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A High-Sensitivity Survey of the North Galactic Polar Region at 1415 MHz

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Results of a 1415 MHz north galactic polar survey with the Ohio State University 260 by 70 ft radio telescope are presented in the form of source lists and detailed maps. The survey covers nearly 1000 square degrees of the sky at a resolution of 8.5 beam areas per square degree. A list of 236 sources is given with flux densities of 0.37 flux unit or greater. Of these 129 do not appear in other lists. Additional lists are included of sources with flux densities less than 0.37 flux units, but which are at 4C positions, and of sources which appear to have either very high or very low spectral indices. The low index sources are of interest because of the possibility that they are variable quasars. The log N–log S curve for all the sources has a slope of -1.8.

I. INTRODUCTION

A CONTINUUM survey of the north galactic polar region has been conducted at 1415 MHz with the Ohio State University 260 by 70 ft radio telescope. The survey covers an area of sky which includes the north galactic pole (1950.0: R.A. $=12^{\mathrm{h}}49^{\mathrm{m}}$, Dec. $=27\overset{\circ}{.}4N$) and contains approximately 975 deg^2 of sky corresponding to 8300 beam areas of 8.5 beam areas per deg^2. Included is most of the area between right ascensions $08^{\mathrm{h}}00^{\mathrm{m}}$ and $16^{\mathrm{h}}00^{\mathrm{m}}$ and declinations $25°00'N$ and $37°40'N$. The antenna half-power beamwidths are about $10'$ in right ascension and $43'$ in declination.

Records for this survey were obtained during the period beginning 2 March 1965 and ending 2 July 1965. Declination scans were spaced at $20'$ intervals and for purposes of data processing the 8-h scans were divided into four 2-h segments. A minimum of two records per declination was averaged, and in some cases, as many as five records were averaged. During the observing period of 120 days a total of 289 2-h segments were obtained which were acceptable for further processing. The results of the survey are presented in two tables which include 262 sources and in detailed contour maps of the regions covered.

II. DATA PROCESSING

The essential steps in the main data reduction program have been described in a previous paper (Kraus, Dixon, and Fisher 1966) with modifications as follows. In the present survey, record drift removal was performed twice, once for each 2-h declination scan with a sixth-order polynomial of best fit and again for the average of two or more scans with a third-order polynomial. The survey area lies in the vicinity of the galactic north pole where the sky background radiation varies quite slowly. Most record drift would therefore be due to receiver effects and removal of this drift probably results in the loss of but little significant information. Drift removal is required in order that adjacent profiles be compatible for combining into a contour map.

The flux density of most sources was computer evaluated by calculating the volume under the observed temperature versus position pattern. It is this pattern which is indicated on the contour maps. The position of most sources was obtained by computer determinations of the centroid of this volume. In some cases where the pattern was incomplete, as near the edge of the map, the flux density and position were determined from the peak value. The radio telescope was calibrated using measured flux densities (Kellermann 1964; Pauliny-Toth, Wade, and Heeschen 1966) of sixteen 3C sources (Bennett 1962).

The flux density of each source tabulated in the present survey was evaluated using the relation

$$S=\frac{2k}{A_e\Omega_M}\int\int \Delta T_A(\theta,\phi)d\Omega$$

where k is Boltzmann's constant ($=1.38\times10^{-23}$ J °K^{-1}), A_e is the antenna effective aperture ($=635$ m^2), Ω_M is the antenna main beam solid angle ($=0.131$ deg^2) and $\Delta T_A(\theta,\phi)$ is the antenna temperature (°K). The integral is equal to the volume under the temperature versus position surface.

The contour maps for the present survey, presented in Plates I–IV, are the result of hand-smoothing the original maps plotted with a Cal Comp 563 digital increment plotter using data obtained from the main data reduction program. The contour interval on each of these maps is 0.025°K antenna temperature. It is important to note that, owing to the data reduction procedure, the contours are relative to an arbitrary local background level and that a given contour at one point on the map is not necessarily at the same absolute value as the same contour several degrees distant. For the most accurate positions or flux densities reference should be made to the tables and not to the maps. All data processing was done with IBM 7094 and 1620 computers.

III. TABLES OF SOURCES

For the bandwidth (8 MHz) and the integration time (40 sec) used and an average of two records, the rms noise temperature of the system was about 0.02°K. Since each source catalogued in the survey appeared on at least three adjacent declination scans, the sensitivity was further increased by a factor of about $\sqrt{2}$. The minimum detectable sensitivity of the telescope,

TABLE I. Sources in the Ohio State University north galactic pole survey (1415 MHz). $S \geq 0.37$ flux unit.

Source number	Celestial coordinates (1950.0) α h	m	s	δ deg	min	Flux density (flux units)	Spectral index[a] n	Remarks[b]
OJ316	08	09	36	36	11	0.47	1.12	4C35.18
OJ318	08	10	34	35	10	0.42	0.84	4C35.19
OJ320	08	12	11	36	38	0.78	<0.47	
OJ324	08	14	25	32	51	0.60	<0.58	
OJ337	08	22	17	34	20	0.73	0.80	4C34.28
OJ341	08	24	31	35	26	0.92	0.52	4C35.20
OJ347	08	28	29	36	43	0.37	<0.83	
OJ349	08	29	29	33	32	0.59	<0.59	
OJ353	08	31	52	34	43	0.38	<0.81	
OJ356	08	33	43	33	52	0.45	<0.72	
OJ357	08	35	04	36	23	0.57	<0.60	d
OJ373	08	43	46	35	00	0.50	<0.67	
OJ378	08	47	14	36	14	0.37	<0.83	c, d
OJ383	08	50	17	33	15	0.51	0.66	c, d, 4C33.22
OJ385	08	50	35	34	15	0.56	0.78	4C34.29, NRAO302
OJ392	08	55	34	36	54	0.41	<0.77	
OK305	09	03	13	36	23	0.37	<0.83	
OK313	09	08	54	33	58	0.92	<0.39	
OK324	09	14	03	35	02	0.59	0.82	4C34.31
OK338	09	22	42	36	39	1.09	0.47	4C36.14
OK347	09	27	51	35	23	0.49	<0.68	c, d
OK359	09	35	18	33	55	0.71	<0.50	
OK373	09	43	36	33	13	0.75	<0.49	
OK391	09	54	50	34	27	0.39	<0.80	
OL302	10	01	34	32	02	1.70	0.64	4C32.34
OL308	10	04	43	34	53	0.57	<0.60	d, NRAO346
OL311	10	06	24	31	25	0.50	<0.67	
OL314	10	08	43	32	18	1.16	<0.27	
OL318	10	11	00	34	59	0.61	<0.57	
OL326	10	15	31	35	58	1.01	<0.33	
OL327	10	16	28	33	10	0.54	0.72	4C32.35
OL329	10	17	52	31	57	1.05	0.79	4C31.35
OL333	10	19	52	31	06	0.99	<0.34	
OL343	10	26	03	37	20	0.78	<0.46	e
OL348	10	28	27	30	20	0.55	0.63	4C30.18
OL350	10	30	02	30	35	0.43	<0.75	
OL353	10	31	55	34	05	0.41	0.83	4C34.32
OL361	10	36	11	36	19	0.40	0.86	4C36.17
OL362	10	36	49	31	37	0.37	<0.83	
OL364	10	38	09	33	30	0.54	0.72	Poss. 4C33.24 lobe shifted
OL367	10	39	52	30	12	0.57	<0.60	
OL368	10	40	36	31	46	0.81	<0.45	
OL372	10	43	22	37	16	0.42	0.86	4C37.28
OL376	10	45	49	35	25	1.24	0.26	4C35.23
OL379	10	47	34	30	50	0.44	<0.73	
OL382	10	49	04	34	26	1.14	0.57	4C34.33
OL391	10	55	01	31	37	0.61	<0.57	
OL395	10	57	01	31	46	0.43	<0.75	
OL398	10	58	41	33	50	0.37	<0.83	
OL399	10	59	23	35	11	0.66	0.88	4C35.24
OM307	11	04	16	30	41	0.38	<0.81	c, d
OM308	11	04	37	36	33	0.47	0.89	4C36.18
OM320	11	12	03	33	18	0.99	0.43	4C33.25
OM326	11	15	55	31	34	0.48	<0.69	
OM336	11	21	49	31	25	0.47	<0.69	

[a] The index n is defined by $S \propto \lambda^n$ in accord with the convention of Conway, Kellermann, and Long (1963).
[b] 4C: Pilkington and Scott (1965); CTD: Kellermann and Read (1965); NGC: Dreyer (1888); NRAO: Pauliny-Toth, Wade, and Heeschen (1966).
[c] Computer evaluated source position strongly influenced by adjacent source or interference. Position quoted is that of peak.
[d] Flux density S determined assuming a point source; $S = 4.35T$(max) flux units.
[e] Source not completely on map. Position and S based on peak.

TABLE I (*continued*)

Source number	Celestial coordinates (1950.0) α h	α m	α s	δ deg	δ min	Flux density (flux units)	Spectral index[a] n	Remarks[b]
OM338	11	23	27	30	20	0.63	0.99	4C30.21, NRAO374
OM339	11	23	42	34	04	1.02	0.49	4C33.26
OM342	11	25	29	32	40	1.09	0.56	4C32.37, NRAO375-NRAO376 unresolved
OM348	11	28	16	31	28	0.55	<0.62	Uncertain
OM350	11	30	05	35	04	0.64	0.57	4C34.35
OM351	11	30	43	33	46	1.32		4C33.27–33.28 unresolved
OM352	11	31	45	31	02	0.53	<0.64	c, d
OM354	11	32	26	37	28	0.64	<0.55	
OM359	11	35	23	31	28	0.73	<0.49	
OM362	11	37	21	35	30	0.41	<0.77	
OM368	11	41	31	35	17	0.38	0.82	4C35.26
OM369	11	41	47	30	10	0.53	0.92	c, d, 4C30.23
OM370	11	41	56	37	25	1.47	0.45	e, 4C37.32
OM374	11	44	36	35	21	0.39	<0.80	
OM381	11	48	24	36	34	0.44	0.92	4C36.19
OM383	11	50	09	33	27	0.52	<0.65	
OM389	11	53	42	31	44	3.39	0.38	4C31.38, NRAO389
OM397	11	58	19	34	48	0.85	0.50	4C34.36
ON202	12	02	23	29	45	1.50	0.67	4C29.46
ON205	12	03	05	26	49	0.55	0.71	4C26.36
ON208	12	04	52	28	08	0.63	<0.56	
ON209	12	05	28	25	42	0.42	<0.76	
ON231	12	18	57	28	22	0.44	<0.73	
ON235	12	20	52	29	47	0.46	<0.71	
ON237	12	22	05	26	26	0.54	0.97	4C26.37
ON244	12	26	12	27	23	0.55	<0.62	
ON254	12	32	32	29	28	0.62	<0.57	
ON273	12	43	52	26	24	0.44	<0.73	
ON281	12	48	53	28	22	0.37	<0.83	d
ON283	12	50	01	29	10	0.63	<0.56	
ON286	12	51	37	26	47	0.40	1.02	4C26.40
ON289	12	52	25	25	46	0.38	<0.81	c, d
ON292	12	55	32	26	42	0.44	<0.73	
ON294	12	56	39	28	16	0.90	<0.39	NRAO416
ON301	12	00	58	31	02	0.45	0.80	4C30.24
ON307	12	04	16	37	06	0.68	0.80	4C37.33
ON309	12	04	42	34	12	0.54	<0.63	
ON319	12	11	42	33	35	1.13	<0.27	
ON322	12	13	18	32	15	0.41	<0.77	
ON323	12	13	33	35	06	1.44	0.20	4C35.28
ON325	12	15	14	30	31	0.46	<0.71	
ON329	12	17	28	36	49	0.51	0.75	4C36.20
ON332	12	19	14	31	43	1.04	0.77	4C31.40
ON334	12	20	33	37	29	0.43	<0.75	
ON343	12	25	38	36	56	2.59	<−0.13	
ON353	12	32	22	36	29	0.37	<0.83	
ON358	12	34	52	36	27	0.50	<0.67	
ON361	12	36	45	32	49	0.87	0.58	4C32.40
ON366	12	39	44	32	46	1.28	<0.22	NGC4631
ON369	12	41	21	32	01	0.39	<0.80	
ON371	12	42	33	36	21	0.89	0.60	4C36.21
ON374	12	44	43	32	29	0.87	0.51	4C32.41
ON375	12	45	09	34	06	0.45	<0.72	
ON379	12	47	28	33	40	1.34	0.48	4C33.30
ON385	12	51	10	30	45	0.45	<0.72	
ON389	12	53	51	35	26	0.44	<0.73	
ON393	12	56	04	32	58	0.79	0.45	4C33.31
ON394	12	56	49	36	46	0.50	<0.67	
OP207	13	04	08	27	26	0.72	0.56	4C27.23
OP211	13	06	37	27	06	0.63	<0.56	

TABLE I (*continued*)

Source number	Celestial coordinates (1950.0) α h	m	s	δ deg	min	Flux density (flux units)	Spectral index[a] *n*	Remarks[b]
OP215	13	08	53	26	34	0.55	<0.62	
OP228	13	16	40	29	48	1.16	0.49	4C29.47
OP229	13	17	41	25	51	1.06	0.41	4C25.42
OP233	13	19	59	27	00	1.08	0.62	4C27.25
OP234	13	20	35	29	56	1.79	0.39	4C29.48, CTD80
OP255	13	33	12	27	36	0.72	0.88	4C27.26
OP256	13	34	03	26	34	0.37	<0.83	
OP257	13	34	21	28	53	0.69	0.60	4C28.32
OP268	13	40	39	25	47	0.42	<0.76	
OP276	13	46	06	28	49	1.17	0.80	4C28.34
OP278	13	46	37	26	50	0.96	0.79	4C26.42
OP291	13	54	59	25	44	0.39	<0.80	
OP301	13	00	37	32	00	0.37	<0.83	
OP303	13	01	50	35	19	0.71	<0.50	
OP305	13	03	12	36	21	0.67	<0.54	
OP312	13	07	44	34	09	0.55	<0.62	
OP313	13	08	20	32	35	1.01	<0.33	c, d
OP315	13	08	54	31	34	0.47	<0.70	
OP316	13	09	18	32	49	0.58	0.92	c, d, 4C32.42
OP326	13	15	31	34	42	0.51	<0.66	
OP329	13	17	26	36	19	0.41	0.91	4C36.23
OP331	13	18	38	34	33	0.51	<0.66	
OP333	13	19	31	35	21	0.59	<0.59	
OP334	13	20	29	32	33	0.65	0.90	c, d, 4C32.43
OP335	13	21	24	31	43	1.69	<0.08	
OP337	13	22	25	36	26	0.75	0.63	4C36.24
OP339	13	23	44	37	13	0.45	0.97	4C37.38
OP340	13	24	01	32	07	4.24		c, d, poss. 4C32.44 lobe shifted
OP341	13	25	17	32	06	0.86		c, d
OP342	13	25	24	35	08	0.38	<0.81	
OP343	13	26	15	30	48	0.60	0.93	4C31.42, NRAO423
OP346	13	27	57	32	09	0.55	<0.62	
OP353	13	32	16	31	57	1.02	<0.32	
OP354	13	32	34	35	15	0.72	<0.50	
OP364	13	38	25	30	12	0.40	<0.78	
OP367	13	40	17	35	24	0.69	0.75	4C35.30
OP368	13	40	46	31	55	0.69	0.66	4C32.45
OP370	13	42	16	34	13	0.38	<0.81	
OP372	13	43	35	37	15	0.70	0.63	4C37.39
OP381	13	48	24	30	40	0.62	<0.57	
OP386	13	51	46	32	03	0.49	<0.68	c, d
OP391	13	54	33	32	32	0.73	0.85	4C32.46
OP397	13	58	20	30	27	0.55	<0.62	
OQ208	14	04	53	28	46	1.09	<0.29	
OQ210	14	06	01	25	48	0.39	<0.80	
OQ217	14	10	02	29	21	0.80	<0.45	
OQ229	14	17	44	27	16	1.31	0.65	4C27.28, CTD85
OQ237	14	22	24	26	45	0.82	<0.44	c, d, CTD86
OQ238	14	22	30	27	41	0.56	0.70	c, d, poss. 4C27.29 lobe shifted
OQ241	14	24	44	27	23	1.19	0.32	c, poss. 4C27.30
OQ242	14	25	10	26	43	0.37	<0.83	c
OQ243	14	25	18	28	40	0.57	0.95	4C28.35
OQ244	14	26	18	29	34	0.72	<0.50	
OQ248	14	28	47	25	40	0.83	<0.44	
OQ252	14	31	00	27	10	0.43	<0.75	
OQ256	14	33	53	27	00	0.79	<0.45	
OQ259	14	35	53	28	59	0.59		c, 4C28.36, NRAO450
OQ260	14	35	58	28	24	0.37		c, d, 4C28.36, NRAO450; OQ259 and OQ260 may be same source
OQ268	14	40	35	28	45	0.43	<0.75	
OQ274	14	44	28	28	12	1.33	0.41	4C28.37

Table I (*continued*)

Source number	Celestial coordinates (1950.0) α h	m	s	δ deg	min	Flux density (flux units)	Spectral index[a] n	Remarks[b]
OQ286	14	52	05	27	05	0.83	<0.44	
OQ287	14	52	15	29	54	0.84	<0.43	
OQ291	14	54	33	27	50	0.40	<0.78	
OQ293	14	55	50	28	55	1.12	0.55	4C28.38
OQ302	14	01	15	35	13	0.96	0.64	4C35.32
OQ313	14	07	46	31	41	0.37	1.18	4C31.44
OQ314	14	08	49	37	04	1.31	0.53	4C37.40
OQ316	14	09	36	34	17	0.44	<0.73	
OQ323	14	13	58	34	59	1.62	<0.10	
OQ324	14	14	49	35	54	0.65	0.75	4C36.25
OQ329	14	17	31	30	19	0.73	<0.49	
OQ332	14	19	28	31	22	0.99	0.39	4C31.45
OQ338	14	22	40	30	38	0.84	0.55	4C30.27
OQ342	14	25	29	33	13	0.41	<0.77	
OQ346	14	27	27	30	46	0.66	<0.54	
OQ348	14	28	48	37	02	0.52	<0.65	
OQ361	14	36	34	34	09	0.97	0.61	4C34.39
OQ366	14	40	09	32	49	0.61	<0.57	
OQ367	14	40	32	31	00	0.55	<0.62	
OQ371	14	42	34	36	23	0.94	0.43	4C36.26, may be extended in Dec.
OQ384	14	50	49	33	18	0.48	0.69	4C33.33
OQ389	14	53	48	35	18	0.48	0.90	4C35.34
OQ394	14	56	42	35	56	0.47	<0.70	
OR204	15	02	19	28	48	1.43	<0.16	
OR211	15	06	47	28	52	0.60	<0.58	
OR236	15	21	23	28	41	1.44	0.27	4C28.39
OR243	15	25	34	28	42	0.57	<0.60	
OR254	15	32	38	29	24	0.40	<0.78	
OR259	15	35	12	27	18	0.43	<0.75	
OR266	15	39	27	25	30	0.41	<0.77	
OR302	15	01	23	36	28	0.48	<0.69	
OR304	15	02	26	33	49	0.44	1.00	4C33.34
OR307	15	04	07	32	13	0.62	0.63	4C32.47
OR308	15	05	34	36	53	0.62	<0.57	
OR311	15	06	49	34	58	0.46	<0.71	
OR312	15	07	16	35	41	0.39	0.85	4C35.35
OR314	15	08	31	30	40	0.39	<0.80	
OR316	15	09	30	34	50	0.65	<0.55	
OR317	15	10	11	32	12	0.80	0.62	4C32.48
OR321	15	12	48	37	05	0.99	0.76	4C37.43
OR326	15	15	50	35	26	0.41	<0.77	
OR331	15	19	01	31	09	0.47	<0.70	
OR337	15	22	03	32	27	0.74	<0.49	
OR342	15	25	17	31	23	0.81	<0.44	
OR343	15	25	52	33	13	0.41	<0.77	
OR344	15	26	32	37	45	1.00	0.81	e, 4C37.44
OR347	15	27	55	34	58	0.61	0.66	4C34.40
OR348	15	28	28	34	01	0.76	0.71	4C34.41
OR353	15	31	50	35	56	0.40	0.90	4C35.37
OR362	15	37	34	32	25	0.60		Complex
OR366	15	39	26	34	28	0.64	0.85	4C34.42
OR370	15	42	44	32	26	0.80	0.44	4C32.49
OR371	15	42	50	35	04	0.40		
OR376	15	45	22	35	38	0.52	0.73	4C35.38
OR378	15	47	09	31	00	1.32	0.79	4C30.29
OR382	15	49	10	33	50	1.07	0.69	4C33.36–33.37
OR393	15	55	53	35	07	0.62	0.69	4C35.39
OR398	15	59	29	34	32	0.76	0.87	4C34.43
OR399	15	59	56	36	16	0.40	<0.78	
OS201	16	00	14	26	02	0.43	<0.75	d
OS300	16	00	11	33	37	1.91	0.11	4C33.38, lobe shifted

neglecting confusion effects, was therefore about 0.014°K. Previous measurements showed that the confusion level for the telescope operating under conditions similar to those for this survey is about 0.01°K rms (Kraus, Dixon, and Fisher 1966). The resultant minimum detectable temperature is equal to the square root of the sum of the squares of the sensitivity and confusion values or about 0.017°K. For a high probability that an observed source not be due to a random peaking effect, a temperature deflection should be about five times this amount or 0.085°K. In the present survey, this temperature corresponds to a point source having a flux density of about 0.37 flux unit (1 flux unit $= 10^{-26}$ W m^{-2} Hz^{-1}).

Table I presents a list of 236 sources with flux densities equal to or greater than 0.37 flux units (level 5 or more times the minimum detectable flux density). Each source has been assigned an Ohio number which consists of five characters made up of two letters and three digits. The first letter (O) stands for Ohio, and the second letter (B to Z, inclusive, omitting O) indicates the source right ascension in hours (0 to 23, inclusive). The designation OA is reserved for sources in the first Ohio lists (Kraus 1966). The first digit gives the source declination in 10° increments. Thus, 3 indicates that the source declination is between 30° and 40° north. The last two digits give the source number within the 1 h right ascension by 10° declination region. These digits (0 to 99, inclusive) increase according to source right ascension roughly one unit per 0.01 h of right ascension. For example, source OP386 is between 30° and 40° north declination, and at a right ascension P of 13 h and about $0.86 \times 60 = 52$ min. We have adopted the above designation for the sources in our list because it is very concise and yet indicates the source position to within $\pm 5°$ of declination and $\pm 1^{m}$ of right ascension. By adding an S between the two letters and three digits for sources with south declinations this designation is adequate for cataloguing over 30 000 sources which exceeds the number we expect to find in our survey.

The 236 sources in Table I do not include any of the 22 3C sources which are in the region surveyed. These 3C sources are 211, 220.2, 223, 236, 248, 252, 261, 265, 268.2, 269, 270.1, 277.3, 284, 286, 287, 290, 293, 294, 301, 310, 315, and 320. Of the 236 sources in Table I, 129 do not appear in other lists. The remaining 107 sources appear in one or more lists as follows: 103 in the 4C list (Pilkington and Scott 1965), 10 in the NRAO list (Pauliny-Toth, Wade, and Heeschen 1966) and 3 in the CTD list (Kellermann and Read 1965).

All source positions were corrected with respect to instrumental errors and a correction for aberration was applied. A systematic correction was then made as based on NRAO, Owens Valley, and Royal Radar Establishment positions for 21 3C sources (Tyler *et al.* 1965; Pauliny-Toth *et al.* 1966; Formalont *et al.* 1964; Wyndham and Read 1964; Adgie and Gent 1966). From Monte Carlo tests and comparisons of sources common to other lists the standard deviations for the positions are taken to be 5 sec of time in right ascension and 4 min of arc in declination. The flux densities S are believed accurate to about ± 30 percent. Spectral indices n are given for those sources corresponding to ones in the 4C list with the index based on two flux densities: at 178 MHz (4C) and 1415 MHz (Ohio). Limiting values of spectral index are given for those sources which do not correspond to ones in the 4C list assuming a flux density of less than 2 flux units at 178 MHz. The approximate positions of the 4C sources are indicated by dots on the contour maps.

Another 26 sources were found at 4C positions but with flux densities less than 0.37 flux units. These are listed in Table II. They are of particular interest since

TABLE II. Sources in Ohio State University north galactic pole survey (1415 MHz). $S < 0.37$ flux unit but at 4C positions.

Source number	Celestial coordinates (1950.0) α h	m	s	δ deg	min	Flux density (flux units)	Spectral index[a] n	Remarks[b]
OJ313	08	07	45	34	57	0.34	0.98	4C34.27
OJ399	08	59	20	33	22	0.26	1.13	d, 4C33.23
OK388	09	52	39	35	50	0.31	1.13	4C35.21
OL360	10	36	08	32	33	0.36	1.10	4C32.36
OL363	10	38	03	30	07	0.19	1.15	4C30.19
OM310	11	05	56	31	24	0.33	0.89	4C31.36
OM323	11	14	06	34	57	0.29	0.96	4C34.34
OM347	11	27	58	32	42	0.31	0.90	4C32.38
OM349	11	30	00	37	08	0.27	1.10	4C37.31
ON308	12	04	39	35	28	0.27	1.21	4C35.27
ON344	12	26	23	31	51	0.29	0.98	4C31.41
ON351	12	30	25	34	59	0.32	0.95	4C34.37
ON357	12	34	19	37	15	0.28	1.40	4C37.34
ON365	12	37	59	35	10	0.32	0.91	4C35.29
ON380	12	47	58	30	34	0.36	0.95	4C30.25
ON390	12	53	54	37	31	0.28	1.39	4C37.35
ON391	12	55	01	36	46	0.33		Poss. 4C36.22 lobe shifted
OP265	13	39	13	26	41	0.35	0.89	Poss. 4C26.41 lobe shifted
OP296	13	57	36	27	21	0.32	0.97	4C27.27
OP347	13	28	23	33	04	0.32	0.93	4C33.32
OP382	13	48	56	35	19	0.32	0.95	4C35.31
OQ222	14	13	29	25	38	0.36	0.94	c, d, poss. 4C25.45
OQ364	14	38	55	35	45	0.34	1.10	4C35.33
OR235	15	21	10	27	09	0.14	1.41?	4C27.31
OR309	15	05	48	30	23	0.20	1.12	Poss. 4C30.28 lobe shifted
OR372	15	42	52	37	19	0.33	1.13	4C37.45

For footnotes see Table I.

TABLE III. Summary of sources detected at 1415 MHz in north galactic polar survey.

Sources at 0.37 or more flux units		
3C sources	22	
In other lists } Table I	107	
Not in other lists } Table I	129	
	258	258
Sources less than 0.37 flux units but common to 4C (Table II)		26
Sources between 0.30 and 0.37 flux units and not in other lists		63
Total detected		347

TABLE IV. 4C sources in north galactic polar survey (1415 MHz).

Detected at 0.37 or more flux units		
3C sources	22	
Others (in Table I)	104	
	126	126
Detected at less than 0.37 flux units (Table II)		26
Detected or possibly detected but too near edge of map, etc.		20
Probably undetected		3
Total in region surveyed		175

they all have high spectral indices but their position and flux density errors may be larger than those for Table I. Another 63 sources between 0.30 to 0.37 flux units and not on other lists have been numbered and appear on the maps, but are not tabulated herein. A list of these with positions and flux densities is available on request. Lists of the sources in Tables I and II in galactic coordinates are also available.

A summary of the sources detected in the survey is given in Table III.

IV. COMPARISON WITH 4C CATALOGUE

There are 175 4C sources in the region surveyed. Of these 126 were detected at flux densities of 0.37 flux units or more and 104 of these are listed in Table I. The remaining 22 are 3C sources. Twenty-six 4C sources were detected at less than 0.37 flux units and these appear in Table II. In the case of seven sources in Tables I and II much closer position agreement is obtained if the 4C positions are lobe shifted. There are 20 more sources which were detected but which appeared on less than three adjacent declination profiles, as when too close to the edge of the map, or were possibly detected (indication weak and/or position agreement less good). One source (4C37.23) is in the vicinity of several strong sources but is remote from them and so was probably undetected. The remaining two sources (of the 175) have such weak indications in their vicinity that they also were probably undetected. These are

TABLE V. Sources with high ($n \geq 0.95$) or low ($n < 0.35$) spectral indices which are in 4C catalogue.

Source	S_{1415}	n	4C No.
		High index	
OJ313	0.34	0.98	4C34.27
OJ316	0.47	1.12	4C35.18
OJ399	0.26	1.13	4C33.23
OK388	0.31	1.13	4C35.21
OL360	0.36	1.10	4C32.36
OL363	0.19	1.15	4C30.19
OM323	0.29	0.96	4C34.34
OM338	0.63	0.99	4C30.21
OM349	0.27	1.10	4C37.31
ON237	0.54	0.97	4C26.37
ON286	0.40	1.02	4C26.40
ON308	0.27	1.21	4C35.27
ON344	0.29	0.98	4C31.41
ON357	0.28	1.40	4C37.34
ON380	0.36	0.95	4C30.25
ON390	0.28	1.39	4C37.35
OP296	0.32	0.97	4C27.27
OP339	0.45	0.97	4C37.38
OP382	0.32	0.95	4C35.31
OQ243	0.57	0.96	4C28.35
OQ313	0.37	1.18	4C31.44
OQ364	0.34	1.10	4C35.33
OR235	0.14	1.41	4C27.31
OR304	0.44	1.00	4C33.34
OR309	0.20	1.12	4C30.28?
OR372	0.33	1.13	4C37.45
		>1.23?	4C26.38
		>1.00?	4C26.44
		>1.27?	4C37.23
		Low index	
OL376	1.24	0.26	4C35.23
ON323	1.44	0.20	4C35.28
OQ241	1.19	0.32?	4C27.30?
OR236	1.44	0.27	4C28.39
OS300	1.91	0.11	4C33.38

TABLE VI. Sources with more than 0.7 flux units at 1415 MHz but which are not in 4C catalogue.

Source	S_{1415}	n
OJ320	0.78	<0.47
OK313	0.90	<0.39
OK359	0.71	<0.50
OK373	0.75	<0.49
OL314	1.16	<0.27
OL326	1.01	<0.33
OL333	0.99	<0.34
OL343	0.78	<0.46
OL368	0.81	<0.45
OM359	0.73	<0.49
ON294	0.90	<0.39
ON319	1.13	<0.27
ON343	2.59	<−0.13
ON366	1.28	<0.22
OP303	0.71	<0.50
OP313	1.01	<0.33
OP335	1.69	<0.08
OP353	1.02	<0.32
OP354	0.72	<0.50
OQ208	1.09	<0.29
OQ217	0.80	<0.45
OQ237	0.82	<0.44
OQ244	0.72	<0.50
OQ248	0.83	<0.44
OQ256	0.79	<0.45
OQ286	0.83	<0.44
OQ287	0.84	<0.43
OQ323	1.62	<0.10
OQ329	0.73	<0.49
OR204	1.43	<0.16
OR337	0.74	<0.49
OR342	0.81	<0.44

26.38 and 26.44. It could be inferred that these three probably undetected sources have high spectral indices or else are spurious. A summary of the 4C sources is presented in Table IV.

Twenty-six sources common to the 4C catalogue with high index ($n \geq 0.95$) are listed in Table V with the flux density (S_{1415}) at 1415 MHz. Also included are three 4C sources probably not detected in our survey for which high spectral indices might be inferred. A flux density of less than 0.25 flux units at 1415 MHz is assumed for these three sources. In addition Table V lists another five sources common to the 4C catalogue but with low or probably low spectral indices.

A list of 32 sources with more than 0.7 flux units at 1415 MHz, but which are not in the 4C catalogue, is presented in Table VI. The sources in this list have low or probably low spectral indices. The limiting index in Table VI is calculated on the assumption that the flux density is less than 2 flux units at 178 MHz (4C frequency).

V. DISCUSSION

Our survey has been conducted at a higher frequency (1415 MHz) than most surveys. It has often been pointed out, as by Kellermann (1966), that surveys at 1415 MHz or higher are very desirable. Thus, such a survey might include sources with flat spectra that would have escaped detection at lower frequencies. Such sources are of particular interest because this type of spectrum is characteristic of a variable quasar, as for example, the prototype 3C273B. If 3C273B were not accompanied by a low-frequency component (3C273A) it might not have been detected so readily at the lower frequencies. Also our survey has been conducted in a region near and including the north galactic pole. This part of the sky has the highest density of known quasars. Hence, the 32 sources in Table VI with low or probably low spectral indices are of much interest. To these may be added the five sources in Table V which have low spectral indices. The sources in these lists (Tables V and VI) with lowest indices (≤ 0.3) are: OL314, OL376, ON319, ON323, ON366, OP335, OQ208, OQ323, OR204, OR236, and OS300. ON343 has a negative index (flux increases with frequency).

A spectral index histogram of the sources common to the 4C catalogue shows a slightly asymmetrical distribution with a peak at about $n=0.85$ and a mean value at $n=0.76$. A $\log N$–$\log S$ graph of all of the sources detected in our survey has a slope of -1.8.

The maps of Plates I–IV reveal several interesting associations. Thus, there are clusters of sources with extensions forming partially closed circles situated around R.A.$=10^{h}40^{m}$, Dec.$=32\overset{\circ}{.}5$ and R.A.$=12^{h}22^{m}$, Dec.$=28°$. These structures are suggestive of supernova remnant rings. There are three sources in these two clusters which correspond to 4C sources. They all have high spectral indices: 0.72, 0.97, and 1.10. There is a another ringlike group near R.A.$=10^{h}22^{m}$, Dec.$=35°$. At other locations on the maps there are several close pairs with similar indices, such as OL327 ($n=0.72$) and OL329 ($n=0.79$), OR353 ($n=0.90$) and 3C320 ($n=0.81$); OR347 ($n=0.66$) and OR348 ($n=0.71$); OQ229 ($n=0.65$) and OQ238 ($n=0.70$); OP228 ($n=0.49$) and OP234 ($n=0.39$); and finally OP207 ($n=0.56$) and 3C284 ($n=0.61$). A group of three involves OJ313 ($n=0.98$), OJ316 ($n=1.12$) and OJ318 ($n=0.84$). A group of eight sources near R.A.$=11^{h}25^{m}$, Dec.$=34°$ includes OM339 ($n=0.49$), OM342 ($n=0.56$), OM350 ($n=0.57$), OM347 ($n=0.90$) and OM351 (n between 0.54 and 0.91 depending on whether one or two 4C sources are involved). The source OM348 is uncertain and the other two sources of this group, OM345 and OM346, have flux densities less than 0.34 flux units (not listed in Tables I or II) and are also uncertain.

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REFERENCES

Adgie, R. L., and Gent, H. 1966 *Nature* **209**, 549.
Bennett, A. S. 1962, *Mem. Roy. Astron. Soc.* **68**, 163.
Conway, R. G., Kellermann, K. I., and Long, R. J. 1963, *Monthly Notices Roy. Astron. Soc.* **125**, 261.
Formalont, E. B., Matthews, T. A., Morris, D., and Wyndham, J. D. 1964, *Owens Valley Radio Obs. Rept.* 5.
Harris, D. E., and Roberts, J. A. 1960, *Publ. Astron. Soc. Pacific* **72**, 237.
Kellermann, K. I. 1964, *Astrophys. J.* **140**, 969.
Kellermann, K. I., and Read, R. B. 1965, *Owens Valley Radio Obs., Publ.* 1.
Kellermann, K. I. 1966, *Astrophys. J.* **146**, 621.
Kraus, J. D., Dixon, R. S., and Fisher, R. O. 1966, *ibid.* **144**, 559.
Kraus, J. D. 1966, *Radio Astronomy* (McGraw-Hill Book Company, Inc., New York), p. 439.
Pauliny-Toth, I. I. K., Wade, C. M., and Heeschen, D. S. 1966, *Astrophys. J. Suppl.* **XIII**; 1965, Suppl. No. 116.
Pilkington, J. D. H., and Scott, P. F. 1965, *Mem. Roy. Astron. Soc.* **69**, 183.
Tyler, W. C., Hogg, D. E., and Wade, C. M., 1965, *Astron. J.* **70**, 332.
Wyndham, J. D., and Read, R. B. 1964, *Owens Valley Radio Obs., Rept.* 9.

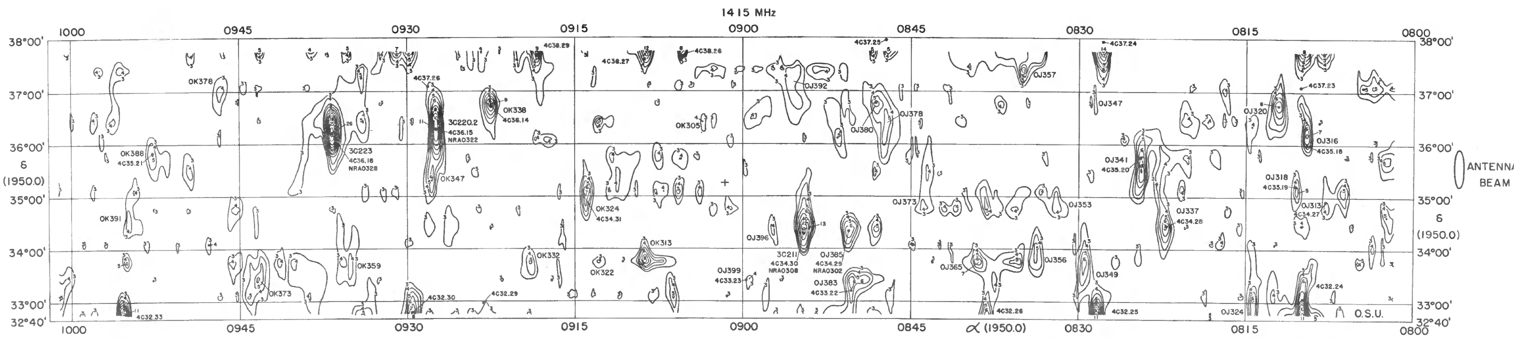

PLATE I (No. 1, Scheer and Kraus). Contour map of 8 to 10 h portion of 1415 MHz survey with O.S.U. 260-ft radio telescope. The contour interval is 0.025°K. Reference should be made to tables for most accurate positions and flux densities.

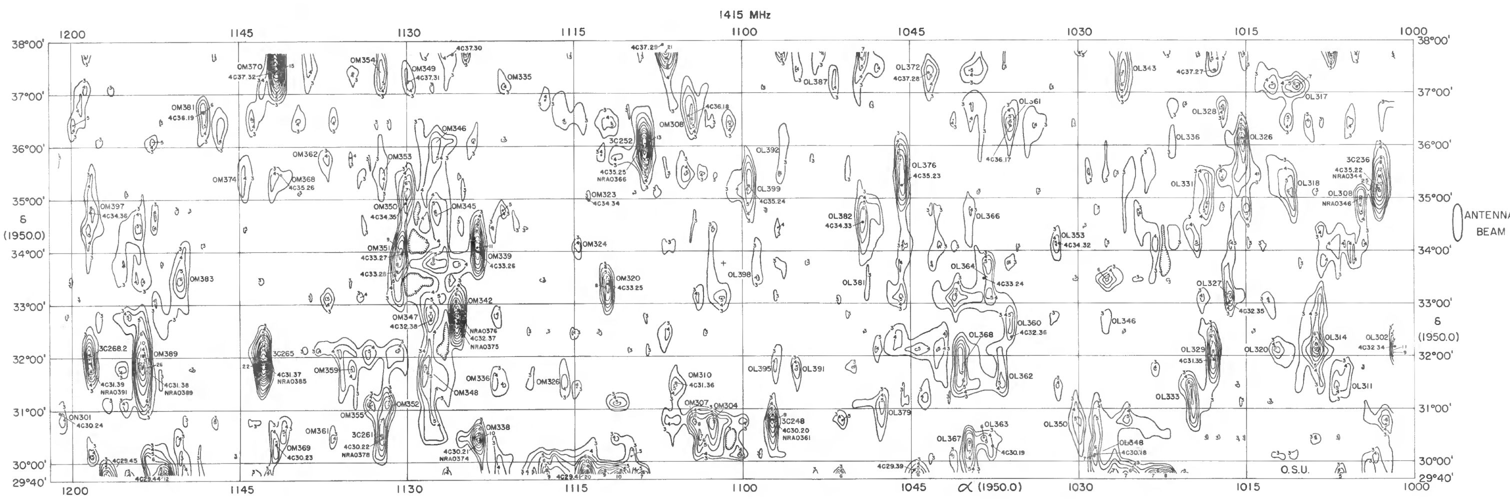

Plate II (No. 2, Scheer and Kraus). Contour map of 10 to 12 h portion of 1415 MHz survey with O.S.U. 260-ft radio telescope. The contour interval is 0.025°K. Reference should be made to tables for most accurate positions and flux densities.

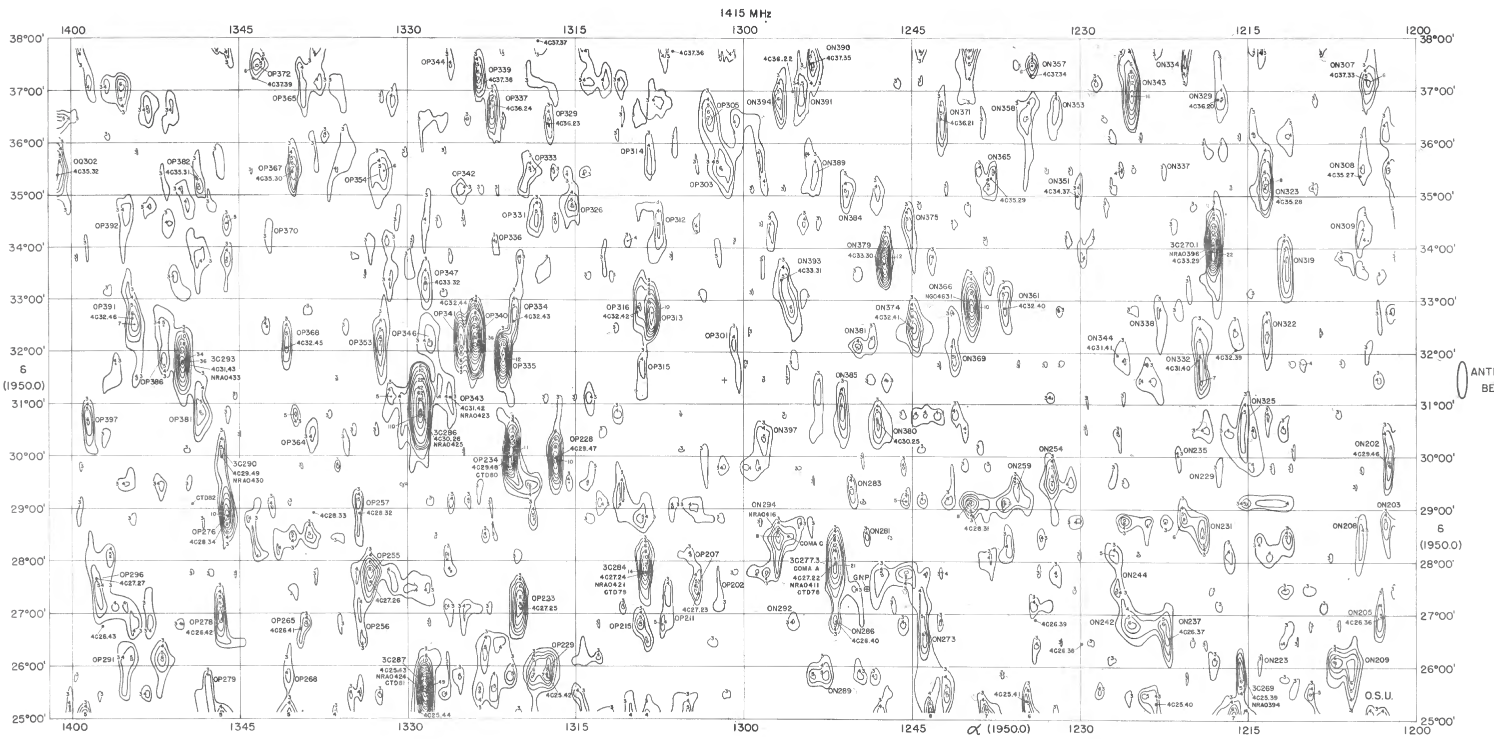

PLATE III (No. 3, Scheer and Kraus). Contour map of 12 to 14 h portion of 1415 MHz survey with O.S.U. 260-ft radio telescope. The contour interval is 0.025°K. Reference should be made to tables for most accurate positions and flux densities.

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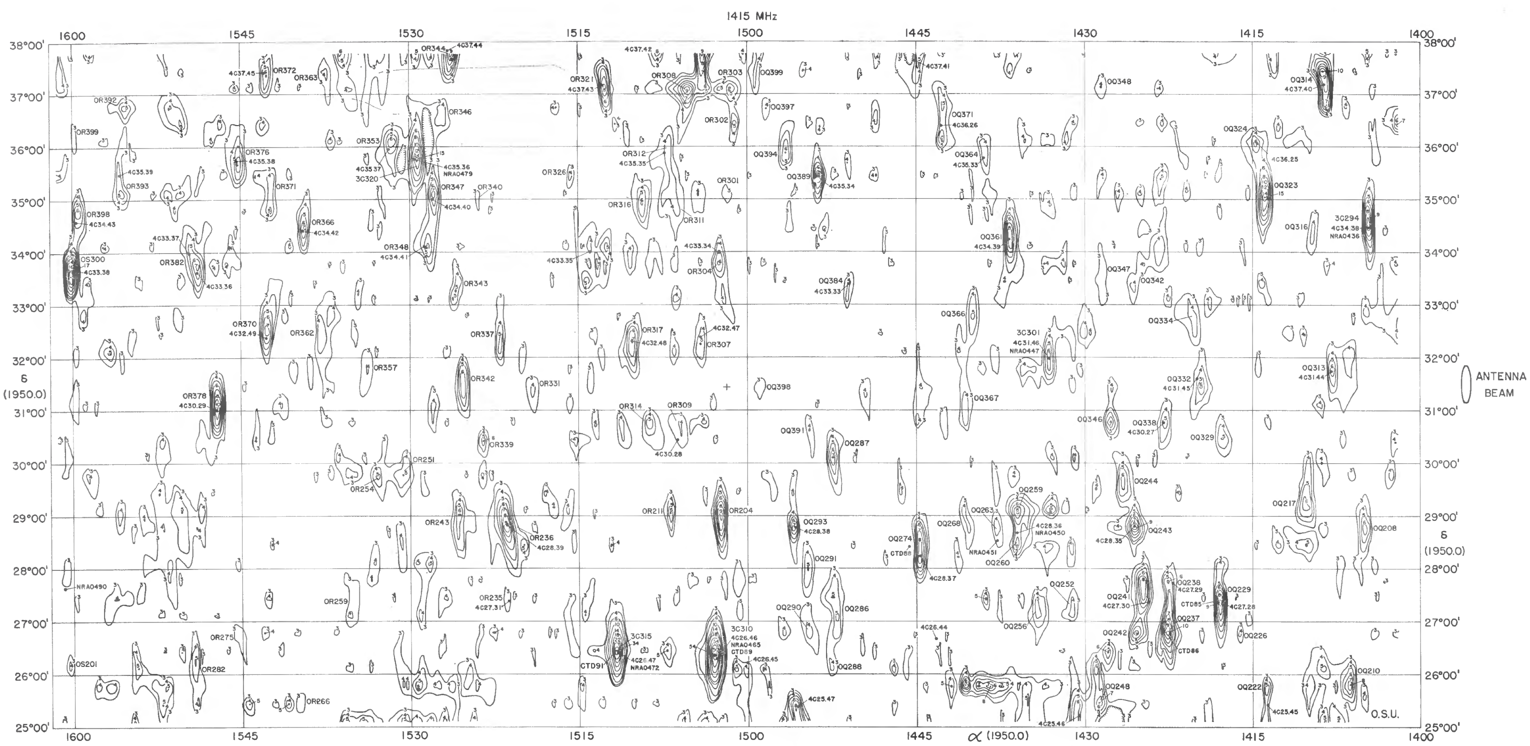

PLATE IV (No. 4, Scheer and Kraus). Contour map of 14 to 16 h portion of 1415 MHz survey with O.S.U. 260-ft radio telescope. The contour interval is 0.025°K. Reference should be made to tables for most accurate positions and flux densities.