

A COMPARISON IMAGE MICROMETER.

C. R. Davidson and L. S. T. Symms.

(Communicated by the Astronomer Royal)

PART I.—*Design*, by C. R. DAVIDSON

The micrometer is designed on the principle that the difference between two nearly equal objects is readily detected whilst the measurement of their actual dimensions is more difficult.

In the observation of double stars the filar micrometer is almost invariably employed. It is true that in a few special cases the interferometer may be used, but in the great mass of double-star measures the filar micrometer has been unchallenged. It has, however, some objections, two of which may be mentioned. The spurious disk of the star image is frequently, with faint stars, comparable in size to the width of the spider-line with which the bisection is made, consequently a bisection amounts to extinction, and this in the case of close and difficult pairs may introduce systematic error. Secondly, owing to variations of atmospheric refraction, the star image in the telescope is rarely steady; it is constantly dancing about its mean position, the amplitude of its gyrations amounting to 1 to 2 seconds of arc. The observer therefore has to catch the star as he can, and this is not at all easy.

Six years ago Mr. Hargreaves suggested a method by which the measurement of double stars might be improved.* It was in fact to produce in the field of the telescope an artificial double star which could be so varied in distance, position-angle and brightness as to match the real double star in these three respects. When this match has been realised the readings on the artificial mechanism would give a measure of the position-angle and distance of the double star under observation. He made a micrometer on this principle, described in the paper referred to, and measured a number of double stars with it. The measures so produced were greatly superior to those made under similar conditions with the filar micrometer, their internal accordance being remarkable.

That the micrometer might be tried out on a larger telescope it was sent to Greenwich to be applied to the 28-inch refractor. In its form as originally designed there were difficulties in fitting it to the telescope; also there were one or two points which it seemed desirable to modify, so that whilst the principle has been preserved the micrometer as now applied to the 28-inch is somewhat different in construction.

To produce the double star we have used a Wollaston prism. The idea is not new, as it was proposed by the Rev. W. Pearson more than a hundred years ago, though in a different manner.†

* *M.N.*, 92, 72, 1931.

† *Memoirs of the Astronomical Society of London*, 1820 March.

A Wollaston prism is a rectangular parallelepiped made of two right-angled prisms of Iceland spar of the same refracting angle, but one is cut so that the refracting edge is perpendicular to the optical axis and the other so that the refracting edge is parallel to it. They are cemented together so as to make a parallelepiped, the optical axis of each prism being perpendicular to the direction of the incident light.

Thus in a normal cross-section of the united prisms the section ABD of one contains the axis, its direction being parallel to the face AB , whilst the section BCD of the other is perpendicular to the axis.

A ray incident normally on the face AB travels along the normal in the crystal as an ordinary ray with velocity v_o and also as an extraordinary ray with velocity v_e . On reaching the interface the ordinary ray is refracted extraordinarily, for the planes of the two prisms are at right angles, whilst the extraordinary ray is refracted ordinarily. The two emerging rays are therefore equally deviated on opposite sides of the normal. Thus the ray from S on passing through the prism is divided into two rays, one in the

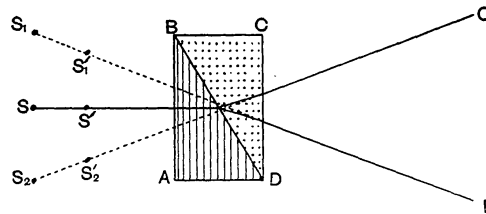


FIG. 1.—*The Wollaston Prism.*

(*The angles are exaggerated.*)

direction O , the other in the direction E , and the point S viewed through the prism will be seen as two points, S_1S_2 , of equal brightness.

Now it will be noticed that if the prism is moved towards S (or S towards the prism) the separation S_1S_2 will diminish in exact proportion to the distance of S from the prism, becoming zero when S falls on the interface. As S passes to the other side of the interface the images cross and again separate.

Also if the Wollaston is rotated the double images rotate about their common centre.

If a Nicol prism be placed in the path of the rays with its polarising plane at right angles to the plane of $ABCD$ only one of the polarised rays will be permitted to pass and one image only will be seen. If the Nicol is turned through 90 degrees the other ray will pass and the second image will be seen. In intermediate positions both images are visible, their relative brightness depending on the position of the Nicol. If the first Nicol is crossed by a second the total brightness of the images may be controlled by rotating the Nicols relatively to each other.

Here then is the principle on which an artificial double star has been produced—a double star which may be varied in distance, position-angle and magnitude, both total and relative.

To produce the point of light S an image of the filament of a 3-watt

electric lamp is projected on a small pinhole. An image of the illuminated pinhole is formed by a second lens, and this is the point from which the artificial double star emerges.

The arrangement is shown in fig. 2, which is self-explanatory.

That part of the optical system producing the primary image S is held in a tube which by means of a rack-and-pinion may be moved backward or forward longitudinally. Its position, read on a millimetre scale showing the position of S relatively to the Wollaston, furnishes the measure of distance.

The Wollaston and crossed Nicols are carried on a rotating circle, giving the position-angle.

The micrometer is bracketed to the eye end of the telescope so that it may be easily manipulated by the observer at the eyepiece. The beam

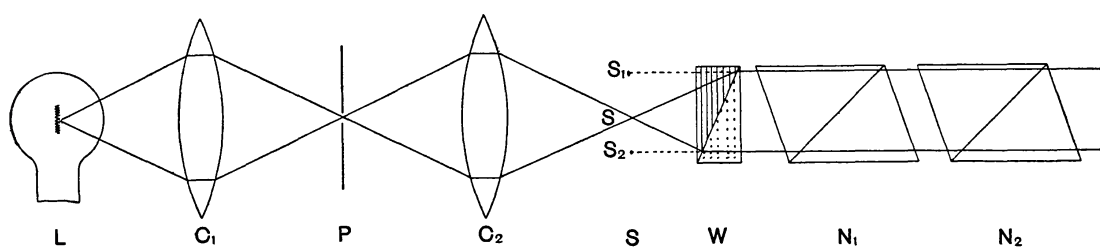


FIG. 2.—Schematic Diagram of the Comparison Image Micrometer.

An image of the electric lamp L is formed on the pinhole P . An image of the pinhole is formed at S . The beam then passes through the Wollaston prism W and the crossed Nicols N_1N_2 . The image S is seen as two, S_1S_2 , whose separation will vary as the distance from S to W varies.

from the micrometer is directed up the outside of the telescope tube on to a plane reflector 14 feet away. Sent back it falls on a diagonal prism which directs it into the telescope tube near the eyepiece. It now falls on a small object-glass of $11\frac{1}{4}$ -inch focus and *via* a quarter-silvered cube the image of the artificial star is formed in the field of the telescope. The images so formed are minute points of light comparable with the nuclear images of the 28-inch at its best.

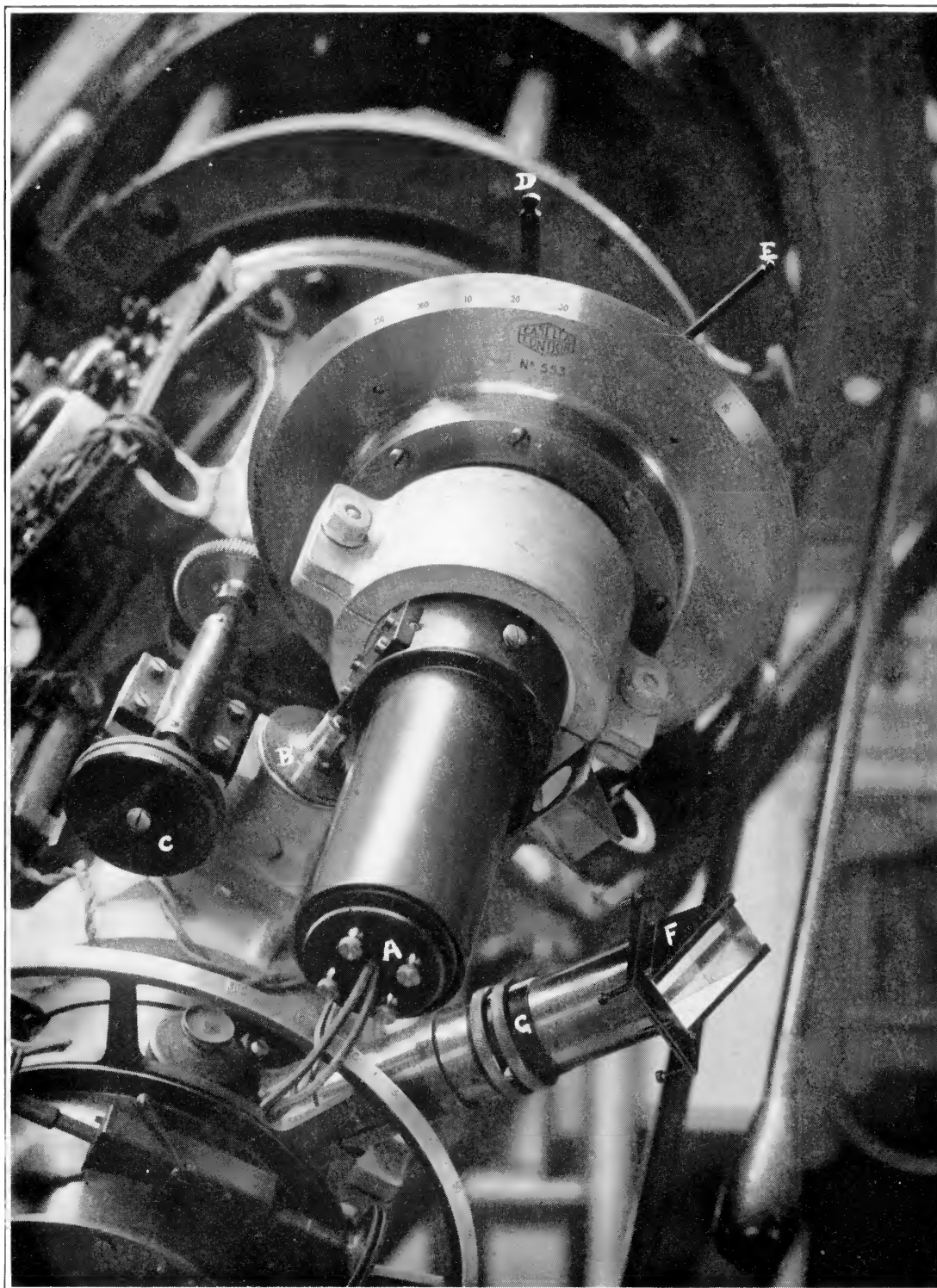
The deviation of the beams O and E (fig. 1) is a constant depending on the refracting angles of the component prisms. In the prism employed the divergence of the two beams is about 6 degrees, consequently a longitudinal movement of the Wollaston of 10 mm. causes a separation of the images S_1S_2 of about 1 mm. Viewed at a distance of 28 feet with an object-glass of $11\frac{1}{4}$ -inch focus the separation becomes $\cdot 033$ mm., which in the field of the 28-inch = $\cdot 8$ approx.,

or, 1 mm. on the scale = $\cdot 08$.

The actual value determined with the filar micrometer is

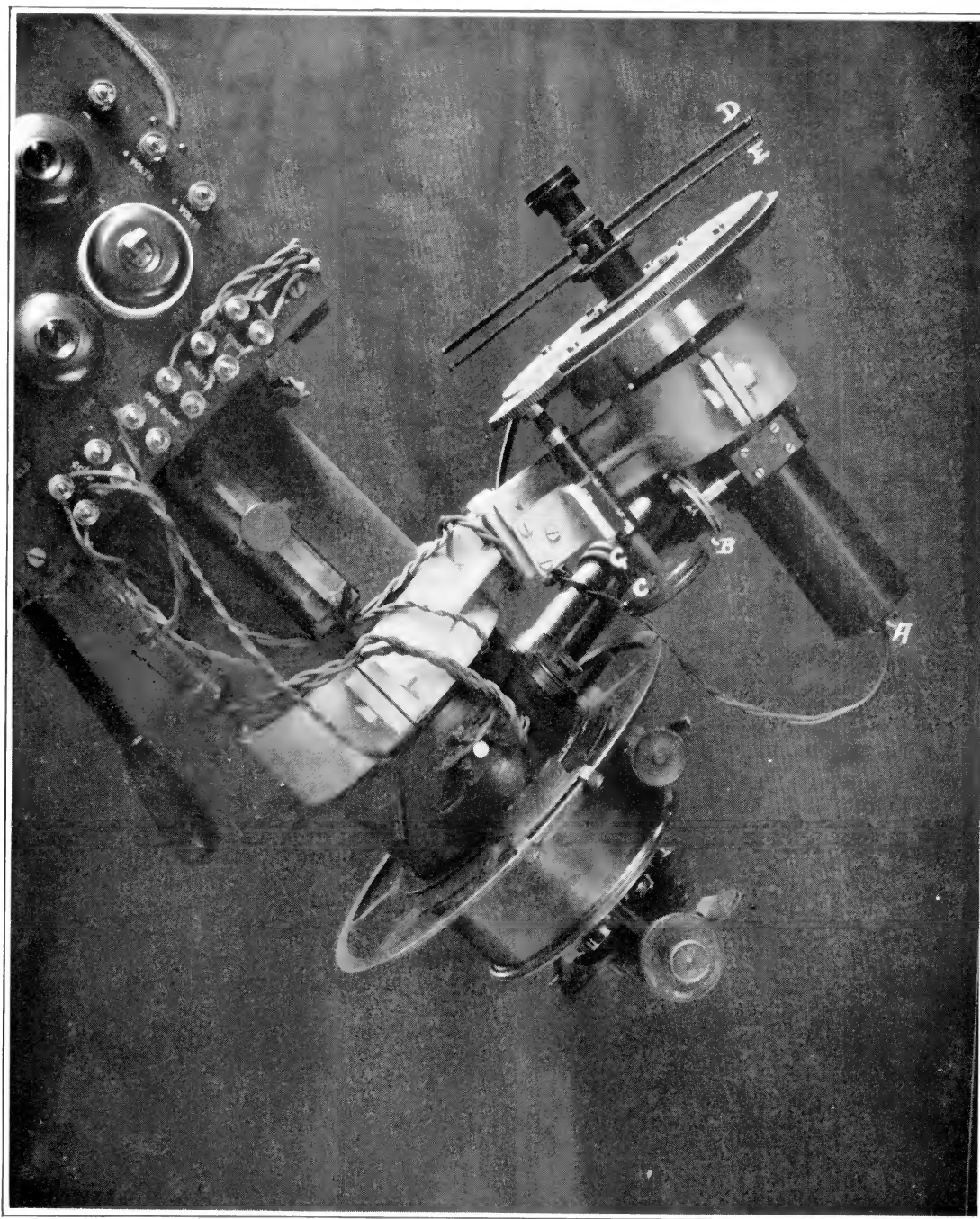
$$1 \text{ mm.} = \cdot 0804.$$

It should not be overlooked that the image points produced by the Wollaston are really short spectra, whose angular dispersion between $\lambda 4861$



Comparison Image Micrometer mounted on 28-inch Telescope.

C. R. Davidson and L. S. T. Symms, A Comparison Image Micrometer.



- A. Lamp.
- B. Pinion to rack controlling separation of images.
- C. Pinion rotating Wollaston prism and position-circle.
- D, E. Controls of crossed Nicols.
- F. Diagonal directing beam into 28-inch telescope.
- G. Focussing rings of O.G. forming images in focal plane of 28-inch.

C. R. Davidson and L. S. T. Symms, A Comparison Image Micrometer.

and $\lambda 6563$ is about 4 per cent. of the angular deviation, or of the separation of the images. The eye, however, is sensitive chiefly to those wave-lengths in the neighbourhood of $\lambda 5500$, and so long as the effective wave-length of the artificial star is not altered the scale remains unchanged. Actually with such separations as we are concerned with, the image is a point without trace of colour. The light source is a tungsten filament burning at a temperature of 2800° K. The colour temperature of a star image in the 28-inch may be taken as 5500° K. It was necessary therefore to introduce a blue filter to make the colours similar. In the result the artificial star, except that it is always steady and well-defined, is exactly similar to the real star.

PART II.—*Results of Observations*, by L. S. T. SYMMS

Method of Observation.—The real star image is brought near to the artificial star and a rough adjustment made for separation and position-angle. Then by manipulation of the crossed Nicols an exact match is made of the total and relative brightness of the components of the double. The images are next placed so that the four points are in a line and the final adjustment made for position-angle. The match for separation of the components is made with the images side by side, *i.e.* with the four points forming a rectangle or parallelogram. If the components are of unequal brightness it is found that the observation for position-angle cannot be made with certainty with the images side by side.

The comparison image is then rotated through 180° and the two components interchanged by moving the separation adjustment until they pass through each other. The matching of position-angle and separation is then repeated in the new position. This gives two measures of angle differing by 180° and one measure of separation corresponding to the double-distance method with the filar micrometer.

For a complete observation of a double star this process is repeated a second time and sometimes, if the measure appears difficult, a third time.

Results.—The micrometer has been in use since September 23 and we have gained enough material and experience of its performance to give the following report.

Wide and Close Pairs.—Dealing first with both wide and close pairs, the inconvenience of the continual movement of the image as a whole due to wind or variable refraction is greatly reduced, as was expected. The observation can be carried out without the exasperating waits for the image to cease from bouncing long enough to enable the wires to be placed on to it.

Much fainter stars can be measured as there is no need for either bright-field or bright-wire illumination. More is gained on this score than is lost by the inevitable loss of light by reflection and absorption at the quarter-silvered cube. The fact that the image is not covered by the wires in making the observation also allows of fainter stars being observed.

The diffraction disks of the artificial and real star images are so alike

that on a night of good seeing, but for the continual oscillation of the real star's images, they appear identical. In fact the images are so similar that it is impossible for the estimated separation to be seriously in error without the discrepancy being obvious. The great similarity of the images leaves no room for any personality in the observation of separation.

Wide Pairs.—On wide pairs (> 1 second separation), apart from the advantages just mentioned, there is not a great deal to choose between the new method of observing and the filar micrometer method. While the results obtained with the comparison image micrometer in the measurement of separation are much more self-consistent the probable errors in the position-angle measures appear to be of the same order by both methods.

There is an important difference, however, where the filar micrometer scores over the comparison image micrometer. On a night of very bad definition, when the diffraction disks are never visible, the components of a wide pair may be so far apart that the two disks of diffusion are quite separate. When this is the case the artificial star can never be made to match the real star and the observer in attempting to match the distance between two small points of light with that between two diffused patches is liable to measure the separation too small. With the filar micrometer a reliable distance observation is still possible under these circumstances, as the two diffused images can be bisected with wires almost as accurately as the smaller diffraction disks.

Close Pairs.—It is on the close pairs (< 1 second separation) where the great advantages of the new method are most apparent, and we have obtained some remarkable results.

The seeing at Greenwich is such that on most nights the images are large diffused disks with the diffraction disk appearing as a nucleus in glimpses of very short duration. On a close pair these disks of diffusion overlap, so that the double star appears as an elongated patch with glimpses, of about half-a-second duration, of two nuclei. These glimpses are more frequent the better the seeing. With average seeing they may appear at intervals of about ten seconds or so.

Under these conditions it is impossible to measure the pair with the filar micrometer. Each time the observer attempts to place the wires on the nuclei they disappear. With the comparison image micrometer, however, it has been found that these glimpses of the nuclei are of quite long enough duration to observe whether the real and artificial images match. If an adjustment is necessary it is made and the next glimpse shows whether the match is satisfactory.

As the nuclei flash out the strong resemblance between the artificial and real images is such as to give the observer confidence that an error of 10 per cent. in the estimated separation would be obvious.

The increase in the number of observations of close pairs which this condition makes possible is indicated already by comparison of measures obtained in the past year with the filar micrometer with those obtained since the comparison image has been in use. During the whole of last year only 19 measures of separation less than half a second were obtained,

whereas 16 have been made between October 8 and December 15. These were obtained on 9 nights and there was never an occasion when the filar micrometer could have been used on these close stars.

The Measures.—The results obtained on 20 pairs are given, together with measures made recently by Baize, Simonow, van Biesbroeck and Greenwich with the filar micrometer.

It will be noticed that for pairs with separation greater than a second the comparison image micrometer is in agreement with the filar micrometer measures, but for the closer pairs there are systematic differences in the observed separations. When there is a comparison with Baize or with Greenwich filar micrometer measures the new micrometer in some cases gives a smaller separation, but in every case where there is a comparison with van Biesbroeck's results or with the ephemeris of a very recently published orbit they agree extremely closely. Baize uses a 12-inch telescope and evidently experiences difficulty in measuring these close pairs, for he states that for stars with separation less than $0''.7$ he replaces the usual bisection of the stars by an estimation of their separation made by placing the wires so that their distance apart appears equal to that of the stars. This is in effect what we are doing with the comparison image micrometer, except for the important difference that the scale which we place beside the real pair is a replica of it. We feel that if two wires are placed beside the pair in an effort to measure the separation in this way there is a danger that the *space between the wires* will be made equal to the star's separation instead of the distance between the centres of the wires. This would account for this systematic difference.

Van Biesbroeck, on the other hand, is using a 40-inch telescope of long focal length, and an inspection of his measures indicates that he can measure stars as close as $0''.15$ with comparative ease, in which case the pairs considered here should be quite easy objects.

In view of the extraordinary resemblance between the real and artificial star images on these close pairs we feel that the measures of separation cannot possibly be much in error, and in this case the results from last year's observations at Greenwich with the filar micrometer are too large on these stars.

The claim of great accuracy made by Mr. Hargreaves for the method seems fully justified. The filar micrometer is still available, and our future observing policy will probably be to measure the very wide pairs with it, using the comparison image micrometer for the closer pairs and for stars whose faintness causes difficulty with the older method of observing. An interferometer with which it is proposed to measure some of the very close pairs is nearing completion, and with the three observing methods simultaneously available the 28-inch telescope should prove a powerful instrument for double-star work.

[TABLE

Comparison Image Micrometer Measures			Filar Micrometer Measures			
ADS 746. OΣ 20. 5.9-7.0. Ao.						
			1931.69	281.2 ^o	0.48 ["]	Simonow
			31.93	287.4	0.63	„
			32.05	288.5	0.38	„
			34.81	284.7	—	„
			1932.62	285.5	0.50	„
1937.79	276.5 ^o	0.48 ["]	1933.02	283.7	0.76	Baize
37.84	279.5	0.48	33.91	285.4	0.59	„
37.88	274.2	0.49	34.11	286.5	0.49	„
37.90	275.4	0.51	34.12	282.3	0.59	„
			35.05	282.4	0.45	„
1937.85	276.4	0.49	1934.04	284.1	0.58	„
			1937.03	286.0	0.54	Gr. O. (RW)
			From orbit by Zagar (1926) :—			
			1932.0	284.8 ^o	0.42 ["]	
			34.0	279.5	0.35	
			36.0	272.5	0.26	
			38.0	255.7	—	

The pair is not closing in as rapidly as foreseen by Zagar and periastron passage will probably occur later than 1939.

Comparison Image Micrometer Measures			Filar Micrometer Measures			
ADS 755. Σ 73. (36 Andromedæ.) 6.2-6.8. Ko.						
			1931.69	$^{\circ}$ 86.7	" 0.56	Simonow
			31.75	83.9	0.75	"
			31.76	83.5	0.85	"
			31.85	85.0	0.53	"
			31.91	86.1	0.50	"
			31.93	91.2	0.71	"
			1931.82	86.1	0.65	"
1937.79	$^{\circ}$ 108.5	" 0.55	1933.08	92.8	0.66	3 n Baize
37.84	111.8	0.51	34.12	97.3	0.60	4 "
37.86	108.3	0.53	35.05	99.8	0.57	5 "
37.88	104.7	0.51	1936.86	102.8	0.75	Gr. O. (LS)
37.90	109.8	0.55	36.98	105.3	0.68	" (LS)
1937.85	108.6	0.53	37.00	108.1	0.71	" (RW)
			37.04	105.6	0.71	" (LS)
			1936.97	105.4	0.71	"
			From Berman's orbit (1926) :—			
			1931.0	$^{\circ}$ 88.4	" 0.52	
			33.0	101.7	0.43	
			35.0	123.0	0.32	
			37.0	169.4	0.20	

An approximate extrapolation of the results given in Aitken's catalogue gives the separation at the mean date of Simonow's, Baize's and the comparison image micrometer observations as $0''.63$, $0''.60$ and $0''.54$ respectively. The discordance, therefore, is merely apparent and can be accounted for by the orbital motion between the dates. The Greenwich filar micrometer results appear to be too large. Evidently the pair is not closing in as rapidly as indicated by Berman's orbit.

Comparison Image Micrometer Measures			Filar Micrometer Measures			
ADS 955. β 303. 7.1-7.3 Fo.						
			1933.91	288.7 ^o	0.74 ["]	Baize
			34.06	289.3	0.64	,,
			34.12	285.9	0.66	,,
1937.79	287.0 ^o	0.58 ["]	1934.03	288.0	0.68	,,
37.84	290.9	0.56				
37.86	288.4	0.59	1936.84	287.6	0.68	Gr. O. (RW)
37.88	285.5	0.63	36.92	289.5	(0.84)	,, (RW)
37.90	285.1	0.59	36.98	287.2	0.66	,, (LS)
			37.00	287.9	(0.78)	,, (RW)
1937.85	287.4	0.59	37.03	286.1	0.65	,, (RW)
			1936.95	287.7	0.66	,,

ADS 1005. Hu 803. 8.5-9.5. —.

			1928.76	181.8 ^o	0.59 ["]	van Biesbroeck
1937.79	181.0 ^o	0.61 ["]	28.83	181.7	0.54	,,
37.90	184.8	0.55	29.85	179.9	0.65	,,
37.90	183.0	0.60	32.75	183.9	0.53	,,
			32.85	183.5	0.58	,,
1937.86	182.9	0.59				
			1930.61	182.2	0.58	,,

This pair is opening out very slowly. The agreement between the comparison image micrometer and van Biesbroeck is perfect.

ADS 1473. Ho 311. 7.0-7.2. A₅.

1937.79	190.5 ^o	0.45 ["]				
37.90	188.2	0.45	1936.98	190.9 ^o	0.64 ["]	Gr. O. (LS)
1937.85	189.4	0.45				

ADS 1579. Σ 194. 8.0-8.3. A₃.

			1933.91	273.7 ^o	1.28 ["]	Baize
			34.04	274.1	1.30	,,
			34.06	272.9	1.13	,,
1937.79	273.6 ^o	1.22 ["]	1934.00	273.6	1.24	,,
37.88	273.2	1.21				
37.90	271.7	1.15	1936.86	271.5	1.16	Gr. O. (LS)
			36.89	272.4	1.25	,, (RW)
1937.86	272.8	1.19	36.96	273.9	1.28	,, (N)
			36.97	271.7	1.35	,, (N)
			37.00	273.5	1.22	,, (RW)
			1936.94	272.6	1.25	,,

Comparison Image Micrometer Measures			Filar Micrometer Measures			
ADS 1630. $\text{O}\Sigma 38$. (γ^2 Andromedæ.) 5.0-6.2. A0.						
			1931.72	105.4°	$0.47''$	4n Simonow
			32.78	105.3°	$0.59''$	3 „
			1933.77	103.9°	$0.45''$	3n van Biesbroeck
			1933.09	106.0°	$0.49''$	4n Baize
1937.90	103.5°	$0.46''$	34.12	103.1°	$0.47''$	4 „
			35.14	103.4°	$0.45''$	3 „
			1937.07	104.7°	$0.48''$	3n Gr. O. (RW)
From orbit by Woolley and Symms :—						
			1937.9	103.5°	$0.40''$	

ADS 2616. $\Sigma 412$. (7 Tauri.) 6.6-6.7. A2.

			1925.42	80.5°	$0.26''$	4n van Biesbroeck
			26.92	77.3°	$0.26''$	3 „
			29.87	64.2°	$0.29''$	4 „
			34.14	50.0°	$0.35''$	3 „
			1924.91	81.9°	$0.26''$	4n Van den Bos
1937.90	47.6°	$0.34''$	1926.05	59.3°	$0.37''$	Gr. O. (HF)
37.95	50.7°	$0.34''$	34.07	47.7°	$0.34''$	„ (HF)
			37.14	45.4°	$0.39''$	„ (RW)
1937.93	49.2°	$0.34''$	37.15	45.4°	$0.33''$	„ (RW)
From orbit by Luyten (1934) :—						
			1925.0	75.3°	$0.22''$	
			30.0	60.1°	$0.26''$	
			35.0	48.8°	$0.30''$	
			40.0	40.2°	$0.34''$	

The separations observed with the comparison image micrometer agree with van Biesbroeck and with the orbit by Luyten. It may be noted that while making the observation of date 1937.15, given under Gr. O. filar micrometer results, the observer remarked on the very excellent seeing. Evidently, given perfect conditions, the 28-inch filar micrometer results agree with van Biesbroeck and the comparison image micrometer. Two of the earlier Gr. O. separations appear large.

Comparison Image Micrometer Measures			Filar Micrometer Measures			
ADS 3082. OΣ 77. 7.5-7.5. F8.						
			1931.88	243.9 ^o	0.62 ["]	7n Simonow
			35.22	249.0	0.63	1 ,,
			1933.22	247.5	0.63	2n Baize
			35.22	246.7	0.82	2 ,,
1937.90	247.2 ^o	0.62 ["]	1930.81	245.3	0.68	6n van Biesbroeck
			34.85	244.8	0.65	4 ,,
			1936.95	246.7	0.70	4n Gr. O. (RW)
From orbit by Hynek (1935):—						
			1934.0	246.9 ^o	0.62 ["]	
			36.0	248.6	0.63	
			38.0	250.2	0.64	
ADS 11005. Σ 2262. (τ Ophiuchi.) 5.0-5.7. F0.						
1937.73	266.3 ^o	1.99 ["]	1931.54	264.7 ^o	1.77 ["]	4n Simonow
37.76	266.3	2.03	32.47	265.2	2.04	4 ,,
1937.75	266.3	2.01	1934.66	264.2	1.92	3n Baize
			1936.53	267.1	2.12	6n Gr. O.
ADS 11635. Σ 2382. (ε ¹ Lyræ.) 4.6-6.3. A ₃ .						
			1933.92	4.8 ^o	2.82 ["]	4n Baize
1937.75	6.7 ^o	2.93 ["]	1936.68	2.4	2.98	Gr. O. (N)
37.76	3.5	2.92	36.73	4.5	2.91	,, (N)
			36.76	6.8	2.97	,, (RW)
1937.76	5.1	2.93	1936.72	4.6	2.95	,,
Σ 2383. (ε ² Lyræ.) 4.9-5.2. A ₅ .						
			1933.92	111.8 ^o	2.33 ["]	4n Baize
1937.75	112.1 ^o	2.23 ["]	1936.68	111.5	2.42	Gr. O. (N)
37.76	109.5	2.14	36.73	111.8	2.26	,, (N)
			36.76	111.6	2.31	,, (RW)
1937.76	110.8	2.19	1936.72	111.6	2.33	,,
ADS 11811. β 137. 8.2-8.7. G0.						
1937.75	139.6 ^o	1.37 ["]	1933.74	142.0 ^o	1.31 ["]	3n Baize
			36.63	141.7	1.40	5n Gr. O.

Comparison Image Micrometer Measures			Filar Micrometer Measures			
ADS 11956. Σ 2437. 7.8-8.0. G5.						
1937.74	40.6 ^o	0.66 ["]	1935.46	46.8 ^o	0.80 ["]	4n Baize
37.79	51.3	0.58				
37.80	47.9	0.65				
37.80	47.5	0.59				
1937.78	46.8	0.62	1936.55	47.7	0.85	5n Gr. O.
ADS 12040. Σ 2454. 8.0-9.2. Ko.						
1937.74	265.9 ^o	0.77 ["]	1932.62	264.0 ^o	1.10 ["]	5n Simonow
37.75	267.0	0.86	34.99	266.4	1.02	4n Baize
1937.75	266.5	0.82	37.06	266.1	0.96	3n Gr. O.
ADS 12067. J 813. 9.4-9.8. —.						
1937.74	2.7 ^o	1.00 ["]				
ADS 12972. O Σ 387. 7.2-8.2. F5.						
			1931.66	282.6 ^o	0.50 ["]	4n Simonow
			32.63	282.4	0.54	4 „
			1933.75	282.6	0.53	2n Baize
			34.69	279.0	0.50	2 „
			35.78	274.7	0.50	4 „
1937.77	272.3 ^o	0.42 ["]	1925.49	301.1	0.50	3n van Biesbroeck
37.79	271.4	0.40	26.50	299.4	0.49	2 „
37.80	273.2	0.42	29.50	291.2	0.47	2 „
1937.79	272.3	0.41	35.57	276.3	0.40	3 „
			1936.65	274.2	0.55 \pm	4n Duruy
			1936.89	271.8	0.52	4n Gr. O.
			Voronov's orbit (1934) gives :—			
			1933.6	267.4 ^o	0.37 ["]	
			35.7	255.7	0.34	
			37.8	242.5	0.33	

This pair is closing in, but not as rapidly as Voronov's orbit foresees. Allowing for orbital motion, the separations measured by the comparison image micrometer accord with van Biesbroeck's.

Comparison Image Micrometer Measures			Filar Micrometer Measures			
ADS 13277. $\text{O}\Sigma$ 395. (16 Vulpeculi.) 5.8-6.2. Fo.						
	$^{\circ}$	"	1931.63	108.7	0.67	6n Simonow
1937.79	109.5	0.76	32.53	109.1	0.80	4 "
37.80	109.3	0.70				
37.80	110.9	0.73	1934.49	109.4	0.85	4n Baize
1937.80	109.9	0.73	1936.59	110.4	0.91	5n Gr. O.

ADS 16836. β 720. (72 Pegasi.) 6.0-6.0. K2.						
	$^{\circ}$	"	1932.82	209.0	0.40	2n Simonow
1937.79	224.5	0.35				
37.88	223.4	0.35				
37.90	212.2	0.35	1934.44	221.3	0.42	4n Baize
37.94	219.2	0.35				
37.95	218.1	0.35	1934.69	215.3	0.43	1n van Biesbroeck
			35.77	215.7	0.36	1 "
1937.89	219.5	0.35				

This pair has been used as a test object to estimate the seeing; this accounts for the large number of observations. The agreement of the separation measures is remarkable. There was never an occasion when it was possible to measure the pair with the filar micrometer.

ADS 16951. A 1242. 9.0-9.0. G5.						
	$^{\circ}$	"	1928.57	291.5	0.60	7n van Biesbroeck
1937.80	295.9	0.65	31.92	292.9	0.57	5 "
37.88	289.8	0.62				
1937.84	292.9	0.63	1933.73	292.6	0.62	2n Aitken

Summary.—The paper deals with a method of measuring double stars by comparison with an artificial double star.

Part I describes the instrument, in which a Wollaston prism is used to produce the double star, the relative brightness of the components being controlled by means of crossed Nicols.

Part II describes the method of use. Some results of measures of double stars made with the micrometer are given, and compared with filar micrometer results.

Note added 1938 February 5.—The following observations of three of the above stars * were made by Mr. F. J. Hargreaves, using his original comparison image micrometer mounted on his 12-inch reflector, focal length 78 inches, at the Newtonian focus. The agreement between these measures

* *B.A.A. Handbook*, 1933 and 1934.

1938 Jan.

A Comparison Image Micrometer

189

and those made with the Greenwich instrument (allowing in the case of the first star for orbital motion) is striking.

ADS	755	Σ	73	1931.8	88.6 ^o	0.60 ["]
				1932.9	93.2	0.57
ADS	1630	O Σ	38	1932.0	102.7	0.54
				1932.9	105.3	0.52
ADS	13277	O Σ	395	1931.7	108.8	0.80

*Royal Observatory,
Greenwich :
1938 January 7.*