IDENTIFICATION OF EXTRAGALACTIC RADIO SOURCES BETWEEN DECLINATIONS 0° AND +20°

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Summary

Identifications or suggested identifications are given for 138 extragalactic radio sources in the declination zone 0° to +20°. The identifications are based on a search of the Palomar Sky Survey plates in the positions of sources in the Parkes catalogue. Forty-two of the identifications are with quasi-stellar objects or suggested quasi-stellar objects and the remainder with galaxies. The radio luminosity distribution and a possible variation in the identification percentage with galactic latitude are discussed.

I. Introduction

The Parkes catalogue of radio sources for the declination zone 0° to +20° (Day, Shimmins, Ekers, and Cole 1966, hereafter referred to as DSEC) lists the positions of 500 sources to an accuracy of about $1'\cdot 0$ arc in both right ascension and declination. A search for optical objects in the positions of most of the sources in that section of the Parkes catalogue has now been made, and the results are given in the present paper.

The search of an area 2′ arc square centred on each source position was made initially on prints of the 48 in. Palomar Sky Survey. Previous work had shown that a large proportion of discrete radio sources could be identified with either galaxies (mainly ellipticals) or quasi-stellar objects. Identifications are suggested here whenever a galaxy or an object with the characteristics of a quasi-stellar object occurs within the error rectangle.

Hubble (1934) has estimated the mean density on the sky of galaxies falling within different ranges of apparent photographic magnitudes. These data have been used to compute the probability N_m of finding a galaxy of apparent magnitude less than m in an area of 4 sq min arc chosen at random on a photographic plate, with the following result.

$$\text{For}\quad m<17,\quad N_m=0\cdot 01;$$
$$m<18,\quad N_m=0\cdot 04;$$
$$m<19,\quad N_m=0\cdot 16.$$

It follows that if the probability of finding a galaxy by chance within the error rectangle associated with a radio source is comparable with the rate at which "identifications" are reported, then considerable doubt must be cast on the validity of many of these identifications. It will be seen that, while very few of the suggested

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identifications with galaxies brighter than 17^{m} can be dismissed as chance coincidences, positions of higher accuracy are required to confirm identifications with fainter galaxies. Position measurements with typical errors of about $0'\cdot2$ arc are available for a large number of the sources with flux densities greater than $1\cdot8\times10^{-26}$ W m^{-2} (c/s)$^{-1}$ at 1410 Mc/s and for a few of the weaker sources, and these additional data have been used whenever applicable.

Quasi-stellar objects have compact starlike images and are characterized by an unusual ultraviolet excess (Ryle and Sandage 1964). This ultraviolet excess is manifested on the Sky Survey prints by a brighter image on the "O" (blue) than on the "E" (red) print. Any appreciably "blue" stellar image that occurs within the error rectangle of a radio source may therefore be a quasi-stellar object, although photometric measurements are necessary to confirm such an identification.*

Of the 96 galaxies and 42 quasi-stellar objects (referred to subsequently as QSO's) found in the present search, 48 objects have been reported previously, including eight objects that were first noted during the present work and which have already been investigated in more detail (Bolton *et al.* 1965; Wyndham 1965). References are given in Table 1 to what we believe to be the original reports of the 48 identifications mentioned above, and we apologize for any accidental omissions from this list. References are also given to photometric, spectroscopic, or positional data.

The present work is the largest systematic search for optical identifications of radio sources that has been carried out with a search area as small as 4 sq min arc. Some of the implications of the results are discussed in Section IV.

II. The Search

The search for identifications was carried out in a manner similar to that used for our earlier work on the declination zone −20° to −44° (Bolton, Clarke, and Ekers 1965). A transparent overlay drawn to the scale of the survey prints was prepared for each source. The positions of about six reference stars, taken from the Yale Photographic Catalogue, and an error rectangle centred on the position of the radio source, were marked on each overlay.

The radio source positions were examined initially on prints of the 48 in. Sky Survey prints and subsequently on the original plates at the California Institute of Technology. Examination of the original plates has the advantage that the plates are free from flaws produced in the printing, and where plate flaws are suspected the reject plates can also be examined. Further, for faint objects, small colour differences can be detected with more certainty than on the prints.

Other radio source position measurements, of higher accuracy than the DSEC survey position measurements, were taken into account whenever they existed. These included measurements made at Parkes with errors less than about $0'\cdot2$ arc (Shimmins, Clarke, and Ekers, unpublished data; paper in preparation), measurements made at the California Institute of Technology (Read 1963; Fomalont *et al.*

* The rate of chance coincidences of radio sources with objects with a blue colour excess is difficult to assess, but it is probably of the same order of magnitude as for galaxies.

1964; Wyndham and Read 1965), and measurements made at Cambridge (Clarke 1964*a*).

Magnitudes for the suggested identifications have been estimated in most cases from the 48 in. Sky Survey prints by comparison with the Sky Survey images of galaxies in the list given by Maltby, Matthews, and Moffet (1963) and of QSO's in the list given by Sandage (1965). Published magnitudes are available for many of the better-known identifications. For galaxies brighter than $m_{pg} = 15$, magnitudes have been taken from the "Catalogue of Galaxies and Clusters of Galaxies" (Zwicky, Herzog, and Wild 1963) or from unpublished work on later sections of that catalogue (communicated personally by Dr. E. Herzog). For the relatively bright objects in unobscured regions, our estimates are probably accurate to a few tenths of a magnitude, but for fainter objects and in low galactic latitudes, errors may be as high as one magnitude. Photoelectric "V" magnitudes are given for confirmed quasi-stellar objects and estimated for the remainder.

Optical positions of all the new identifications have been estimated from the prints by use of transparent overlays. The accuracy of these estimates varies considerably. Near the centre of a plate of good image quality where the overlay fits the reference stars well, or where the identification is close to a reference star, the accuracy is probably better than $0'\cdot 1$ arc. In less favourable cases, the errors could be two or three times as large.

III. Results

(*a*) *Classification of Optical Fields of Radio Sources*

A total of 498 positions was examined in the search, and the optical fields were classified according to the system of Harris and Roberts (1960), as follows.

Class I: 44 fields contained galaxies brighter than $m_{pg} = 17$.

Class II: 52 fields contained galaxies fainter than $m_{pg} = 17$.

Class III: 320 fields contained only stars or faint galaxies ($m_{pg} > 19$) that could not be distinguished easily from stars. Forty-two of these fields contained objects of abnormally blue colour. Some of these objects have already been confirmed as QSO's, and the rest are suggested as QSO's.

Class III–IV: 50 fields contained stars only, but considerable obscuration was suspected.

Class IV: 32 fields were so heavily obscured, or had such a high star density, that they could not be reliably classed in one of the above groups.

(*b*) *Tabular Data*

Details of the identified sources are summarized in Table 1.

Column 1 of the table contains the Parkes catalogue number. Where a source has been previously listed in the 3C catalogue (Edge *et al.* 1959), in the Revised 3C catalogue (Bennett 1962), or in the MSH catalogue (Mills, Slee, and Hill 1958), the appropriate 3C or MSH number is given in the final column. Columns 2 and 3 contain the optical position of the identified source. Where previously published optical

TABLE 1

RADIO SOURCES BETWEEN 0° AND +20° DECLINATION THAT HAVE BEEN IDENTIFIED WITH EXTRAGALACTIC OBJECTS

Parkes Catalogue Number	Optical Position (1950·0) R. A. h m s	Optical Position (1950·0) Dec. ° ′	Flux Density at 1410 Mc/s (flux units)*	Spectral Index	Type	m_{pg}	Galactic Coordinates l^{II} °	Galactic Coordinates b^{II} °	References†	Transit Position Data‡	Remarks§	Other Cat. No.
0007+12	00 07 18·5	12 27·5	1·9	−0·8	E 3	17·7	107	−49		α, δ		
0017+15	00 17 49·7	15 24·4	2·1	−0·9	QSO	18·2	112	−47	14, 19	α, δ		3C 9
0029+01	00 29 28·2	01 11·6	0·5		E 4	18·6	113	−61				
0030+19	00 30 01·5	19 37·6	1·9	−0·6	D?	19	117	−43		α, δ	In small cluster	3C 12
0031+01	00 31 50	01 04·5	0·5	−1·2	N	19	114	−61				00+*06*
0034+19	00 34 39	19 45·6	0·7	−1·1	QSO?	18	118	−43				
0036+03	00 36 44·8	03 03·3	1·6	−0·7	E 2	14·3	117	−59				00+0*10*
0059+05	00 59 37	05 38·1	0·7	−0·8	E	18·5	128	−57				
0106+01	01 06 04	01 19·0	1·4	−0·7	QSO	18·4	132	−61	4	α, δ		
0106+13	01 06 14·5	13 04·3	14·2	−0·7	D	15·6	129	−49	2, 5, 9, 18	α	P	3C 33
0107+17	01 07 01	17 37·3	0·5	−1·5	S	17·5	129	−45				
0110+15	01 10 19	15 13·5	1·0	−1·1	db.	16	131	−47				
0114+07	01 14 49·7	07 26·3	1·6	−1·1	QSO	18	134	−55	4	α, δ	P	
0118+03	01 18 27	03 28·5	1·2	−1·1	QSO?	18·5	137	−58				
0124+18	01 24 12	18 57·4	1·5	−0·3	E	15·5	134	−43		α, δ		
0128+06	01 28 45	06 09·2	1·5	−1·0	QSO?	18	140	−55		α, δ		3C 44
0153+05	01 53 45·5	05 22·7	1·0	−1·0	E 4	13·2	153	−53			NGC 741	
0203+05	02 03 24	05 13·1	0·5		db.	17	155	−53			In small cluster. Jets on red plate?	
0207+09	02 07 08	09 36·1	1·2	−1·0	N	17·2	153	−48				02+0*2*
0217+01	02 17 25	01 41·9	0·5	−0·9	E 7	15·2	163	−54				
0238+08	02 38 25	08 31·4	1·3	−0·7	db.	14·8	163	−45		α, δ	NGC 1044. Radio position 1′ north foll.	
0251+18	02 51 04	18 52·9	0·6	−0·7	QSO?	18	159	−35				
0255+05	02 55 03·0	05 49·5	5·9	−0·8	db.	14·8	170	−45	2, 9, 12, 13	α, δ	Radio position 1′ south following	3C 75
0255+13	02 55 47·3	13 22·3	0·5	−0·6	E 4	16·5	164	−39			In large cluster	
0259+01	02 59 04	01 43·5	0·5	−1·2	D	18·5	175	−47	12		In cluster	02+0*11*
0300+16	03 00 27	16 14·8	3·2	−0·6	E	16	163	−36		α		3C 76·1
0305+03	03 05 49·1	03 55·2	7·6	−0·5	D	14·7	175	−45	2, 9, 12, 18	α, δ	NGC 1218. P	3C 78

0307+16	03	07	11·0	16	54·6	5·3	−0·9	E	19	164	−34	8, 10, 18	α, δ		3C 79
0320+05	03	20	41·5	05	23·6	2·9	−0·8	g	20	177	−41		α, δ	Scintillates	
0325+02	03	25	18·8	02	23·4	4·7	−0·7	D	15	181	−41	10, 11, 18	α		3C 88
0340+04	03	40	51·5	04	48·4	2·5	−0·9	QSO	18·1	182	−38	16	α, δ	P	3C 93
0342+15	03	42	27	15	18·1	0·6	−0·9	S	17·7	173	−30				
0347+13	03	47	15	13	10·3	0·5	−1·4	QSO?	19	176	−31				
0348+17·0	03	48	23	17	02·4	0·5		E 3	17·0	173	−28				
0348+17·6	03	48	25	17	34·8	0·7	−0·5	g	18	172	−27			Diffuse object of low surface brightness	
0356+10	03	56	10·2	10	17·5	10·8	−0·7	E	15·0	180	−31	2, 6, 9, 18	α	P	3C 98
0359+19	03	59	19·5	19	21·0	0·8	−0·7	E	16·8	173	−24			In small cluster	
0422+08	04	22	59	08	27·4	1·5	−0·7	E	17·7	186	−27				
0430+05	04	30	32·5	05	15·1	4·4	−0·1	D	15·0	190	−27		α, δ	Flat spectrum, highly polarized. Scintillates	
0505+03	05	05	00	03	02·6	1·0	−0·7	g	19·5	198	−21		α		
0511+00	05	11	32·2	00	53·2	3·0	−0·9	E	18	200	−21		α		3C 135
0518+16	05	18	16·5	16	35·5	9·3	−0·4	QSO	18	187	−11	15	α, δ		3C 138
0531+19	05	31	48·2	19	25·4	6·3	−0·4	E	17·7	186	−7		α, δ		
0758+14	07	58	44·1	14	23·0	2·7	−1·0	QSO	17·5	208	22	15	α, δ		3C 190
0802+10	08	02	03·8	10	24·0	2·0	−1·1	QSO	18·4	212	21	15	α, δ		3C 191
0812+13	08	11	58·5	13	07·4	1·7	−0·8	E	18·0	210	24				
0812+02	08	12	47·5	02	04·3	2·0	−0·9	QSO?	18·5	221	20		α, δ	Scintillates	08+02
0818+17	08	18	53	17	58·0	1·9	−0·6	g	19	206	28		α, δ	Scintillates	
0819+06	08	19	52·1	06	06·8	2·3	−1·1	E	17·4	218	23	9, 18	α, δ	P	3C 198
0838+13	08	38	02·9	13	23·2	2·6	−0·7	QSO	18·2	213	30	15	α, δ		3C 207
0845+06	08	45	57	06	06·2	1·1	−0·9	E	18·2	221	29				
0850+14	08	50	23	14	04·0	2·6	−1·0	QSO	17·4	214	33	16	α	Scintillates	3C 208
0855+14	08	55	55·7	14	21·4	2·6	−0·8	N	21	214	35	7, 8, 15	α, δ		3C 212
0903+16	09	03	44·1	16	58·3	1·4	−0·9	QSO	18·3	212	37	15	α, δ		3C 215
0917+18	09	17	25·5	18	06·6	1·0	−0·8	D	17·0	212	41			Very extended envelope	
0922+14	09	22	22·3	14	57·4	0·7	−1·0	QSO	18·0	217	41	4	α	P	
0932+02	09	32	41·8	02	16·3	0·8	−1·0	E	17·5	232	37				09+04
0945+07	09	45	06	07	39·4	7·8	−0·8	N	17	229	42	11	α		3C 227
0947+14	09	47	26	14	34·8	3·5	−0·9	QSO¶	18	220	46	16			3C 228

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

† For explanation of numbering of references, see corresponding footnote at end of table (p. 382).

‡ The symbols α (R.A.) and δ (Dec.) indicate that accurate positions due to Shimmins, Clarke, and Ekers were available (see text, Section II).

§ Occurrence of P in this column indicates that the position quoted is taken from one of the published references.

¶ *Note added in proof*. Later more precise radio position measurements have suggested that this "identification" is probably incorrect.

TABLE 1 (*Continued*)

Parkes Catalogue Number	Optical Position (1950·0) R. A. h	m	s	Dec. °	′	Flux Density at 1410 Mc/s (flux units)*	Spectral Index	Type	m_{pg}	Galactic Coordinates l^{II} °	b^{II} °	References†	Transit Position Data‡	Remarks§	Other Cat. No.
0957+00	09	57	43·8	00	19·8	1·0	−0·9	QSO	17·6	239	41	4	α, δ	P	
1040+12	10	40	05·9	12	19·3	3·0	−0·7	QSO	18	233	56	7, 14, 19	α, δ		3C 245
1055+01	10	55	55·5	01	49·7	3·8	−0·1	QSO?	18	251	53				10+*010*
1107+10	11	07	10	11	00·1	1·7	−0·8	QSO?	18·5	243	61		α, δ		
1111+11	11	11	56·5	11	06·8	0·8	−1·2	db.	18·2	244	62				
1116+12	11	16	20·8	12	51·1	1·9	−0·6	QSO	19·3	242	64	4	α	P	
1137+12	11	37	54	12	20·0	1·6	−0·8	E 3	16·5	252	68				
1139+18	11	39	02	18	50·2	0·6	−0·9	E 2	18	237	72				
1142+19	11	42	29·7	19	53·1	5·5	−1·0	E	13	236	73	10, 11, 18	α, δ	NGC 3862. P. In small cluster	3C 264
1150+11	11	50	26	11	25·6	0·7	−0·9	E	18·2	259	69			In small cluster	
1151+09	11	51	33	09	58·2	0·6	−1·1	D	17·4	262	68				
1209+12	12	09	11	12	37·4	0·6	−1·2	E	19	269	73				
1215+03	{12	15	07	03	56·0}	2·2	−1·0	{D	17}	283	65	7	α, δ	In small cluster	12+*04*
	{12	14	58·3	03	53·8}			{E	17·4}						
1216+06	12	16	50·0	06	06·1	16·5	−0·6	E	12·0	282	67	2, 9, 12	α, δ	NGC 4261	3C 270
1217+02	12	17	38·4	02	20·3	0·8	−0·9	QSO	16·5	285	64	4		P	12+*07*
1218+09	12	18	01	09	44·5	1·1	−1·1	db.	19·5	279	71				12+*06*
1222+13	12	22	31·5	13	09·9	6·6	−0·6	E	9·3	278	74	11	α, δ	M 84	3C 272·1
1226+02	12	26	33	02	19·6	41	−0·1	QSO	13	290	64	15, 17	α, δ		3C 273
1228+12	12	28	18	12	40·1	210	−0·8	E 2	9·9	284	74	3		M 87. P	3C 274
1233+16	12	33	57·5	16	48·8	2·2	−1·1	db.	18·0	284	79		α, δ	In small cluster	
1241+16	12	41	27·7	16	39·3	2·9	−0·9	QSO	19·0	293	79	15	α, δ	Near NGC 4651	3C 275·1
1249+09	12	49	11	09	12·6	1·8	−0·9	E	19	303	72		α		
1252+11	12	52	07·9	11	57·3	1·2	−0·1	QSO	16·6	306	75	4	α, δ	P	
1313+07	13	13	46	07	18·4	2·2	−0·8	D	15·5	320	69		α, δ	In small cluster	13+*05*
1318+11	13	18	49	11	22·8	2·5	−0·7	QSO?	19	328	73		α, δ		
1320+03	13	20	46	03	23·8	1·4	−1·0	D	19·5	322	65		α, δ	In small cluster?	
1326+06	13	26	43	06	56·4	0·4	−1·3	QSO?	16	328	68				
1330+02	13	30	21	02	16·1	2·9	−0·7	N	19	326	63	15	α, δ		3C 287·1
1340+05	13	40	12	05	19·4	1·9	−0·9	N	17·8	334	65		α, δ		

1341+14	13 41 55	14 23·7	1·4	−1·1	QSO?	18	349	72				
1345+12	13 45 06·2	12 32·3	5·3	−0·5	SO	17·0	347	70		α, δ		
1346+09	13 46 03	09 59·5	0·8		QSO?	18	343	68				
1352+16	13 52 16	16 27·2	1·3	−1·0	D	18·4	0	72		α		3C 293·1
1354+01	13 54 29·5	01 19·8	1·9	−0·8	E	18·2	337	60		α, δ		13+01*2*
1407+17	14 07 36	17 46·8	1·6	−1·2	E 3	13·4	9	70		α	NGC 5490	
1411+09	14 11 33	09 29·3	1·3	−0·8	E	18·3	354	64		α, δ		
1414+11	14 14 26·6	11 02·4	4·7	−1·0	E 2	13·3	358	64		α	NGC 5532. Curved spectrum	3C 296
1416+06	14 16 38·8	06 42·4	6·2	−1·1	QSO	16·8	352	61	1, 15	α, δ	P	3C 298
1420+19	14 20 39·5	19 49·3	4·1	−0·9	E 5	18·8	18	68		α, δ		3C 300
1427+07	14 27 28	07 28·5	2·1	−1·0	E	15·6	357	59		α, δ	Radio position 1′ following	
1446+00	14 46 07	00 30·6	1·7	−0·7	E	19·2	354	51		α, δ		
1452+16	14 52 03	16 33·7	1·6	−0·7	E 3	14·9	19	60		α, δ		3C 306
1455+11	14 55 38	11 57·3	0·5	−0·8	QSO?	19	12	57			Extended source?	
1514+00	15 14 15	00 26·1	2·5	−0·6	QSO?	18·8	1	46				15+0*6*
1514+07	15 14 17·0	07 12·3	5·6	−1·2	E 3	16·0	9	48	2, 12, 18		P	3C 317
1518+04·7	15 18 45·7	04 40·8	4·3		g	18·2	7	48		α, δ	Diffuse object of low surface brightness	
1559+02	15 59 55·7	02 06·2	7·4	−0·9	D	17·0	13	38	2, 9, 18	α, δ	P	3C 327
1603+00	16 03 39·5	00 08·5	2·2	−0·9	E 4	16·5	11	36	21	α		16+0*3*
1618+17	16 18 07	17 43·5	2·2	−0·9	QSO	16·4	33	41	15, 21	α, δ		3C 334
1641+17	16 41 34·1	17 21·2	3·4	−0·8	E 3	17·5	35	36		α, δ		3C 346
1648+05	16 48 40·0	05 04·6	46	−1·0	D	19·0	36	34	9, 20	α, δ	Herc A. P	3C 348
1739+17	17 39 25·3	17 21·7	1·7	−0·9	D	15	41	23		α, δ		
1834+19	18 34 29	19 41·0	1·8	−0·7	E	14	49	12				
1836+17	18 36 12·8	17 09·1	7·6	−0·6	D	16	47	11	10, 11, 18	α, δ	P	3C 386
1949+02	19 49 44	02 22·7	5·1	−0·8	SO	16·5	42	−12	16, 21	α, δ	Incorrectly identified as QSO (16)	3C 403
2045+06	20 45 44·7	06 50·1	2·6	−0·9	E	18·4	54	−22	12, 21	α, δ	In cluster	3C 424
2103+12	21 03 48	12 28·0	1·4	−0·5	SO	17·3	62	−22		α, δ		
2120+16	21 20 25	16 51·7	1·7	−1·2	QSO?	18·8	68	−23		α, δ	Or faint galaxy 0′·2 preceding	3C 432
2123+00	21 23 13	00 42·8	0·7	−0·8	db.	17·5	54	−33				

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

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‡ The symbols α (R.A.) and δ (Dec.) indicate that accurate positions due to Shimmins, Clarke, and Ekers were available (see text, Section II).

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2148+12	21	48	31·5	12	08·7	1·4	−0·7	QSO?	17	69	−31				
2201+04	22	01	46·5	04	25·3	1·0	−0·4	E 2	16	65	−39				
2209+08	22	09	32·5	08	04·5	1·9	−0·6	QSO?	18·5	70	−38		α, δ	E galaxy 1′ north	
2212+13	22	12	19·5	13	35·7	3·7	−0·9	db.	14·3	75	−34	11, 18		NGC 7236–7	3C 442
2217+12	22	17	34	12	52·9	0·8	−0·6	S	18·5	76	−36				
2230+11	22	30	07·7	11	28·4	6·7	0·0	QSO	17·3	77	−39	16, 19, 21	α, δ	Curved spectrum. P	CTA 102
2238+12	22	38	05	12	56·7	0·5	−1·0	E	18·4	81	−39				
2247+11	22	47	23	11	20·2	2·7	−0·9	E	14·4	82	−41		α, δ	In cluster	
2248+06	22	48	15·1	06	46·0	1·6	−0·8	E 2	18·5	78	−45		α		22+09
2249+18	22	49	07	18	32·6	2·4	−0·8	QSO?	18	87	−36		α, δ		3C 454
2252+12	22	52	34	12	57·3	3·2	−0·9	E 3	15·2	84	−41	21	α, δ		3C 455
2254+16	22	54	39	16	43·6	1·4	−0·8	E	18·2	88	−38				
2308+07	23	08	10	07	18·0	1·7	−0·9	E	14·9	84	−48		α, δ		23+02
2314+03	23	14	02·6	03	49·0	4·6	−0·9	N	18	83	−51	8, 10, 15, 18	α, δ	Scintillates	3C 459
2318+07	23	18	04	07	57·2	0·8	−0·7	E	12·8	88	−48			NGC 7626	
2318+02	23	18	18	02	39·9	0·7	−0·8	QSO?	19	88	−53			E galaxy 1′ south following	
2328+10	23	28	09	10	44·0	1·2	−0·4	QSO?	18	93	−47		α		
2345+18	23	45	57	18	27·6	1·8	−1·1	E	19·5	103	−42		α, δ		3C 467
2350+05	23	50	16	05	43·7	1·3	−0·3	SO	17·3	98	−54				
2357+00	23	57	25	00	25·0	0·5	−1·1	db.	16	97	−60				

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

† References to previous identifications and optical data are: 1. Adgie (1964); 2. Bolton (1960); 3. Bolton, Stanley, and Slee (1949); 4. Bolton *et al.* (1965); 5. Dewhirst (quoted by Elsmore 1959); 6. Harris and Roberts (1960); 7. Hazard, Mackey, and Nicholson (1964); 8. Longair (1965); 9. Maltby, Matthews, and Moffet (1963); 10. Matthews (quoted by Schmidt 1965*a*); 11. Matthews, Morgan, and Schmidt (1964); 12. Mills (1960); 13. Minkowski (1960); 14. Ryle and Sandage (1964); 15. Sandage (1965); 16. Sandage and Wyndham (1965); 17. Schmidt (1963); 18. Schmidt (1965*a*); 19. Schmidt (1965*b*); 20. Williams, Dewhirst, and Leslie (1961); 21. Wyndham (1965).

‡ The symbols α (R.A.) and δ (Dec.) indicate that accurate positions due to Shimmins, Clarke, and Ekers were available (see text, Section II).

§ Occurrence of P in this column indicates that the position quoted is taken from one of the published references.

measurements are available, these are quoted and are indicated by the letter P in the Remarks column. In the case of double galaxies, the mean position is given. The type of optical object is indicated in column 6. The classification db. (for dumb-bell or close pair of galaxies) and the subdivision of ellipticals into E and D (the latter indicating a diffuse outer envelope) follows that of Matthews, Morgan, and Schmidt (1964). However, the old classification SO is retained for spherical systems where there is a suggestion of a dust lane. S indicates a spiral galaxy, and g is used for galaxies too faint for reliable classification. QSO is used to indicate a quasi-stellar object that has been confirmed by photoelectric observation of an ultraviolet excess, while QSO? indicates a suggested new identification. The photographic magnitudes, either estimated or previously published as explained in Section II, are given in column 7. Visual magnitudes are quoted for quasi-stellar objects.

The radio data are taken from the DSEC catalogue; flux densities at 1410 Mc/s are given in column 4, and the mean spectral indices in the frequency range 400–2650 Mc/s, where available, are given in column 5.

The new galactic coordinates of the radio sources are given in columns 8 and 9.

For sources that have been previously identified, the number in column 10 refers to the original publication (see footnotes to table). The symbols α (right ascension) and δ (declination) in column 11 indicate that accurate positions due to Shimmins, Clarke, and Ekers were available (see Section II, paragraph 3).

Additional points of interest (e.g. radio polarization or peculiar radio spectrum) are noted in column 12. "Scintillates" indicates that a source shows radio scintillations that are believed to be of interplanetary origin and are an indication of very small angular size. The scintillation data are provided by unpublished observations of R. D. Ekers. Not all the sources listed have been studied for scintillations, and the absence of "scintillates" should not be taken to imply that a source does not scintillate.

(c) *Finding Charts*

Plates 1–14 contain finding charts for 109 of the identified objects that are fainter than 16^{m}, and they include previously identified sources. The charts were prepared by photography of the Sky Survey prints, and contrast has been deliberately increased over that of the original prints. In general, the "E", or red, print has been used for galaxies and the "O", or blue, print for QSO's. In some cases, the finding charts are slightly off centre of the identification in order either to include a bright star within the area or to avoid flaws in the original prints.

IV. Discussion

(a) *Radio Luminosity of Identified Sources*

Red shifts and distance measurements are not yet available for most of the galaxies and quasi-stellar objects that have been tentatively identified with radio sources, so that no direct measurement of absolute optical and radio magnitude is possible. Existing data have shown, however, that the mean absolute photographic magnitude M_{pg} of those galaxies that have had red shifts measured lies close to -21, and there is dispersion of considerably less than one magnitude about this mean. If this value is adopted for all the galaxies in the present sample, then an estimate can be obtained for the absolute radio magnitude M_r or the radio luminosity P for each source.

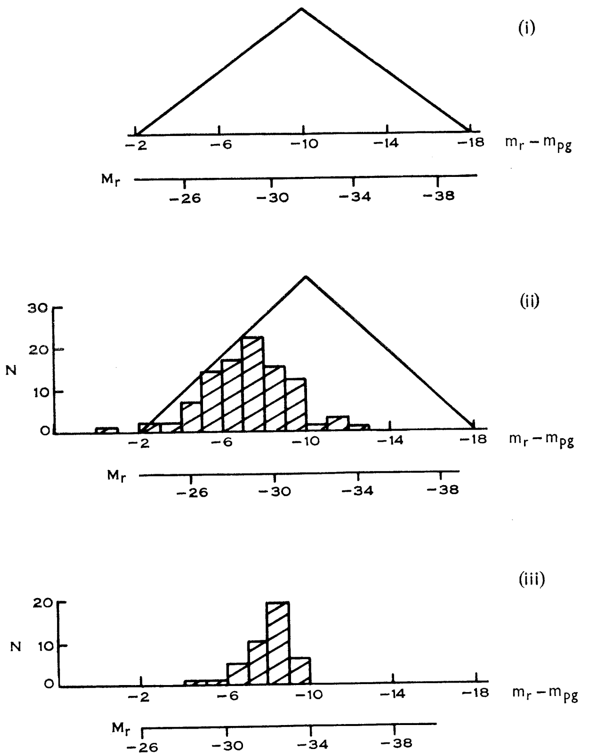


Fig. 1.—Luminosity distributions. (i) Model luminosity distribution for radio galaxies; the lower scale is absolute radio magnitude assuming all the galaxies have an absolute photographic magnitude of -21; (ii) distribution of identified galaxies as a function of $m_r - m_{pg}$; (iii) distribution of identified quasi-stellar objects as a function of $m_r - m_{pg}$; the lower scale is absolute radio magnitude assuming all the objects have an absolute photographic magnitude of -24.

Neglecting differential effects of red shifts on radio and optical magnitudes, we have:

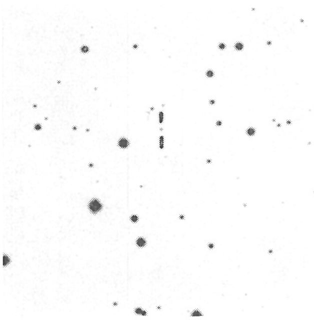
$$m_r - M_r = m_{pg} - M_{pg}$$

or

$$M_r = -21 + (m_r - m_{pg}).$$

Here we define m_r, the apparent radio magnitude, by setting $m_r = 10{\cdot}5$ for a flux density of 10^{-26} W m^{-2} (c/s)$^{-1}$ at 1410 Mc/s. This corresponds closely to the original

Plates 1–14.—Finding charts for 109 of the identified sources. The object with which the source is identified is shown by short bars. The scale is 5 mm = 1′ arc. North-east is at the top left-hand corner.



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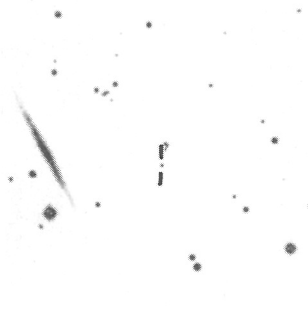

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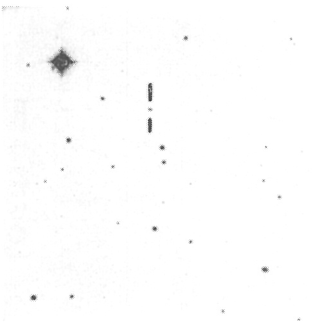

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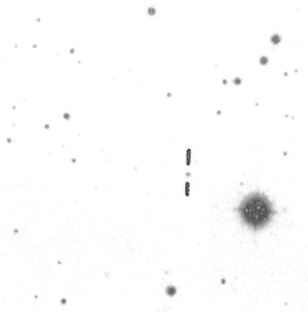

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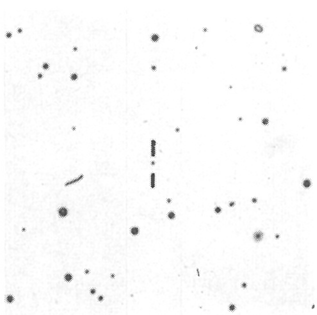

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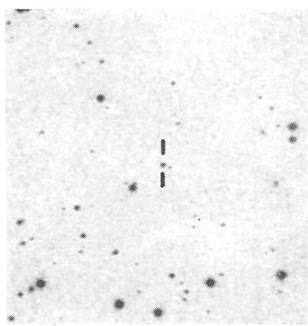

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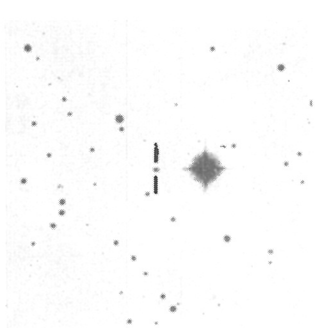

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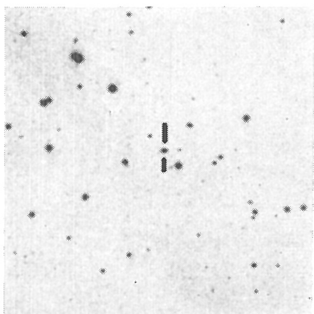

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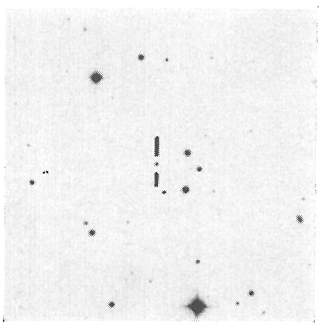

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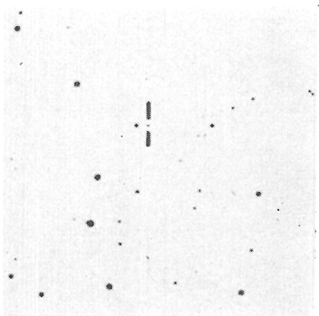

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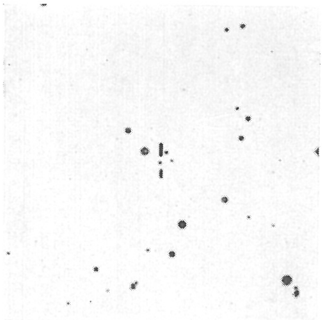

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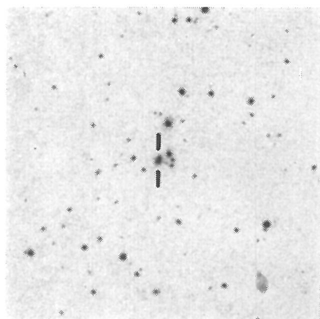

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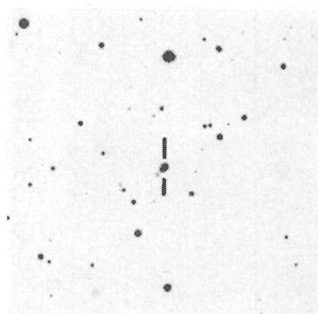

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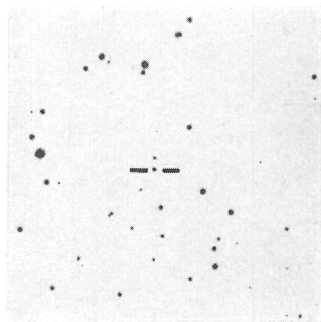

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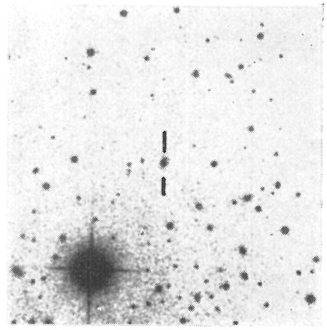

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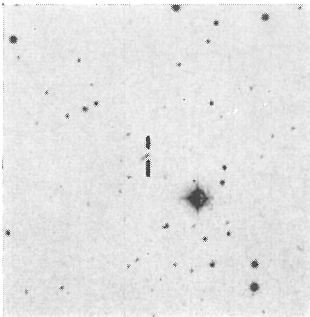

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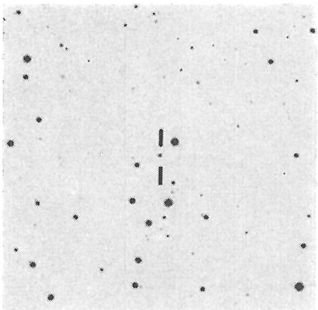

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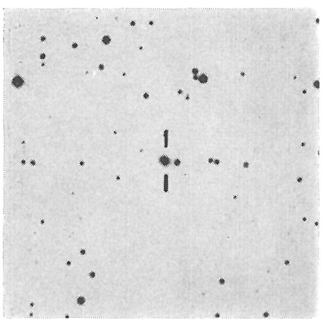

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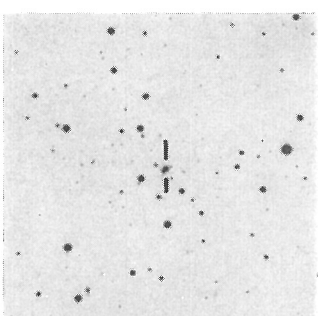

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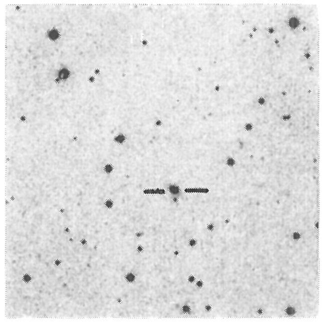

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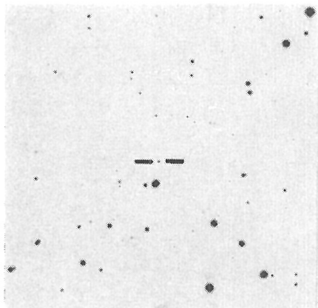

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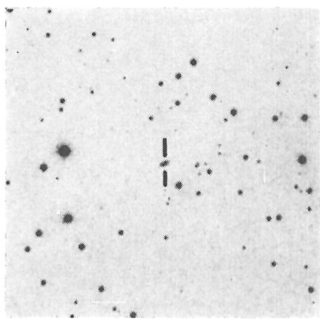

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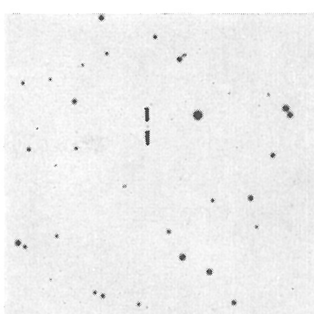

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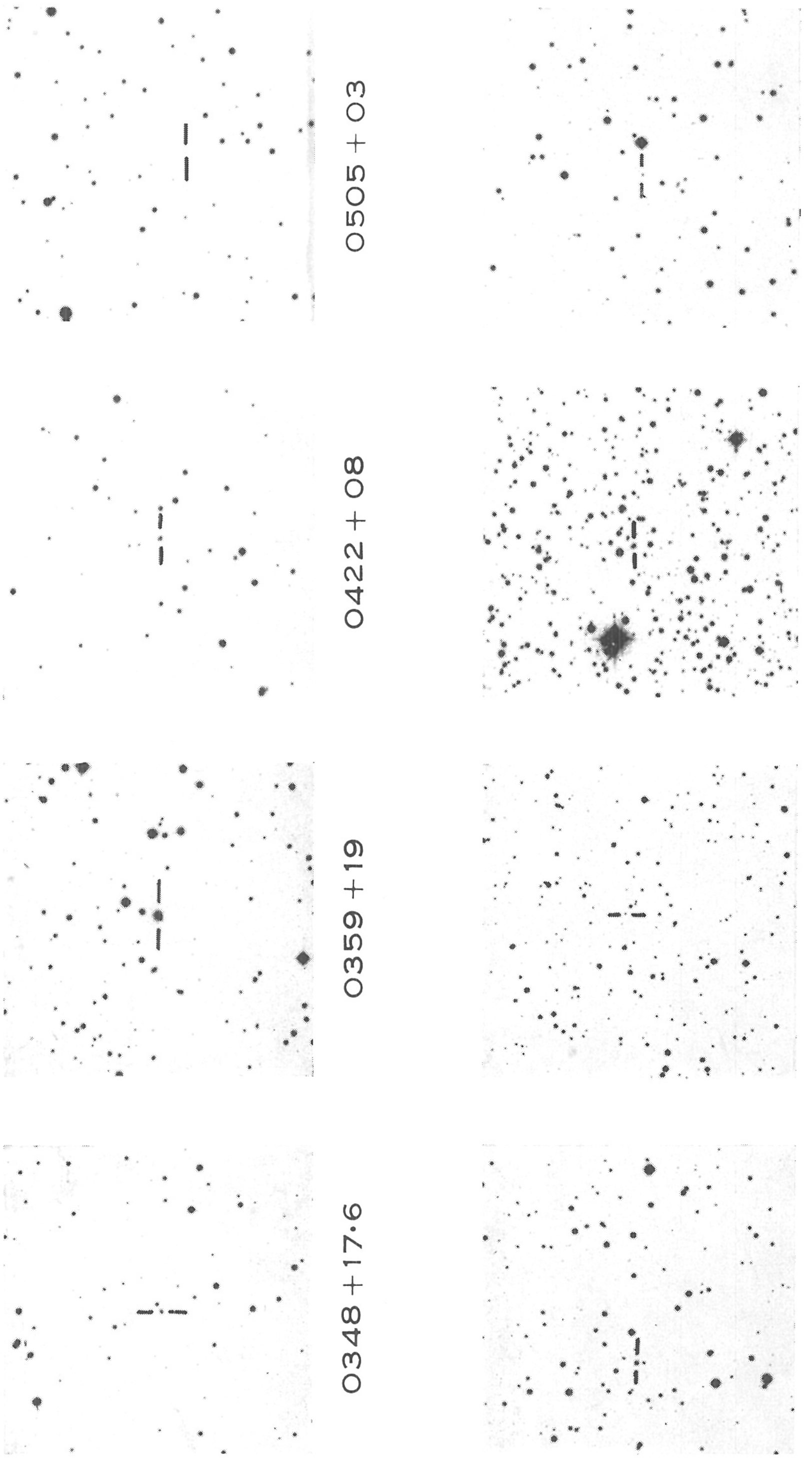
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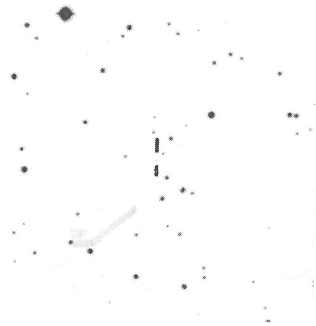

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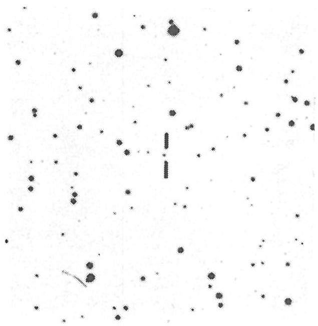

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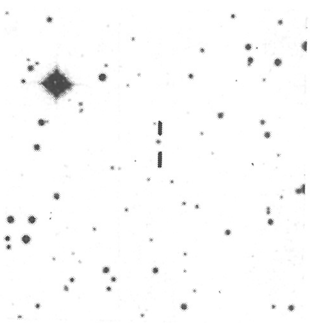

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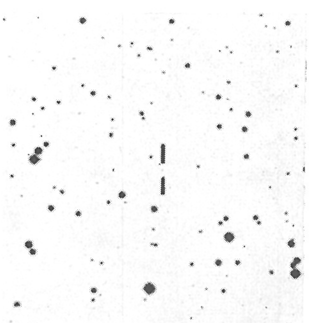

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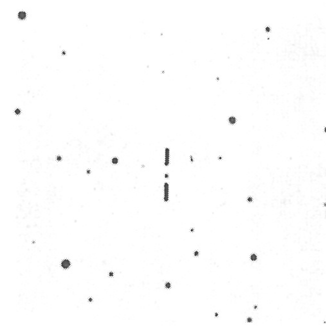

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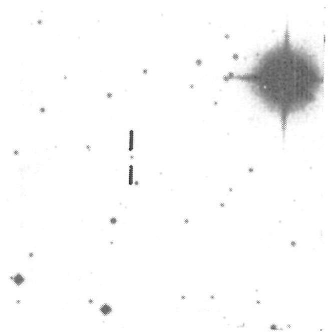

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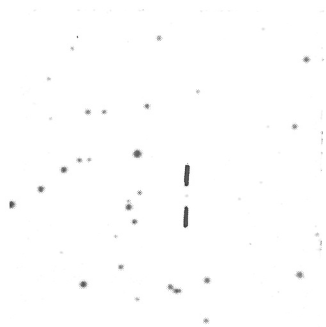

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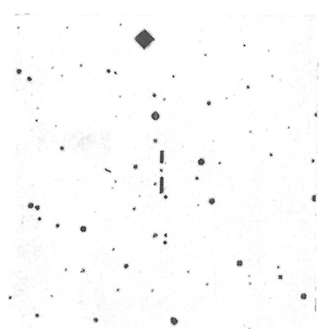

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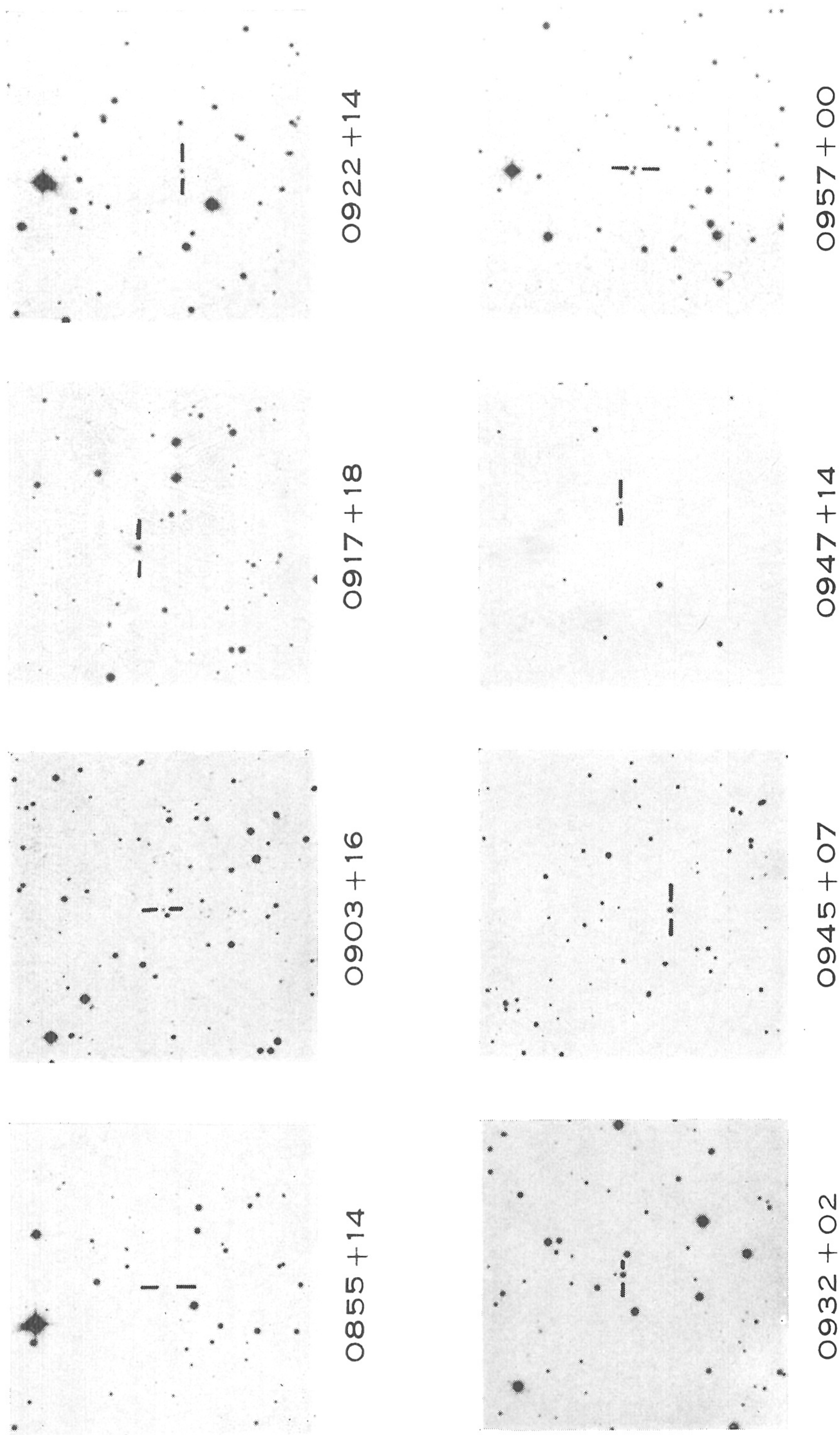
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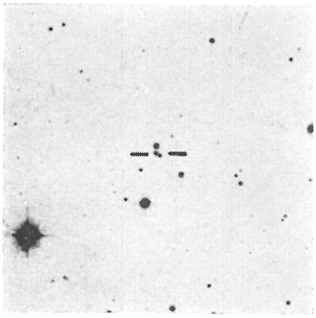

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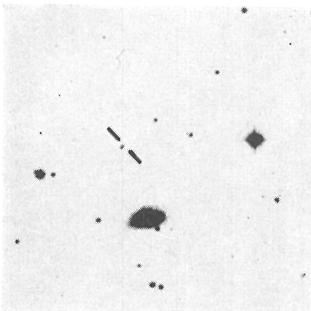

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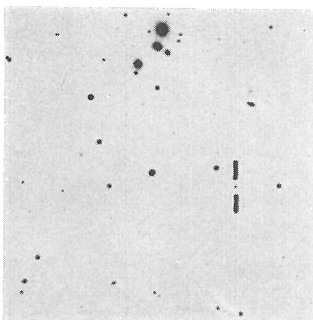

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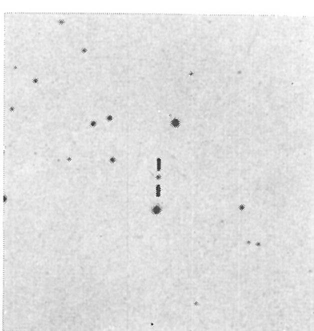

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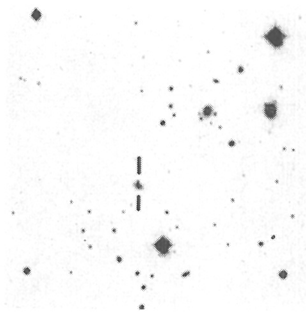

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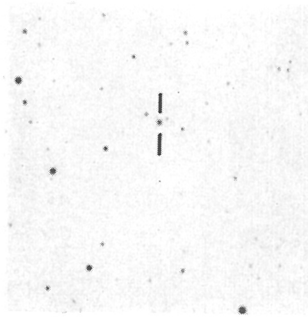

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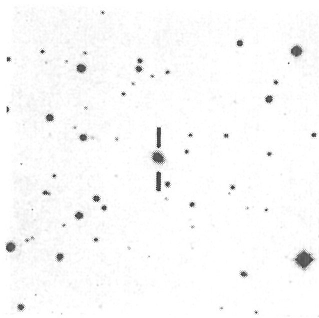

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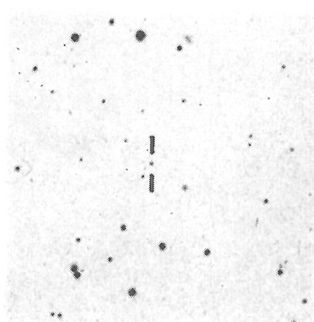

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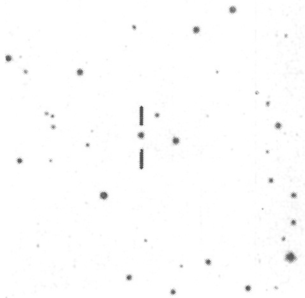

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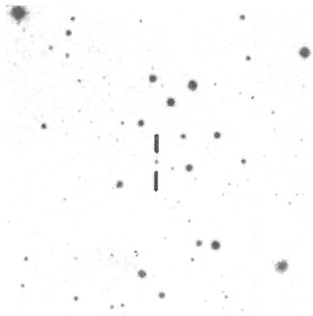

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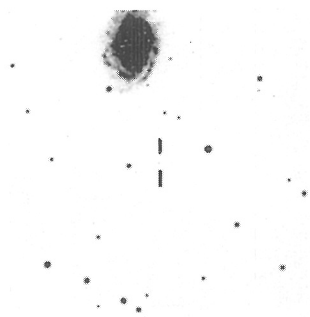

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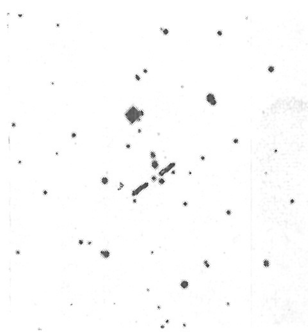

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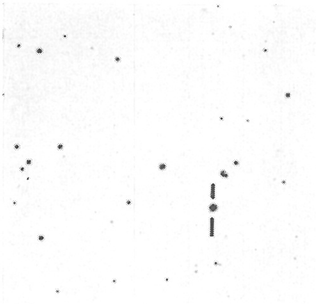
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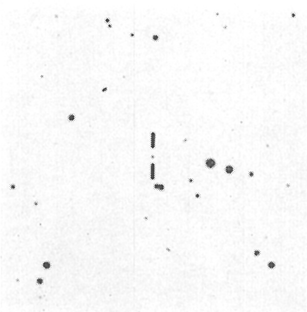
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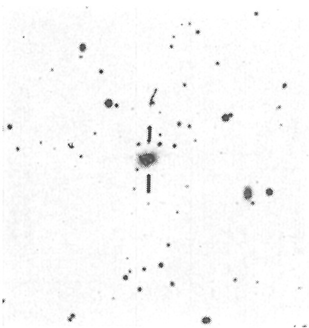
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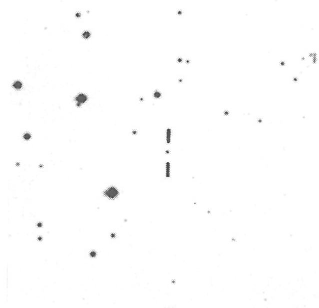
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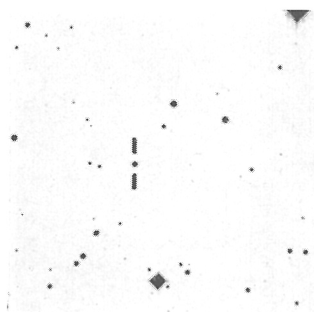
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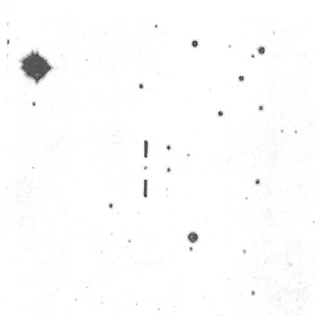
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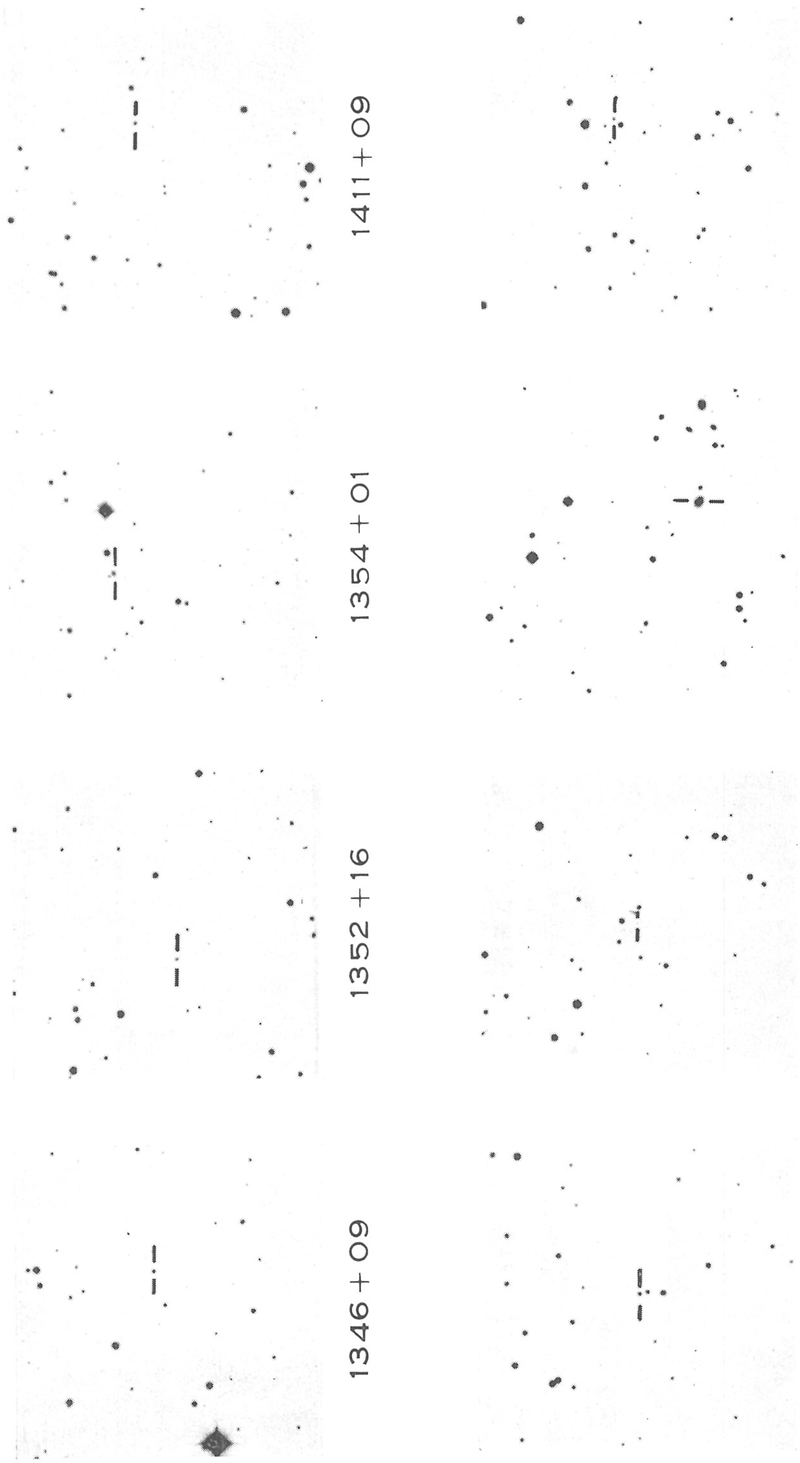
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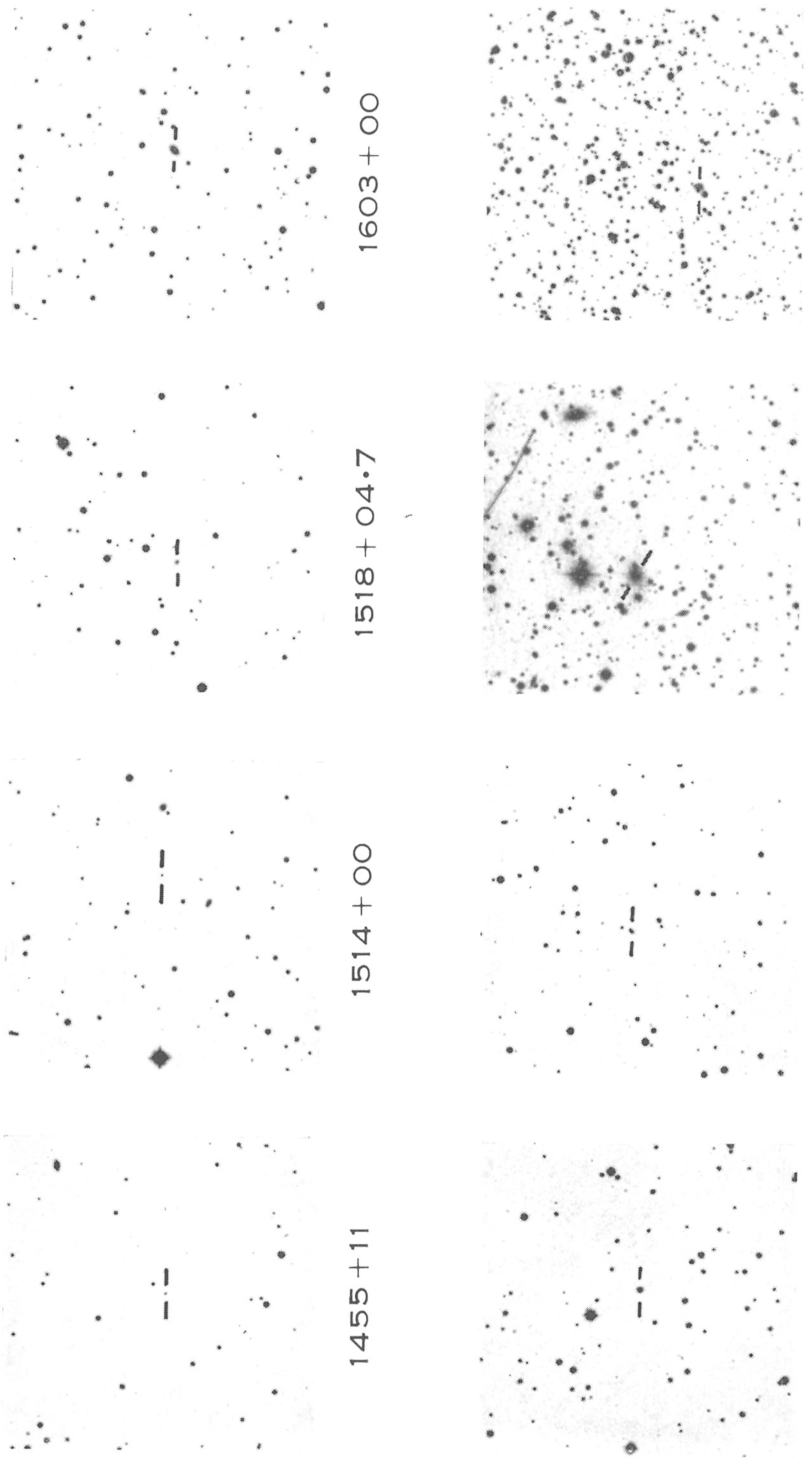
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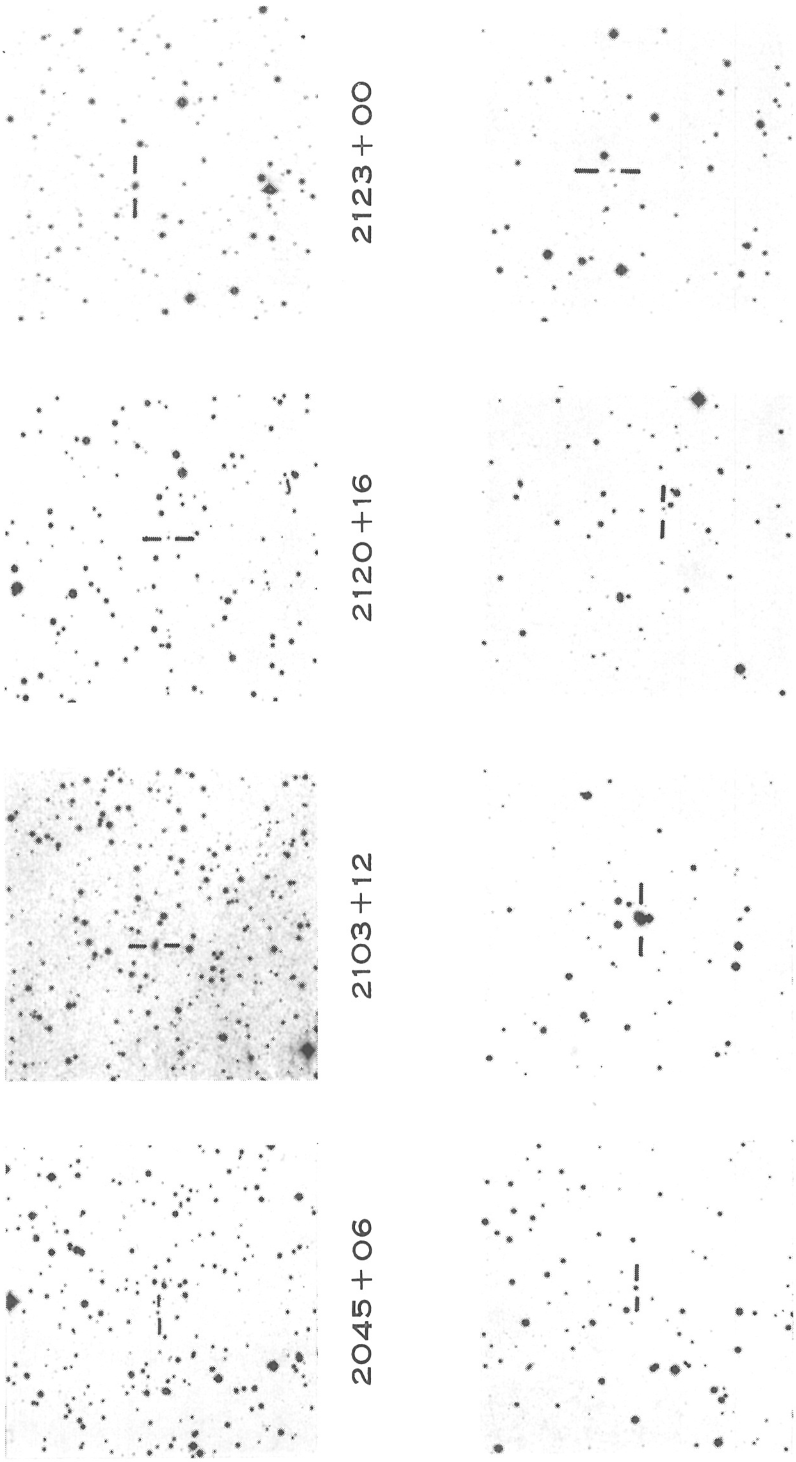
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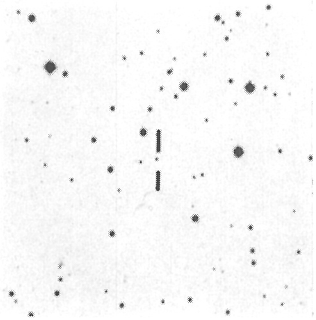

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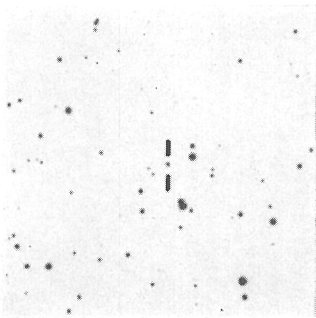

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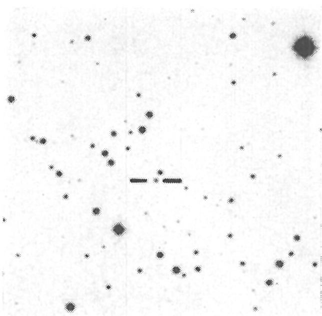

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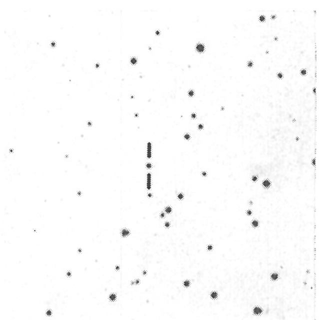

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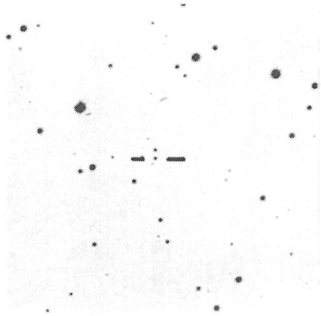

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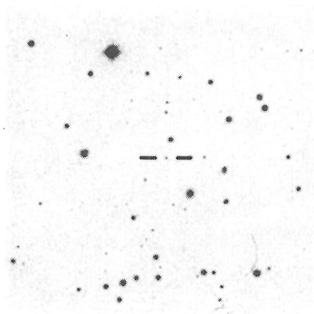

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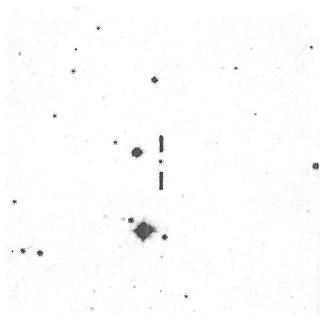

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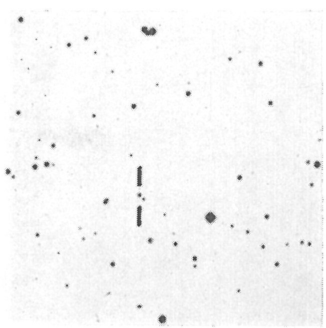

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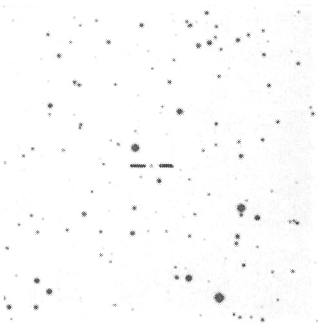

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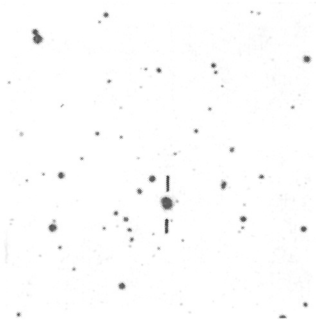

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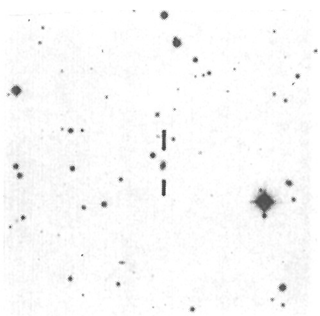

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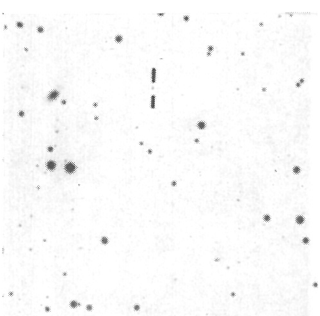

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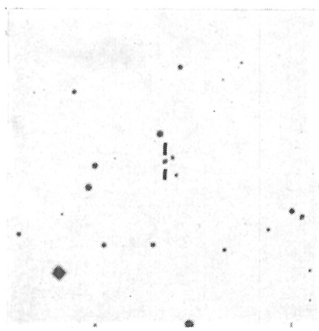

1139+18

definition by Hanbury Brown and Hazard (1951) at 160 Mc/s when allowance is made for a mean spectral index of $-0 \cdot 8$.

From a detailed study of all the sources in the Revised 3C catalogue that have flux densities greater than 20×10^{-26} W m^{-2} (c/s)$^{-1}$ and that are not in low galactic latitudes, Clarke (1964*b*) has found that between 25% and 35% are probably quasi-stellar objects. For the remainder, which are presumably galaxies, a simple form of luminosity distribution was proposed. This luminosity distribution, which is shown in Figure 1(i), is also compatible with the distribution of $\log P$ derived directly using measured red shifts (see, for example, Ryle 1963).

From this model luminosity distribution, we may calculate the number of identifications to be expected with galaxies for the sources in the DSEC catalogue, again assuming that 30% of the total number are quasi-stellar objects. Of the 418 objects in field classes I, II, and III, i.e. unobscured regions, it is estimated that 51 would be identified with galaxies brighter than 17^{m}. This is in fair agreement with the observed number of 44, in view of the small number of identifications used for the original model and the statistical uncertainties in the observed number. It was shown earlier that, on the basis of positions with 1′ arc accuracy, there was a probability of $0 \cdot 01$ of making a false identification with a galaxy brighter than 17^{m}, so out of 418 objects four such misidentifications could be expected. The actual number is unlikely to be as high as this, since most of the identifications are supported by more precise positions than those of the DSEC catalogue.

Values of $m_{\mathrm{r}}-m_{\mathrm{pg}}$ have been calculated for all the proposed identifications with galaxies, and these are shown as a histogram in Figure 1(ii). If sources have been incorrectly identified, the value of $m_{\mathrm{r}}-m_{\mathrm{pg}}$ is an upper limit to the true value, since identifications have generally been made with the brightest likely object in the field. The model luminosity distribution used in the comparison described above is shown superposed on Figure 1(ii), and it is seen to be consistent with the present observations for small values of M_{r} or intrinsically low radio luminosity.

Figure 1(iii) shows the apparent luminosity distribution for the quasi-stellar objects, assuming that their absolute photographic magnitudes are -24. However, this distribution will almost certainly be altered when red shifts are known. The range of M_{pg} for these objects is certainly several magnitudes, moreover some of them are known to vary, thus their radio luminosities can only be determined reliably from the red shifts.

(*b*) *Distribution of Identifications as a Function of Galactic Latitude*

An investigation of the number of identifications occurring at different galactic latitudes disclosed an unexpected difference between the percentage of identifications obtained at high and intermediate latitudes. The results are summarized in Table 2 and have been separated into two groups for sources with flux densities respectively greater than and less than $1 \cdot 5 \times 10^{-26}$ W m^{-2} (c/s)$^{-1}$ at 1410 Mc/s.

The number of QSO identifications is too small to show a significant variation with galactic latitude, but the distribution of the percentage of identifications with galaxies, at galactic latitudes greater than 20°, does appear to differ significantly from that expected for a random isotropic distribution (statistically significant at the 2% level). Sources in the range $|b^{II}| = 40°–60°$ and $|b^{II}| = 20°–40°$ are approximately equally distributed between positive and negative galactic latitudes, and the percentage of identifications does not differ significantly between the two hemispheres. However, almost all the sources at galactic latitudes $|b^{II}| > 60°$ lie to

TABLE 2

DISTRIBUTION WITH GALACTIC LATITUDE OF IDENTIFICATIONS BETWEEN 0° AND +20° DECLINATION

Range of Galactic Latitude	Identified Sources QSO's	Galaxies	Not Identified	Total	Percentage Identified	Percentage Identified with Galaxies
	Strong sources, $S \geqslant 1 \cdot 5 \times 10^{-26}$ W m^{-2} (c/s)$^{-1}$					
60°–90°	6	17	9	32	72	53
40°–60°	9	20	37	66	44	30
20°–40°	9	17	29	55	47	31
10°–20°	1	3	14	18	22	17
	Weak sources, $S < 1 \cdot 5 \times 10^{-26}$ W m^{-2} (c/s)$^{-1}$					
60°–90°	6	12	22	40	45	30
40°–60°	7	12	97	116	16	10
20°–40°	5	13	96	114	16	11
10°–20°	0	0	62	62	0	0

the north of +60° and between $l^{II} = 230°$ and 10°, which is in the same direction as the Virgo cluster. Two of the identifications in this region are with galaxies of $m_{pg} < 10$ and four with galaxies where $10 < m_{pg} < 14$. If these six identifications with relatively nearby galaxies are omitted from the analysis, the excess number of identifications at high galactic latitudes is barely significant.

TABLE 3

DISTRIBUTION WITH GALACTIC LATITUDE OF IDENTIFICATIONS BETWEEN −20° AND −44° DECLINATION

Range of Galactic Latitude	Identified Sources QSO's	Galaxies	Not Identified	Total	Percentage Identified	Percentage Identified with Galaxies
>60°	5	9	39	53	26	17
40°–60°	2	7	23	32	28	22
20°–40°	1	24	59	84	30	29

These results may be compared with the distribution of identifications obtained in the declination zone −20° to −44° (Bolton, Clarke, and Ekers 1965), which is summarized in Table 3. This latter distribution is again not statistically significantly different from that expected for a random isotropic distribution of identifications.

We conclude from the present limited samples of identifications that there is no evidence for galactic obscuration affecting the percentage of identified sources for latitudes greater than 20°.

V. Acknowledgments

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