

IDENTIFICATION OF STRONG EXTRAGALACTIC RADIO SOURCES IN THE DECLINATION ZONE 0° TO -20°

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[Manuscript received April 29, 1966]

Summary

Identifications are proposed for 71 extragalactic radio sources between declinations 0° and -20° . The identifications, which comprise 37 galaxies and 34 possible quasi-stellar objects, resulted from inspection of the 48 in. Sky Survey prints in the positions of 113 sources.

I. INTRODUCTION

The 48 in. Palomar Sky Survey prints have been examined for identifications in the positions of 113 radio sources in the declination zone 0° to -20° . The positions of these sources were determined by Shimmins, Clarke, and R. Ekers (1966) with the 210 ft telescope. These authors estimate that the maximum errors of their measurements are such that two-thirds of the positions are within 15 sec of arc in right ascension and 12 sec of arc in declination of the true position. The area searched for identification was limited to within $24''$ of the radio position. The results of this search are as follows:

In 15 cases no identification was possible as the search area was either obscured or heavily populated with stars.

In 4 cases an HII region coincided with the position.

In 37 cases galaxies that coincided with the radio positions within the set error limits were found.

In 34 cases objects that were noticeably blue and thus could be quasi-stellar objects were found within the error limits.

In 4 positions there were no objects visible within the error limits and in 19 positions there were faint "stars" of normal colour. Some of the latter may possibly be faint galaxies but the combination of plate scale and seeing made it impossible to judge whether the images were those of galaxies or faint stars.

Neglecting the obscured fields and galactic objects, identifications were found for 71 out of a possible total of 94 objects.

The 113 sources in this declination zone, for which precise positions were determined, were chosen mainly from the Parkes catalogue for 0° to -20° (in preparation). At the time the position measurements were made, this catalogue was not complete for right ascensions 9–16 hr. For the completed areas a source was included if its flux density was ≥ 1.8 flux units (1 flux unit = 10^{-26} W m $^{-2}$ (c/s) $^{-1}$) at 1410 Mc/s or if its flux density was ≥ 1 flux unit at 2650 Mc/s, where

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TABLE 1
LIST OF IDENTIFICATIONS

Parkes Catalogue Number	Position (1950.0)		Flux Density at 1410 Mc/s (flux units)*	Spectral Index	Type	Magni- tude	Galactic Coordinates		Refer- ences†	Remarks	Alternate Cat. No.
	R.A. h m s	Dec. ° ' "					l°	b°			
0000-17	00 00 48.0	-17 43.9	2.5	-0.6	N	17.8	71	-75		Very blue, possible jet	00-17
0034-01	00 34 30.5	-01 25.8	4.7	-0.4	E	18	114	-63			3C 15
0035-02	00 35 47.0	-02 24.2	7.0	-0.5	E	19	115	-64	9		3C 17
0051-03	00 51 35.5	-03 50.3	2.4	-0.6	E	19	124	-66	4		3C 26
0055-01	00 55 02.0	-01 39.6	5.3	-0.6	E	15.6	126	-64	8		3C 29
0056-00	00 56 31.5	-00 09.3	2.5	-0.4	QSO	18	126	-62	3	PHL 923	
0122-00	01 22 55.5	-01 21.5	1.7		QSO	17	141	-61	3	Curved spectrum	3C 40
0123-01	01 23 27.0	-01 36.4	4.8	-0.8	db.	13.2	142	-62	1	NGC 545/7	01-111
0125-14	01 25 05.0	-14 18.7	2.7	-0.6	QSO?	20	156	-74			
0130-17	01 30 17.0	-17 10.4	1.0	0.0	QSO?	19	168	-76			
0159-11	01 59 30.5	-11 47.0	3.5	-0.6	QSO	17.5	173	-67	3		3C 57
0202-17	02 02 34.0	-17 16.0	1.4		QSO?	18.5	185	-70		Curved spectrum	
0213-13	02 13 12.0	-13 13.5	5.6	-0.6	E	18.5	181	-65			3C 62
0218-02	02 18 21.5	-02 10.6	4.4	-0.7	E	19.5	167	-57			3C 63
0240-00	02 40 07.0	-00 14	5.5	-0.3	Sc	9.8	171	-51	6	NGC 1068	3C 71
0331-01	03 31 42.0	-01 21.2	2.9	-1.1	D	18.5	185	-42			3C 89
0336-01	03 36 58.6	-01 56.1	1.9		QSO?	17.5	187	-42		Curved spectrum	CTA 26
0349-14	03 49 09.5	-14 38.1	3.3	-1.0	QSO	16.2	205	-46	3		3C 95
0350-07	03 50 04.5	-07 19.9	3.5		QSO	17.5	196	-42	3	Curved spectrum	3C 94
0403-13	04 03 14.0	-13 16.3	3.7	-0.4	QSO	18	205	-42	3		
0405-12	04 05 27.5	-12 19.6	2.8		QSO	16	204	-41	3	Curved spectrum	04-12
0431-13.3	04 31 54.5	-13 17.1	1.6	-1.0	E	18.8	209	-36			04-112
0431-13.5	04 31 50.5	-13 28.4			E	16.3	209	-36		Flux at 2650 Mc/s = 0.43	04-112
0458-02	04 58 41.0	-02 03.6	2.5	-0.2	QSO?	20	201	-25			05-11
0502-10	05 02 31.5	-10 19.1	1.5	-0.7	db.	15.4	210	-28			05-114
0533-12	05 33 13.0	-12 04.5	1.7	-0.6	N	17.8	208	-19		Stellar on blue print	07-06
0724-01	07 24 33.5	-01 58.5	2.7	-0.5	g	19	218	6		Probably obscured	07-117
0745-19	07 45 20.5	-19 10.2	2.5	-0.8	D	18	236	3			3C 193
0803-00	08 03 04.5	-00 49.7	1.3	-0.7	E4	15.9	222	16		In small cluster	
0806-10	08 06 30.0	-10 18.9	3.8	-0.6	E	18.8	231	11			3C 195

0809-05	08 09 34.5	-05 40.6	1.5	-0.7	QSO?	18	227	15	08-04
0812-02	08 12 56.5	-02 59.3	1.8	-0.5	D	18.5	225	17	3C 196.1
0825-20	08 25 03.5	-20 16.5	3.7	-0.8	QSO?	18	242	10	08-24
0855-19	08 55 48.5	-19 39.2	1.5	-0.5	QSO?	19.5	246	16	08-119
0859-14	08 59 55.0	-14 03.6	3.5	-0.4	QSO	17.8	242	20	09-17
0915-11	09 15 41.5	-11 53.1	42	-0.8	D	14.8	243	25	Hyd. A
1136-13	11 36 38.5	-13 34.2	4.6	-0.6	QSO?	17.8	277	45	11-18
1159-10	11 59 39.0	-10 24.1	1.8	-0.6	E	18.5	283	49	11-179
1201-04	12 01 29.0	-04 06.1	2.3	-0.4	db.	18	281	56	12-07
1237-10	12 37 07.3	-10 07.1	1.9	-0.4	QSO	18.2	298	52	Probably s.p. galaxy of pair
1252-12	12 51 58.5	-12 17.7	7.8	-0.4	db.	13.2	304	50	Curved spectrum
1253-05	12 53 36.0	-05 31.1	11.7	-0.5	QSO	17.8	305	57	Curved spectrum
1306-09	13 06 01.0	-09 34.3	4.8	-0.5	D	18.5	309	52	Very blue
1334-17	13 34 54.0	-17 56.6	1.9	-0.7	g	19.5	318	43	Radio position not sufficient- ently accurate to distinguish between this galaxy and star immediately north preceding. However, star is of normal colour
1335-06	13 35 31.0	-06 12.0	3.6	-0.9	QSO	17.7	323	54	13-011
1358-11	13 58 59.0	-11 22.1	2.1	-0.7	E2	15.0	329	46	13-177
1404-01	14 04 15.0	-01 39.9	1.3	-0.8	QSO?	19.5	338	56	14-01
1417-19	14 17 02.0	-19 14.5	2.0	-0.7	N	17.5	329	38	14-15
1425-01	14 25 55.5	-01 10.7	3.4	-0.5	QSO?	18	346	53	Stellar image on blue print
1436-16	14 36 42.0	-16 46.2	2.1	-0.7	D	19	336	38	Jet on red print (N gal?)
1453-10	14 53 12.5	-10 56.7	4.2	-0.5	QSO	17.5	345	41	3C 300.1
1504-16.7	15 04 17.0	-16 41.1	3.0	-0.3	g	18.5	343	35	14-121
1510-08	15 10 09.0	-08 54.8	3.4	-0.1	QSO?	17.8	351	40	15-13
1524-13	15 24 13.0	-13 40.7	2.7	-0.6	QSO?	20.5	350	34	Star 0'.5 of north following is blue. However, radio position favours galaxy
1712-12	17 12 53.0	-12 03.7	1.1	-0.6	D	17.5	10	14	15-06
1717-00	17 17 53.5	-00 55.8	56	-0.7	D	16.8	20	19	15-19
									Obscured, probably brighter
									3C 353

* 1 flux unit = $10^{-26} \text{ W m}^{-2} (\text{c/s})^{-1}$.

† For explanation of numbering of references, see corresponding footnote at end of table (overleaf).

TABLE 1 (Continued)

Parkes Catalogue Number	Position (1950.0)			Flux Density at 1410 Mc/s (flux units)*	Spectral Index	Type	Magni- tude	Galactic Coordinates		Refer- ences†	Remarks	Alternate Cat. No.
	R.A. h m s.	Dec. ° ' "						l^{II}	b^{II}			
1949-01	19 49 54.5	-01 25.3		1.7	-0.4	E	17.5	38	-14		In small cluster	3C 403.1
2048-14	20 48 22.0	-04 46.4		1.7	-0.4	D	19.5	43	-28		In cluster	20-172
2059-13	20 58 59.0	-13 30.9		1.5	-0.6	E3	15.2	35	-34			20-179
2135-18	21 35 18.5	-18 57.1		1.6	-0.7	D	19.5	34	-44			21-176
2144-17	21 44 17.5	-17 54.1		1.6		QSO?	19.5	35	-46		Or N galaxy, curved spec- trum	21-178
2146-13	21 46 46.0	-13 18.4		1.7	-0.9	QSO	20	41	-45	3		21-179
2154-18	21 54 12.5	-18 28.5		4.0		QSO?	16.5	35	-49		Curved spectrum	21-123
2203-18	22 03 25.0	-18 50.2		7.0	-0.3	QSO?	19.5	36	-51			22-17
2211-17	22 11 41.5	-17 16.8		10	-1.0	D	19	40	-52	12	In small cluster	3C 444
2216-03	22 16 16.5	-03 50.7		1.1		QSO	17.5	59	-46	3	Curved spectrum	22-06
2223-05	22 23 10.5	-05 12.3		6.7	-0.5	QSO	18.4	59	-48	11		3C 446
2300-18	23 00 23.0	-18 57.5		1.7	-0.3	N	18.3	45	-63			
2313-18	23 13 09.0	-18 17.1		1.5	-0.5	g	19.3	49	-66			
2322-12	23 22 44.0	-12 23.8		2.2	-0.7	E5	17.2	65	-64	7	Radio position closer to star 0'.5 south preceding. With galaxy of this mag- nitude, discrepancy not unusual. However, star is blue and could be alternative identification	23-172
2324-02	23 24 20.0	-02 18.8		2.6	-0.5	E	18.3	80	-57		Curved spectrum	23-011
2345-16	23 45 27.0	-16 48.1		1.4		QSO?	18.5	63	-72			
2354-11	23 54 57.0	-11 42.8		2.0	-0.2	QSO?	19	81	-69			

* 1 flux unit = $10^{-26} \text{ W m}^{-2} (\text{c/s})^{-1}$.

† References to previously published identifications are: 1. Bolton (1960); 2. Hazard, Mackey, and Nicholson (1964); 3. T. D. Kinman (personal communication, see text); 4. T. A. Matthews (unpublished, quoted by Schmidt 1965); 5. Mills (1960); 6. Mills, Snee, and Hill (1958); 7. Milne and Scheuer (1964); 8. Minkowski (1960); 9. A. T. Moffet (unpublished, quoted by Schmidt 1965); 10. Roberts, Bolton, and Harris (1960), also Dewhurst (quoted in 3C catalogue); 11. Sandage and Wyndham (1965); 12. Wyndham (1965).

measurements at 1410 Mc/s were not available. In the incomplete 9–16 hr region, sources from the 3C or MSH catalogues were observed if their flux densities, estimated on the basis of normal spectra, exceeded the level of 1.8 flux units at 1410 Mc/s. The selection basis plus the effects of galactic obscuration both contribute to the uneven distribution of identifications over the zone and no significance should be drawn from this distribution.

As described in previous papers (Bolton, Clarke, and R. Ekers 1965; Bolton and J. Ekers 1966*a*, 1966*b*; Clarke, Bolton, and Shimmins 1966), the inspection of the Sky Survey prints was carried out with the aid of a transparent overlay containing the position of the radio source and those of 10 stars from the Yale catalogue. Use was made of an electronic computer to evaluate the star coordinates for the overlay.

In the present work the computer was also used to select the reference stars from an abridged version of the Yale catalogue on magnetic tape and to provide the output plot on the scale of the Sky Survey prints. A magnetic tape of the Yale catalogue, which was kindly provided by the U.S. Naval Observatory, was used to prepare an abridged tape containing only the star positions. The authors are indebted to Mr. E. R. Hill of this laboratory for providing both the program for selecting the 10 nearest stars from this tape and for the program for producing the output plot.

II. LIST OF IDENTIFICATIONS

Table 1 contains the list of identifications. Column 1 contains the Parkes catalogue number for the source, while the final column contains the equivalent 3C or MSH number. Columns 2 and 3 contain the position of the proposed optical counterpart, estimated with the use of the transparent overlay. These positions are given to the nearest $0^s.5$ and $0'.1$; the accuracy of measurement depends considerably on the location of the Yale reference stars with respect to the source and the proximity of the source position to the edge of the Survey print. It is believed that two-thirds of the positions are within $0'.2$ of the correct values, i.e. the errors are of the same order as those of the radio determinations.

Columns 4 and 5 contain the flux density of the source and its spectral index for the range 408–2650 Mc/s. *These values are preliminary*; improved values will be given in the Parkes catalogue for 0° to -20° . A source whose spectrum cannot be represented by a simple power law is noted in the Remarks column as “curved spectrum”.

Columns 6 and 7 contain the type of object and the estimated magnitude. Galaxies have been classified broadly on the system of Matthews, Morgan, and Schmidt (1964). The classifications are: E, elliptical; D, elliptical galaxy with diffuse outer envelope; N, compact galaxy, generally with a rather blue nucleus; and db., dumb-bell or double system. Objects that are clearly galaxies on the Sky Survey print but whose images are affected by poor seeing are denoted by “g”. Quasi-stellar objects are denoted by QSO? where the evidence for their identification is position agreement and a pronounced blue colour, and by QSO where photometric or two-colour photographic evidence for an ultraviolet excess is available. Magnitudes

(photographic for galaxies and visual for quasi-stellar objects) have been estimated by comparison of their images with the images of a sequence of well-known identifications for which published magnitudes are available. For faint objects the errors in these estimates may be as high as one magnitude.

New galactic coordinates are given in columns 8 and 9.

Column 10 contains references to previously published identifications. In general these references are to the first publication that established reasonable agreement between radio and optical positions. The authors apologize for any omissions in this respect. Firm or suggested identifications have been previously published for 14 of the sources although one of these, 2322-12, is now questioned (see Remarks column, Table 1). Ten of the new quasi-stellar objects have been confirmed by observations of ultraviolet excess by Dr T. D. Kinman and his associates at the Lick Observatory and additional data on these objects are being published elsewhere.

The Remarks column contains additional notes, such as NGC number and spectral peculiarity.

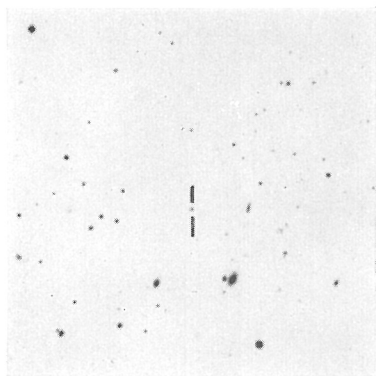
III. FINDING CHARTS

Finding charts are given in Plates 1 to 9 for all sources except the brightest galaxies. The finding charts were prepared from the Sky Survey prints and the contrast has been increased over that of the original print. The E or red print was used for galaxies and the O or blue print for quasi-stellar objects. The scale of the finding charts is 5 mm = 1 min of arc.

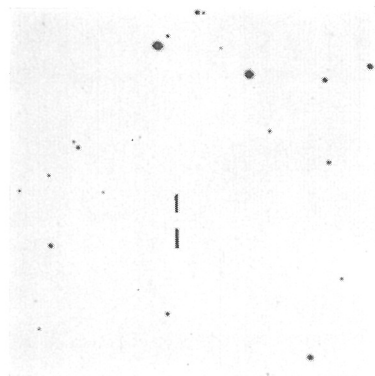
IV. REFERENCES

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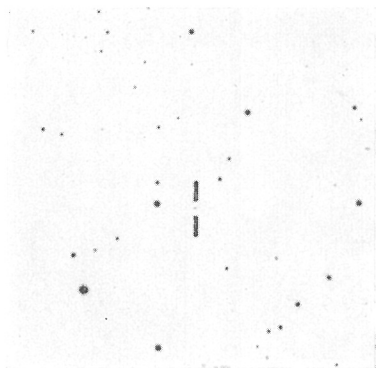
Plates 1-9.—Finding charts for the identifications. Scale is 5 mm = 1 min of arc. North-east is at the top left-hand corner of each chart.



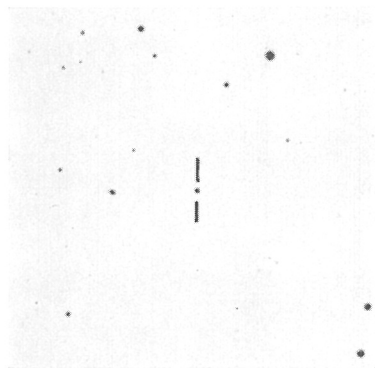
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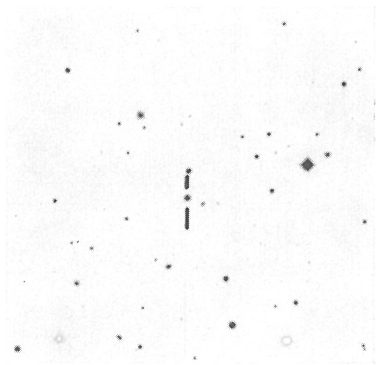
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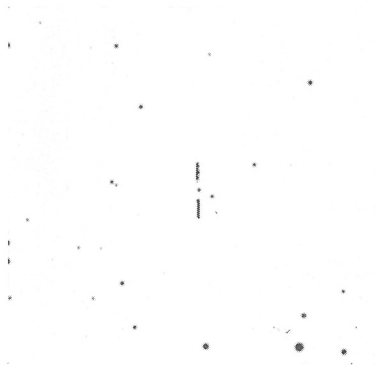
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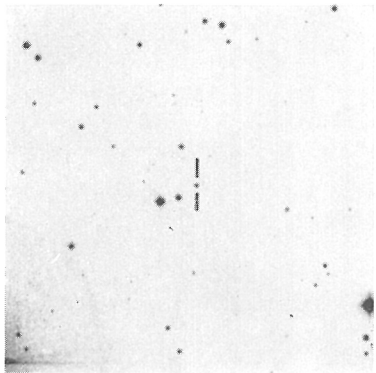
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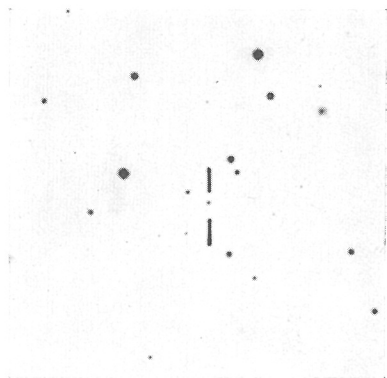
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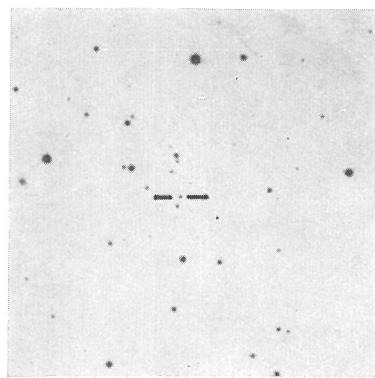
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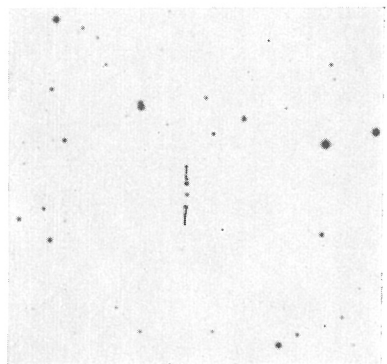
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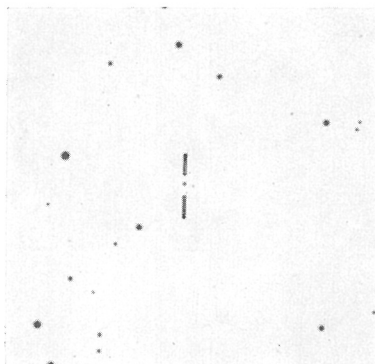
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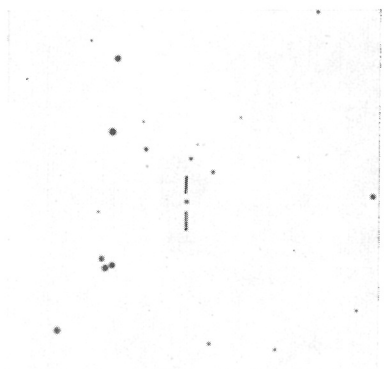
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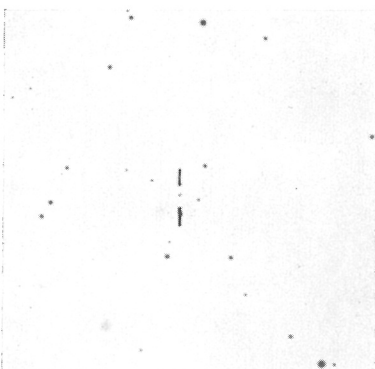
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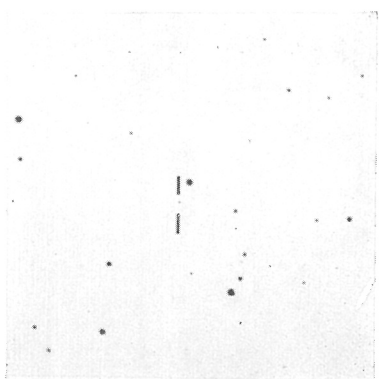
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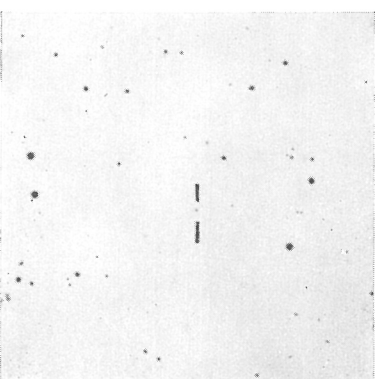
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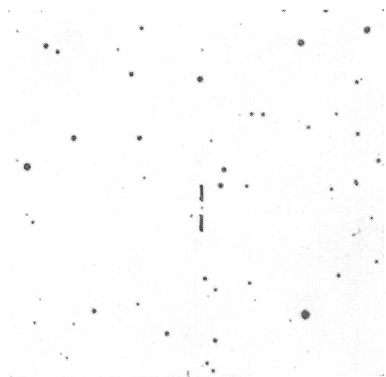
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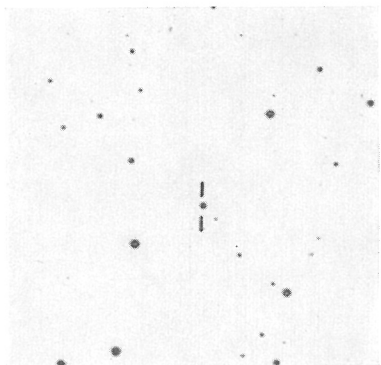
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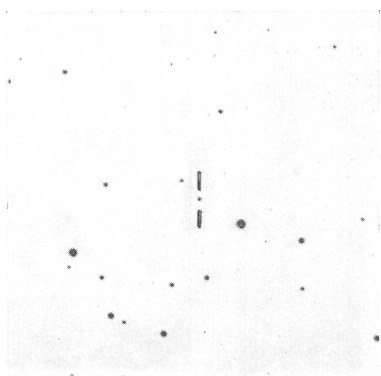
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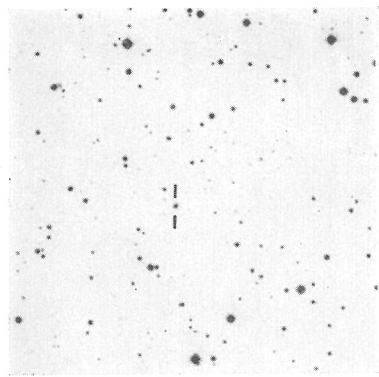
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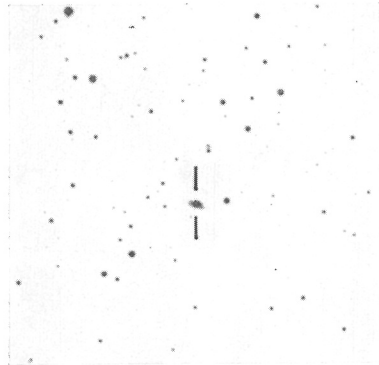
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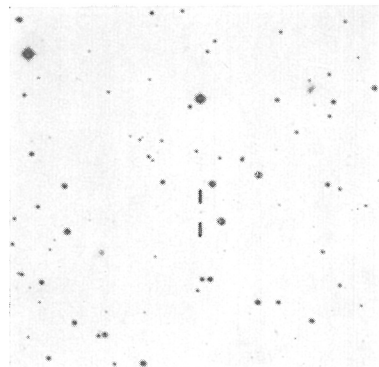
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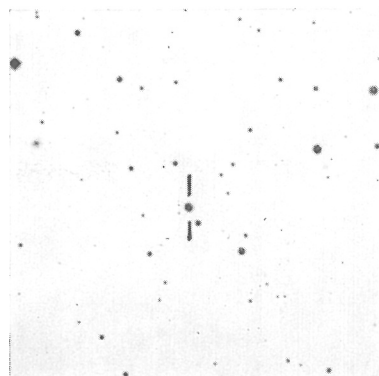
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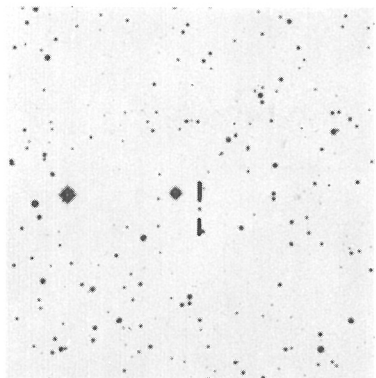
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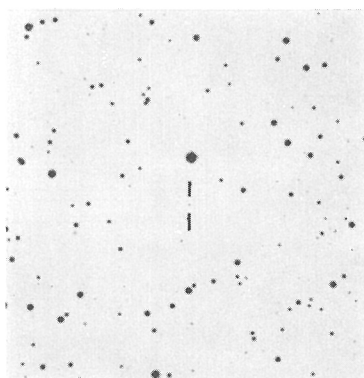
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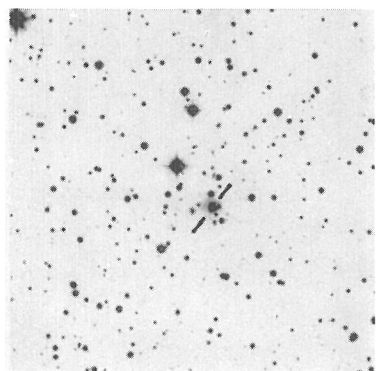
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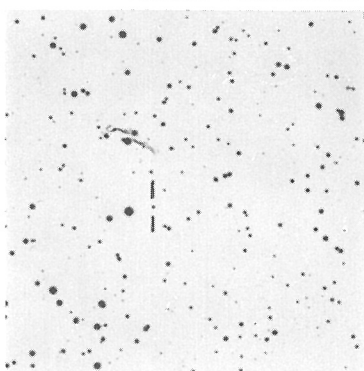
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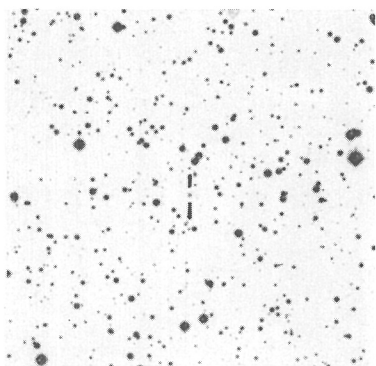
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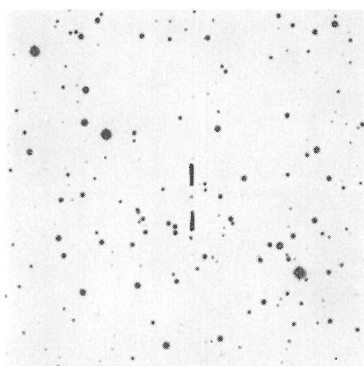
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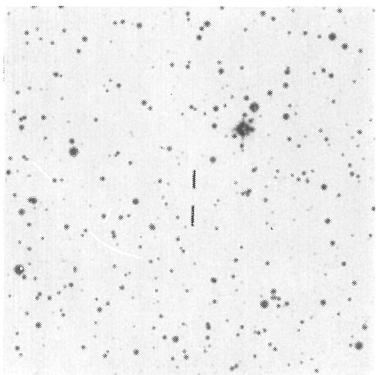
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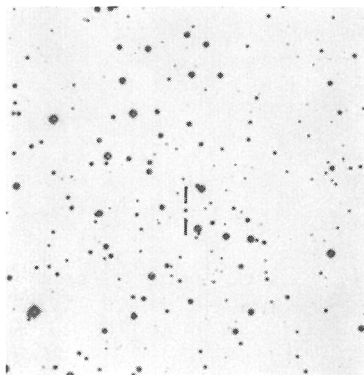
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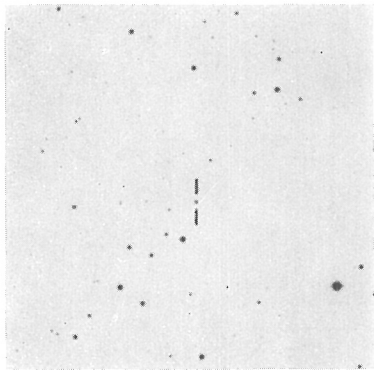
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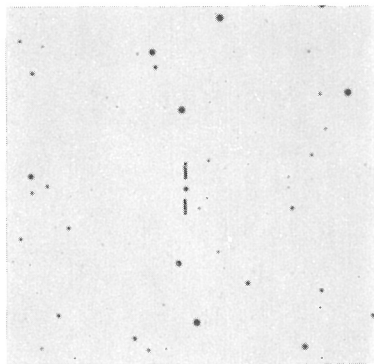
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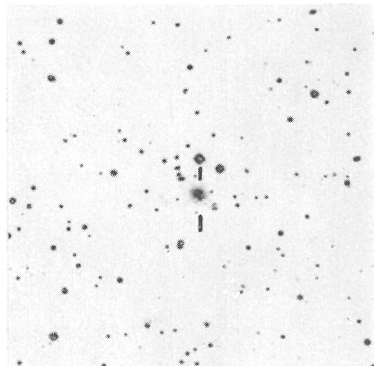
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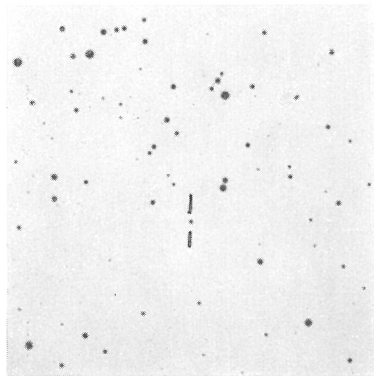
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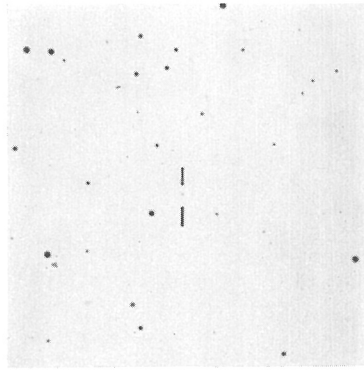
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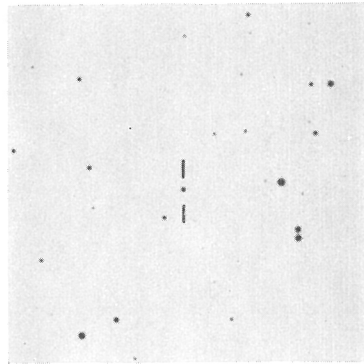
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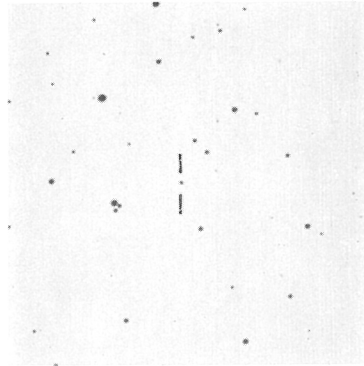
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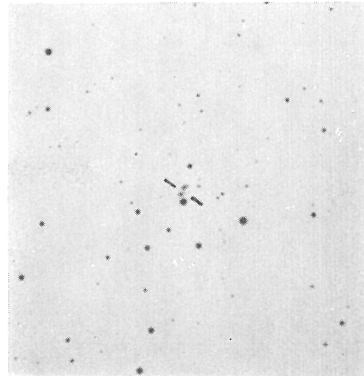
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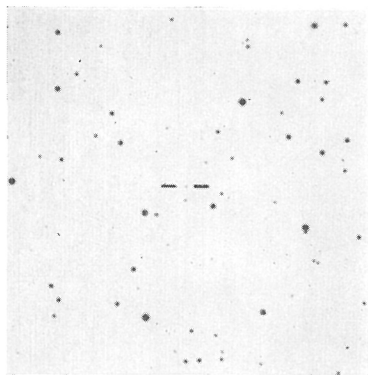
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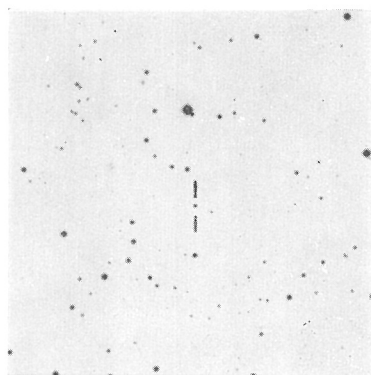
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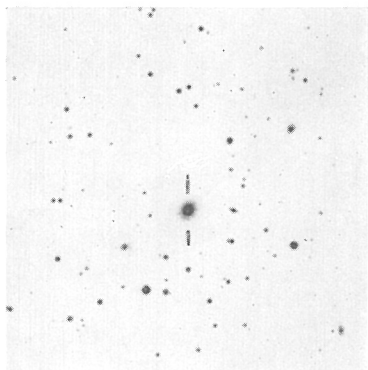
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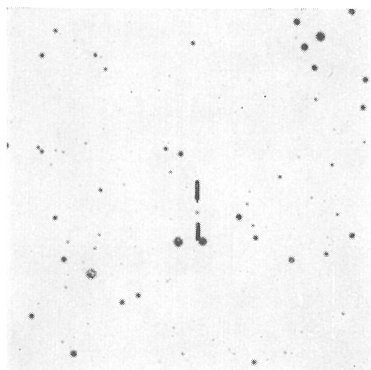
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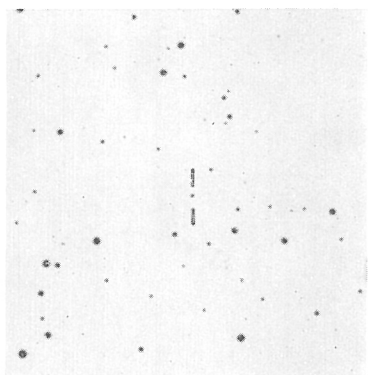
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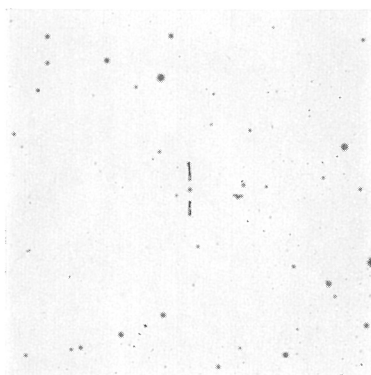
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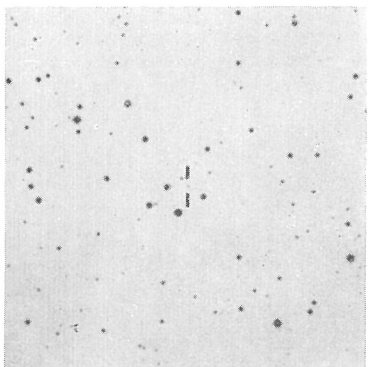
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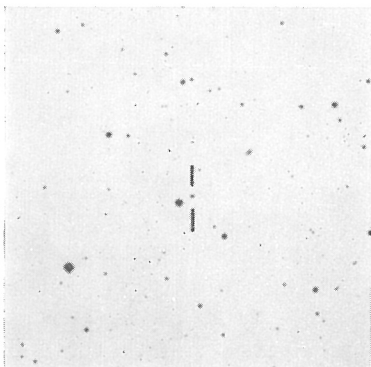
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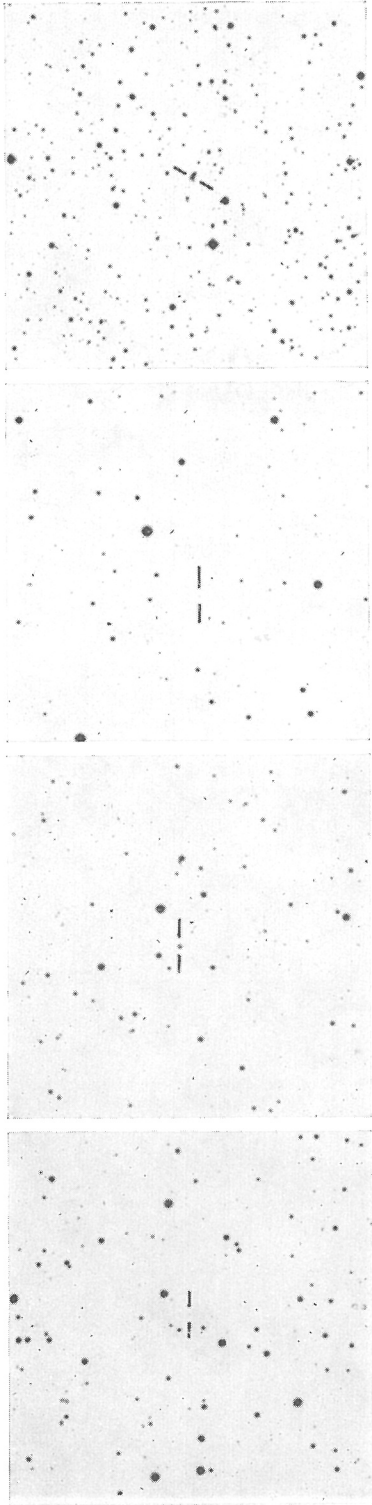
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1334-17



1417-19

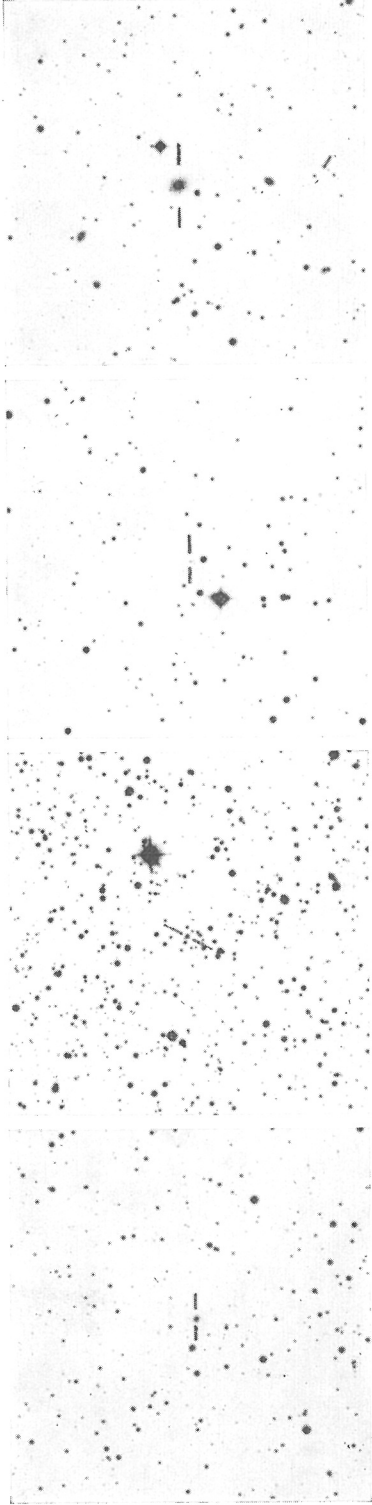


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1524-13

1510-08

1504-16.7

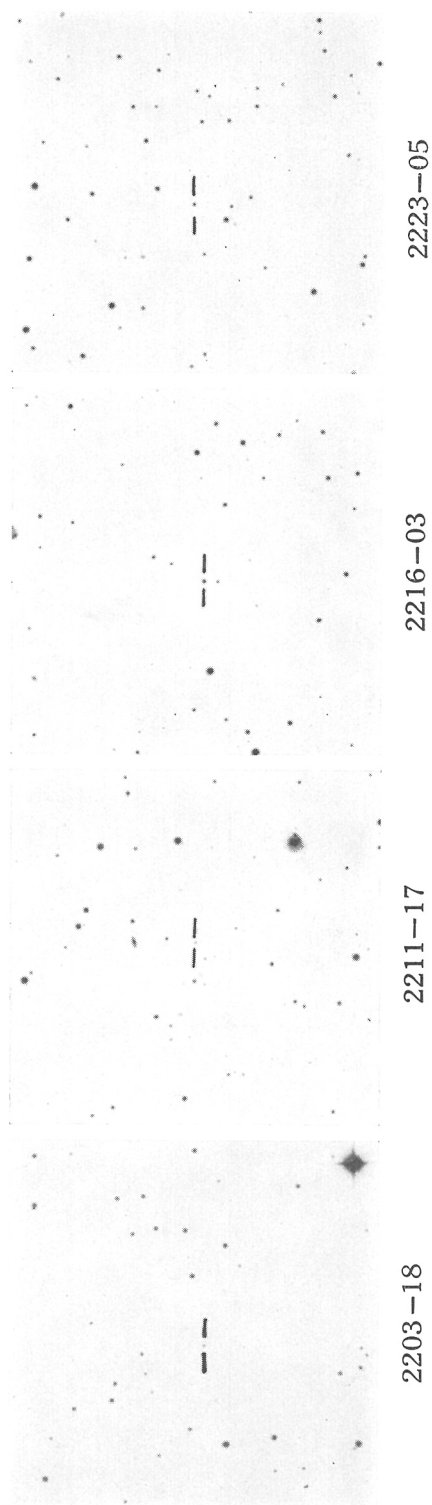
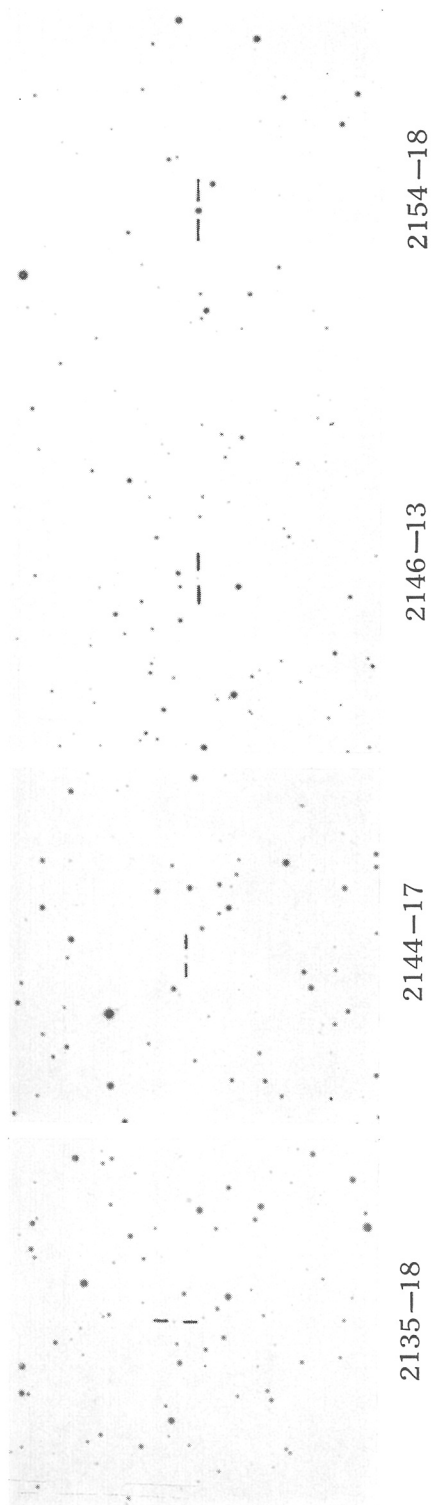


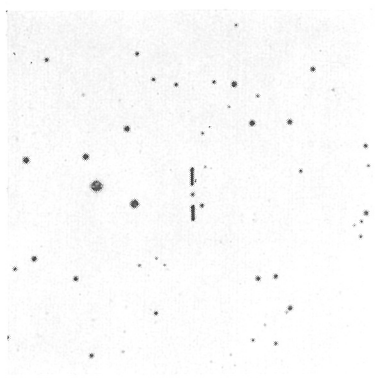
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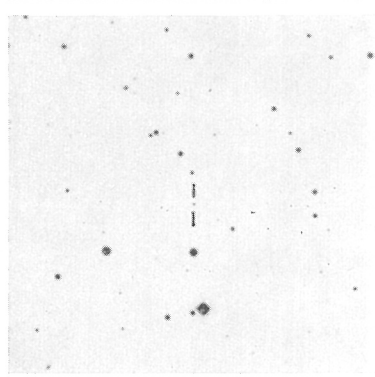




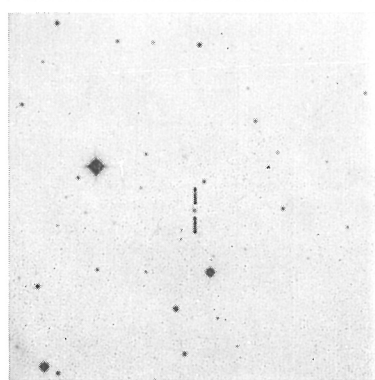
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2322-12



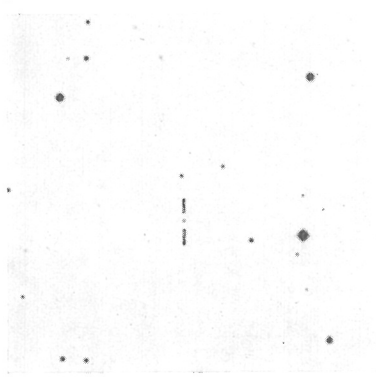
2313-18



2300-18



2354-11



2345-16

