UChicago Project Team / February 18, 2021
Kris Palmieri, Rich Kron, Lauren Boegen, and Andrea Twiss-Brooks

Women of Yerkes

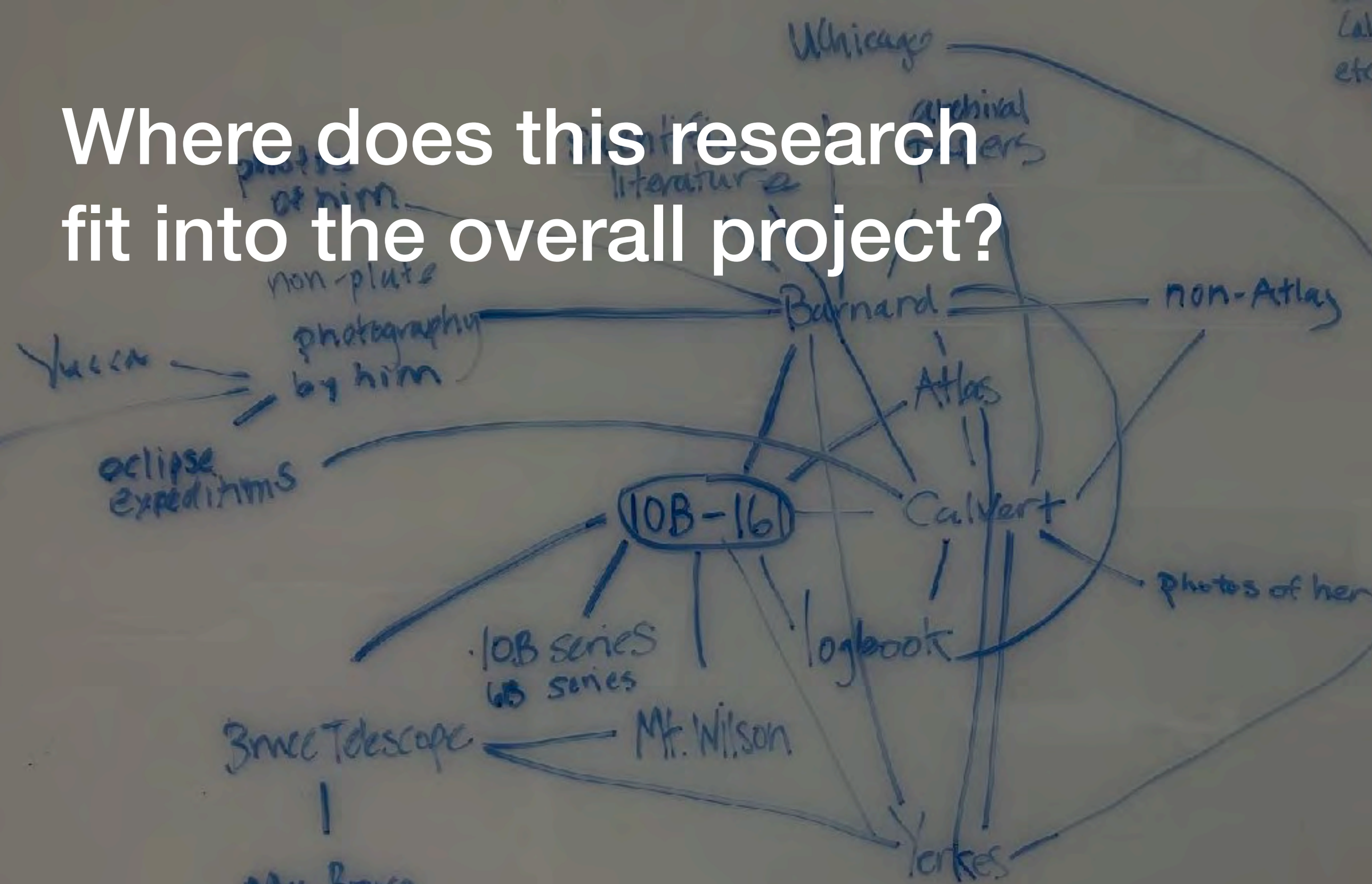
The People Behind the Plates

Yerkes Observatory, 1921.
apf6-00415, University of Chicago Library Photographic Archive.

Our approach

- Understand the astronomy community, including atmosphere and culture
    - Understand Yerkes community as part of a whole (astronomy & UChicago)
- Explore networks and connections between people and across institutions
- Understand motivations, including what was the attraction of Yerkes
- Understand how women were treated as scientific colleagues
- Clarify the “pipeline” of work, including what they did and how they did it

Where does this research fit into the overall project?



What we have

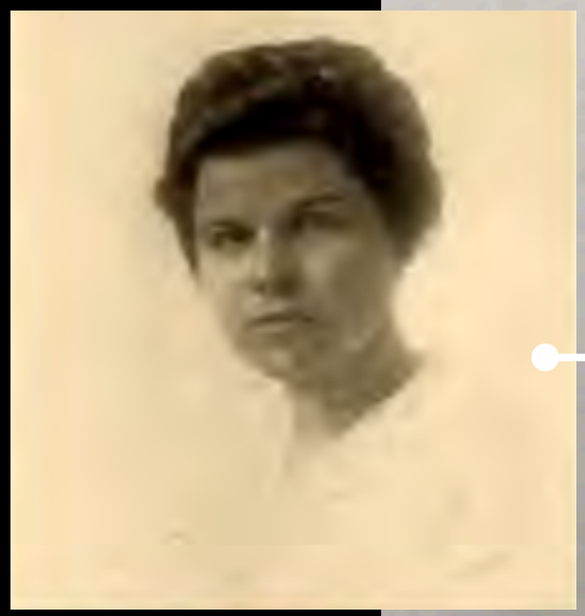
- Glass plates with annotations
- Logbooks
- Notebooks
- Published research papers
- Measuring engines and other artifacts
- Yerkes Digital Photo Archives
- Other archival documents (papers, correspondence, ledgers, etc.)

April 5, 1917

Professor R. D. Salisbury,
Dean of the Graduate School,
The University of Chicago.

Dear Professor Salisbury:

I enclose herewith three recommendations for candidacy for the degree of S.M.:



Alice Hall Farnsworth, B.A., Mt. Holyoke, 1916.

Thesis subject: Photographic and Photo-visual Magnitudes of Stars in the North Polar Sequence.

Vera Marie Gushee, B.A., Smith, 1916.

Thesis subject: A Search for Proper Motions in the Cluster N.G.C. 663.

Evelyn Wornham Wickham, B.A., Vassar, 1916.

Thesis subject: Investigation of Spectrograms made with Different Dispersions for Detection of Systematic Error.

All of these young women desire to come up for their Master's degree during the Summer Quarter. Their theses are well advanced.

Very truly yours,

EBF

3 encs.

Evelyn Wornham Wickham (1895–1988)

B.A. Vassar, 1916

Below: Pictured in 1919

Above: Yerkes Observatory staff, 1916, from left (back row): Helen N. Davis, Max Petersen, Clifford Crump, Frances Allen; (front row): Evelyn W. Wickham, Harriet M. Parsons, Anne S. Young, Alice Hall Farnsworth, and Inez Wendell.

Vera Marie Gushee (1894–1937)

Above: Smith College yearbook photo, 1916

Right: 1916 Yerkes staff photo

Sent Dec. 14 1916

191 Frederick St.,
San Francisco, Calif.,
Dec. 5, 1916.

Mr. E. B. Frost,
Director of Yerkes Observatory,
Williams Bay, Wis.

Dear Sir:

Your letter enclosing Misses Steele's and Wickham's survey cards has just been rec'd. I shall be most appreciative if you will call the matter to the attention of Miss Gushee & Miss Farnsworth. I am sorry to occasion additional trouble but in California, up to this time (report from Mt. Lowe) though fourteen women are employed, none is engaged in photographic phase of astronomy. So it

is a gratifying discovery to find four at Chicago University, and their contributions will add not a little strength to our argument in favor of this field of college women's employment.

Again thanking you, I am

Sincerely yours,
(Miss) Ida M. Manley.

F. Hurter and V.C. Driffield quantified the response of an emulsion to light (1890)

The exposure is plotted on the x-axis - this is the amount of light input to the photographic plate.

The measured density of silver in the image is plotted on the y-axis - this is the output, what the photograph recorded.

Here successive doubling of the exposure does not give a constant increase in the density; that is, the opacity is not proportional to the exposure. The graph of this table is shown in Fig. 6. This curve giving the relation between density and exposure is known as the "characteristic curve" of the plate. It is also called the "H & D" curve after Hurter and Driffield,* who were the first to state the relation between density and exposure. The underexposure part (below log $E = 8.9$) is called the "toe." The overexposure region (above log $E = 1.1$) is sometimes referred to as the "shoulder."

Since, in the correct representation of the light and shade of the subject photographed, the opacity of the negative should be proportional to the quantity of light coming from the subject, it

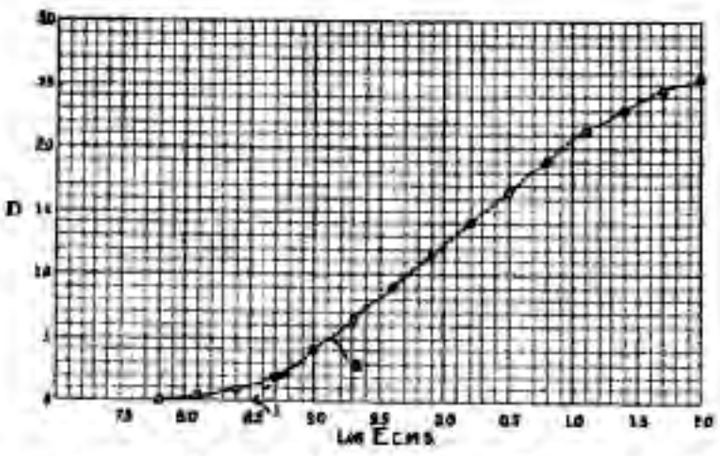


FIG. 6.—*Density-exposure curve showing toe, straightline, and shoulder*

follows that the time of exposure should be such as to give densities on the plate which lie on the straight-line portion of the density-exposure curve. It is found that if the exposure is too short, there is no detail in the shadows, although there may be a slight deposit of silver all over the plate, or if the development has been such that detail does show, the representation of light and dark in the picture does not correspond to the light and dark of the subject.

When the exposure is too long, there is not sufficient difference in density to give detail in the portions of the negative which represent the brightness parts of the subject.

Hurter and Driffield, who were the first to express the relation between the darkening of the negative and the light coming from the subject, in terms of density and exposure, have expressed this fundamental law of photography as follows:

*Journal of the Society of Chem. Ind., May, 1890.

The curve calibrates the response of the plate to light. The curve depends on the kind of emulsion and the development process in the darkroom. Best practice is to measure the curve for each plate separately.

This can be done by exposing a series of patches of light with known ratios of brightness onto the plate with a *sensitometer*.

J.A. Parkhurst 1912 ApJ 36, 169

Out-of-focus photograph of the Pleiades. The star images look like the sensitometer patches and can be compared directly.

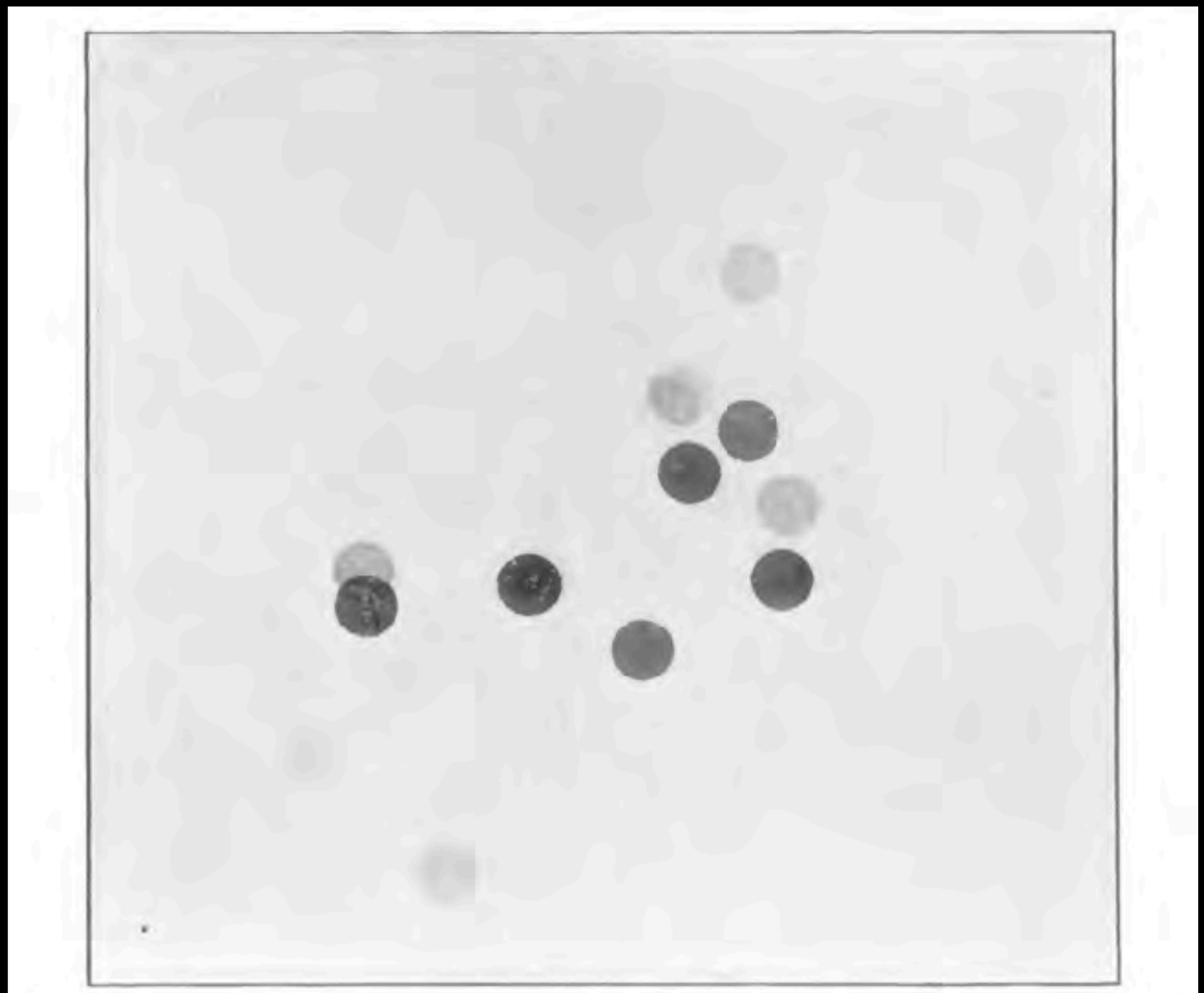


FIG. 2.—Extra-focal images of the *Pleiades* taken with Zeiss camera

Harriet Parsons' Masters dissertation
1918 ApJ 47, 38

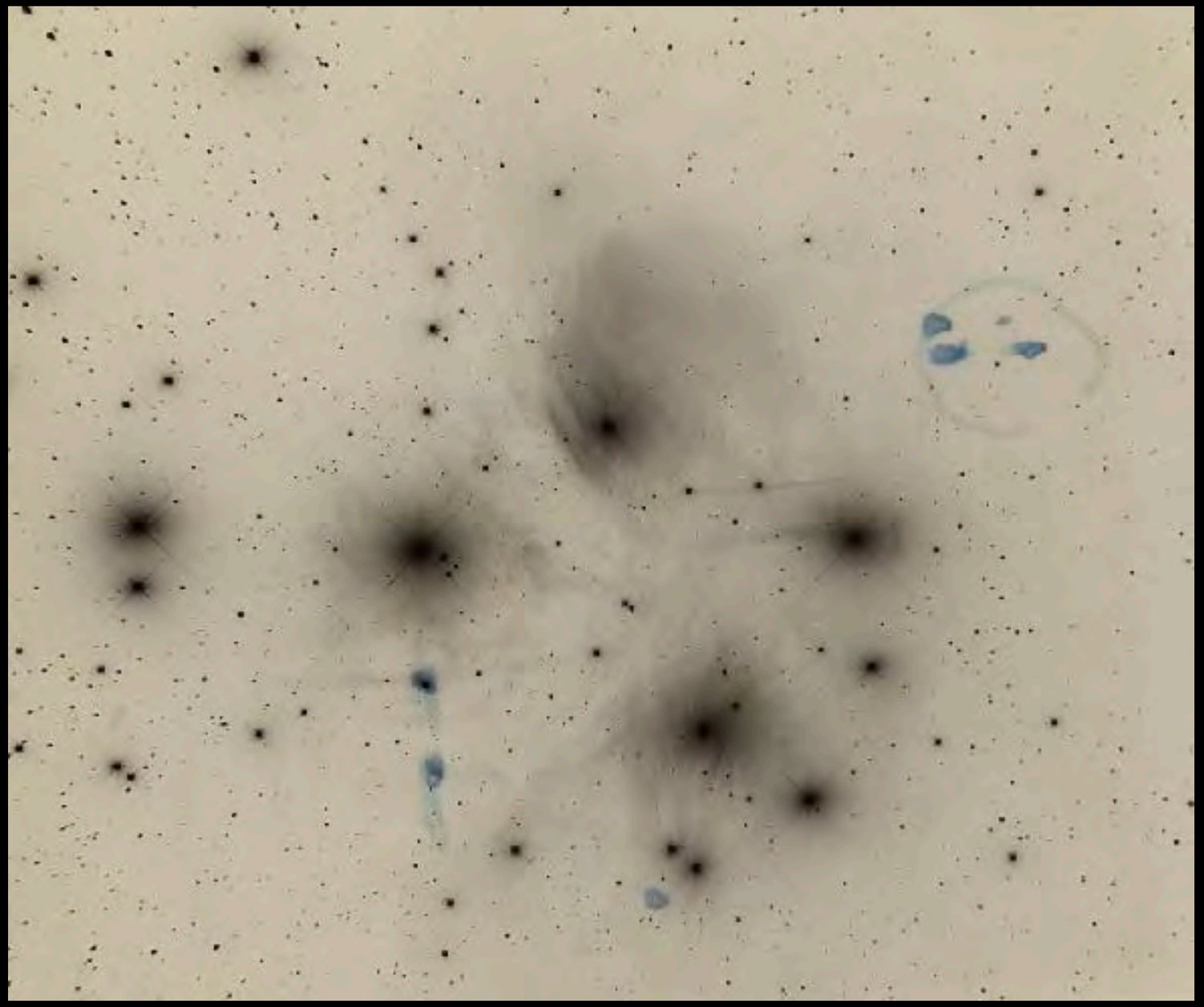
She used filters that would block blue light - the combination of filter and emulsion would replicate the response of the human eye. This way, photo-visual magnitudes could be measured. Faster, better, fainter!

PHOTO-VISUAL MAGNITUDES OF THE STARS IN THE PLEIADES

By HARRIET McWILLIAMS PARSONS

Although many photometric workers have investigated the stars in the Pleiades both visually and photographically, a determination of photo-visual magnitudes seemed advisable. This determination furnishes (1) the data for testing the photo-visual scale by comparing photo-visual with visual magnitudes, and (2) the data for finding directly the color-indices of the stars measured by comparing photo-visual with photographic magnitudes.

Two telescopes:
an ultraviolet-transmitting refractor,
and George Ritchey's reflector.

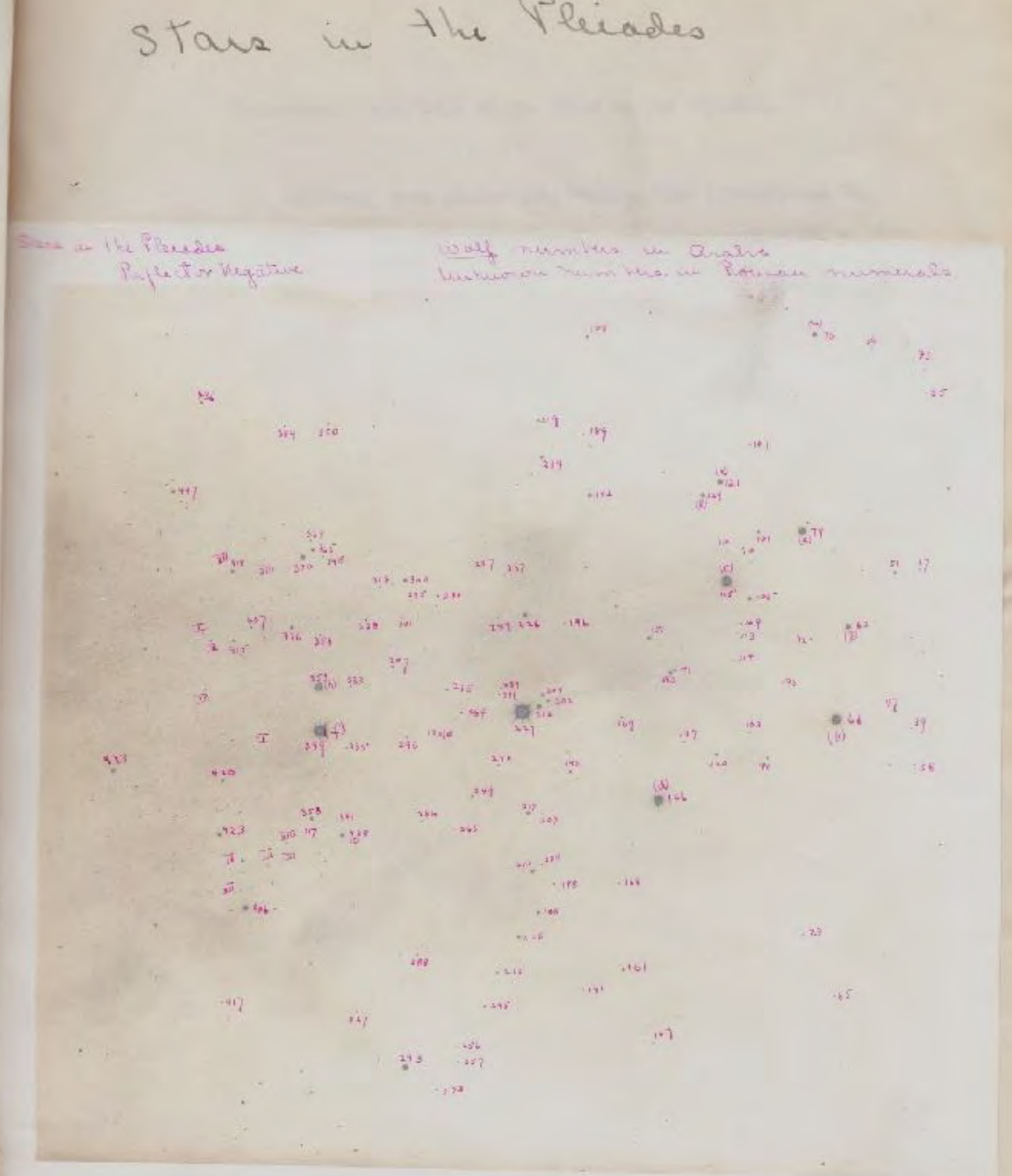


Of the twenty plates used in this determination, fifteen were taken with the Zeiss doublet camera by Professor Parkhurst and the writer, and five with the Yerkes two-foot reflector. The doublet has lenses of "ultra-violet" glass and is of the Petzval type, with aperture of 14.5 cm and focal length of 81.4 cm. This instrument has a two-inch guiding telescope and gives sharp focal images. One of two parallel-wire gratings, known as R8 and R9, is placed over the objective for part of the exposure. In the case of the former the diameter of the wire is equal to the free space. Only two plates

Harriet Parsons

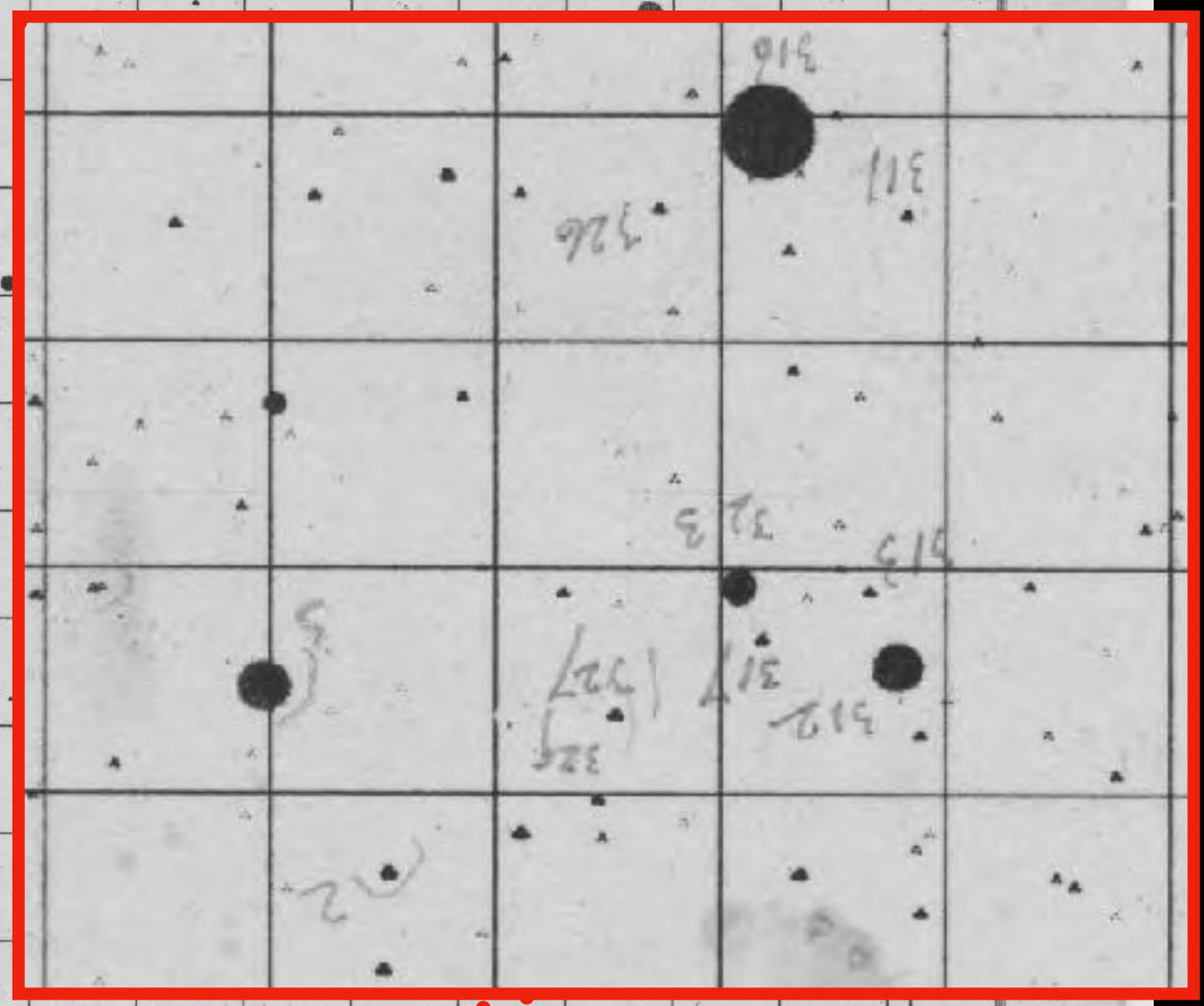
Original MS dissertation copy (Regenstein Library)

Harriet Parsons (B.A. Vasser, 1916), 1919. apf6-04206, University of Chicago Library Photographic Archive.



Copy of the *Carte du Ciel* chart in the direction of the Pleiades

Note the faint pencil annotations - we have not identified the graffitist



This is the photometric comparator used by Alice Farnsworth and Harriet Parsons.

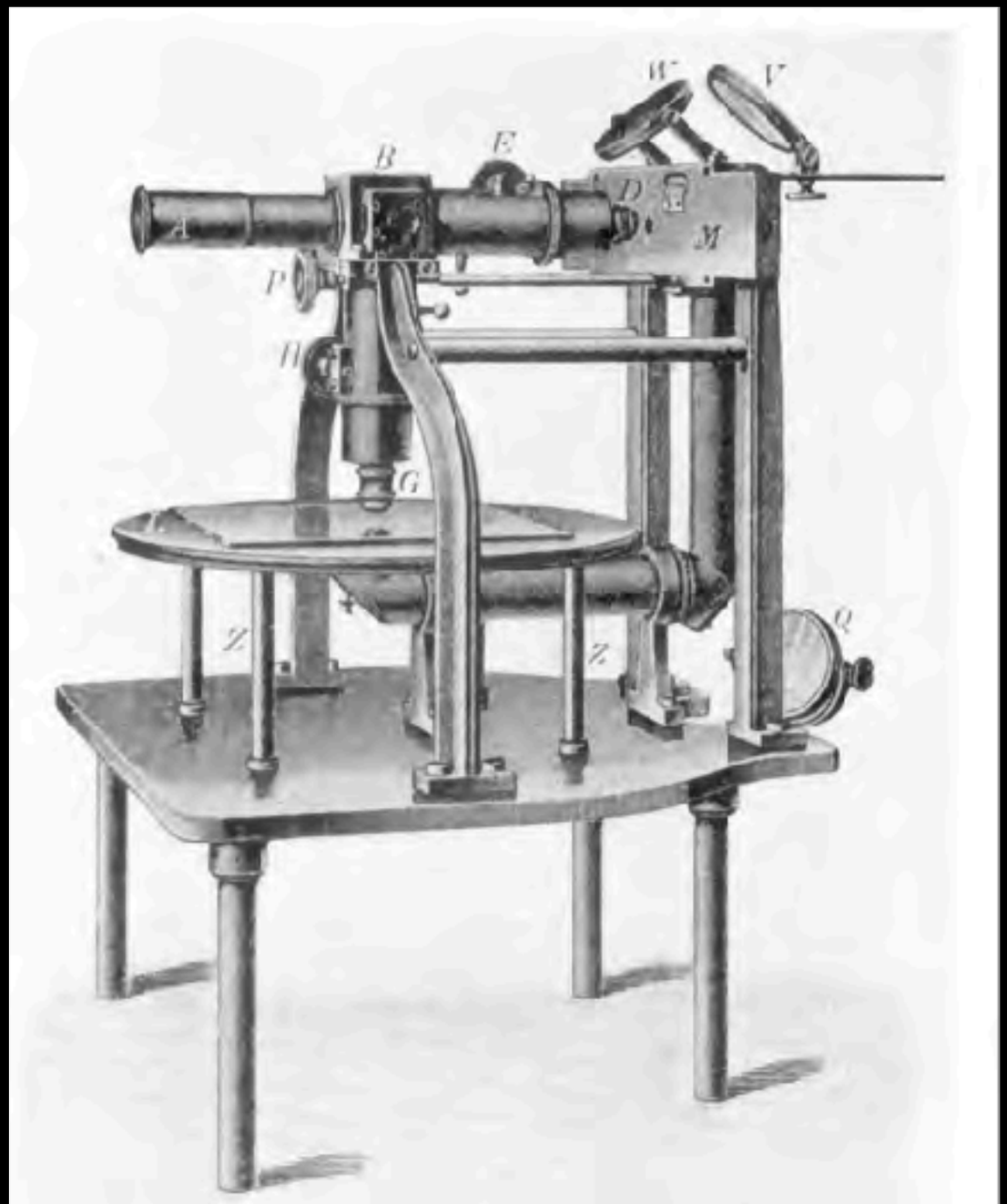


FIG. 3.—Hartmann "Mikrophotometer"

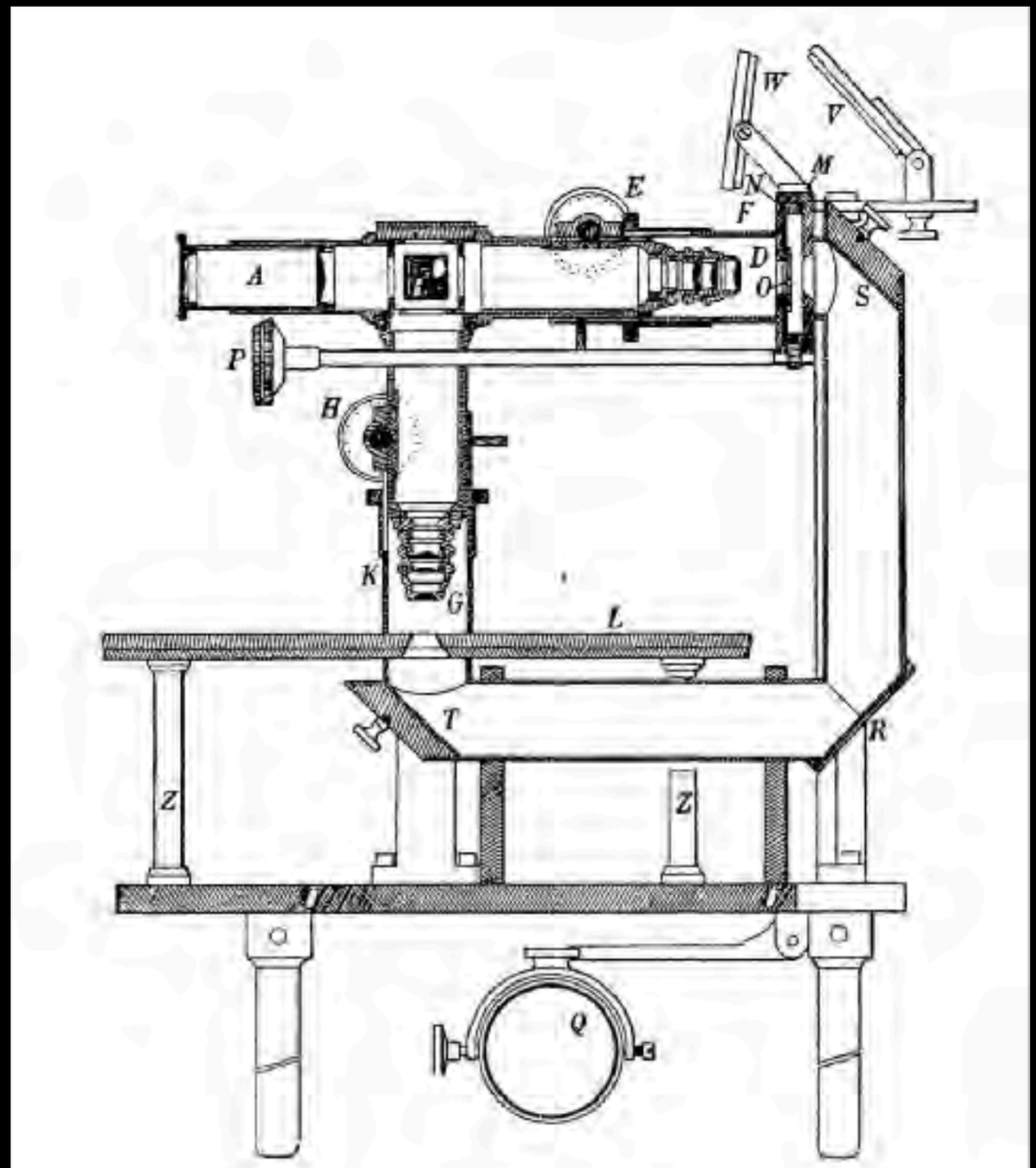


FIG. 2.

The University of Chicago

PUBLICATIONS OF THE YERKES OBSERVATORY

VOLUME IV PART VI

ZONE −45° OF KAPTEYN'S SELECTED AREAS: PHOTOGRAPHIC PHOTOMETRY FOR 1550 STARS

BY

JOHN ADELBERT PARKHURST

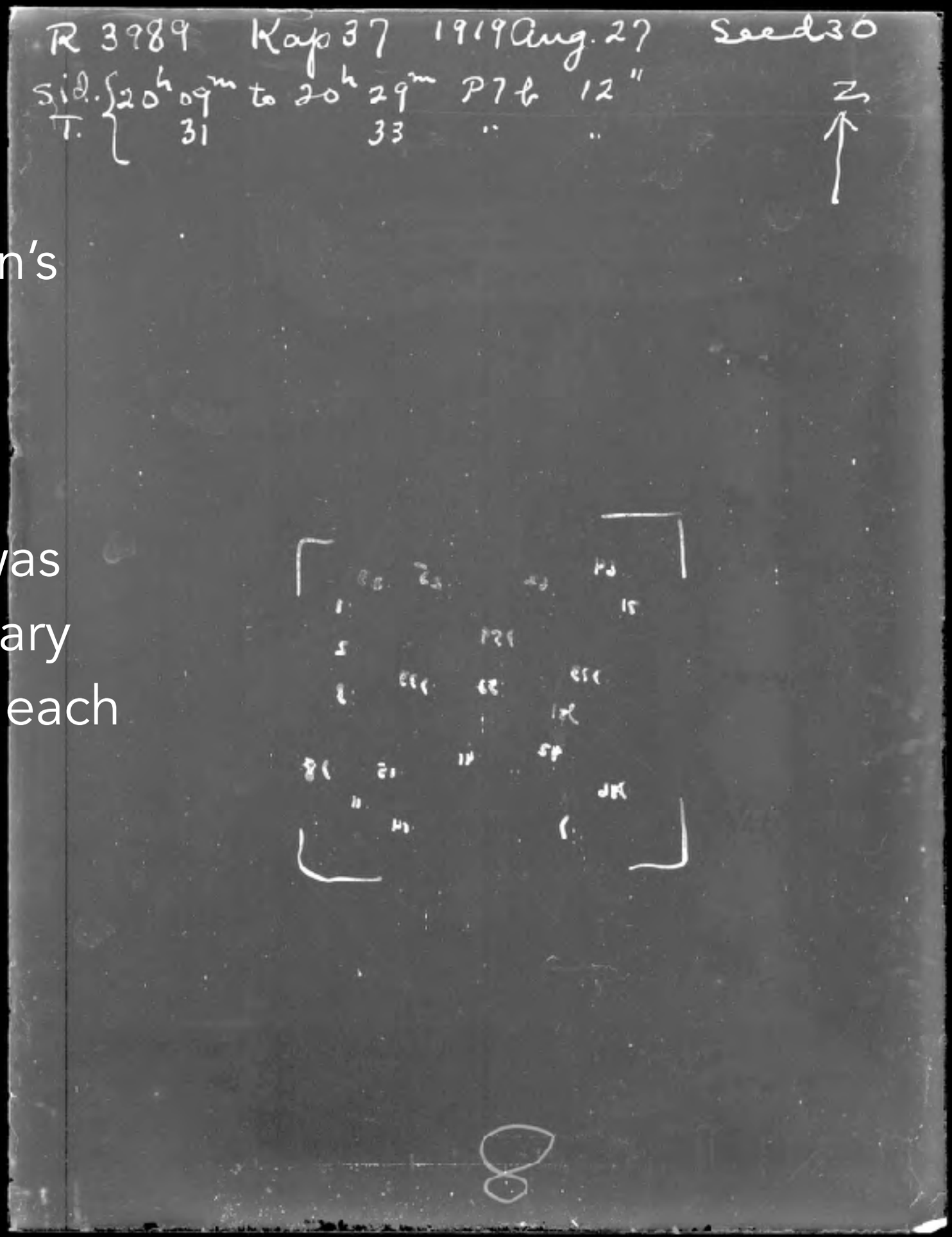
THE PREPARATION FOR PUBLICATION WAS COMPLETED AFTER THE AUTHOR'S DEATH

BY

ALICE HALL FARNSWORTH

Photograph of Kapteyn's Selected Area 37 with Ritchey's reflector.

An *objective grating* was used to create secondary and tertiary images of each star via diffraction.



The secondary and tertiary images are fainter than the primary image by a constant that depends only on the geometry of the grating - the spacing and thickness of the rods.

Steele (Pettit) worked with George van Biesbroeck to measure parallaxes of stars photographically. They needed the highest possible precision in the measuring engine.

Hannah Steele Pettit (M.A. Swarthmore, 1912), n.d.
apf6-04329, University of Chicago Library Photographic Archive.

INVESTIGATION OF A NEW SCREW MEASURING MACHINE AT THE YERKES OBSERVATORY.

By OLIVER J. LEE and HANNAH B. STEELE

This machine is one of several of the same type that have recently been completed by Wm. Gaertner & Co., of Chicago, for astrometric purposes at various observatories in this country. The general design of the machine is due to Dr. FRANK SCHLESINGER, and the details of the design were laid out by the Gaertner Company.

The use of this instrument at the Yerkes Observatory was made possible by a generous grant of six hundred and forty dollars to Professor Frost by the Directors of the Gould Fund of the National Academy of Sciences.

The details of the investigations by the writers will appear shortly in Vol. IV of the *Publications of the Yerkes Observatory*. The present note gives the chief results.

The machine has a screw 18mm. in diameter, with 249 threads of millimeter pitch. Its periodic errors were derived in the usual way, by measuring an interval of 0.20mm. with successive fifths of a revolution of the screw. Two series of measures were made by each of us at three points on the screw, viz. at readings 40, 100 and 160 on the attached scale. The errors therefore are derived from the appropriate means from twelve revolutions of the screw. The average deviation of a complete measure from the mean is 0.00017 millimeter. The errors are represented by the following equation:

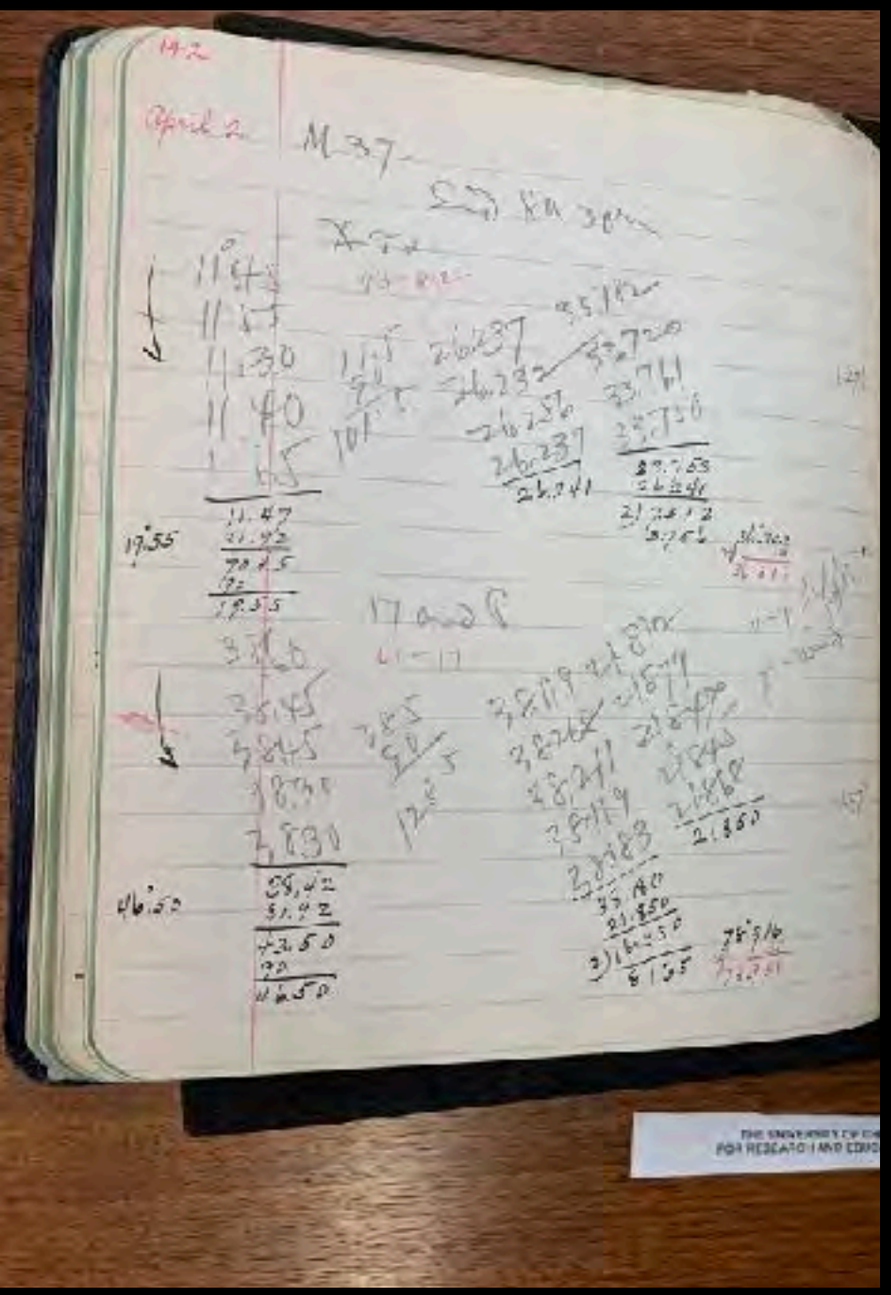
$$f(\theta) = +0.000036\cos\theta - 0.000041\sin\theta - 0.000013\cos 2\theta - 0.000033\sin 2\theta.$$

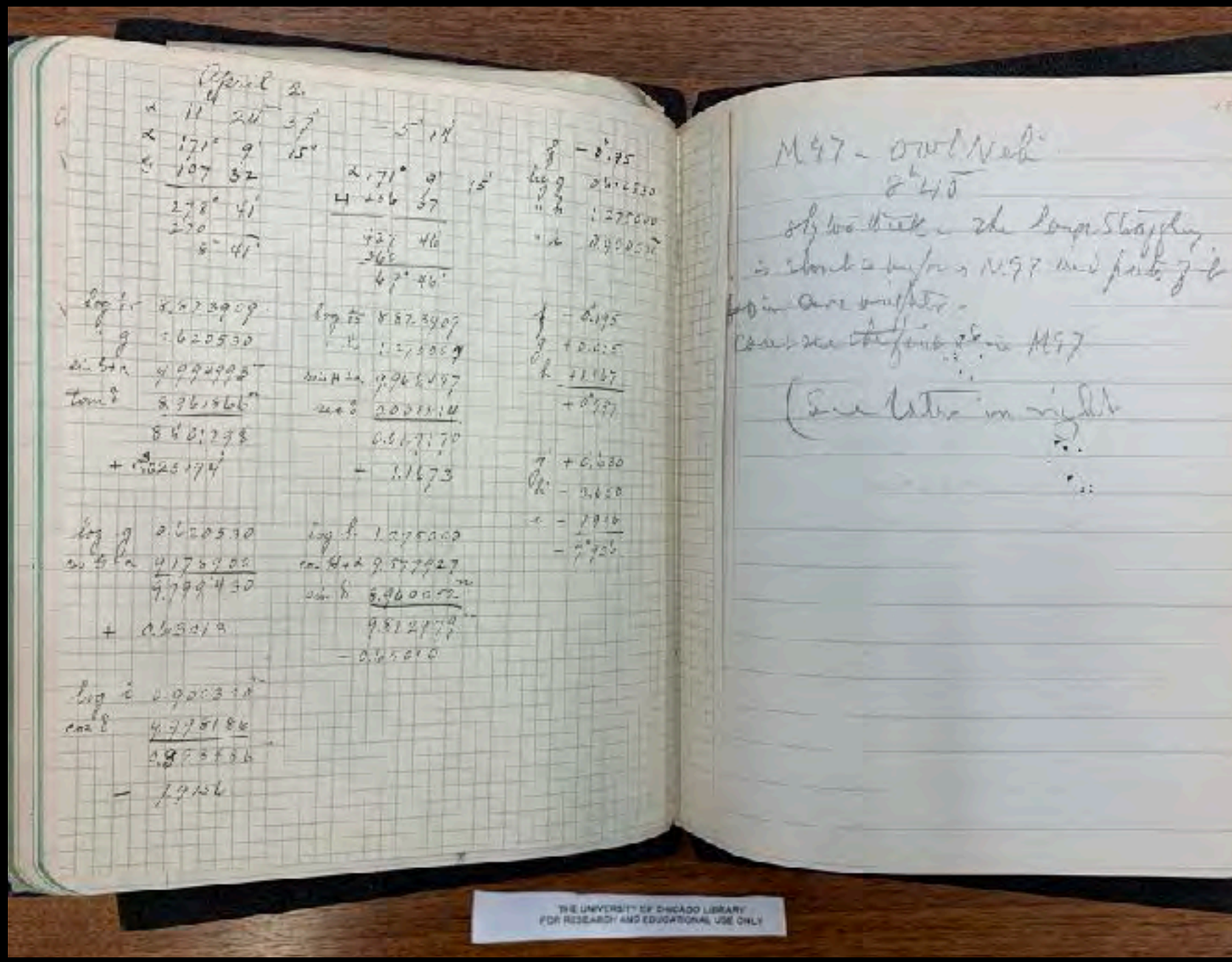
errors. Satisfactory measures were obtained, however, by means of a long glass scale, silvered on the under side, and adjusted so that a beam of light sent into it from a mirror mounted on the microscope showed the ruled diamond rulings of the scale most distinctly. Several accordant series of measures were made with this apparatus in December, 1916, and from the means of them the progressive errors were derived for every centimeter of the screw from readings 5 to 195 on the attached scale. The arrangement of the observations is similar to that described in Vol. V of *Travaux et Memoires du Bureau International des Poids et Mesures*. The resulting symmetrical system of equations was solved in the manner employed by P. A. HANSEN. The range of temperature during the period of measurement was about 1°.3 C. The final means, involving double measures of 190 distances on screw and scale, were used in deriving the errors at 18 points on the screw, the errors at readings 15 and 185 having been assumed to be zero. The values of the corrections for progressive errors are as follows:

Readings	Corrections
5	−0.0004mm
15	.0000
25	+ .0010
35	+ .0007
45	+ .0002
55	+ .0007
65	+ .0012
75	+ .0012

O.J. Lee and Hannah Steele 1917
Astronomical Journal 30, 128.

E.E. Barnard notebook – clearly 2 different people working



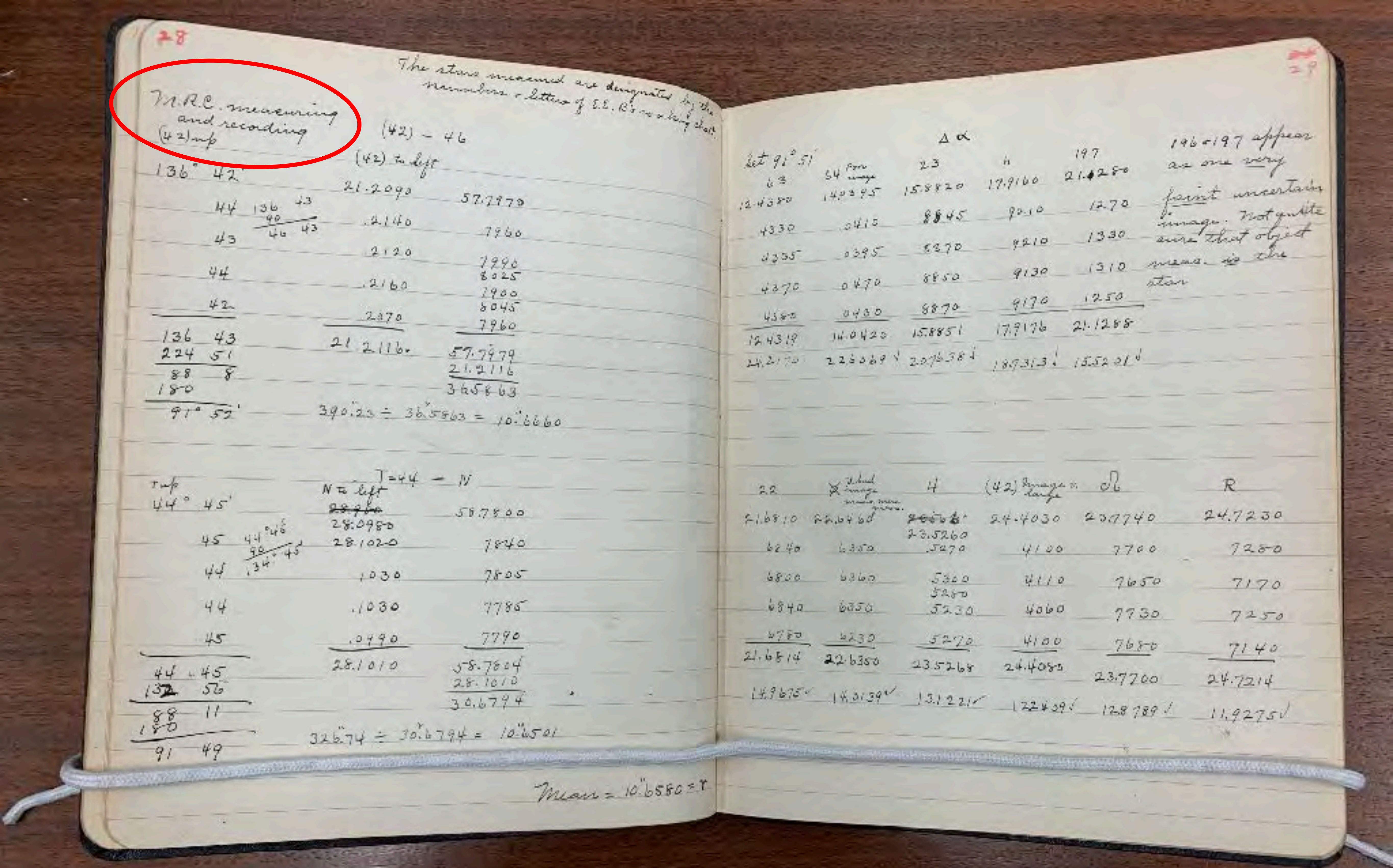


Barnard. Edward Emerson. Papers,[Box 33, Folder 3], Hanna Holborn Gray Special Collections Research Center, University of Chicago Library.

July 6 - Saturday

Experimenting with photographing enlarged images of Mars. Following data copied from E.E.B's records found on small sheets of paper with plates (M.R.C. 1924 Aug. 13)

No. 6,	11h	21m ½	Exp. 15s – 15s	
" 2,	11	25	15 - 20	
" 8,	11	42	40 - 45	Aperture 15 in
" 2,	12	18	30 - 40	Aperture 15 in
" 6,	12	29	15 - 20	Aperture 25 in
" 5,	12	32	15 - 20	" "
" 8,	12	36	20 - 17	
" 7,	12	39	15 - 20	
" 5,	13	6	15 - 20	
" 8,	13	9	15 - 20	
" 2,	13	13	17 - 22	
" 7,	13	16	20 - 25	
" 6,	13	18	16 - 20	
✓ " 1		13 21	15 - 20	



Barnard. Edward Emerson. Papers,[Box 44, Folder 1],
Hanna Holborn Gray Special Collections Research Center,
University of Chicago Library.

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The stars measure
numbers + letter

M.R.C. measuring
and recording
(42) up

(42) – 46

(42) to left

136° 42'

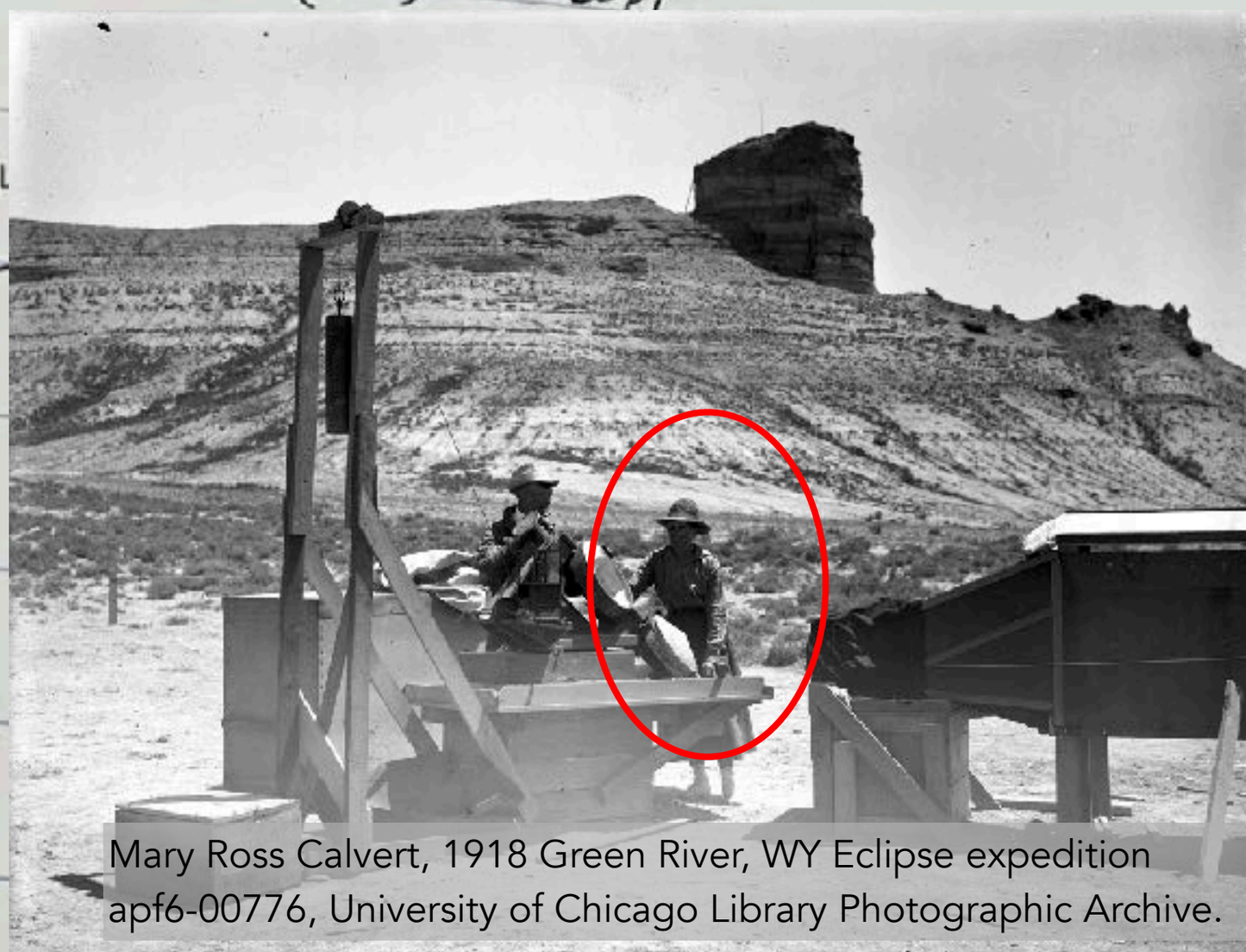
44 136
90
46

43

44

42

136 43
224 51



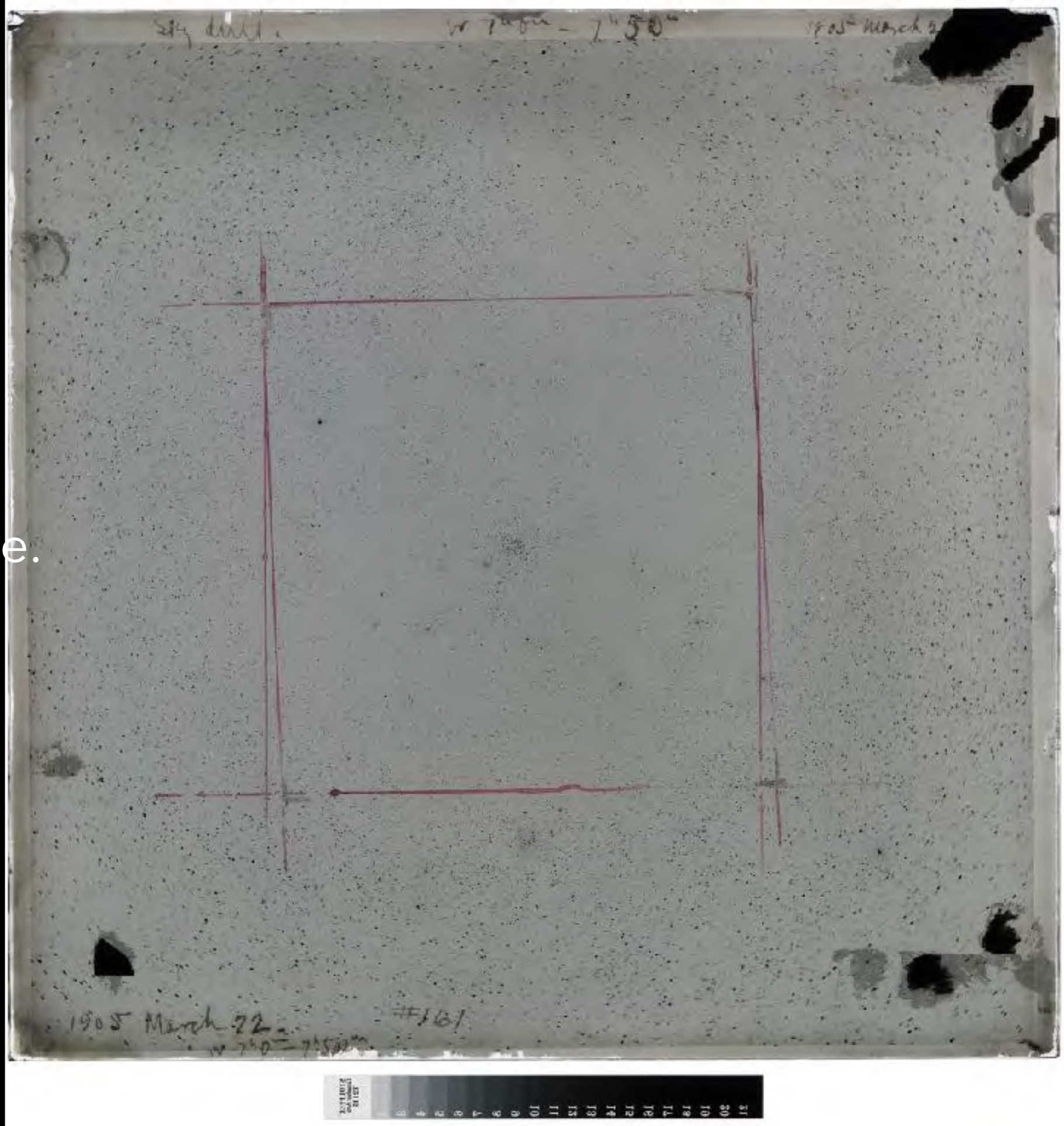
Mary Ross Calvert, 1918 Green River, WY Eclipse expedition
apf6-00776, University of Chicago Library Photographic Archive.

10B-161
22 March 1905
Mount Wilson
E.E. Barnard

M35 is in the center of the plate.

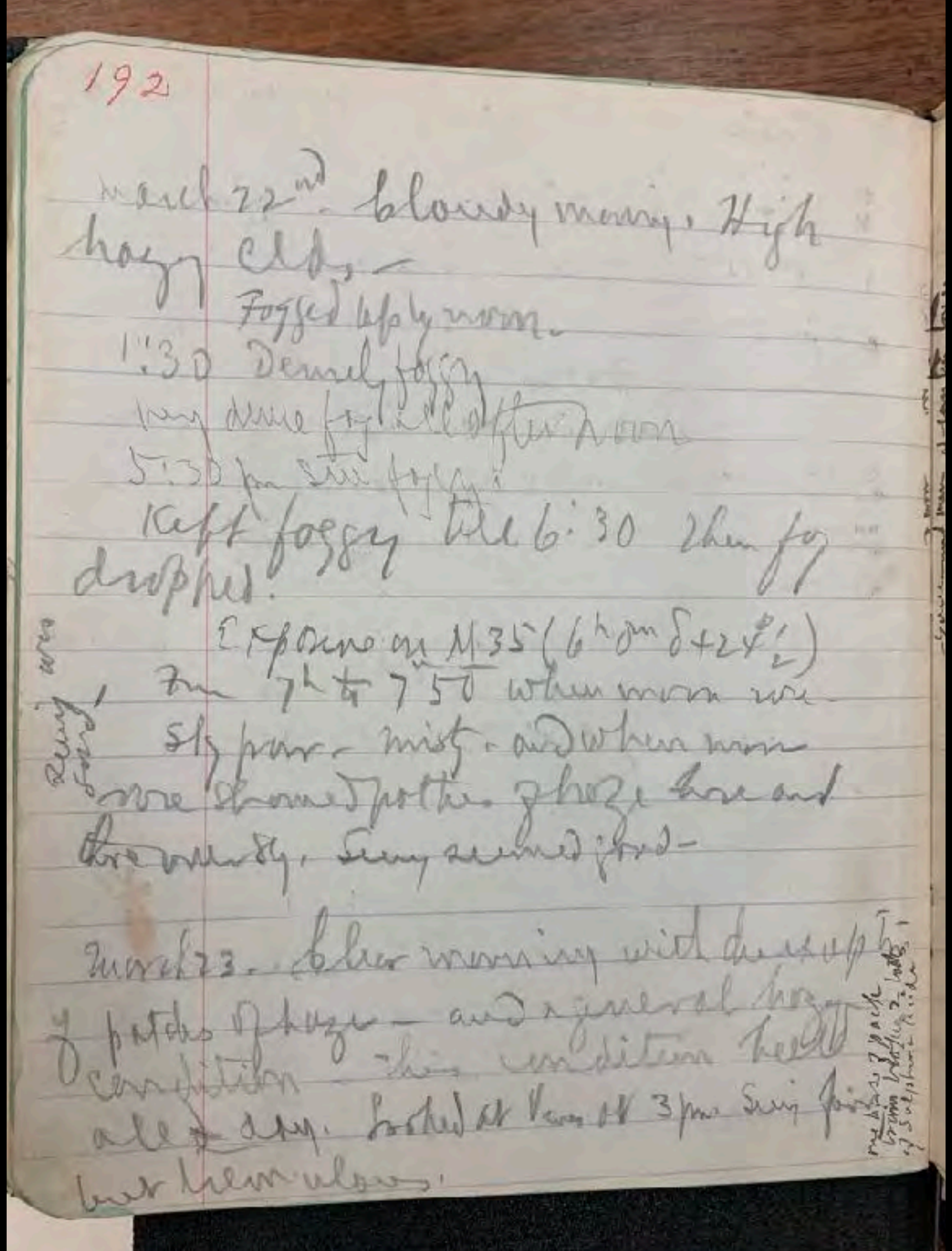
Plate 8 in Barnard Atlas.

Department of Astronomy
and Astrophysics,
University of Chicago.



No.	Date	α	δ	± focus	Dir. of negative	
	1904					
✝135	Nov 11	3h 40m	+ 24°	7h 47m	a b	Pleiades – Trail of Eight
✝ 136	" 15	5 34	− 5½	4 0	a b	Orion Nebula Leonids
	1905					
✝135	Jan. 27	10 1	+ 13	0 15	a	Region of Regulus
✝136	" 28	6 25/45	+ 7.5/+5	2 28	a	Near 15 Monocerotis
✝ 137	" 29	5 30	− 6	2 25	a b	Orion Nebula
✝ 138	" 30				b	negative broken Trails of Hyades [illegible]
✝ 139	Feb. 6	7 30	− 14		a	– missing –
✝ 140	" 7	7 40	− 24		a c	(a) out of focus
✝ 141	" 8	7 40	− 24	2 28	a b c	
✝ 142	" 12	13 27	± c	4 0	a b c	5 Virginis
✝ 143	" 13	15 50	− 28	2 5	a b c	P Scorpii
✝ 144	" 22	4 30	+ 17	0 14	a b	Hyades
✝ 145	" 23	6 0	+ 15	3 55	a b c	
✝ 146	" 24	5 45	± 0	2 45	a b c	Gt. curved nebula in
✝147	" 25	~~5 45~~ 5 45	+ 1 ~~+ 64~~	0 25	a b c	" " "
✝148	" 26	7 4	− 13	1 30	a b c	
✝ 149	Mar. 2	5 50	+ 2	0 30	a b d	Orion
✝ 150	" 3	7 15	− 23	3 45	a b c	Plate 10 (faint)
✝ 151	" 3	16 5	− 19	3 45	a b c d	Nu Scorpii
✝ 152	" 5	16 30	− 10	3 35	a b c d	3 Ophiuchi
✝ 153	" 6	17 5	− 16	3 20	a b d	η Ophiuchi
✝ 154	" 6	5 30	+ 22	3 50	a b c	15 Tauri

	Date 1905	α	δ	± focus	Dir. of negative	
	Mar. 7	5h 30m	1 24°	3h 50m	a b c	5 Tauri
	" 7	16 5	− 19	3 55	a b c d	Nu Scorpii
	" 8	− −	− −	0h 5m 40s	a	New moon
	" 9	8 5	− 35	1h 5m	a b c	S.E. of Orion
	" 9	16 20	− 23	3 2	a b c d	ρ Ophiuchi
	" 13	16 20	− 23	3 15	a b c d	" "
	" 22	6 0	+ 24½	0 50	a b c	M 35 Plate 8
	" 23	7 20	− 29	2 0	a b c d	η Canis Majoris
	" 24	6 30	+ 17	3 20	a b c d	γ Geminorum
	" 25	5 20	+ 28	2 41	a b c d	ε Tauri
	" 27	6 0	+ 32½		c d	Near M 37
	" 27	12 20	+ 27	0 30	a b	
	" 28	11 40	± 15	1 35	p c d	β Leonis
	" 31	5 45	+ 32	1 35	a b c d	M 37 Plate 7
	" 31	16 5	− 19	4 27	a b c d	Nu Scorpii
	Apr. 1	7 5	± c	2 17	a b c d	
	1	16 5	− 19	4 30	a b c d	Nu Scorpii
	2	6 35	+ 10	2 18	a b d	15 Monocerotis
	2	15 50	− 26	4 0	a b c d	π Scorpii
	3	15 50	− 26	4 55	a b c d	" "
	4	6 7	+ 22	2 0	a b c d	Plate 7 Comet trail
	4	16 5	− 19	4 55	a b c d	Nu Scorpii Plate 12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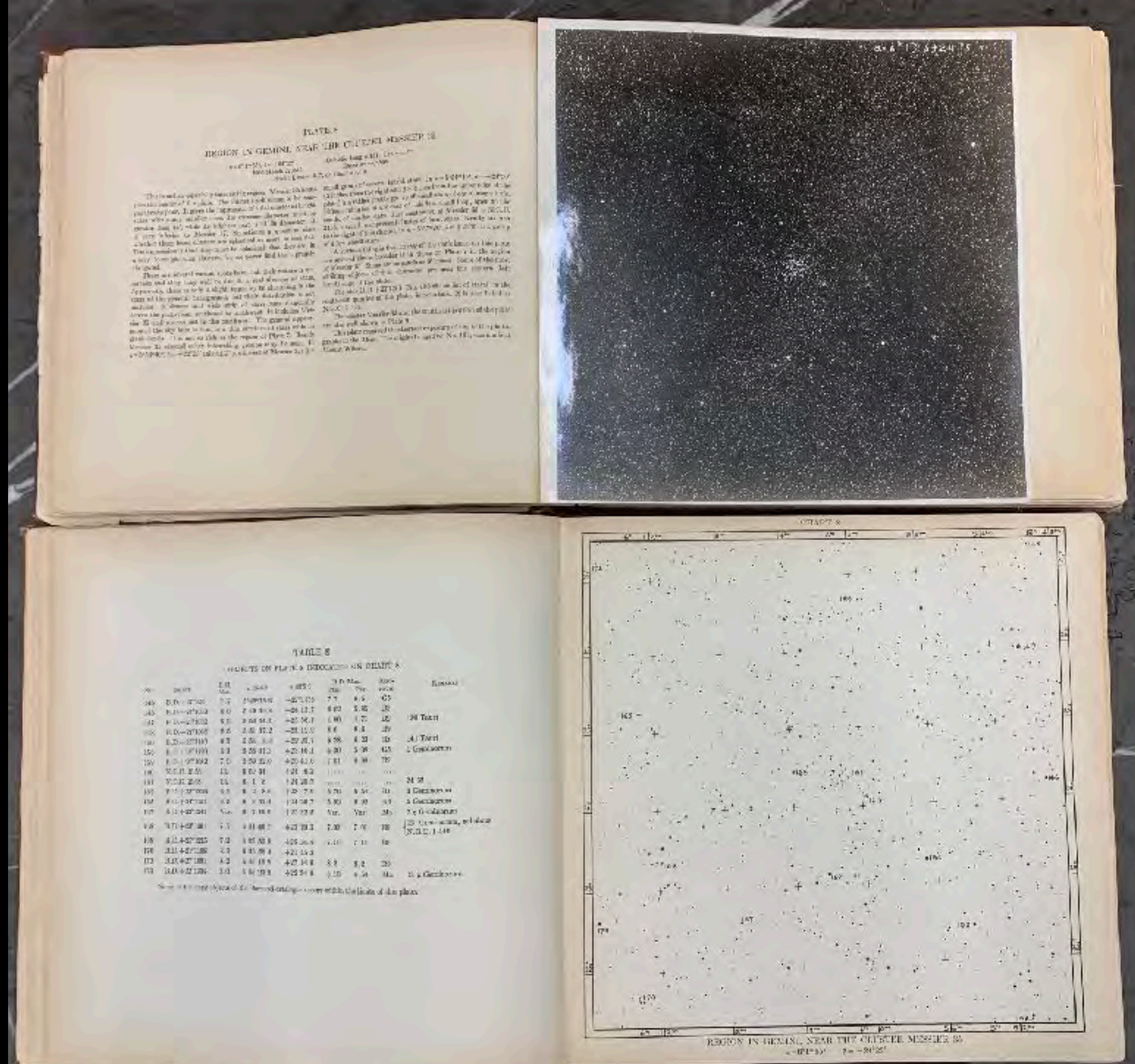
March 22nd Cloudy [illegible].
High hazy clds
Fogged up by noon
1:30 Densely foggy
very dense fog all afternoon
5:30 pm still foggy
Kept foggy till 6:30 then fog dropped
Exposure on M35 (6 h 0 m δ+24 o [1 2 ??]
7 m 7 h to 7 40 when moon rose
sky poor – misty and when moon
rose showed [illegible] of haze - [illegible]
and [illegible]. Seeing seemed good

March 23 Clear morning with the exception of patches of haze – and a general hazy condition. This condition held all day. Looked at Venus at 3 pm. Seeing fair but tremulous.

margin notes: [] has of pack
train [] 2 []
w/ Sulphur []

E.E. Barnard, *Photographic Atlas of Selected Regions of the Milky Way*, Vols. 1 and 2, 1927. Crerar Library.



Big Questions

- Solo female operation of telescopes?
- Unique working environments for women?
- Resources of networks beyond academia?
- “Family albums” in your collections?
- How do we contribute to the larger picture of women in STEM, how do we make the stories of these people more equitably visible?
- AI that can ID handwriting across documents?