werner Co.

Young, C.A., 1895b. *The Sun*. New York, Appleton.

Young, C.A., 1896. *The Sun*. New York, Appleton.

Young, C.A., 1899. The wave-length of the corona line. *Astrophysical Journal*, 10, 306-307.

Young, C.A., 1900. Eclipse observations by the Princeton Party at Wadesboro; N. C., May 28, 1900. *Astrophysical Journal*, 12, 77-95.

Young, C.A., 1902. *Manual of Astronomy*. Boston, Ginn.

Young, C.A., 1910. *The Sun*. London, Kegan Paul, Trench, Trubner.

Young, K.A., 1911. Polarization of the light in the solar corona. *Lick Observatory Bulletin, Number 205*, 6, 166-181.

Zirker, J.B., 1995. *Total Eclipses of the Sun*. Princeton, Princeton University Press.

9. APPENDICES

9.1 Appendix 1 Stations and Personnel of the Nineteenth Century Eclipse Expeditions: 1840-1871

Eclipse Dates (yr/m/d)	LOCATION and OBSERVERS
1842/07/08	Momtpellier, Lipsek, Perpignan, 42 41 43 N. 2 53 50 E., (M. Arago), Milan, 45 25 N., 9 10 E., (Prof. Majocchi); Pavia, Padua (Capt. Biela)
1851/07/28	Gottenburg, 57 42 58 N., 11 56 20 E., (Swan); Konigsberg, 54 42 N., 20 31 E., (A.L. Busch) Frederiksvoern, 58 59 33.9 N., 10 3 52 E., (M. Broch); Roevelsberg, 56 16 N., 12 54 E., (W.Dawes)
1858	Paramagua-Pinheiros, Brazil, 25 30 33 24 S., 25 30 S., 48 26 W., (M. Liais, M. d'Oliverira, M, d'Azambuja, M. de Mello, M. de Birto, M. d'Aranjo)
1860/07/18	Pancerbo, Spain 42 39 N., 3 5 W., (Prof. Chevallier, J.M. Wilson); Rivabellosa, 42 43 24 N., 2 55 20 W., (W. De La Rue); Vitoria, 42 50 41 N, 2 40 20 W., (H. Goldschmidt, Rev. H.A. Goodwin, Prof. J.H. von Mädler, G. Schulz, Prof. G.D.E. Weyer); Sierra De Tolono, Spain 42 38 N., 2 40 W., (Prof. Grant); La Guardia, Spain, 42 34 N., 2 35 W., (Rev. H.A.S. Atwood, F. Galton); Desierto De Las Palmas, 40 5 N., 0 0 Long.(Padre A. Secchi, Prof. Monserat, Don A. Aguilar); Torreblanca, 40 15 10 N., 0 10 E. (Signor G. Temple); Cammesa, Spain, 42 46 N., 4 12 W., (Breen, Buckingham, W. Wray; Ungava Bay, Labrador, 59 47 49 N., 64 13 15 W., (Lieut. Ashe); Burgos, 42 21 N., 3 43 W., (T. C. Janson); Santander, 43 26 N., 3 41 W., (Commander Thompson); Briviesca, 42 33 3 N., 3 20 W., (M. Lespiault, M. Burat); San Lorenzo Mt., 42 20 N., 3 2 W., (Bryne, G.E. Gavey, R. Winter); Miranda De Ebro, 42 43 N., 3 2 W., (J. Bonomi, W. Beck, F.M. Weedon); Pobes, 42 48 2.3 N., 2 57 51 W., (O. Struve); Sta. Marina, 42 47 12 N., 2 56 13 W., (C. Weiler, Prof. Winnecke); Bilbao, 43 15 N., 2 55 W., (Wm. J. Lewis); Alto D'Urbaneja, 42 46 44 N., 2 53 22 W., (Lieut. F. A. Oom); Llodio, 43 7 N., 2 50 W., (E. W. Murray, J. Stronglein); Hill of Cantabria, 42 27 N., 2 30 W., (J.G. Perry); Valencia, 39 30 N., 3 50 W., (Baron de Rottenberg, C. von Wallenberg); Castellon De La Plana, 39 57 N., 0 4 W., (Arndt, von Feilitzsch, E. Plantamour, Geo. Rumker); Lambessa, 35 29 N., 6 22 E., (M.C.Bulard)
1867/08/	Colchagua, near Santiago, Chile, (L. Grosch, Lieut. Vidal)
1868/08/18	Aden 12 45 47N., 45 2 55 E. (Dr. B. Tiele, Dr. E. Weiss, Dr. G. Fritsch, Dr. H. Vogel, Dr. W. Zenker); Guntoor-India, 16 17 29 N, 80 24 40 E., (Col. Tennant, Serg. Phillips); Masulipatam, 16 11 33 N., 81 12 15 E., (N.R. Pogson, C.G. Walker, G.K. Winter); Wha-Tonne, 11 42 35 N., 99 47 45 E., (M.E. Stephan); Barram Point, Borneo, 4 35 N., 113 55 E., (Governor Pope Hennessy); Mantawalu Kiki, Celebes, 0 32 36 S., 123 4 48 E., (C. Bullock, F. Fauro, F.W. Sutton, F. Sutton)
1869/08/07	Shelbyville-Ken., 38 12 45 N., 85 13 22 W., (F.J. Blake, Jun., J.J. Dixwell, J. Winlock); Sioux Falls City, 42 34 N., 96 15 W., (C. Abbe); White Top Mountain-Virgina, 40 48 17 N., 91 4 0 W., (A.M. Mayer); Des Moines-Iowa, 41 35 4 N., 3'12 W., (Prof. S. Newcomb, J.R. Eastman, J.H. Lane); St. Paul Junction, 96 8 42 W., 42 47 30 N., (S. Gilman); Ottumwa, 41 2 N., 92 23 W., (C. Himes, J. Browne); Mt Pleasant, 40 57 N 93 38 W., (E.C. Pickering); Springfield, Illinois, 39 49 2.5 N., 89 38 24 W., (C.A. Schott, F.B. Meek, R. Mcleod, J.M. Peirce, Black, Fitzgerald, Pourtales); Maltoon, 39 29 10.5 N., 88 23 0 W., (Pres. Hill, D. Murray, G.W. Hough, Oakland, Kent. 27 2 29 N., 86 15 18 W., (S. Langley); Bristol, Tenn. 36 35 49 N., 82 11 13 W., (R. Cutts)
1870/12/22	Hacienda De Torre-Breva, San Lucar, 36 40 N., 6 23 W., (Baynes, Moulton); San Fernando, (Senor S. Marquez); Maria Louisa Observatory, 36 38 N., 6 12 W., (Lord Lindsay, D. Jose Iglesius, D.A. Lassaletta, A. Thuillier, E. Thuiller, B. Browne, C. Becker, Greaves); San Antonio, 36 37 13 N., 6 11 13 W., (F.H. Browne, Hostage, W.H.H. Hudson, S.J. Perry); Jerez De La Frontera, 36 43 56 N., 6 10 8 W., (S.P. Langley, Naftel, Norman, C.A. Young, J. Winlock); Gibraltar, 36 8 N., 5 21 W., (Abbatt): Estepona, 36 25 N., 5 10 W., (J.H. Anson); Buena Vista, 36 6 43 N., 5 20 51 W., (S. Newcomb); Argos, 41 10 N., 2 17 W., (Gillman, W. Smyth); Terranova, 37 3 56.2 N., 14 14 15 E., (A. Tacchini); Carlentini, Sicily, 37 14 N., 15 13 E., (J. Watson); Villa San Giuliano, 37 30 N., 15 5 E., (C. Peirce, Burton, Corallo, A.C. Ranyard); Catania, 37 30 13.4 N., 15 5 23 E., (J. Lane); Syracuse, 37 3 53 N., 15 18 57 E., (A. Hall, W. Harkness, Tupman, Eastman, A. Brothers)
1871/12/12	Baikul, India, 12 25 N., 75 0 6 E., (J.Lockyer, Maclear, H. Davis); Shoolor, India, 11 27 8 N., 76 42 45 E., (J. Janssen); Dodabetta, 11 24 N., 76 43 E., (Tennant, J. Hershcel, Waterhouse, J.B.Hennessy, Morant); Ootacamund 10 24 N., 76 47 E., (J. Boesinger) Mandalore, 12 52 N., 74 54 E., (T.Pillay, O. Annappa); Poodoocotta, 10 25 N., 79 15 E., (Holiday); Jaffna, 9 40 N., 79 59 E., (F. Foenander, Tupman, Hogg); Kaits, 9 43 N., 80 20 E., (Dawson); Tjebatjap, Java, 7 48 S., 109 5 E., (Dietrich)

9.2 APPENDIX 2 Direct Photographic Eclipse Instruments at the Lick Observatory

A brief synopsis lists and describes the direct photographic instruments used for coronal imaging and nearby sky regions during the entire LO eclipse expedition period. Further information on several of the eclipse instruments may be found in a summary of the LO instruments (Holden 1887: 59-77).

The 6½ inch Clark Equatorial Refractor

This telescope was of the usual variety manufactured by Alvan Clark & Sons, but was shorter in focal-length of 76 inches. Its objective was originally ordered for use on the Repsold meridian circle. Because of the ease which it could be removed from the Repsold instrument, it was decided to make it available as a regular refractor telescope objective. It was mounted on an equatorial clock-driven mount manufactured by Warner & Swasey. From the beginning, the instrument was anticipated to be used on field expeditions. For field work the top part of the cast-iron pier which also contained the clock-work was removed and provided with a heavy timber stand (Holden 1887: 65-67). It was taken on the first three eclipse expeditions to and including the 1893 eclipse. Comment was made about the difficulty of keeping this instrument working properly under harsh climate conditions due to its complex nature (Burnham and Schaeberle 1891: 24-25). The shutter consisted of a black velvet flap hinged on the top above the objective. An attached string was pulled at the eyepiece end causing the flap to fall by gravity to make an exposure. This instrument had proven itself capable of producing fine photographs of the Moon and stars in the hands of Barnard.

The Clark Water Reservoir Telescope

This telescope was manufactured by Alvan Clark & Sons. It was of 3¼ inches aperture with a focal length of 49 inches. Its intended use was to view the water-level markings on the water reservoirs that were used to operate the hydraulic system that raised and lowered the floor in the building housing the 36 inch refractor. It was used once by Barnard at the January 1889 eclipse. The aperture was reduced to 1.75 inches (Holden 1889a: 11; Barnard 1889: 56). The instrument was assigned the task of recording the inner detail of the corona near the limb of the Moon. The plate holder consisted of a wooden box lined with black cloth. Diaphragms were fitted to a slide to enable effective aperture variation. A 5 x 7 inch plate-holder was affixed to the rear of the box.

The Clark Back Lens of the 36-inch Refractor

The back focus double element lens of the 36 inch refractor served the function of adjusting the position of the effective photographic focus of the large refractor. The aperture of this lens combination was 1 1/10 inches with a focal length of 23 inches. This unit was fitted to Scovill camera box by the use of extension tubing. The plate size of this camera was 8 x 10 inches. Its stated purpose at the January 1889 eclipse was to record a very wide-field image of the corona that would be especially suitable for photometric use. In addition, the positions of the stars and planets would be recorded at the time of the eclipse (Barnard 1889: 56). It was used in this configuration just once at the January 1889 eclipse.

The Voightländer Lens Camera

A 1 inch aperture of 9 inch focal length standard Voightländer camera lens was fitted to a conventional 8 x 10 inch Scovill camera box. This combination was typical of that used by commercial photographic studios and landscape photographers. For the eclipse of January 1889, it was assigned the same duties as the Clark Back Lens of the 36 inch refractor (Barnard 1889: 56).

The Brashear Wheel-Photometer

This instrument was used just once, at the January 1889 eclipse. The Wheel-Photometer of the Lick Observatory was made to J.E. Keeler's specifications after a unit that Brashear had make for the Allegheny Observatory. Its construction is basically a 12 inch diameter wheel mounted on a horizontal axis. The wheel has four thin discs mounted on it that can slide on each other on common axis. Near each disc is mounted a ring with sectors cut out. The ratio of light transmission by each sectored disk is reduced by 25%. The four disks can be rotated so that up to 100% of the light can be blocked. The wheel was adjusted while turning using a rod system designed by Brashear that controlled the sectors on disks. Adjustment was accomplished by pushing in or pulling out the rod. Turning the wheel was done by a separate wheeled reduction system that was turned by hand or by foot. A graduated scale of the percentage of light transmission of the photometer was provided and tested for accuracy using general sky light. Any corrections were noted and logged in tabular form for easy reference (Leuschner 1889: 84-85).

The Dallmeyer Photographic Camera of the U. S. Naval Observatory

The instrument came as a complete package with the camera mounted on a fine Alvan Clark & Sons equatorial mount driven by a Bond escapement clock work. The lens was a Dallmeyer portrait lens of 6 inches aperture. The tube assembly was a short steel tube. The plate-holder was affixed to another tube that slid inside the main tube for focusing. The camera was equipped with a small sextant-sized finder telescope for image-centering purposes. For even more accurate pointing, Barnard mounted a telescope of 3 foot focal length. The camera and mounting sat on a pier with three legs that had adjustment screws for the making of fine altitude adjustments. This camera was equipped with one of Burnham's hinged velvet shutters. At the eclipse site of December 1889, a lens shade was made of barrel hoops and black cloth forming a hollow cylinder that would protect the lens from glare (ibid.). This lens hood was placed on a separate stand placed in front of the lens.

Schaeberle's Site-Made 18-inch Aperture Newtonian Telescope-Camera

This instrument was assembled at the December 1889 eclipse by Schaeberle. The 18 inch mirror was figured by Schaeberle at Ann Arbor in 1880. The mirror was re-silvered prior to leaving the Observatory. The tube and mounting was put-together from packing crate wood and other local materials. The tube consisted of metal barrel hoops mounted along a wooden backbone made of two 6 x 6 inch beams, 12 foot long. These beams were rigidly connected with diagonal wood braces. The black cloth was wrapped around the barrel hoops to form the tube itself. The mirror cell was bolted to the bottom end of the tube backbone. It consisted of mirror's transport tub with the mirror resting on a cloth cushion. The RA axis of the wooden mount consisted of another 6 x 6 inch beam provided with an iron bearing on both ends. The bearing was made by rounding off a hex bolt already screwed into the wood. The rounded bolt heads turned in heavy iron washers. The lower washer was affixed to one of the large cannon carriages present at the battery-eclipse station. The upper bearing was supported in such a way that a small change was possible to permit fine azimuth alignment of the instrument on the day of the eclipse. Cloudy weather canceled earlier attempts on alignment. Axis adjustment was inclined 5º to the horizon and bolted to the bottom of the tube backbone at an angle of 66½º. Diurnal motion to the instrument was provided by a turning a threaded screw with a wrench. This screw turned in two nuts affixed to a plank with one end abutting against the top of the tube and the lower end braced against the cannon carriage. One turn of the screw yielded 10″of diurnal tracking time (Burnham and Schaeberle 1891: 28).

The Willard Lens 'Crocker' Camera

It was Barnard (1913: 12) that recognized the special attributes of a particular old style portrait lens. He commented "… the so-called Willard lens is of more than passing interest, and a brief account of what is known of it may be of historical value." A Willard portrait lens camera first came to the attention of the Lick Observatory staff, after fine eclipse images were secured at the

January 1889 eclipse by amateur astronomer-photographer Wm. Ireland. His images displayed the extent of the coronal streamers, a fine accomplishment since the camera was provided with a diurnal motion capable mount and drive. His original images were used in the Observatory's coronal mapping project that began immediately after the eclipse party had returned home. Holden purchased this 6 inch (5.85 inch true) aperture, 31 inches focal length Willard lens from its owner, Wm. Shew, a local professional photographer on Montgomery Street, San Francisco. Holden wrote Brashear (1890): "I shall try to scrape together enough to get a mounting for our photo lens. Its [sic]hard work getting money now – but I think I can do it."

Finally, Holden used gift funds from C.F. Crocker and which resulted in the camera being given the Cocker name. The Willard lens was manufactured by Charles F. Usner in New York City, who distributed the lens under the Willard & Co. name (Barnard 1913: 12-14).

The Willard name was associated with superb quality and precision. It was a very expensive lens designed for fashion photography of the 1860's when fast (f/5-f/6) aperture lenses were wanted to shorten exposure times to overcome the slowness of the wet-plate development process.

Yet, upon testing, Holden found a focusing issue. As the lens was originally made for the wet-process era of photography, its optical focus and visual focus (in the yellow band) were the same which permitted the photographer to focus the lens. Lenses made exclusively for astronomical imaging had their optical focus slightly at a different point from their visual focus due to the spectral band of the source image and photographic emulsions. Photographers needed to attempt to calculate and position the plate holder at that point where the blue/violet rays came to focus. Holden sent the lens to Brashear who successfully refigured it. When Holden wanted Brashear to refigure a second Willard lens, Brashear turned him down because of the great difficulty that he had faced with the first lens.

The Observatory determined the precise optical specifications of this lens when first acquired.

Diameter of the front lens, 5.85 inches = 148.6 mm.
Solar focus, 42.59 inches = 108.2 cm.
Diameter of the back lens, 6.73 inches = 171.0 mm.
Solar focus, 70.2 inches = 178.3 cm.
Rear surface of front lens to the surface of the back lens distance = 12.8 inches.
Diaphragm of 3.83 inches aperture placed between the lens elements at 5.54 inches from the front lens.

After the refiguring of the lens by Brashear its characteristics were recorded in 1895 tests; Focus: 30.66 inches = 778.9 mm. Scale: 1 inch = 1º.81; 1 cm. = 0º.71.

Barnard would use this lens to produce his epic Lick Observatory Publications Volume XI, of 128 collotype plates, a comprehensive sky survey of the Milky Way and images of comets (Barnard 1913; Metcalf 1914: 241-245). The Willard lens camera was mounted on a Brashear made equatorial mount with a drive-clock. A small building with a dome housed the camera on Mt. Hamilton.

The Dallmeyer Portrait Lens Owned by Amateur Astronomer Wm. M. Pierson

The lens of 6 inches aperture of 32.6 inches focal length was nearly identical to the one on loan by the United States Naval Observatory for the December 1889 eclipse. It saw use on the LO expeditions from 1893 to 1922. It was provided without restrictions from the private observatory of Hon. Wm. M. Pierson of San Francisco. The lens was used for wide-field coverage of the corona. At the 1893 eclipse, it was used to secure plates for the use in determining the photographic absorption of light rays by the Earth's atmosphere and for capturing long-exposure plates of objects in the Southern Sky (Schaeberle 1893e: 230). In 1893 it had been intended to mount this camera to the body of the 6½ inch Clark refractor but instead was provided with its own non-tracking mount.

The Floyd Photographic-Telescope

The Floyd photographic telescope was of 5 inches aperture and 67 to 68 inches focal length – The focal length was reported as 66 inches in 1922. It was first used for medium image-scale coronal imaging on the 1898 expedition where it was mounted on one of the polar-axis mounts that carried other cameras and spectrographs. Normal plate size for this instrument was 5x7 inches. In 1908, the instrument was mounted horizontally receiving its light by a coelostat mirror (Campbell 1923a: 15).

The Forty-Eight Inch Coronal Camera

This camera was used at the 1918 eclipse, where it was operated by Mrs. E.B. Campbell. The 3 inch aperture, 48 inch focal length lens is of unknown manufacturer. Exposure range was 1^s to 76^s. This camera recorded the corona to the furthest distance than any other camera of the expedition (Campbell 1918c: 230-231).

The Eleven-Inch Coronal Camera

This landscape camera was applied to coronal form at the 1918 eclipse for recording the furthest extensions. It complemented the 48 inch camera used during the same year (Campbell 1908c: 231).

The Direct Vulcan Planet Telescope-Cameras

The first generation of this four camera arrangement, built entirely in the Mt. Hamilton shop, consisted of four 3 inch aperture of 11 foot 4 inch focal length lenses of which two were loaned by W.H. Pickering of the Harvard College Observatory. Campbell ordered two exact copies of these single achromatic lenses from Alvan Clark & Sons. The lenses were designed for this line of investigation by Pickering. Each lens was mounted in a metal tapered tube from 5 inches square at the lens end and 14 x 17 inches at the plate-holder end. The four cameras were rigidly fastened together with a wooden frame and equatorially mounted so that they could be moved on two axes. This would permit the cameras to be shifted along the Sun's equator to obtain different field coverage. Each pair of cameras was angled 18º apart from each other and photographed the same region of the sky. For each camera, the plate size was 14 x 17 inches yielding plate coverage of 5º 54′ and 7º 8′. Total instrument coverage was 19º on either side of the Sun. Limiting star magnitude under clear skies was figured to be 10th magnitude (Perrine 1900a: 58-60, Perrine 1900c: 183-184; Perrine 1901c: 192). Two of these sets of cameras were used in 1905 and 1908.

The Original Direct Einstein Cameras

The Einstein Cameras that were to have been used in 1914 initially consisted of one set of the original Vulcan cameras last used in 1908. Each of the four cameras was fitted with a 16 x 20 inch plate holder. The drive speed was changed from the solar rate to the sidereal rate for the accurate tracking of stars (Campbell and Curtis 1914: 231-232).

Circumstances dictated that alternative cameras be quickly assembled for the 1918 eclipse. A four camera instrument was assembled from two lenses from the Observatory and two borrowed from the Chabot Observatory. One former Vulcan camera Clark lens of 3 inch aperture of 11 foot 4 inch focal length was found at the Observatory, and another photographic lens corrected for stellar photography of 4¼ inch aperture of 15 foot focal length was also available. The two

Chabot lenses were Brashear 4 inch aperture lenses of 15 foot focal length last used by Burckhalter at the Georgia eclipse of 1900. Plate size was set at 14 x 17 inches and again the cameras were rigidly mounted and provided with a sidereal driving rate. Only one exposure of about 112^s was made with each camera (Campbell 1918c: 220-230).

The Refined Direct Einstein-Coronal Cameras

New cameras were especially designed for the Einstein test conducted at Wallal in 1922 and would then become the replacement for the 40 foot Schaeberle Camera by 1932. The cameras in their entirety except the lenses were manufactured in the Mt. Hamilton shops. Each set of the cameras were equipped with a powerful finder telescope with 4 inch aperture lenses of 15 foot focal length. The entire set of instruments was broken down into 250 pound segments for transport (Campbell 1922c: 123-124; Campbell 1922d: 188; Campbell 1923a: 15, 20, 36; Campbell and Trumpler 1928; Campbell and Trumpler 1923a: 43-44).

The Lenses, Plate-Holders, and Shutters

Two lenses were Hasting-Brashear quadruplet 5 inch aperture of 15 foot focal length mounted to equatorial mounts of extreme rigidity. Two additional Ross-Brashear quadruplet lenses of 4 inch aperture and 5 foot focal length were mounted on a separate similar mount. Both Hastings of Yale University and F.E. Ross of the Eastman Kodak Company were among a handful of premier lens makers capable of producing this type of precision lens. All lenses were highly corrected to give sharp stellar images to the edge of a flat field of coverage. All lenses were mounted in brass tubes which were 28 inches long and provided with a threaded ring to achieve fine focusing. Field coverage of the 15 foot focal length cameras is 5º x 5º and the field coverage of the shorter focal length cameras is 15º x 15º. Plate size for each camera was 17 inches square. The plates were ¼ inches thick. The plate-holders were made of cast aluminum alloy and sheet aluminum with the slides made of black hard rubber. Each shutter consisted of an objective lens cap mounted on a wire frame and operated by a string that was pulled from the eyepiece end of the telescope. This initial shutter system was found to cause vibrations in the instrument.

The Tube Assembly

Each pair of camera lenses was mounted in a separate tube wrapped with a layer of black cloth and a layer of rubberized cloth that was black on one side and white on the other. The complete tube frame weighed seven hundred pounds. A series of steel diaphragms are mounted internally to separate the two optical systems.

The Equatorial Mounts

The mounts differed from their earlier wooden polar axis counterparts by being constructed entirely of rolled steel, cast steel, cast iron, and brass. Instead of the previous mounting of instruments on top of a box frame, the tubes pass through a metal frame structure providing a more stable-rigid system. There was no provision for the adjustment of declination. Drive power was by wire cable drawn by a clock, allowing the cameras to track by their own weight. The clock cable was connected via a slow motion control and then to a 10 foot arm on each mount. The end of the arm glided on rollers on a metal plate inclined at the same inclination of the plane of the equator. The polar-axis with instruments ran on roller bearings supported on both ends by heavy wooden blocks. The blocks were bolted to concrete pier-foundations.

The Direct Polarigraphs

The first Lick Observatory application of the polarigraph was at the 1901 eclipse. A rotatable Nicol prism was used as the analyzer mounted in front of a camera with a lens of 20.75 inches focal length. The prism could be rotated in 22 1/2º increments. The Spanish station at the 1905 eclipse received the Nicol prism polarigraph and three additional cameras designed by Perrine. One of the cameras had a reduced aperture lens and no analyzer and served as a standard comparison for the other two new cameras. The latter two cameras had plane-glass mirror analyzers mounted in front their objective lenses. The analyzers were adjusted to record the coronal polarization on four radii of the corona. All three cameras had 50 inch focal lengths of unknown aperture and all were mounted on a single polar axis mount. Images were sharp enough to permit accurate readings of intensity within the inner-middle and middle corona although this analysis was not done. No measuring instrument yet existed at the time of first use of the cameras (Campbell and Perrine 1906: 31-32). For 1914 in Russia, light shields were installed forwards of the analyzers to prevent stray light from reaching the system. Clouds did not permit the intended observations.

Direct Lens-less Camera-Photometer

This instrument was added to the Lick Observatory eclipse inventory for the 1905 eclipse at the station at Alhama in Spain station for photometric investigations and would continue service until

1918. Its first use would be to compare the brightness of the corona to the Moon.   The circular field coverage was 4 degrees. It was mounted initially on a polar-axis mount and later mounted alongside the intra-mecurial-Einstein cameras (Campbell and Perrine 1906: 32).

Direct Extra-focal Cameras-Photometers

This class of photometer was first employed at the 1914 eclipse in Russia, although not used because of clouds. Two camera tubes, set 7 inches apart, were fitted with two of the former Vulcan lenses used in 1905 and 1908. They were fitted with 14 x 17 inch plate holders and both tubes were placed on the side of the Einstein Camera apparatus. The lenses were set 3 inches out of focus and one lens was stopped down to reduce incoming light by one magnitude. Photometric readings of high accuracy were made of the coronal light and the star Regulus upon comparison with the imbedded standard squares on the plates (Campbell and Curtis 1914: 232).

9.3 APPENDIX 3 The Staff of the Lick Observatory

The Directors:

Holden (1888-1897)

Edward Singleton Holden (1846-1914) joined the U.S.N.O. in 1873 and assisted S. Newcomb. The two men monopolized the new 26 equatorial refractor for the first 18 months of its operation. Holden lead one of three U.S.N.O. parties to Central City, Iowa for the total eclipse of 1874. Along with Newcomb, Holden became embroiled in the growing controversy of hiring a civilian as head of the observatory. By 1881, Holden had produced his monograph of extensive observations of the central part of the Orion Nebula which Campbell referred to decades later of being of high value (Dick 2003: 203-204, 213-215, 233, 299). Holden left to take a position at the Washburn Observatory, Michigan, in 1881.

Holden was appointed as the first Director of the Lick Observatory in 1888. His authoritarian style of leadership would influence the outcome of the early eclipse expedition's photographic results. Holden's best talent was his ability to socialize with the high society of San Francisco and raise funds from these individuals. He was also known for his penchant to seek out wealthy women. He often mentioned the large numbers of staff present at the Harvard, Paris and Pulkovo observatories and compared them to the meager staff at the LO in order to build the guilt factor among the donors (Osterbrock *et al.* 1988: 90).

Holden's astronomical knowledge came from his ability to absorb what he read in the reports of his colleagues. His academic abilities in the classroom, his ability to supervise students at the Ph.D. level, and his ability to conduct original research, were marginal at best. Holden's connection to the LO came as a result of his friendship with Newcomb, who was in charge of the installation of the great 36 inch refractor. Newcomb found him to be an energetic individual with great abilities (Campbell 1914a: 76-84).

Holden had previous eclipse expedition experience from leading an expedition on 29 July 1878 in the vicinity of the Rocky Mountains. He followed with another American expedition, venturing to the distant Caroline Island in the South Pacific on 6 May 1883 with Royal Astronomical Society photographers Lawrance and Woods attending. He conducted a wide range of scientific investigations for the National Academy of Sciences. Campbell (ibid. 81) later reported, "The memoir on the eclipse of 1883 is a model in form, and is frequently referred to by past and prospective observers of eclipses." Holden's gift at selecting a highly qualified but unproven staff did not go unnoticed by Newcomb:

> The institution makes its mark almost from the beginning. I know of no example in the world in which young men, most of whom were beginners, attained such success as did those whom Holden collected around him.

Holden is credited for the creation of the Astronomical Society of the Pacific. His personal research was exclusively limited to lunar photography and observations of the Orion nebula. Holden was urged to resign in 1897, effective 1 January 1898, after years of contention with his staff, the University of California's Board of Regents, and the San Francisco press.

After leaving the LO, Holden wrote many popular articles on astronomy and served as Librarian of the United States Military Academy at West Point, New York until he passed.

Keeler (1899-1900)

James Edward Keeler (1857-1900) was the son of Wm. F. Keeler, who served as an officer aboard the vessel 'Monitor' during its historic Civil War sea battle with the Merrimac, which ended in a draw. At the age of 12, Keeler became interested in astronomy under the guidance of his father and older brother. He founded the small Mayport Astronomical Observatory that existed for a couple of years, 1875-1877. He kept a log of his basic observations which included colored drawings of the closer planets and the Orion Nebula viewed through a 2 inch aperture telescope. He majored in Physics and German at the John Hopkins University and graduated in 1881. He then traveled as an assistant to Hastings on Holden's 1878 eclipse party of the United States Naval Observatory (Campbell 1900c: 139-140). Keeler served under Langley as an assistant at the Allegheny Observatory in the same year. Keeler accompanied Langley on his Mt. Whitney Summit expedition to determine a value of the Solar Constant.

Keeler started as Assistant to the Lick Trustees in 1886 where he proceeded to set up the time services and helped with the installation of the original instruments. Keeler was appointed Staff Astronomer at the same time as the initial professional staff was hired. He became the house expert on spectrographic issues and designed the principle stellar Bruce spectroscope for the 36 inch refractor. Keeler's use of a Hasting style spectroscope at the 1 January 1889 total solar eclipse showed the power of this instrument in the hands of a capable observer and scientist. In a short few minutes, Keeler was able to observe at totality and then used his own observations to solve a coronal problem that had bothered solar researchers since 1883 (Moore 1938).

He officially resigned at the LO on 1 June to take the Directorship of the Allegheny Observatory in 1891 and Professor of Astrophysics at Western University of Pennsylvania. Holden (1891h) recommended that the following resolution be entered into the records of the Board of Regents:

> Resolved – that in accepting the resignation of Mr. Keller the Regents desire to express their high appreciation of his astronomical work at the Lick Observatory & that they wish him every success in his new position. Mr. Keeler has richly deserved such a expression – & will value it at his full value. Professor Keeler's published papers have a finish and a ripeness which are rarely seen. His love of the beautiful and his artistic skill are evident in all his work.

As an observer, he determined the radial velocities of the Orion Nebula, thirteen planetary objects, three bright stars and discovered the principle nebular line at 5007 Å in nebulae. His radial velocity determinations remained among the most accurate made through the first half of the twentieth century. Keeler also applied the spectroscope to Saturn's rings and to Uranus in a study of the atmosphere of both planets.

Keeler served as Director of the Lick Observatory, a position he held for only one year in June 1898. Upon his return to the LO to take the Director's position, he surprised his staff by putting himself in charge of operating the unwieldy, 36 inch Crossley reflector. With his work on the shape and nature of galaxies, Keeler is credited with making the reflector telescope the principle tool for astronomical research over the refractor type telescope. He also initiated the Fellows program, which became the new graduate school of astronomy. Keeler proved himself a capable administrator as Director and at once built a bond between the Observatory and the Department of Astronomy at Berkeley. This immediately improved the bad relations that had existed under Holden's tenure. The Lick staff was finally free to teach courses at Berkeley giving the students a chance to hear directly from working professional astronomers (Osterbrock *et. al*., 1979: 124). Osterbrock referred to him as an 'astute astrophysicist' (Campbell 1900d: 141; Osterbrock *et al*. 1988).

Campbell 1901-1930

William Wallace Campbell (1862-1938). It was not until his undergraduate years at the University of Michigan, that Campbell became interested in astronomy after reading Newcomb's popular Treatise on Astronomy. He enrolled in as many astronomy courses as possible in his senior role, although he was to receive his degree in civil engineering. He was to gain his first employment in the field of astronomy when he became an instructor in astronomy and assistant in the observatory in 1888. During this period, he taught practical courses in astronomy, specialized in the observations of comets, and wrote his general textbook, *A Handbook of Practical Astronomy* (Moore 1939: 143-144).

Campbell served nearly three decades as Director beginning in 1901. Campbell came to the LO as a summer volunteer. Due to the impression he had made on Holden as to his spectroscopic abilities, he was appointed to replace Keeler who was then the chief spectroscopic expert in 1901. His work on Wolf-Rayet or 'New' stars was considered pioneering in nature. Under Campbell's directorship, the LO became a 'factory' for radial velocity measurements of stellar objects (ibid.). He made the Observatory first to solve the problem of the accurate determination of stellar radial velocities and then, the discovery that certain stars were spectroscopic binaries. He designed the Mills Telescope and spectrograph to carry on the radial velocity program under the southern skies in Chile beginning in 1902-1903. This line of research was carried on to include gaseous nebulae, and the internal motion within planetary nebulae. His results were later used by other researchers to study galactic rotation. Campbell was aggressive in his leadership and participation on seven of the solar eclipse expeditions. His 'moving-plate' spectrographs were of his unique design, yielding records of the rapidly changing spectrum at the Sun's edge at second and third contacts, as well as the recording of the flash spectrum of the reversing layer. Campbell's spectrograms were used by Menzel in his cutting edge studies of the chromosphere. Campbell's work with Trumpler, using the plates taken at the 1922 Wallal eclipse, provided the most definitive results ever made, as of 1939, on the verification of Einstein's Theory of Relativity, following Eddington's work at the 1919 eclipse. Upon being awarded the Bruce Gold Medal of the American Astronomical Association, President Maw was quoted (Crawford 1915: 156; Moore 1939: 143-148):

> It is, in fact, impossible to overrate the importance of the influence which our Medalist has exercised on the eclipse expeditions…and probably only those who

> have taken part in such expeditions can fully appreciate his powers of organization, and his skill and resourcefulness in devising special lines of research and instrumental means for rendering such researches practicable.

Over his tenure at the Observatory, Campbell was an active participant in the nation's science and astronomical organizations. He was President of the American Association for the Advancement of Science in 1915, President of the International Astronomical Union from1922-1925, Astronomical Society of the Pacific, and President of the American Astronomical Association in the years 1922-1925 (ibid. 147).

In 1923 he was appointed President of the University of California. He retained the title of Director of the Observatory, living on Mt. Hamilton. While he hoped to return to this work at the Observatory, he was to retire after seven years had lapsed then living in Berkerly. Regent of the University of California Chester H. Rowell said, “With a hand always gentle but firm and never shirking, President Campbell ruled the University wisely and well.” (ibid. 150).

Schaeberle (1897)

John Martin Schaeberle (1853-1924) was born in Oeschelbronn, Würtemberg, Germany. At age of only one, his family immigrated to the Ann Arbor, Michigan, U.S. in 1854. At age 15 and for the next three years, he learned the machinist trade in Chicago. He also began learning the art of telescope mirror making, being intrigued by astronomical observations. He returned to Ann Arbor and enrolled at the University of Michigan. By 1872, he had built his personal observatory equipped with his hand-made instruments. At the university, he was mentored by James C. Watson and became his assistant in 1876, at the college observatory. He assumed directorship of the observatory in 1886. In 1888, he joined the inaugural group of astronomers of the Lick Observatory (Whitesell 2003: 90-92).

John M. Schaeberle served as Acting Director for just part of one year in 1898, when J.E. Keeler was appointed in his place. Reasonably upset at being passed over, Schaeberle left the field of astronomy. Schaeberle brought to the Lick Observatory experience as an amateur telescope maker and was schooled in astronomy and mathematics. The first published account of his prowess with photographic instruments at the LO comes with his careful attention to detail and precision in correcting image problems with the 40 Foot photo-heliograph placed in service in 1882 by Professor Todd for the Transit of Venus of the same year (Schaeberle 1889: 23-24). He designed and built the ‘hall-mark’ 40 Foot Camera that would produce the large image-scale plates that the Observatory would become well known for. He proposed his Mechanical Theory of the Corona beginning in 1889 which attracted world-wide attention and the total support by his colleagues at the Lick Observatory. It was the only complete coronal theory to come from the LO until Menzel's major hypothesis during tenure in the second quarter of the twentieth century.

He specialized in making planetary observations with the 36-inch equatorial. He inspected Uranus, Jupiter and Mars, and their satellites, studying their surface markings and orbital elements. His reports highlighted his study of the binary star 85 Pegasi in 1893, photographic observations of Algol in 1894, and deriving formulae for simultaneous meteor observations.   He was awarded the Donohoe Comet-Medal in 1895. Between 1895 and 1898, he produced several papers on reflecting telescope design and the characteristic optical defects inherent in their mirrored elements. In 1897 he discovered the companion to Procyon and studied the spectrum of the Orion nebula.

After being rejected, by the UC Board of Regents, for the Director's position at the LO, he resigned and spent several years engaged in world travel. Even though he had officially left the field of astronomy in 1899, he proceeded to build his own observatory in Ann Arbor. He continued to publish a handful of papers. Among these "The ring nebula in Lyra, and he dumb-bell nebula in Vullpecula, as great spirals", On the spiral character of the nebulosities surrounding gamma Cassiopeiae", "On the physical structure of the great cluster in Hercules", all in 1903. He 1905 he produced a paper, "On the certain evidence indicating the existence, in the solar system of streams of gravitation matter ejected from the Sun." In 1906, another paper, "The probable volcanic of nebulous matter." His last paper appeared in the peer reviewed literature in 1908, "The earth as a heat-radiating planet." In all, over his life-span, he published more than 100 papers related to the field of astronomy.

Aitken (1930-1935)

Robert G. Aitken (1864-1951) enrolled at Williams College in Massachusetts, where his astronomy mentor was Truman Henry Safford, who was a double-star observer. He received his undergraduate degree in 1887 and took a position at the College of the Pacific teaching mathematics.

In 1894, Holden invited him to spend the summer at the Observatory as a special student. Aitken became an Assistant Astronomer at the LO in 1895, Astronomer in 1907 (Osterbrock *et. al.*1988: 193-197). Aitken was able to continue where Burnham left off as a double-star observer.

In 1899, he began a comprehensive survey of double stars limited only by the light gathering ability and resolution of the 36 inch refractor. He published the *New General Catalogue of Double Stars within 120 degrees of the North Pole* in 1932 which followed up Burnham's *General Catalogue of Double Stars* published in 1906. Aitken also published a standard book, *The Binary Stars*, in 1918 with a second edition published in 1935.

Aitken became Associate Director of the Observatory in 1923 and then was appointed Director in 1930 serving until 1935, which was the date of his retirement.

Aitken was considered to be an observational astronomer rather than an astrophysicist. He did not use photography in his line of research nor did he conduct data reduction in the quest of scientific hypotheses. His chief program was to make visual measurements of double stars down to a limit of ninth magnitude. Menzel was recruited to the L.O. by Campbell and Aitken, who saw a real need to have a theoretical astrophysicist join the staff. Despite his excellent work, Aitken did not encourage Menzel's endeavors. Menzel constantly received 'lectures' from Aitken on staying focused on his assigned duties (ibid.). Pasachoff (2002: 142) on Menzel quoted Aitken in regards to Menzel's line of theoretical astrophysical work '… after all … this is an Observatory!' Your responsibility is to make the observations and record them. Leave the theory to the poor, underprivileged British astronomers, such as Milne and Eddington, who don't have an observatory." Aitken (1933a) was committed to the eclipse program and promoted the value of the expeditions as late as 1933. Aitken, himself was referred to by Osterbrock (2002: 103) as "… a died in-the-wool scientific arch-conservative … ."

Staff Astronomers who participated in the Eclipse Expeditions:

The general scientific caliber of the Lick astronomers is summarized in Table 18 as to their highest degree. The only member of the staff of the Lick Observatory to have a Ph.D. by 1901 was J.H. Moore. It was considered normal for the observational astronomers holding most of America's observatory positions not to have achieved this level of education (Osterbrock 2002: 100).

Astron.	**Position**	**Year**	**Degr.**	**Eclipses**	**Societies**	**Medals****
Holden, E.S.	Director	1888 1898	Sc.D. 1896	01/1889 Partial	ASP, RAS, NAS, ASF, ISS, AAAS	
Keeler, E.S.	Director	1886 1898	Sc.D 1893	01/1889	AAAS, ASP, RAS, AASA, WAS	Henry Draper
Campbell W.W.	Director	1901 1930	Ph.D.	1898,1905,08, 18,14,22,23,30	IAU, ASP, AAS, AAAS	Bruce, Lalande, Janssen, Gold
Aitken, G.A.	Director	1894 1935		1908, 1930	ASP, IAU	Bruce, Lalande, & Gold

Schaeberle J.M.	Act. Dir. (1 Year)	1888 1898	LL.D.	1/1889,12/89189 3,96	ASP	
Barnard, E.E.	Staff Astron.	1887 1894	MA 1889	1/1889	RAS,BAA,AAA AASA,NAAA,SF AAS,RASC,APS	Lanlande, Gold, Janssen, Bruce
Burnham, S.W.	Staff Astron.	1888 1892	Sc.D. 1915	2/1889	ASP, RAS,	Lanlande, Gold,
Leuschner A.O.	Graduate Student	1889 1890	Ph.D.	1/1889, 2/1889	ASP	
Hussey, W.J.	Staff Astron.	1896 1905	Sc.D. 1912	1905	ASP, IAU,AAA AAAS,RAS,MAS	Lanlande
Perrine, C.D.	Staff Astron.	1895 1908	Sc.D. 1907	1900, 1901, 1905, 1908	ASP, RAS	Lanlande
Curtiss, R.H.	Assistant	1901	Ph.D.	1901		
Curtis, H.D.	Staff Astron.	1900 1920	Ph.D.	1900, 1905, 1914, 1918	ASP, AAAS, AAS, NAS, APS, RAS, AG, IAU	
Wright, W.H.	*Staff Astron.	1898 1942		1898, 1923, 1932	ASP	
Moore, J.H.	War Director		Ph.D.	1918,22,23, 1930, 1932	ASP	
Lewis, E.P.	Physics, Berkeley	1902 1918	Ph.D.	1908, 1918, 1923	APS	
Trumpler, R.J.	Staff Astron.	1919 1930	Ph.D.	1922, 1923	ASP	
Menzel, D.H.	Assistant Astron.	1926 1932	Ph.D.	1930, 1932		

*Wright was appointed Director well after the expeditions were over in 1942.
Astronomical Society of the Pacific (ASP), Astrophysical Society (APS), Royal Astronomical Society (RAS), Royal Astronomical Society of Canada (RASC), International Astronomical Union (IAU), American Astronomical Society (AAS), National Acad. of Sciences (NAS), British Astronomical Society (BAA), Astronomical Society of France (ASF), Italian Spectroscopic Society (ISS), American Academy of Arts and Sciences (AAAS), Washington Astronomical Society (WAS). Astronomische Gesellschaft (AG), Maryland Acad. of Sciences (MAS), Acad. of Arts and Sciences of the America (AASA).
**Medals and Prizes:
The Lalande prize of the Paris Academy of Sciences.
The Bruce Gold Medal of the Astronomical Society of the Pacific.
The Janssen Gold Medal of the French Academy.
The Janssen Medal of the Societé Astronomique de France.
The Gold Medal of the Royal Astronomical Society of London.
The Henry Draper Medal of the National Academy of Sciences.

Table 18 The Lick astronomers who were active with the eclipse expeditions, their highest degrees, memberships in professional societies and principal medals awarded.

Barnard, 1857-1923

Edward Emerson Barnard, born on 16 December 1857 in Nashville, Tennessee, began his photographic career at the young age of nine years old, working in a photography studio in Nashville, Tennessee. He remained employed there for the next 16 years. Here he learned the fine art of portrait photography and became highly proficient in all aspects of wet-plate era photography (Aitken 1923: 87-89; Burnham 1894). Around the age of nineteen he had made a small 1 inch aperture telescope out of a found lens and paper tubing, having read a copy of Dr. Thomas Dick's *Practical Astronomer*. Although he had grown up under financial challenging conditions, he managed to secure a 5 inch aperture telescope in 1877 at the age of twenty and met his first professional astronomer, S. Newcomb. In 1881, he discovered his first comet. He had thoroughly learned entire regions of the sky and announced discovery of another new comet that really did not appear comet-like. By 1883, at the age of twenty-six, due to his observation abilities, he was offered a Fellowship in Astronomy at Vanderbilt University. Barnard took charge of the school's 6 inch aperture refractor and observatory and published regularly in the astronomical journals (ibid.; ibid.). The stage was set for Barnard to become a pioneer in astrophotography at the Lick Observatory.

In 1887, Holden hired Barnard at the Lick Observatory to join his elite group of astronomers: Burnham, Schaeberle, and Keeler. His actual date of receiving compensation was in June of the next year. He utilized the Clark 12 inch aperture refractor, the comet-seeker telescope and the small photographic telescopes. Holden asked for assistance with his personal Lunar Atlas photographic project using the 36 inch refractor. Many of Holden's poor quality lunar images were quietly redone by Barnard, even though Barnard does not appear as a co-author. He is credited as the first to make the photographic discovery of a comet in 1892 (Norman 1938: 590). This is the last branch of astronomy for which photography had proved itself far more capable than a direct visual observer or drawer.

In the same year he was assigned time at the 36 inch refractor for one night a week, where he found nebulous matter closely surrounding the star Merope and then began to find other planetary nebulae. He remained fully dedicated to his work in observational-photographic astronomy beginning with celestial photography (Aitken 1923: 89). According to Aitken (1923), Barnard's discovery of the 5^{th} satellite of Jupiter on 9 September 1882 was his most brilliant piece of observational work. He was first to discover a double star as it was being occulted by the Moon.

Barnard made the images of his Milky Way photographic compilation, *Publications of the Lick Observatory, Vol. XI, 1913: Milky Way and Comets*, at a time in the early 1890's when other astronomers were looking to photograph the heavens with large aperture telescopes. Barnard used just a 'portrait' lens equipped camera. J.H. Metcalf (1914) referred to Barnard:

> Professor Barnard has been a daring and a most successful astronomical discoverer, but never did he show such radicalism as when he, one of the keenest sighted and most

experienced of Observers, spent night after night in photographing the sky with so small an instrument and one that was not even made for the stars.

With experience gained with the Willard camera, Barnard went on to photograph the faintest nebula possible using exposures of 5 and 6 hours recording nebulosity that was not seen visually in the large reflector telescopes. He made the most successful photographs yet made of a comet with the great comet in March, 1892.

Barnard's coronal images at the 1 January total eclipse were the best yet made at an eclipse as mentioned in Chapter 6 and, again, were made with an instrument made for non-astronomical duties.

After seven years at the Observatory, Barnard left for a position at the Yerkes Observatory of the University of Chicago. He continued on with his distinguished career, taking on the subject of nebulous clouds, and the possibility of the existence of dark nebulae that could obscure background illumination and were not 'holes in the Heavens' as proposed by Herschel and others. He then did a short stint at the Mt. Wilson station using the Bruce telescope to obtain another fine set of plates of the Milky Way. He was active at the eclipse expeditions of 1900 and 1901, operating large image-scale cameras on the scale and larger than the Schaeberle 40 Foot Camera. He was the first to adequately explain the clouds of stars and the dark 'holes' of the Milky Way. Before his passing in 1923, Barnard had published 843 articles with his *Atlas of the Milky Way* and other works of his observations remaining in prepress (Aitken 1923: 91).

He was a Fellow of the Royal Astronomical Society of London since 1887, belonged to the British Astronomical Association, was a member of the American Academy of Arts and Sciences, held a membership in the American Association for the Advancement of Science, as well as other scientific Societies. In 1889, he received the Honorary Degree of M. A. from the University of the Pacific for his important astronomical work. He received the Lalande gold medal of the French Academy of Sciences.

Aitken described Barnard as having little aptitude for theoretical astronomy, but summed his view of Barnard: "… the greatest astronomical observer of his generation and one of the most lovable of men." Moore (1938: 192) paying tribute to the early Lick astronomers:

Of the early Lick astronomers, Barnard was probably the most versatile and enthusiastic, and as keen observer he has had few equals in the history of astronomy. His patience and diligence in searching for comets was regarded so generously that it was said 'there is not a telescope on the Mountain, except the meridian circle, with which he has not discovered a comet.' Barnard's demonstration of the power of the wide-angle lens in photographing faint extended objects opened a new and rich field for cultivation and deserves to rank as one of his most notable contributions to the progress of astronomy.

Burnham

Sherburne Wesley Burnham (1838-1921) was a self-trained amateur astronomer in his early years with no formal college experience. His work for the first twenty years of his career was as a federal court reporter. He obtained a Clark 6 inch refractor in 1870 and used it to discover double stars of which he kept detailed records. He began publishing lists of double stars in the *Monthly Notices of the Royal Astronomical Society* starting in 1873. In 1878 he obtained access to the 18½ inch refractor of the Chicago University's Dearborn Observatory. In 1880 he assembled his card catalog of double stars and produced the standard reference work *General Catalogue of Double Stars*.

With his keen eyesight, he used his Clark refractor to test the seeing conditions on Mt. Hamilton in 1879 under the Lick Trust. In 1881 he served under Holden, who was then Director of the then new Washburn Observatory of the University of Wisconsin at Madison. He would return to Mt. Hamilton the same year to observe the Transit of Mercury with the 12 inch Clark refractor.

Holden then invited him to work in the position of Astronomer at the LO beginning in 1888. During the next four years he discovered more than 200 close double stars and accurate measured their separations with the 36 inch refractor (Aitken 1928: 155; Moore 1938: 191). He is credited with proving the 36 inch refractor ideal for double star observations. He participated in the solar eclipse expedition with Schaeberle in December 1889, as he had shown special aptitude with general photography. Because of the worsening morale at the Observatory, he resigned in 1892 and took the Office of the Clerk of the United States Circuit Court.

He returned to astronomy by accepting the position of Professor of Practical Astronomy in the University of Chicago, where he received two nights' observing time on the new 40 inch Yerkes refractor. His continued double-star observations continued, with emphasis placed on measuring doubles that pushed the limits of the big refractor. He produced his *General Catalogue of Double Stars within 121º of the North Pole* published in 1906, which continued on with new editions. It contained information on 13,665 stars. Further work by Burnham was published in 1913 as *Measures of Proper Motion Stars Made with the 40 inch Refractor of the Yerkes Observatory in the Years 1907-1912*.

Hussey

William Joseph Hussey (1862-1926) completed his undergraduate studies in Civil Engineering at the University of Michigan in 1889. Hussy was fortunate to take astronomy classes from both Schaeberle and Campbell which might have seeded his future interest in the Lick Observatory. He became an instructor of astronomy and Acting Director of the observatory in 1891-92. Curtis made some very uncomplimentary comments about Hussey's 'home-made' design of the telescope (Curtiss 1926: 605-606).

Hussey accepted a faculty position at Stanford University in 1892. In 1893, he was a special student at the Lick Observatory in 1893 and was appointed to the staff of the Observatory on 1 January 1896 by Holden to fill Barnard's position and area of responsibilities. This included observations with the 12 inch refractor and wide-field photography with the Crocker camera. He was also promised observing time on the Crossley and 36 inch refractor telescopes. Hussey's first assignment was to work with Holden in getting the gift Crossley reflector up and running. By all senses of the imagination, it seemed an impossible task due the condition and construction of this formally intended amateur telescope. Senior Lick staff members made constant fun and made highly uncomplimentary comments regarding the instrument (Osterbrock *et al*. 99-102). Hussey bitterly fought with Holden continuously over the instrument so that little was accomplished that first year. Hussey was a primary factor leading to the final unseating of Holden as Director. The professional astronomical community remained split as to their support of Hussey's actions. It was Hussey who initiated legal proceedings against Holden for his abusive behavior, and was quickly supported by several colleagues on the staff. All of the subsequent actions led to Holden's resignation shortly before the Board of Regents would have formally fired him (Aitken 1926: 376-378; Curtiss 1926; Osterbrock *et al*.: 103-105).

Hussey worked on his own double-star program of making precise measurements of Wilhelm Struve's doubles, assisted by Fellows Ross and Coddington after Holden's departure in 1898-1900. This work was published as Volume 4 of the *Publications of the Lick Observatory*. Hussey ended his stay at the Lick Observatory by leading the successful 1905 eclipse expedition segment to Egypt. Additionally, he discovered 1327 to 1338 closely spaced doubles and continued this line of study after his departure take the position of Director of the Observatory at the University of

Michigan in 1905. He was instrumental in design of the school's 37½ inch reflector telescope, which was fully operational by 1911. Over his career, Hussey worked on measures of the orbits of comets and asteroids, and the moons of Saturn.

In 1902, Hussey was sent out by the Carnegie Institution of Washington to locate a site for solar observatory that was to be built by funds from Andrew Carnegie, who was a steel magnate. Hussey selected Mt. Wilson in Southern California which, under Hale's guidance, became the home of two large reflectors, three solar telescopes and would soon become the world center of observational astronomy.

In 1911, he traveled to Argentina to assist that countries development of an astronomy research and teaching program at the La Plata University. He lost his bid at being appointed to head the program and returned home. He would return to Argentina in 1912 for research purposes and an eclipse expedition to Brazil after setting up a six year co-operative agreement.

The astronomical community's recognition of his achievements was numerous. Hussey actively participated in and was elected President of the ASP in 1897 again in 1905-1906. He was a member of the International Astronomical Union at its founding in 1919, a Fellow of the American Association for the Advancement of Science, president of the Research Club of the University of Michigan (1919-1920), a foreign Associate of the RAS (1903), honorary member of the Mexican Astronomical Society (1904) and Secretary of the AAA from 1908-1912. He was awarded an honorary Doctor of Science degree by Brown University in 1912 and the Lalande Medal in 1906 (Aitken 1926: 379; Curtiss 1926: 611).

Perrine

Charles D. Perrine (1867-1951). Perrine came to the Observatory as the Secretary. He was interested in astronomy so he offered a helping hand with the observations. His first astronomical duty was to make the daily exposures of sunspots and then began helping with observations at the 36 inch. He would make a thousand exposures of the asteroid Eros in 1900-1901. He even found a comet with the 12 inch refractor (Osterbrock *et al*. 1979: 141-142). In 1895, Holden promoted Perrine to assistant astronomer. Campbell placed Perrine in charge of the Crossley near 1901, where he spent 1902 to 1905 essentially reconstructing the instrument. Perrine made high-quality photographs of clusters and nebulae that were often better than those obtained previously by Keeler. They were published in the 1908 volume 8 of the Publications of the Lick Observatory. Using the rebuilt Crossley reflector, Perrine discovered the sixth and seventh moons of Jupiter in

1904 and 1905. With his list of accomplishments in hand, he was promoted to Astronomer and received an honorary Sc.D. degree in 1907 from Santa Clara University.

Perrine's first eclipse expedition was as an assistant to Campbell for the 1900 eclipse. Poor Perrine suffered the effects of bad food so severely that he was bedridden except for the few moments of totality, when he managed to operated his instrument. Perrine was placed in charge of the 1901 eclipse expedition to Sumatra. Perrine's photographic results were excellent, but he did not have the science background needed to understand the physics of the corona (ibid.: 160-161). The next eclipse for Perrine was the 1908 expedition to Flint Island. In the same year Perrine accepted the Director position of the Cordoba Observatory in Argentina. In 1924 he published two papers explaining the green flash seen at Sunset (Perrine 1924: 319-322; Perrine 1926: 134-136).

He had achieved a high level of success as an observational astronomer without having the education and advanced degrees obtained at prestigious institutions that a majority of his colleagues had. He was gifted with ability of hard work, mechanical prowess, concentration and the dexterity of a successful observer.

Curtis

Heber Doust Curtis (1872-1942). Curtis was an undergraduate student at the University of Michigan majoring in classical languages. He would then teach different languages for the next seven years at the high-school and college level. In 1896, he became a Professor of Mathematics and Astronomy at the College of the Pacific. He was awarded the Vanderbilt fellowship at the University of Virginia, where he received his Ph.D. in 1902 (McMath 1942: 68-69).

Curtis traveled with the Lick Observatory group as a volunteer observer on the 1900 Thomaston, Georgia, eclipse expedition.

He was appointed as an Assistant and then Assistant Astronomer at the Observatory from 1902 to 1905. He was promoted in 1906 to Acting Astronomer in charge of the Observatory's Southern D.O. Mills Station at Santiago, Chile, where he spent the next four years. Curtis served as a Staff Astronomer at the LO until 1920. For two of these years in 1917-1918, he preformed war related duties for a variety of agencies.

In1902, he published a paper on determining the magnitude limits of unaided vision after reviewing historic star atlases and catalogues. At the time, it was generally accepted that the limit was 6th magnitude, although under ideal seeing conditions, skilled observers were reporting up to a magnitude fainter. He concluded that magnitude 7th stars could be seen unaided at Cordoba.

Curtis was placed in charge of the Crossley reflector in 1910 to complete a survey of nebulae begun by Keeler. He perceived that this survey was his most important work with the results being published as: *Publications of the Lick Observatory*, Volume 13, 1918. He contributed significantly to the idea than spiral nebulae were galaxies. He made major mechanical improvements to the Crossley reflector, with his keen abilities with mechanical equipment.

In 1920 Curtis accepted the directorship of the Allegheny Observatory, where he participated on four eclipse expeditions. In the same year he would take part in a lecture series with Harlow Shapley that became known as the "Great Debate," following his firmly held views that all dark nebulae were obscuring nebulae. This line of reasoning followed a still not totally convinced Barnard's line of thought. His claim to have measured motion of the Andromeda Galaxy was hugely erroneous. Curtis is credited wrongly as to having proved the Milky Way is a spiral galaxy using his defective observations. He served as President of the Astronomical Society of the Pacific in 1912, Vice-President of The American Association for the Advancement of Science in 1924, Vice-President of the AAS in1926, National Academy of Sciences, American Philosophical Society, Foreign Associate of the RAS, Foreign Associate of the Astronomische Gesellschaft, and a member of IAU Commission 13 on solar eclipses.

Wright

William H. Wright (1871-1959) studied at the University of California and with his graduate astronomy mentor being A.O. Leuschner during . He then took a Fellows position at the Yerkes Observatory in 1896. There he worked with Hale at his Kenwood Observatory in Chicago and assisted with the completion of the 40 inch refractor at Yerkes (Osterbrock *et al*. 1979: 215-217).

Wright was hired by Holden to fill in for Campbell who would be away, leading the 1898 India eclipse expedition. Keeler then made the job permanent upon his Directorship. Wright applied his engineering talents by making a number of significant improvements to fix instrument problems. He led the LO southern expedition to establish a permanent station in Chile. In Chile, Wright obtained 900 spectrograms for 250 stars, returning to the Observatory in 1906.

Wright measured the spectrograms from the southern station and took spectra of novae. He followed Keeler's footsteps in the study of gaseous nebulae by spectral analysis by pushing into the ultraviolet and infrared bandwidths. His measurements led future astronomers to a better understanding of the ionization process and its affect on nebular gas that occurs in the vicinity of the novae's central star.

Wright's photographic planetary work, in the years 1924-1926, on Mars, Jupiter, Saturn, and Venus set new standards for this segment of astrophotography since the start of the dry plate era (Aitken 1928: 158).

After the solar eclipse expeditions had ended, Wright was appointed Director, a position he would hold until 30 June 1942. Wright agreed to the idea that future Astronomers hired by the LO should be astrophysicists. This led to the replacement of the observer class of astronomers with a new generation of astrophysicists.

Moore

Joseph H. Moore (1878-1949). Moore was a graduate student of astronomy under Simon Newcomb at the John Hopkins University in 1897. He was highly fortunate to receive his spectroscopic training under H. Rowland and later R.W. Wood. He received his Ph.D. in 1903.

Moore was the only staff member of the LO with an earned Ph.D., but it started the trend in when nearly all new astronomers came with the higher degree.

Moore took an active role in 5 eclipse expeditions. Moore and Campbell conducted emission line studies from spectrograms they obtained at the 1918 eclipse in Goldendale. Moore participated in the highly successful eclipse expedition of 1922 at Wallal, Australia and helped Campbell with the measuring of the Einstein test plates. Moore found that the LO plates suffered from instrumental defects and that their measurements were precise enough to base a positive conclusion. Moore became a Senior Staff Astronomer, assisted by Menzel and C.D. Shane, and was placed in charge of the 1930 eclipse expedition to Camptonville (Osterbrock *et al*., 1979).

Moore headed took charge of the radial-velocity program after Campbell became President of the University of California. Moore verified the findings of Adams of the displacement of spectral lines in the close companion star of Sirius (Aitken 1928: 244). The findings were considered another astronomical test of Einstein's General Theory of Relativity. Moore became Director of the Lick Observatory at age 63 in 1942.

Lewis

Exum Percival Lewis (1863-1926), was a graduate student in physics at the John Hopkins University in 1891 studying under the influence of renowned Professor Rowland. He learned and researched in the field of spectroscopy receiving his Ph.D. in 1895. For the next three years he was employed by the University of California as an instructor and associate professor of physics. He accepted the Whiting Fellowship at the Physical Institute of the University of Berlin, where he spent the next two years in spectroscopic research. In 1902, he returned to the University of California, taking the position of Associate Professor of Physics, and then as a full Professor in 1908. He was known for his inspiration and teaching ability, as he imparted the intricate field of spectroscopy to his graduate students (Moore 1927: 83-87).

Lewis became highly proficient in ultra-violet spectral studies of the solar corona for which he was highly acclaimed. He joined the LO eclipse expeditions of 1908, 1918, 1923. His UV solar studies would extend to the flash spectrum of the Sun's reversing layer.

He was known for his popular lectures and is praised for his ability to bring difficult scientific topics to an understandable level for the general public. In doing this, he was able to advance science by imparting the importance of the results of scientific investigations. According to J.H. Moore (1927), his principal works for the general public included "*The University and the Physical Sciences*," "*Ethical Value of Science*," "*The Contributions of Astronomy to Civilization*," "*The Evolution, Death and Resurrection of the Stars*," and "*The Spectroscope, Key to Celestial and Atomic Mysteries*." Lewis was active in the American Physical Society, an editor of the *Physical Review*, and President of the APS in 1923.

Trumpler

Robert J. Trumpler (1886-1956). Trumpler immigrated to the United States in 1915 and came to the LO as a Martin Kellogg Fellow in 1919. Trumpler's specialty was the study of star clusters, having developed his abilities in this area of while working at the Allegheny Observatory. He began with the precise determinations of the proper motions of cluster stars in the Pleiades and learned to weed out background and foreground stars that were not members of the Pleiades cluster. At the Lick Observatory, he applied photographic photometry and obtain spectra of the stars of a number of clusters. His work involved using his data on cluster stars to calculate the distances of a hundred clusters by 1930. As a result of problems with his findings, he proved the existence of uniform light absorbing, interstellar matter in our local galaxy and that this matter is highly concentrated in the galactic plane (Osterbrock *et al*. 203-205). Trumpler assisted Campbell design the four precision cameras for use at the 1922 Wallal eclipse to verify Eddington's 1919 positive results for Einstein's General Theory of Relativity. Trumpler would then make the highly precise measurements of the displacement of the test stars (ibid.; Aitken 1928: 243-244). By 1938, Trumpler had taken teaching position at UC Berkeley.

Menzel

Donald H. Menzel (1901-1976) spent his early years in the state of Colorado, moving to Denver, where he graduated from high school in 1917. He majored in chemistry at the University of Denver, Colorado . He discovered his interest in astronomy while viewing the solar eclipse of 1918. Menzel began observing with a 6 inch refractor being encouraged by Professor H.A. Howe. He went on to receive a M.A. in math and astronomy in June 1921. Menzel's mentor was H.N. Russell, a highly regarded and accomplished Princeton astrophysicist whom he studied under in the Ph.D. program at Princeton. Part of his thesis work, completed for the Ph.D. in 1924, was performed under a Proctor fellowship at Harvard under H. Shapley's guidance, but still under the controlling hand of Russell. As it turned out, Russell and Shapley were antagonistic towards each other. Russell ingrained in Menzel the foundations of theoretical astrophysics. Under Shapley's guidance, he became assistant professor of astronomy at Ohio State University. Shapley and Russell were not impressed with Menzel's theoretical abilities, but found him to be an adequate teacher of beginning astronomy (Osterbrock 2002: 96-98). Menzel was hired, with the recommendation of Russell who could not think of anyone else, at the LO in 1926 at a time there were only around four hundred and fifty professional astronomers in America. Fortunately, the astronomers at Lick did mostly research and little teaching. Menzel's acceptance was based on his willingness to be part of the radial-velocity team, although this line of work did not interest him in the least. Lacking personnel to work on the eclipse expedition's results, Aitken gave Menzel the task, which was eagerly accepted. Menzel conducted a comprehensive study of the solar chromosphere using the eclipse plates made with Campbell's moving-plate spectrographs and large scale photographic plates taken at the 1898 to 1908 eclipses (DeVorkin 2002: 119-127; Osterbrock 2002: 100-102; Pasachoff *et al*. 1988: 170-172).

Menzel resigned in 1932 to take a faculty position at the Harvard College Observatory. He joined the Lick 1932 eclipse expedition to continue his chromospheric field research. He observed at more than a dozen solar eclipses, utilized the coronagraph, and established two solar observatories.

9.4 APPENDIX 4 Eclipse Telegraph Codes – 1901 Eclipse (SA, 1901 Eclipse Folder)

Cage = some doubt as to double-image camera [illegible]

Health = Perrine and Curtiss are in good health.

A few days later when plates are developed and ined, cable again as follows:-

One = one strange body on Vulcan plates.

Two = two " bodies " " "

Three = three " " " " "

Four = four " " " " "

More = more than four " " " "

Hoods = Coronal hoods around the prominences, as in India.

Absorption = dark lines in spectrum of corona, (and not across the moon), with radial slit.

Lines = dark lines in spectrum of corona with slit tangential.

Polarize = strong evidences of polarization with double image camera.

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Success = Entire program carried out, so far as ~~you~~ I can tell before developing plates.

Streamers = Corona has very prominent equatorial streamers, as in 1889, 1898, and 1900.

Circular = Corona has no prominent streamers, as in 1893.

Middle = Corona has form intermediate between those of 1893 and 1900.

Light = Sky illumination was pretty strong, as in Georgia.

Twilight = Sky fairly dark, considerably darker than Georgia.

Dark = Sky very dark, difficult to read newspaper outdoors without lamp.

And = some doubt as to 40-foot results

Also = " " " " Vulcan "

Attain = " " " " Floyd "

Band = " " " " Radial slit spectroscope results.

Hong Kong, I shall favor your stopping over one or two steame in Japan, if you so desire. On these points later letters wi instruct you.

All necessary expenses of the expedition will be paid by the Wm.H.Crocker Funds. If a deficit is unavoidable, in order to make success complete, I shall endeavor to reimburse you officially, if possible; personally, if necessary.

As soon as the eclipse is over, send a cable message, unsigned, to Astronomer, San Francisco, using the following code:

Clear = sky in sun's vicinity free from clouds and reasonably free from haze.

Medium = sky in sun's vicinity free from clouds but very hazy.

Mixed = some clouds, seriously interfering, bu probably some useful results.

Formation = sky clear before eclipse, but " eclips clouds " obscured sun.

Cloudy. = sky in region of sun wholly obscured by clouds.

[illegible]

9.5 Appendix 5 The Lick Observatory Graduate School of Astronomy and the Fellowship Programs

The Lick Observatory was established as a research department of the University of California. In the first decade of its operation, the LO became a training ground for future astronomers. In 1888 the first fellowships were temporary in nature, with A.O. Leuschner being one of the beneficiaries. The Hearst Fellowship, financed by P.A. Hearst, lasted one year, at which time Holden spent the remaining funds on the 1893 eclipse expedition.

Although Holden (1892e) initiated the idea of a graduate school of astronomy on Mt. Hamilton, it was Keeler in 1898 who arranged for the University of California to budget three fellowships by leaving Schaeberle's position vacant. This formed a permanent fellowship program under the auspices of Keeler and Leuschner. He also created a cooperative arrangement with the Astronomy Department at UC of Berkeley in support of Ph.D. degrees in astronomy. Lick fellows spent the summer and full semesters at Mt. Hamilton to observe and then spend winter and spring at Berkeley to take graduate courses (Moore, 1938: 202; Lankford 1997: 546). It was intended from the very start that the positions would lead to the Ph.D. Leuschner was the first graduate of the program. The next three graduates under Leuschner's guidance were F.E. Ross, R.T. Crawford and H.K. Palmer, all of whom received their Ph.D.s at a later time, after having left the program. Meyer was hired to teach in 1920 and Shane in 1924, both of them having come from Berkeley with Ph.D.s (ibid.; Campbell 1900i).

Candidates were required to spend sufficient hours in graduate work at Berkeley to meet the course requirements set forth by the Department. Residence was to be assigned by the Director of the Observatory upon consideration of the student's needs and after following consultation with the Department heads at Berkeley. Residency at the Observatory was required for at least one term for each year of graduate work at Berkeley with time assigned by the Director of the LO upon consideration of the student's course work and input by other Department heads (ibid.; Campbell 1900j; Holden 1892e).

Preference was given in accepting a Fellow who was a Ph.D. candidate or a 'better' man, which led Campbell (1900k) to comment "In research work, one first-class man is more valuable than several worthy men."

The Lick Observatory, while closely tied to the astronomy and physics departments at UC Berkeley, retained its individual ranking as a separate department. The staff positions at the

Observatory had no teaching assignments, but did supervise theses of the candidates. The Berkeley Astronomy Department was awarded first place in 1925 as the largest and best in the nation. The graduate school focused on celestial mechanics and orbital theory, with just one professor, Shane teaching true astrophysics. Menzel taught astrophysics part time in 1928 and 1931 while employed at the LO (ibid.).

By 1928, 37 Fellows had successfully graduated (Aitken 1928a: 252-254; Aitken 1928b: 162-163; Osterbrock, *et. al.,* 1979: 124, 181). J. Stebbins, one the three original fellows, was considered by Osterbrock, *et al*. (1979) to have been the best researcher ever produced in the program. H.D. Curtis was considered one of the stellar graduates whose dissertation was supervised by Campbell beginning in 1901 (ibid. 186-187). By the late 1930's, over 60 Ph.D. degrees had been granted. The recipients went on to fill important positions in astronomy at a variety of institutions worldwide.

The coronal photographs from the eclipse expeditions, obtained by Perrine, were used in Young's Ph.D. thesis, which postulated that the proportion of polarized light to unpolarized light in the corona varied with the angular distance from the edge of the Sun, but was independent of the direction from the Sun's center. Polarization is observed stronger in the blue portion of the bandwidth than in the longer wave lengths. Young concluded that 2/3 or more of the coronal light is due to the scattering of the Sun's light by small coronal particles (Campbell, 1912a: 245).

By 1931, the University of California had produced 49 Ph.D.s in astronomy, with Leuschner and Osterbrock, *et al*. (1997) crediting the best of them to have been LO Fellows. Both concurred that the Fellows program was the most 'distinguished' in the nation.

The two year Martin Kellogg Fellowship was established in 1911 to create a learning environment for those with special aptitude and had already proven themselves in professional research (Moore 1938: 202). In 1928, the Alexander F. Morrison Fellowships was initiated.

Frank E. Ross, a Fellows program graduate, influenced the eclipse expeditions in another way. Ross was to become America's finest designer of wide-field lenses for astronomical photography. His four-element design was applied to the Ross-Brashear 4 inch aperture 5 foot focal length lenses used for the direct Einstein-intra-mercurial-coronal photography oon the eclipse expeditions from 1922 to 1932. It was these lenses that replaced the 40 Foot Schaeberle Camera in 1932 (Osterbrock *et. al.* 1979: 224-225).

9.6 Appendix 6 Women and the Lick Observatory and on the Eclipse Expeditions

Elizabeth B. Campbell, traveled with her husband on six consecutive expeditions beginning with the 1898 expedition to Jeur, India. In her unpublished manuscript *In the Shadow of the Moon* (undated) documented that she had left her two babies in the care of others and went to protect her husband from "… fever, cholera, tigers, cobras … plague, pestilence and famine, battle, murder and sudden death …" Her real purpose was to go as secretary, help prepare the extensive food lists, and manage the eclipse camp for six weeks and then episodically continue a world tour with her husband. On later expeditions she would in addition to her regular camp duties, host as the station docent to explain operations to drop-in guests, find housing for overnight guests and keep them away from W.W. Campbell while he was commanding his subordinates.

Despite women's improving positions within the American astronomical community, they were present on the eclipse expeditions to conduct support and volunteer efforts. The first expedition to see women in the field was in 1898, where two women in addition to Mrs. Campbell helped manipulate the instruments at totality. Mrs. Comfort operated a simple camera and Miss Beans assisted with the 'Pierson' Dallmeyer camera. In 1905 at the Spanish station, Mrs. Campbell and Mrs. Perrine helped at the polarigraphs and lens-less photometer. In 1908, Mrs. Campbell again assisted at the polarigraphs. In 1918 Mrs. Campbell and Miss Allen made images with two small coronal cameras. In 1922, Mrs. Adams assisted C.E. Adams in managing the Schaeberle Camera, while Mrs. Campbell was in charge of the Floyd coronal camera. In 1923, a relatively large group of five women were available for assignment to the instruments, but weather prevented observations. By 1932, Miss L.G. Potwin assisted at the jumping film spectrographs, Mrs. K. Campbell operated one of two simple coronal cameras and Mrs. R. Jones helped at the chronograph. Even though several of these women represented other institutions in a professional capacity, there is no record of any of them performing calculations or scientific analysis of the Lick results while on expedition.