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PRECISE POSITIONS OF RADIO SOURCES
II. OPTICAL MEASUREMENTS

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ABSTRACT

Optical positions of forty-one identified radio sources have been measured on 48-inch Schmidt plates or, where crowded or faint, on 200-inch plates. Reductions were made relative to an average of twenty-one standard stars within 1° of each source position. Positions of the standards were updated by proper-motion corrections to the epoch of each plate, retaining the equinox of 1950.0.

Internal rms errors average 0″.3 in each coordinate. The positions, listed in a table, are on the system of the AGK3, which itself is on the FK4 system.

Six new optical identifications have been made. NRAO 140, PKS 1508−05, and 3C 343 are probably QSSs. The first two are bright ($m_{pg} \simeq 17$, and $m_{pg} \simeq 16$). The image of 3C 343 is exceedingly faint ($V \simeq 22$) and may be connected by a bridge (unconfirmed) to a nearby twenty-first magnitude galaxy which itself is a member of a small group. The remaining three new identifications (3C 256, 3C 343.1, and NRAO 530) are probably galaxies, with a possibility that the last is in a cluster. Two previously suggested identifications (3C 256, 0056−17) are found to be incorrect.

Six fields remain empty brighter than $m_{pg} \simeq 21.0$. Of these, PKS 2127+04 is particularly interesting because a cluster of galaxies may be present near the radio position just at the plate limit but so faint as to be unmeasurable on the Schmidt blue plates. No confirmatory 200-inch plates are yet available.

I. INTRODUCTION

Wade's new radio-source positions (Wade 1970, hereinafter called Paper I) have internal errors of less than 1″ in both coordinates. This precision permits almost certain optical identification on the basis of position coincidence alone. Because Wade's results promise a major new advance in the identification of faint sources, it is important to determine the *external* errors of the radio positions in as many ways as possible. As one test, we have measured the optical positions of previously known sources listed in Paper I. The assumption here is that the optical and radio emissions arise from the same spatial region, which is reasonable at the 2″ level because all sources in Paper I are unresolved in radio wavelengths to this limit.

Optical positions for some of the identified sources in Paper I have previously been measured by Griffin (1963), Veron (1966), Bolton (1968), Murray, Tucker, and Clements (1969), Lü and Fredrick (1967, 1968*a*, *b*), and Lü (1969). We have extended these measurements to all sources in Paper I, and have taken several precautions to reduce the optical errors to a level where a comparison with Wade's positions is significant. Comparison with previous position measurements will be made in the paper following (Sandage, Kristian, and Wade 1970, hereinafter called Paper III).

II. THE POSITION MEASUREMENTS

To achieve the required accuracy of less than ±0″.5 requires (1) adequate plate scale, (2) good optical images, and (3) knowledge of the positions of comparison stars updated with proper motions to the epoch of our plates.

Measurements were made on 48-inch Schmidt plates (scale of 67″.12 mm^{-1}), most of them taken specifically for this program. Most of the plates were unfiltered 103*a*-O or IIa-O emulsions. The image quality was usually excellent, with crisp edges and low plate grain. Measurements were made with a dual long-screw, digitized Mann measuring ma-

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chine with the plate in at least two cardinal orientations for all except five fields, three of them empty, and in most cases in four position angles. In each orientation, an average of five measurements was made of the source, so that typically twenty individual measures of each source were made. Tests showed that the measuring reproducibility was 2 μ (rms) on the plates, which gives rms errors due to measurement alone of $0\farcs15$.

An external test of the measuring error and of any difference in personal equation is available from nine plates measured at least once by each of us. The mean difference in final positions is $\langle JK-AS \rangle = +0\farcs1$, with an rms difference of $0\farcs24$ in each coordinate.

Two special precautions were taken in the reduction of the data. (1) Many comparison stars were used, placed as symmetrically as possible about the radio source. In each field, all available AGK2 stars within 1° of the source were located and measured as standards. The average number of standard stars used was twenty-one, with a spread (mean difference) of six. The smallest number was eleven, and the largest was forty-four. (2) The tabulated AGK2 positions are for the equinox 1950.0, but for the epoch about 1930. Because proper motions are not included in the AGK2, these positions cannot be used, since our plates have a typical epoch of 1968. In twenty-six of the fields, positions of the standards were updated to the *epoch* of each plate by applying proper-motion corrections from the unpublished AGK3. We are most indebted to Professor W. Dieckvoss for supplying the very large amount of proper-motion data and AGK3 positions for all standard stars in these fields before publication. For the remaining fields, most of which were south of the declination limit of the AGK3, positions and proper motions were taken from the *Smithsonian Astrophysical Observatory Star Catalogue*, and again the positions were updated to the epoch of the plates and the equinox of 1950.0 was retained.

A least-squares fit was made of δ and $15\alpha \cos \delta$ for the standard stars to a general second-order polynomial in x and y. An iterative procedure was used, and those standards whose calculated positions differed by more than fixed values from the adopted catalog coordinates were progressively discarded. In the first iteration, gross errors of measurement or identification were discarded, and the solution was rerun. Next, stars which deviated by more than $5''$, $3''$, $1\farcs5$, and $1''$ were progressively discarded, and the convergence of the source position for each rerun was noted.

The rms deviation of the residuals of the standard star positions relative to the adopted polynomial in x and y averaged $0\farcs42$ for all fields. This error, which corresponds to 6 μ on the plate, represents a combination of (1) measuring errors for the standard stars, (2) errors in the AGK3 positions themselves (presumed to be $\sim\pm0\farcs2$ rms in the AGK3), and (3) plate errors.

Measurement of the very bright standards was more difficult than for the fainter-source objects because of their much larger size. We generally centered the bright diffraction spikes for the standards, and we could reproduce the standard-star measurements to an rms accuracy of about 4 μ. No magnitude equation was detected at the $0\farcs2$ level, and our positions should have a *systematic* accuracy at least this good.

The small 5- by 7-inch Schmidt plates are not curved to fit the focal surface of the telescope. Rather, a field flattener designed by Bowen is used. This introduces a radially symmetric scale distortion of the field such that a star near the edge of the field is displaced by about 10 μ ($0\farcs7$) from its expected position on a linear scale extrapolated from the plate center. The standards used were within the radius where the displacement is a maximum, and the distortion is sufficiently smooth that it should be effectively compensated by the quadratic terms in the reduction polynomial. We tested this by looking for a systematic trend in the standard-star residuals with distance from the center. No trend was found. Any effect, if present, is smaller than $0\farcs2$, and this shows that other errors of measurement and reduction procedures are more significant. From these tests we conclude that our reduction procedure is sufficiently accurate to reproduce the coordinate system of the standards (which, being AGK3 positions, is on the FK4 system) to better than the rms deviation obtained for any single standard (i.e., better than $0\farcs4$).

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The *systematic* accuracy of a final position should, however, be better than the rms error of the standards. If the errors of the standards are assumed to be entirely random, the final accuracy of the coordinate *system* defined by N standards would be $0\rlap{.}''4/\sqrt{N} \simeq 0\rlap{.}''1$. All we can claim, however, is that the systematic effects of any magnitude equation and the reduction procedure are themselves less than $0\rlap{.}''2$, and this larger value undoubtedly is a more realistic estimate of our *external* accuracy.

The final source positions are listed in Table 1. The quoted errors are internal. They are the rms errors of repeated measurements of the source in each of the two or four position angles of the plate. The largest source of error is the personal difference between measurements with plate orientations 180° apart. The positions are all based on the AGK3 standards, except for those designated by the symbol S in the final column of Table 1 which denote Smithsonian positions. The listed positions are for the equinox of 1950.0, but for the epoch of the plates listed in column (6). Photometric and redshift data are listed for convenience, and have been taken from the original source literature (all *Ap. J.* from 1963 to the present). Magnitudes and colors refer to the epoch of the original observation with no account taken of the optical variability. For 3C 119, 3C 147, 3C 287, 3C 256, and 3C 343.1 the optical object identified as the radio source was either crowded by close companions or too faint to measure on the Schmidt plates, and measurements had to be made on 200-inch plates. Few, if any, AGK3 standards appear in the smaller area of the 200-inch plates, and secondary standards were used whose positions were first obtained from the 48-inch plates relative to the primary AGK3 standards.

Comparison of the results listed in Table 1 with Wade's radio positions is made in Paper III.

III. EFFECT OF NEGLECTING PROPER MOTIONS

To estimate the effect of neglecting proper motions, we performed an auxiliary experiment by reducing twelve fields using only AGK2 positions (epoch ~1930) (a modified case of Veron's [1966] reduction procedure).

The most evident effects were (1) the large number of standards which were rejected in the solution at the $1\rlap{.}''5$ level and (2) the larger rms deviation of *computed* minus *tabulated* positions for the standards, amounting to $\sigma \simeq 1\rlap{.}''0$ (compared with $\sigma \simeq 0\rlap{.}''4$ given in § II for properly reduced positions). The effect on the final *source* position is smaller than $1''$ because, to first approximation, the proper motions of the standards are nearly random, and the motions tend to cancel when the number of standards is large.

The positions from this experiment for almost all of the test cases agree with those in Table 1 to better than $1''$. The largest difference was $1\rlap{.}''3$. The average difference (without regard to sign) was $\Delta\alpha = 0\rlap{.}''5$, $\Delta\delta = 0\rlap{.}''4$, with no evidence of systematic differences.

IV. NEW IDENTIFICATIONS

Wade's increased radio-position accuracy has led to six new optical identifications. Details for NRAO 140, 3C 256, PKS 1508−05, 3C 343, 3C 343.1, and NRAO 530 are given in the Notes to Table 1, and finding charts are shown in Figures 1 and 2 (Plates 1 and 2). Three of the objects (NRAO 140, PKS 1508−05, and 3C 343) are probably QSSs as judged by their starlike optical appearance, although photometric confirmation via the ultraviolet excess is not yet available. However, Lynds (private communication) has independently identified NRAO 140, and his unpublished redshift of $z = 1.258$ and spectrogram confirm the QSS nature.

The remaining three identified objects (3C 256, 3C 343.1, and NRAO 530) may be faint galaxies. The faint object at $V \simeq 22$, identified here with 3C 256, lies $18''$ east of the strongly nucleated galaxy (Seyfert?) marked by Wyndham (1966). This new identification lies within Wade's error box, which is about $0\rlap{.}''7$ on each side; the earlier identification can definitely be ruled out, since its difference in right ascension is 23 σ.

NRAO 530 is of particular interest. The object marked in Figure 1 is within Wade's

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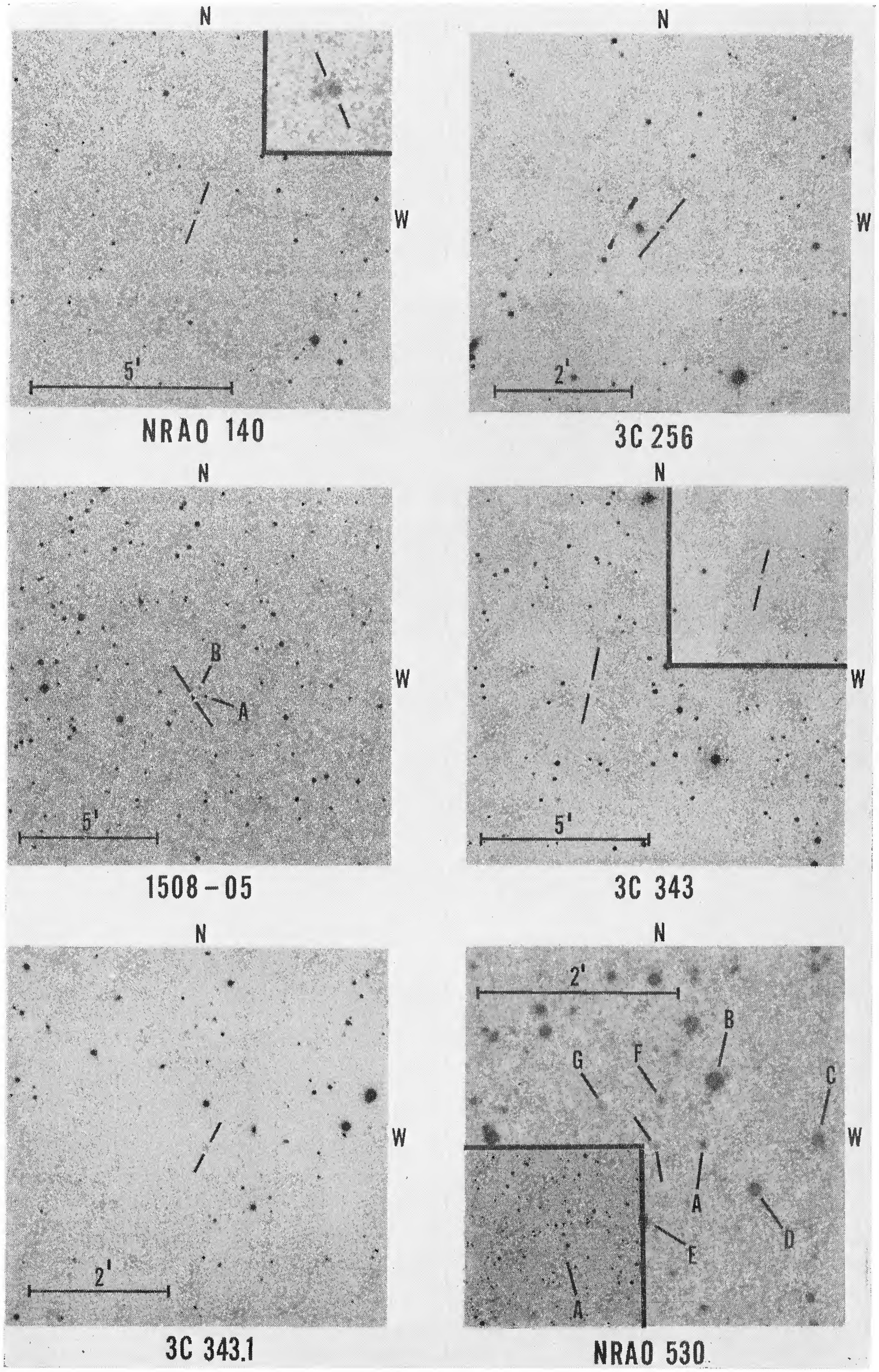

FIG. 1.—Identification charts for six newly identified sources. Reproductions of NRAO 140, 1508−05, 3C 343, and NRAO 530 are from Schmidt plates. 3C 256, 3C 343.1, and the insert for 3C 343 are from 200-inch plates. A faint bridge can be seen on the original plate and paper print of 3C 343, connecting it with a double galaxy 28″ south and 13″ west of the QSS candidate. Confirmation on a second plate has not yet been obtained. (Was not confirmed on plates taken in 1970 June.)

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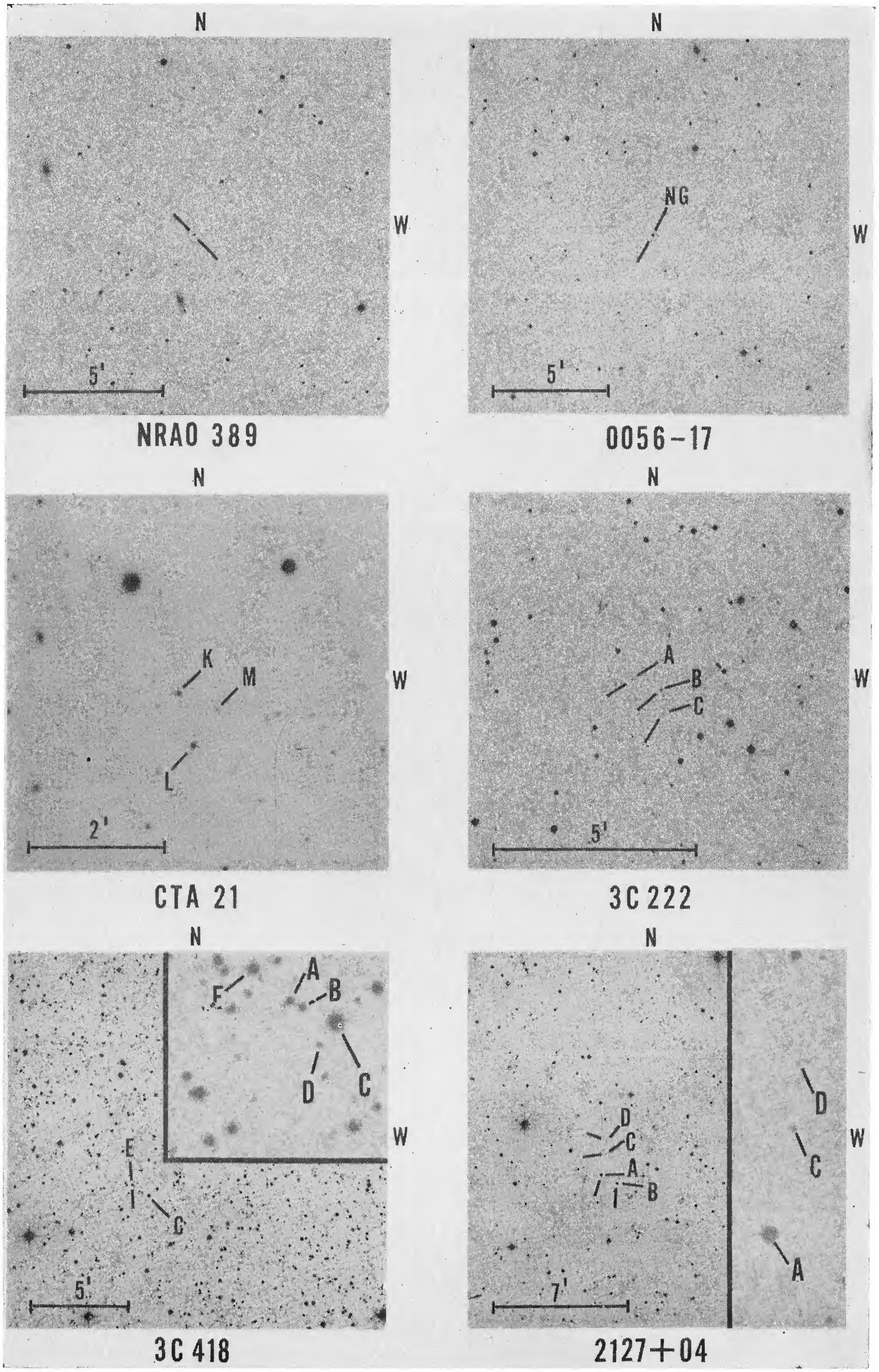

FIG. 2.—Charts for NRAO 389 (previously identified by Parker, Elsmore, and Shakeshaft with no chart published) and the remaining empty fields. The previous, but incorrect, identification for 0056−17 (marked NG) lies $\Delta\alpha = 17''$ west and 3″.0 south of Wade's radio position, which is empty on the reproduced Schmidt plate. CTA 21 is reproduced from a 200-inch plate in poor seeing. All others are from 48-inch Schmidt plates.

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TABLE 1

Optical Positions For 41 Identified Radio Sources

Name	Other	Chart	α (1950)	δ (1950)	Plate Date	V	B-V	U-B	z	Notes
0056 - 17		1NG, Here	Empty Field On 48" (103a-O)		1968.73	>21p				a,S
0106 + 01	4C01.02	2	01 06 04.48 ± .02	+01 19 01.45 ± 0.2	1968.73	18.39	0.15	-0.70	2.107	
3C48	4C32.08	3	01 34 49.83 ± .01	+32 54 20.15 ± 0.15	1960.97	16.2	0.42	-0.58	0.367	
0229 + 13	4C13.14	1	02 29 02.52 ± .02	+13 09 40.7 ± 0.3	1968.74	17.71	0.25	-0.73	2.067	
0237 - 23		4	02 37 52.62 ± .03	-23 22 06.0 ± 0.25	1968.74	16.63	0.15	-0.61	Many	S
CTA 21	0316 + 16	Here	Empty Field On 200" Poor Plate		1968.78	>22p				
NRAO 140	4C32.14	Here	03 33 22.325 ± .04	+32 08 36.1 ± .5	1968.88	~17p			1.258*	b,new id
0403 - 13		5	04 03 13.98 ± .035	-13 16 17.95 ± 0.35	1968.88	17.09	0.28	-0.57	0.571	S
3C119	4C41.13	6	04 29 07.96 ± .02	+41 32 08.8 ± 0.2	1968.88					c,S
3C120	0430 + 05	7	04 30 31.60 ± .015	+05 14 58.9 ± 0.3	1969.11	13.8	0.6	-0.7	0.033	d, S
NRAO 190	0440 - 00	8	04 40 05.27 ± .03	-00 23 20.0 ± 0.4	1968.88					S
3C138	0518 + 16	6	05 18 16.525 ± .02	+16 35 26.75 ± 0.3	1968.74	17.9	0.23	-0.38	0.759	
3C147	4C49.14	9(g)	05 38 43.495 ± .06	+49 49 43.3 ± 0.5	1968.74	16.9	0.35	-0.59	0.545	e
3C191	0802 + 10	6	08 02 03.76 ± .02	+10 23 57.6 ± 0.3	1964.91	18.4	0.25	-0.84	1.946	
0834 - 20		10	08 34 24.56 ± .04	-20 06 29.7 ± 0.4	1968.88					S
3C222	0933 + 04	Here	Empty Field On 48" (IIIa-J)		1968.33	>22p				f
3C230	0949 + 00	11NG, 12d	09 49 24.78 ± .02	+00 12 39.5 ± 0.3	1969.11	15.5	0.75	0.27		g, new id?, S
0952 + 17		13	09 52 11.84 ± .02	+17 57 44.45 ± 0.2	1967.18	17.23	0.08	-0.74	1.471	
3C232	T on 469	14	09 55 25.435 ± .02	+32 38 23.2 ± 0.5	1965.92	15.78	0.10	-0.68	0.534	
1055 + 01	4C01.28	5	10 55 55.33 ± .02	+01 50 03.35 ± 0.3	1969.11	~18				
1116 + 12	4C12.39	2	11 16 20.755 ± .02	+12 51 06.5 ± 0.2	1967.10	19.25	0.14	-0.76	2.118	
3C256	1118 + 23	11NG, Here	11 18 04.15 ± .03	+23 44 21.2 ± 0.4	1969.11	~22				h, new id, S
1127 - 14		15	11 27 35.61 ± .03	-14 32 54.0 ± 0.4	1969.11	16.90	0.27	-0.70	1.187	
1148 - 00	4C-00.47	15	11 48 10.17 ± .03	-00 07 13.05 ± 0.4	1969.11	17.60	0.17	-0.97	1.982	S
NRAO 389	4C31.38	Here	11 53 44.08 ± .02	+31 44 46.85 ± 0.2	1967.18	18.96	0.37	-0.65	1.557	i
1245 - 19		None	Empty Field On 48" (103a-O)			>21p				S
3C279		17	12 53 35.82 ± .02	-05 31 07.65 ± 0.25						S
3C287	1328 + 25.4	16	13 28 15.925 ± .04	+25 24 37.7 ± 0.6	1967.18	17.67	.63	- .65	1.054	j
3C286	4C30.26	3	13 28 49.67 ± .02	+30 45 58.35 ± 0.15	1964.3	17.30	.22	- .84	0.846	S
3C298	1416 + 06	9d, 17	14 16 38.80 ± .02	+06 42 20.65 ± 0.5	1967.43	16.79	.33	- .70	1.439	
3C309.1	4C71.15	11	14 58 56.70 ± .06	+71 52 10.8 ± 0.25	1967.4	16.78	.46	- .77	0.903	
1508 - 05	4C-05.64	Here	15 08 14.95 ± .02	-05 31 49.1 ± 0.35	1969.5	~16p				k, new id, S
1510 - 08		15	15 10 08.915 ± .02	-08 54 47.2 ± 0.2	1969.5	16.52	0.17	-0.74	0.361	S
3C343	4C62.26	Here	16 34 01.115 ± .09	+62 51 42.35 ± 0.45	1968.33	~22p				l, new id
3C343.1	4C62.27	Here	16 37 55.215 ± .08	+62 40 35.0 ± 0.4	1969.27	~22.5V				m, new id
3C345	4C39.48	16	16 41 17.56 ± .03	+39 54 10.7 ± 0.3	1967.43	15.96	0.29	-0.50	0.594	
NRAO 530	1730 - 13	Here	17 30 13.43 ± .04	-13 02 46.2 ± 0.5	1968.78	~21p				n, new id, S
3C371	4C69.24	11	18 07 18.49 ± .04	+69 48 57.55 ± 0.3	1968.73	14.81	0.72	-0.35	0.051	
3C380	4C48.46	16	18 28 13.485 ± .045	+48 42 40.15 ± 0.4	1964.52	16.81	0.24	-0.59	0.691	
3C418	4C51.42	Here	Empty Field On 48" (IIa-O)		1968.78	>20.5p				
2127 + 04		Here	Empty Field On 48" (IIIa-J)		1968.56	>22p				o
2145 + 06	4C06.69	1	21 45 36.07 ± .02	+06 43 41.25 ± 0.25	1968.78	16.47	0.41	-0.79		
2203 - 18		1	22 03 25.675 ± .025	-18 50 16.8 ± 0.2	1968.78					S
3C446	2223 - 05	16, 17	22 23 11.04 ± .02	-05 12 17.2 ± 0.3	1967.83	18.4	0.44	-0.90	1.403	p, S
CTA 102	2230 + 11	16	22 30 07.78 ± .03	+11 28 22.8 ± 0.3	1967.66	17.32	0.42	-0.79	1.037	
3C454	2249 + 18	11	22 49 07.65 ± .03	+18 32 43.7 ± 0.2	1965.73	18.4	0.12	-0.95	1.756	
3C454.3	2251 + 15	11NG, 12	22 51 29.485 ± .035	+15 52 54.45 ± 0.4	1966.8	16.1	0.47	-0.66	0.860	q

* Redshift for NRAO 140 from unpublished data by C. R. Lynds.

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NOTES TO TABLE 1

a) 0056−17. Original identification by Bolton and Ekers (1966) refers to a galactic star as shown from spectra by Lynds (see Burbidge 1968). Wade's radio position (Paper I) differs by 17″ in right ascension and 3″.0 in declination from this optical object which we measured to be at $\alpha(1950) = 00^h56^m36^s.81 \pm 0^s.03$, $\delta(1950) = -17°16'52''.5 \pm 0''.3$. The field is empty on a Schmidt 103a-O plate at the radio position.

b) NRAO 140. New identification. Independently and previously identified by Lynds. Preliminary, unpublished redshift by Lynds of $z = 1.258$.

c) 3C 119. Close optical pair with galactic star 2″ distant. Position is from 200-inch plate using secondary standards from 48-inch plate.

d) 3C 120. Seyfert galaxy with variable nonthermal nuclear component. Photometry refers to the total magnitude and color 1967 September 11/12 (Sandage 1967*b*). Kinman (1968) gives a light curve.

e) 3C 147. Close triple. Position is from 200-inch plate using secondary standards from 48-inch plate.

f) 3C 222. Wyndham's (1966) marked object is far from the radio position. Furthermore, the object marked there is not visible on a new IIIa-J 48-inch plate, and may be a defect. None of the three optical objects measured and identified in Figure 2 is at the radio position.

g) 3C 230. Possible but highly suspect new identification. Wyndham (1966) and Bolton and Eker's (1966) identification is definitely incorrect, differing from Wade's radio position by $\Delta\alpha = 0^s.45$ east and $\Delta\delta = 9''$ north. Furthermore, photometry of the Wyndham and Bolton and Ekers object gives normal stellar colors of $V = 18.34$, $B - V = 0.66$, $U - B = 0.10$. Object marked *d* by Veron (1966) is close to the radio position. Our optical position for this object is given in Table 1. However, the identification is highly suspect because photometry shows normal stellar colors of $V = 15.51$, $B - V = 0.75$, $U - B = 0.27$, and the positional agreement with Wade is only moderately good with $\Delta\alpha = 0^s.17 \pm 0^s.08$ (combined errors), and $\Delta\delta = 1''.1 \pm 1''.6$ (combined errors). Radio position may be affected by confusion.

h) 3C 256. Wyndham's identification (1966) differs by 18″ in R.A. from Wade's position and is incorrect. The object marked in Figure 1 is a faint (galaxy?) 18″ east of Wyndham's object. It is within Wade's radio error box and is almost certainly the identification.

i) NRAO 389. Identified by Parker, Elsmore, and Shakeshaft (1966), but with no chart.

j) 3C 287. Our optical position should be considered with some suspicion at the ±1″ level because of unresolved difficulties in fitting the secondary standards transfered to the 200-inch plates. The assigned errors are twice the computed rms values of secondary standards finally retained in the solution.

k) 1508−05. New identification. Shimmins (1968) did not identify this sixteenth-magnitude QSS candidate and states "error rectangle includes no galaxies above plate limit (48 inch Schmidt)." His radio position differs from Wade's by $\Delta\alpha = 1^s.05$, which is 15 times Wade's stated error.

l) 3C 343. New identification. Starlike object near the limit of 48-inch IIIa-J plate, confirmed by a 103a-E+RG1 200-inch plate. The image does not appear diffuse as expected if a normal E galaxy. Tentative identification is that object is a faint ($m_{pg} \simeq 22$) QSS.

m) 3C 343.1. New identification suggested by positional agreement of $\Delta\alpha = 0''.86$ and $\Delta\delta = 1''.0$ with Wade's radio position. Invisible on 48-inch Schmidt plate but seen on a good 103a-D+GG11 200-inch plate at $V \simeq 22.5$. Image is diffuse, suggesting object is a galaxy. No evident cluster present.

n) NRAO 530. New identification. Object near plate limit of poor-seeing 48-inch Schmidt plate. Image character suggests a galaxy, possibly in a cluster, but plate grain noise is too high for certainty. Object measured by Lü and Fredrick (1968*a*) is object *E* of the enclosed chart. This is far from the Wade's radio position, and is not the identification.

o) 2127+04. Empty on excellent 48-inch IIIa-J plate whose limit is $m_{pg} \simeq 22$. Suggestion of very faint images at the plate limit near Wade's radio position (possible cluster of galaxies?). There is nothing on our plate at the optical position reported by Lü and Fredrick (1968*a*), which, in any case, is far from Wade's radio position.

p) 3C 446. Photometric data refer to observations in 1964 early October. During an outburst in 1966 June-July the QSS reached $V = 15.2$, and the $U - B$ color became appreciably redder (e.g., *Ap. J.*, **146**, 322, 1966).

q) 3C 454.3. Identification by Wyndham (1966) is incorrect. Identification by Veron (1966) is correct as shown by photometry, spectra, and position agreement.

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error box. It is about $m_{pg} \simeq 21$, near the Schmidt plate limit on IIa-O emulsion. Inspection suggests that it may be the brightest member of a cluster of galaxies; but such cluster members, if real, appear only as smudges at the plate limit. Confirmation of the cluster is needed with the 200-inch, although the identification of the radio source itself appears to be definite.

Identification of both 3C 343 and 3C 343.1 is of special interest because these sources have similar and unusual radio spectra (Moffet 1965; Williams 1966). This circumstance, together with an angular separation of only 29′ on the plane of the sky, led Moffet and Williams to suggest a physical connection. Our data show that 3C 343 is probably a QSS ($m_{pg} \simeq 22$), while 3C 343.1 is probably a faint galaxy ($V \simeq 22.5$) seen only on a 200-inch plate. If the sources are physically connected, their projected separation is of the order $r \simeq 2 \times 10^7$ pc. This follows from an estimated redshift of $z = 0.55$ for a galaxy at this apparent magnitude (by analogy with 3C 295 at $V = 21.9$, $z = 0.461$ with appropriate K-corrections and the Hubble diagram cf. Sandage 1967*a*, *b*, 1968), and with a Hubble constant adopted of 75 km sec^{-1} Mpc^{-1}. This separation is at least half an order of magnitude larger than the size of typical clusters of galaxies. Redshift measurements of both sources would presumably settle the question of a physical connection, and they may be even more interesting because of the following circumstances.

The insert reproduction of 3C 343 in Figure 1, taken from a 200-inch plate, shows a *faint bridge* connecting the starlike identified object with a galaxy of $V \simeq 21$ located 28″ south and 13″ west. The galaxy has a double nucleus and is the bright member of a small group of five galaxies, all of which may be only the brightest members of a larger cluster. The bridge is present on the original plate, but its most definite part coincides with part of a small ring around a plate defect, and there is no confirmatory plate yet available. We suspend judgment on its reality until additional data are available.[1] The bridge was actually pointed out to us by Donald Lynden-Bell during his inspection of the final prints.

As an auxiliary step in the identification of the six sources, we measured positions of other stars in the fields. The measured stars are marked in Figure 1, and their optical positions are listed in the first half of Table 2.

V. REMAINING EMPTY FIELDS

Six sources remain unidentified. In none of these fields do we have photographs taken to the 200-inch limit, so future identifications are still possible. But in each case the optical object will be fainter than $m_{pg} \simeq 21$–22, which are our present limits from the available plate material.

a) PKS 0056−17

As mentioned in the Notes to Table 1, the previously suggested identification (Bolton and Ekers 1966) is far from the radio position. There is no optical object at Wade's position brighter than $m_{pg} \simeq 21$ on a good 48-inch Schmidt plate taken on 103a-O emulsion. Galactic latitude is −79°.

b) CTA 21

Repeated attempts to identify CTA 21 have failed. We have not yet obtained a 200-inch plate in good seeing, but the plate material now on hand shows no object brighter than $m_{pg} \simeq 22$ at Wade's radio position. Latitude is −34°.

c) 3C 222

Empty to $m_{pg} \simeq 22$ on a 48-inch Schmidt IIIa-J plate in good seeing. Latitude is +38°.

[1] *Note added 1970 June 12.*—Several 200-inch plates taken this month fail to show the bridge, which we therefore believe not to be real.

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d) PKS 1245−10

Empty to $m_{pg} \simeq 21$ on a 48-inch Schmidt 103a-O plate in good seeing. Latitude is +44°.

e) 3C 418

This field is at low galactic latitude ($b = +6°$) and is undoubtedly obscured. The field is crowded with stars (Fig. 2), but the region enclosed by Wade's radio position is particularly clear to $m_{pg} \simeq 20.5$.

TABLE 2

OPTICAL POSITIONS OF OBJECTS MEASURED IN SOURCE FIELDS

Field	Object	α(1950)	δ(1950)
	Fields of New Identifications (Fig. 1)		
NRAO 140	Nearest*	03ʰ33ᵐ22ˢ.78±0ˢ.04	+32°08′35″.2±0″.5
3C 256	{N Galaxy E of ID	11 18 2.91±0.04	+23 44 19.5±0.5
1508−05	A	15 08 13.11±0.02	−05 31 47.3±0.2
	B	15 08 13.96±0.03	−05 31 28.5± .3
NRAO 530	A	17 30 11.44±0.03	−13 02 45.2±0.25
	B	17 30 10.91±0.03	−13 02 04.7±0.3
	C	17 30 06.51±0.03	−13 02 43.7±0.25
	D	17 30 09.25±0.03	−13 03 14.4±0.25
	E	17 30 14.05±0.035	−13 03 32.6±0.4
	F	17 30 13.20±0.035	−13 02 16.3±0.4
	G	17 30 15.75±0.03	−13 02 20.2±0.35
	Empty Fields (Fig. 2)		
0056−17	Previous misidentification	00 56 36.81±0.03	−17 16 52.5±0.3
CTA 21	K	03 16 11.92±0.03	+16 18 02.6±0.4
	L	03 16 11.03±0.03	+16 17 15.5±0.4
	M	03 16 09.50±0.03	+16 17 47.8±0.4
3C 222	A	09 33 54.93±0.04	+04 36 00.4±0.6
	B	09 33 52.09±0.04	+04 35 43.0±0.6
	C	09 33 51.87±0.04	+04 35 07.0±0.6
3C 418	A	20 37 07.54±0.06	+51 09 20.0±0.5
	B	20 37 06.71±0.06	+51 09 15.8±0.5
	C	20 37 04.50±0.06	+51 09 05.7±0.5
	D	20 37 05.63±0.06	+51 08 50.8±0.5
	E	20 37 09.93±0.06	+51 09 40.6±0.5
2127+04	A	21 28 01.97±0.02	+04 48 01.8±0.3
	B	21 27 58.61±0.03	+04 47 33.2±0.25
	C	21 28 00.10±0.02	+04 49 09.2±0.2
	D	21 28 00.86±0.015	+04 49 51.7±0.2

f) PKS 2127+04

Empty to $m_{pg} \simeq 22$ on an excellent 48-inch Schmidt IIIa-J plate. Latitude is = 32°. There are many faint (but unmeasurable) images near Wade's position which suggest a very distant cluster of galaxies.

Finding charts of the region of each of these sources (except for PKS 1245−19 where there is nothing visible within 10 σ of Wade's position) are given in Figure 2. Optical positions of the marked stars are listed in the second part of Table 2.

The success in making new identifications has been sufficiently high in this pilot program that we plan to continue the search in many presently empty fields above $|b| \simeq 15°$. In cooperation with Wade and G. K. Miley we hope to extend the present program

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to 100 currently unidentified sources. The search will be primarily aimed at finding clusters of galaxies more distant than 3C 295 in an effort to determine eventually the deceleration parameter q_0.

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