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NATIONAL RADIO ASTRONOMY OBSERVATORY  
Charlottesville, Virginia

Quarterly Report  
April 1 - June 30, 1969

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RESEARCH PROGRAMS

Interferometer (three 85-foot telescopes and the 42-foot telescope)

	<u>Hours</u>
Scheduled observing	2025.00
Scheduled maintenance and equipment changes	135.00
Time lost due to: equipment failure	51.50
power	6.75
weather	6.00
interference	4.75

During this quarter a set of towing dollies was installed on 85-3. The additional set of dollies has resulted in a very substantial saving of time (about one day) when the baseline configuration requires that both 85-2 and 85-3 be moved, and has also eliminated the hazardous task of moving dollies from 85-2 to 85-3.

Observations during this quarter, all at a wavelength of 11 cm, were as follows:

<u>Observer</u>	<u>Program</u>
J. Basart, D. Buhl, and A. Sinclair (Bell Comm. Inc.)	Interferometric observations of Venus around inferior conjunction and the synthesis of Jupiter.
J. Basart	VLA study data to attempt to correlate water vapor fluctuations measured by hygrometers following the sun and phase fluctuations observed in the output of the interferometer as it observed a radio source near the sun.
G. Miley and G. Macdonald	A study of the structure of quasi-stellar radio sources.
W. Webster (Case Western Reserve)	An attempt to detect a planetary nebula, M328-116.
J. Basart, G. Miley, and B. Clark	Observations with a phase-stable interferometer of 300,000 wavelengths baseline using the 42-foot portable telescope.

J. Sutton	Attempt to measure a pulsar, NP 0527, at 2695 MHz that was at that time being measured at the 300-foot telescope.
E. Fomalont (Calif. Inst. of Tech.)	Synthesis of the polarization brightness distribution of about 50 sources from the 3C catalog.
B. Clark and D. Hogg	Fan beam synthesis.

140-foot Telescope

	<u>Hours</u>
Scheduled observing	1906.25
Scheduled maintenance and equipment changes	239.75
Time lost due to: equipment failure	145.50
power	2.25
weather	7.25
interference	0.75

Line observations were conducted as follows:

<u>Observer</u>	<u>Program</u>
P. G. Mezger, W. Altenhoff, and E. Churchwell (Indiana)	Measurement of H109 $\alpha$ recombination lines and some of the higher order recombination lines in extended H II regions; measurement of centroids of a sample of H II regions to determine the galactic abundance of helium; measurement of non-thermal galactic sources to investigate a correlation between their continuum spectrum and their line emission.
Y. Terzian (Cornell) and B. Balick (Cornell)	Measurement of the H109 $\alpha$ recombination line in selected planetary nebulae.
R. Rubin and B. Turner	An attempt to detect H109 $\alpha$ radiation in NGC 6857 to investigate the temperatures of planetary nebulae relative to those of H II regions.
W. Howard and H. Hvatum	The testing of a new line search technique. Observations of the radio source W3, W49, and VY CMa in an attempt to detect radio spectral lines in the frequency range 20-25 GHz with antenna temperatures exceeding 150° K.

- K. Turner (D.T.M.) and J. Erkes (D.T.M.) A search for water vapor in Messier 31, the Andromeda Nebula.
- T. Reifenstein, R. Rubin, P. Mezger, and E. Churchwell (Indiana)  $H\alpha$  radio recombination lines near the water vapor and ammonia ( $NH_3$ ) lines.
- D. Buhl and L. Snyder Search for  $H_2O$  in Venus and Jupiter and in W3 and W49; search for  $NH_3$  in Venus and Jupiter.
- P. Mezger, B. Turner, D. Buhl, L. Snyder, and E. Churchwell (Indiana) Observations to study  $NH_3$  lines within a given source, a survey within the galactic plane for other  $NH_3$  sources, and a search for new water sources primarily in the vicinity of known OH emitters.
- A. Barrett (M.I.T.), D. Staelin (M.I.T.), J. Waters (M.I.T.), P. Schwartz (M.I.T.), P. Rosenkrantz (M.I.T.), D. Buhl, and L. Snyder Spectroscopic observations to detect or measure  $H_2O^{16}$ ,  $H_2O^{18}$ , HDO,  $H_2O_2$ , HCN,  $H_2CO$ ,  $HNO_3$ , and HCNS lines in OH emitters and Venus and Jupiter, and a search for new water vapor sources.
- A. Barrett (M.I.T.), D. Staelin (M.I.T.), J. Waters (M.I.T.), P. Schwartz (M.I.T.), P. Rosenkrantz (M.I.T.), D. Buhl, L. Snyder, B. Turner, P. Mezger, and E. Churchwell (Indiana) Collaborative program to investigate  $H_2O$  in selected sources.
- F. Kerr (Maryland), A. Sandqvist (Maryland), and J. Knapp (Maryland) H I observations of Kapteyn Selected Areas.
- F. Kerr (Maryland) and A. Sandqvist (Maryland) Lunar occultation of the galactic center in the formaldehyde line.
- T. K. Menon (Hawaii) Observations to confirm an unidentified absorption line at 1447 MHz and HI line profiles in the galactic plane from longitude  $l^{II} = -7^\circ$  to  $+7^\circ$ .
- W. Altenhoff Observations to map the Rosette Nebula in 6 cm continuum and line radiation.
- P. Palmer (Chicago), B. Zuckerman (Maryland), L. Snyder, and D. Buhl Observation of  $H_2C^{13}O^{16}$  to measure the isotopic abundance ratio  $C^{13}/C^{12}$ , limited observations of  $H_2C^{12}O^{16}$  to study its distribution near the galactic center and in dark clouds, and an

attempt to detect formic acid and trimethylene oxide.

R. Davies (Jodrell Bank, England)

Observations of higher order recombination lines in bright H II regions, specifically the intensity ratios of H158 $\gamma$ , H110 $\alpha$ , H138 $\beta$ , H173 $\delta$ , and H186 $\epsilon$  lines near 4900 MHz.

J. Simpson (Berkeley)

Study of the detailed shape and structure of hydrogen recombination lines.

Continuum observations at 6 cm were as follows:

K. Kellermann, I. Pauliny-Toth, and M. Davis

Survey of selected regions, including 5C1 and 5C2 sources.

K. Kellermann and I. Pauliny-Toth

Flux densities of variable sources.

M. Kundu (Maryland)

Polarized brightness distribution of supernova remnants at 6 cm.

D. Morrison (Cornell)

Brightness temperature measurements of Venus to obtain phase effects and the mean brightness temperature.

W. Altenhoff

Observations in the direction of dark clouds associated with formaldehyde in absorption to investigate the following: The possible association of a nearby continuum source and the background temperature near the dark clouds.

D. Morrison (Cornell), C. Sagan (Cornell), and M. Klein (JPL)

Brightness temperature measurements of Mercury to obtain phase effects and the mean brightness temperature.

An 18 cm VLB and a 6 cm VLB observational run were conducted between the 210-foot Parkes (Australia) telescope, the 130-foot telescope of the California Institute of Technology, and the NRAO 140-foot telescope. Participants in these experiments were M. Cohen (California Institute of Technology), D. Jauncey (Cornell), B. Clark and K. Kellermann.

S. Goldstein (Virginia) and D. McCarthy (Virginia) conducted 234, 256, and 405 MHz observations in the direction of DQ Hercules to attempt to detect pulsar-like radiation. T. K. Menon (Hawaii), K. Gordon (Michigan), and J. Sutton attempted to observe the pulsar in Tau A at 21 cm. Simultaneous observations at Jodrell Bank by B. Rickett (Jodrell), Arecibo by K. Lang (Cornell), and the NRAO 140-foot telescope by J. Sutton were made to determine whether

long period variations in pulsars are caused by scintillation processes in the interstellar medium.

### 300-foot Telescope

	<u>Hours</u>
Scheduled observing	1934.50
Scheduled maintenance and equipment changes	249.50
Time lost due to: equipment failure	23.25
power	1.00
weather	28.00
interference	0.00

Line observations were conducted at the 300-foot telescope as follows:

<u>Observer</u>	<u>Program</u>
M. Kesteven (Queen's University, Canada) and A. Bridle (Queen's University, Canada)	Absorption measurements of neutral hydrogen in the direction of supernova remnant suspects, sources in the 10 MHz Penticton list and sources with unusual spectra.
G. Verschuur	Measurements of neutral hydrogen in high-latitude intermediate-velocity clouds.
F. Kerr (Maryland) and W. Sullivan III (Maryland)	Search for H I high velocity clouds, extending an existing program to velocity ranges not previously observed.
C. Gordon	Measurements of neutral atomic hydrogen in the Orion Nebula.
G. Verschuur and B. Turner	Strip of sky survey for OH emission sources at 1612 MHz within $\pm 1^\circ$ of the galactic plane.
K. Gordon (Michigan)	The search for neutral hydrogen in approximately 100 high velocity galaxies to gain a significant improvement in the statistical sample of galaxies that exhibit useful 21 cm data.

Final software and hardware testing of the 400-channel autocorrelation receiver at the 300-foot telescope was accomplished this quarter through the combined efforts of G. Westerhout (Maryland), C. Gordon, G. Verschuur, and J. Greenhalgh.

The following continuum observations at 1400 MHz were made:

<u>Observer</u>	<u>Program</u>
M. Felli (Arcetri, Italy) and E. Churchwell (Indiana)	Survey of Sharpless H II regions
D. Jauncey (Cornell) and A. Neill (Cornell)	1400 MHz fluxes of 4C and uncataloged sources exhibiting less than 0.7 flux units at 408 MHz. Data is supplemental to that collected at Arecibo and in Australia with the Mills Cross.
J. Kraus, R. Dixon, J. Ehman, and L. Fitch (all Ohio State U.)	Measurements to obtain more accurate radio source positions and to confirm some of the weaker sources in the Ohio State University Survey.
Pulsar observations were also made.	
J. Sutton	1400 MHz search for pulsars with large dispersion measures.
S. Goldstein (Virginia), D. Meisel (Virginia), J. James (Virginia), and W. R. Burns	Observations to obtain models of the electron density of the solar corona by measuring the change in delay times between pulses from NP 0532 at 115 MHz and at 230 MHz during conjunction; observations to determine the magnetic field in the solar corona by measuring time of arrival differences in polarized emission at 115 MHz; measurements of the dispersions of known pulsars and a search for new sources exhibiting pulsar-like emission.
J. Sutton, M. Ewing (M.I.T.), M. Price (M.I.T.), and D. Staelin (M.I.T.)	Observations of known pulsars to determine internal pulse structure and variability and a search for new pulsars.

Preliminary tests on a low-frequency travelling feed assembly were also conducted by representatives of the Engineering, Telescope Operations, and Central Shops Divisions and by J. Sutton.

### 36-foot Telescope

	<u>Hours</u>
Scheduled observing	941.50
Scheduled maintenance and equipment changes	6.00
Time lost due to: equipment failure	49.00
power	0.00
weather	145.00
interference	0.00

During this quarter F. Low (Arizona) tested a receiver at 300 GHz, and J. Schraml performed both receiver and antenna tests at 31 and 85 GHz. The following observational programs were carried out.

<u>Observer</u>	<u>Frequency (GHz)</u>	<u>Program</u>
C. Wade	31	Observations of normal galaxies.
K. Kellermann	31 and 85	Flux density determinations of radio sources.
M. Simon (Calif. Inst. of Tech.)	31	Solar and lunar scans, equipment familiarization.
D. S. Heeschen	31 and 85	Observations of elliptical galaxies.
J. Schraml	31 and 85	W49, W51, mapping.
J. Schraml	85	Scans of strip of sky.
A. Maxwell (Harvard)	31 and 85	Galactic center, DR 21, and other sources.
R. Rubin and B. Turner	31 and 85	Observations of K3-50 and various planetary nebulae.

#### ELECTRONICS DIVISION--EQUIPMENT DEVELOPMENT

During the past quarter the manpower assignments within the Electronics Division have been divided among the following programs:

Interferometer Development	10%
Interference Protection	9%
Millimeter Receiver Development	6%
Very Long Baseline Interferometer	6%
OH-Line Receiver Construction	12%
Water Vapor Receiver	2%
Pulsar Receiver Construction	4%
3-cm Receiver	2%
6-cm Receiver	4%
413-Channel Autocorrelation Receiver	6%
50-Channel Receivers	4%
Visitor Support and Routine Maintenance	35%

A dual-channel, cryogenically-cooled parametric amplifier for OH-line observations has been completed. This is the first paramp constructed by NRAO and is now being packaged in a front-end box for use on the 140-foot telescope in August. The system will reduce the integration time required for OH-line observations by a factor of 10. Portable front-ends operating at 6 cm and 3 cm have also been completed.

Contracts have been let during the past quarter for the following items:

1. Magnetic Tape Recording and Playback System - This system will greatly increase the capability of very-long baseline interferometer experiments.
2. Schottky Diode Development - This contract with the University of Virginia is to foster the development of Schottky-diodes for mm-wave paramps and mixers.
3. Interferometer Delay Line System - This is a dual-channel 30 MHz bandwidth delay-line system for use on the 3-element interferometer.
4. Interferometer H-Line Parametric Amplifiers - Three, uncooled 1420 MHz paramps are being purchased for spectral line work on the interferometer.
5. Parametric Amplifiers for the 5 to 10 GHz Range - This is for a set of paramps for spectral line searches in this frequency range.

Work is continuing on new 3 cm/11 cm front-ends for the interferometer, a new 0.95 cm paramp receiver, and a new 6 cm receiver. A 3 cm parametric amplifier has been received and is now being installed in a radiometer system.

The following new projects have been started during this quarter:

1. 384-Channel Autocorrelation Receiver - This will have similar specifications to the one now in use; it is needed due to increased spectral-line observations at all telescopes.
2. 50-Channel Filter Receivers - Units at bandwidths of 10 kHz and 30 kHz are under construction. A new scanning system for the 50-channel receiver has been completed.
3. Antenna Measuring Instrument - This is a radar-type device to accurately monitor the shape of paraboloidal reflectors.
4. 12-18 GHz Receiver - A tunnel-diode receiver with a versatile LO system is being constructed.

## ENGINEERING

The second quarter of 1969 saw the Engineering Division move into more convenient and spacious quarters in the Jansky Laboratory building, and the addition of an electrical engineer, whose prime assignment is electrical power distribution and the maintenance of our existing power system.

Some areas of major effort by the Engineering Division within the quarter have been:



1. The development of a design for resurfacing the 300-foot transit telescope.
2. A measurement program to determine the deflection characteristics of the 300-foot telescope from zenith to 30 degrees north position.
3. A computer study to calculate the deflection of the 300-foot telescope for a movement from the zenith position to a 30 degree zenith angle.
4. Structural and mechanical design and feasibility studies for a 300-foot homology antenna. Preparation of cost estimates for fabrication and erection of the antenna and preparation of portions of a report covering progress of the homology antenna design.
5. Preparation of plans for dome door modification, dish surface painting, investigation of thermal warpage of the dish and feed leg adjustment of the 36-foot telescope at Kitt Peak.

#### ANTENNA DESIGN STUDIES

##### The Homology Telescope

A status report on the design of a 31.5 m (300-foot) fully steerable homologous telescope has been completed. It was presented to the ad hoc NSF Advisory Panel for Large Astronomy Facilities (the Dicke Committee) in June 1969.

#### NRAO SUMMER STUDENT PROGRAM

Over 120 students responded to announcements of the NRAO summer student program mailed in December 1968 to over 265 departments of astronomy, physics, mathematics, and electrical engineering. An internal committee of three staff members chose 11 graduate students and 19 undergraduate students to participate in the program. The National Science Foundation supported 10 of our undergraduate students for 12 weeks as part of its Undergraduate Research Participation Program. The students are assigned to the scientific staff, the Electronics Division and the Computer Division for various research assignments. In addition, three students are chosen as tour guides for part of the summer.

Twenty-one students are resident in Charlottesville and 9 are resident in Green Bank. The following table shows the summer 1969 participants.

##### Graduate Students

<u>Name</u>	<u>Year</u>	<u>College</u>	<u>Hometown</u>
Ames, Susan	2	U. of Calif., Berkeley	New York, N. Y.
Balick, Bruce	3	Cornell	Ithaca, N. Y.
Carpenter, Robert	1	North Carolina State	Salisbury, N. C.
Jansson, Sven	1	Chalmers	Goteborg, Sweden

<u>Name</u>	<u>Year</u>	<u>College</u>	<u>Hometown</u>
Kintner, Paul	1	U. of Minnesota	Bayside, Wis.
Nordsieck, Kenneth	2	U. of Calif., San Diego	Santa Barbara, Calif.
Pankonin, Vernon	1	Cornell	Grant, Neb.
Scharlemann, Ernst	1	Cornell	St. Louis, Mo.
Shaffer, David	1	Calif. Inst. of Tech.	Huntingdon, Pa.
Smith, Charles	2	U. of Virginia	Richmond, Va.
Yao, Stanton	4	Purdue	W. Lafayette, Ind.

#### Undergraduate Students

Allen, Michael	1	Ohio State	Mansfield, Ohio
Ames, Mary	3	Randolph-Macon	Newport News, Va.
Baldwin, John	3	U. of Florida	Paxton, Fla.
Braly, Kenneth	4	Princeton	Pikesville, Md.
Cashdollar, Kenneth	4	Dickinson	Mars, Pa.
Ceperley, David	2	U. of Michigan	Charleston, W. Va.
Chen, Kok	4	Purdue	Kuala Lumpur, Malaysia
Detweiler, Steven	4	Princeton	Hinsdale, Ill.
Gallagher, John	4	Princeton	Columbus, Ohio
Jacobson, Michael	2	Harvard	Pittsburgh, Pa.
Johnson, Keith	4	Luther	Joliet, Ill.
Ko, Malcolm	2	Princeton	Hong Kong
Kwoh, Daniel	3	Princeton	Hong Kong
McDonald, Lee	2	U. of Arizona	Tucson, Ariz.
McGrath, Daniel	4	Ohio State	Columbus, Ohio
McLarren, James	4	Buffalo State	Cheektowaga, N. Y.
Owen, Frazer	4	Duke	Cumming, Ga.
Tsang, Yuen	3	U. of Toronto	Hong Kong
Williams, Theodore	2	Purdue	Youngstown, Ohio

#### PERSONNEL

##### Appointments

Kurtiss J. Gordon	Research Associate	April 1, 1969
Thomas L. Wilson	Research Associate	May 20, 1969
Rodney D. Davies	Visiting Scientist	June 16, 1969

##### Terminations

David H. Staelin	Visiting Assistant Scientist	April 25, 1969
Edward C. Reifenstein	Research Associate	June 11, 1969
Julius Marymor	Contracts/Business Manager	June 13, 1969
Wilhelm J. Altenhoff	Assistant Scientist	June 26, 1969

K. I. Kellermann returned from a three months' leave of absence at the California Institute of Technology on June 1, 1969.

S. von Hoerner left on April 1, 1969 for a three months' leave of absence at the University of California at Los Angeles.

## OBSERVATORY COLLOQUIA

Outlined below is the NRAO colloquium program for the past fiscal year. Speakers, who generally talk on topics of current interest in radio astronomy or closely allied fields, are usually invited by our scientific staff. The University of Virginia, Department of Astronomy also invites speakers to participate in their own colloquium series. These series are announced jointly and are well attended by our staff, university physicists and astronomers and by students. The outside speakers listed below visited the NRAO in our colloquium series.

Speaker	Institution	Date
T. K. Menon	University of Hawaii	July 15, 1968
Ludwig Biermann	Max Planck Institut für Physik und Astrophysik	August 28, 1968
Franz D. Kahn	University of Manchester	August 29, 1968
Willi Deinzer	Joint Institut for Labora- tory Astrophysics	September 26, 1968
W. G. Tifft	University of Arizona	October 3, 1968
Arcadio Poveda	Universidad Nacional de Mexico	October 4, 1968
Paul Stewart	University of Manchester	December 12, 1968
J. S. Shklovsky	Sternberg Astronomical Institute	December 13, 1968
John E. Gaustad	University of California, Berkeley	February 27, 1969
Edward B. Jenkins	Princeton University	April 10, 1969
David S. De Young	Los Alamos Scientific Laboratory, University of California	April 11, 1969
D. S. Mathewson	The Australian National University	April 15, 1969
Gerard de Vaucouleurs	University of Texas	May 8, 1969
Richard Larson	Yale University	May 29, 1969
Leo Goldberg	Harvard College Observatory	June 6, 1969

A list of Observatory reprints issued since June 30, 1968.

No.	Title	Author	Reference
<u>Series A</u>			
76	On the Electron Temperatures of the Orion Nebula and NGC 2024 (I): Radio Observations of the Free-Free Continuum	Y. Terzian, P. G. Mezger, J. Schraml	<u>Astrophys. Letters</u> , <u>1</u> , 153-158, 1968
77	On the Electron Temperatures of the Orion Nebula and NGC 2024 (II): Observations of the Radio Recombination Lines	P. G. Mezger, S. A. Ellis	<u>Astrophys. Letters</u> , <u>1</u> , 159-165, 1968
78	Radio Recombination Lines: A New Observational Tool in Astrophysics	P. G. Mezger, P. Palmer	<u>Science</u> , <u>160</u> , 29-42, 1968
79	Discovery of Hydroxyl Radio Emission from Infrared Stars	W. J. Wilson, A. H. Barrett	<u>Science</u> , <u>161</u> , 778-779, 1968
80	Radio Emission from the Nebula Sharpless 261 and the Surrounding Galactic Region	J. R. Dickel	<u>Astron. J.</u> , <u>73</u> , 310-312; 380, 1968
81	Spectral Characteristics of Radio Sources from a Limited Survey at 6 cm	E. J. Blum, M. M. Davis	<u>Astrophys. Letters</u> , <u>2</u> , 41-44, 1968
82	Intermediate Velocity Hydrogen Cloudlets in the Galaxy	C. Heiles	<u>Astrophys. Letters</u> , <u>2</u> , 31-35, 1968
83	Measurements of the Flux Density of Discrete Radio Sources at Centimeter Wavelengths. I. Observations at 2695 MHz (11.3 cm)	K. I. Kellermann, I.I.K. Pauliny-Toth, W. C. Tyler	<u>Astron. J.</u> , <u>73</u> , 298-309, 1968
84	Positive Determination of an Interstellar Magnetic Field by Measurement of the Zeeman Splitting of the 21-cm Hydrogen Line	G. L. Verschuur	<u>Phys. Rev. Letters</u> , <u>21</u> , 775-778, 1968

No.	Title	Author	Reference
<u>Series A, cont.</u>			
85	The Beam Shape of the NRAO 300-ft Telescope and its Influence on 21-cm Line Measurements	C. Heiles, W. Hoffman	<u>Astron. J.</u> , <u>73</u> , 412-414, 1968
86	High Central Densities in Stellar Systems	S. von Hoerner	<u>Bull. Astron. (Paris)</u> , <u>3</u> , 147-161, 1968
87	The Dependence of Radio Source Counts and the Spectral Index Distribution on Frequency	K. I. Kellermann, I.I.K. Pauliny-Toth, M.M. Davis	<u>Astrophys. Letters</u> , <u>2</u> , 105-111, 1968
88	Radio Interferometry at One-Thousandth Second of Arc	M. H. Cohen, D. L. Jauncey, K.I. Kellermann, B. G. Clark	<u>Science</u> , <u>162</u> , 88-94, 1968
89	Occultations of the Galactic Center Region in the 1667-MHz OH Line	F. J. Kerr, A. Sandqvist	<u>Astrophys. Letters</u> , <u>2</u> , 195-200, 1968
90	The Interferometer in Radio Astronomy	G. W. Swenson, Jr., N. C. Mathur	<u>Proc. IEEE</u> , <u>56</u> , 2114-2130, 1968
91	On the Space-Frequency Equivalence of a Correlator Interferometer	G. W. Swenson, Jr., N. C. Mathur	<u>Radio Science</u> , <u>4</u> , 69-71, 1969
92	Pulsating Radio Sources Near the Crab Nebula	D. H. Staelin, E.C. Reifenstein III	<u>Science</u> , <u>162</u> , 1481-1483, 1968
93	Radio-Frequency Structure and Time Variations in the Seyfert Galaxies 3C 84 and 3C 120	K. I. Kellermann, I.I.K. Pauliny-Toth	<u>Astron. J.</u> , <u>73</u> , 874-876, 1968
94	Radio Structure of Seyfert Galaxies and Other Spirals	C. M. Wade	<u>Astron. J.</u> , <u>73</u> , 876-878, 1968
95	Observations of 28 Hydrogen $\alpha$ Lines from the Orion Nebula	T. K. Menon, J. Payne	<u>Astrophys. Letters</u> , <u>3</u> , 25-27, 1969
96	A New Way of Determining the Optical Depth of Interstellar Neutral Hydrogen Clouds	C. Heiles, G. L. Verschuur	<u>Astrophys. Letters</u> , <u>3</u> , 21-22, 1969

No.	Title	Author	Reference
<u>Series A, cont.</u>			
97	Measurements of the Flux Density and Spectra of Discrete Radio Sources at Centimeter Wavelengths. II. The Observations at 5 GHz (6 cm)	I.I.K. Pauliny-Toth, K. I. Kellermann	<u>Astron. J.</u> , <u>73</u> , 953-969, 1968
98	Neutral Atomic Hydrogen in 32 Galaxies of Small Angular Diameter	M. S. Roberts	<u>Astron. J.</u> , <u>73</u> , 945-949, 1968
99	Crab Nebula Pulsar NP0527	E. C. Reifenstein III W. D. Brundage, D. H. Staelin	<u>Phys. Rev. Letters</u> , <u>22</u> , 311, 1969
100	Frequency Dependence of Polarization of Pulsar CP 0328	S. J. Goldstein, Jr. D. D. Meisel	<u>Science</u> , <u>163</u> , 810-812, 1969
101	A Pseudodynamic Programming Technique for the Design of Correlator Supersynthesis Arrays	N. C. Mathur	<u>Radio Science</u> , <u>4</u> , 235-244, 1969
102	National Radio Astronomy Observatory - Annual Report	D. S. Heeschen	<u>Amer. Astron. Soc. Bull.</u> , <u>1</u> , 86-92, 1969
103	Microwave Detection of Interstellar Formaldehyde	L. E. Snyder, D. Buhl, B. Zuckerman, P. Palmer	<u>Phys. Rev. Letters</u> , <u>22</u> , 679-681, 1969
104	Venus: Absence of a Phase Effect at 2-Centimeter Wavelength	D. Morrison	<u>Science</u> , <u>163</u> , 815-817, 1969
105	Color Excess and Atomic Hydrogen at High Latitudes	C. Sturch	<u>Astron. J.</u> , <u>74</u> , 82-84, 1969
106	The Planetary Nebulae NGC 7027 and IC 418 at $\lambda 9.5$ mm	Y. Terzian	<u>Astrophys. Letters</u> , <u>3</u> , 87-90, 1969
107	Estimates of Pulsar Distances from Neutral Hydrogen Absorption	C. P. Gordon, K. J. Gordon, A. M. Shalloway	<u>Nature</u> , <u>222</u> , 129-132, 1969
108	Intensities of Radio Recombination Lines	R. M. Hjellming, M. H. Andrews, T. J. Sejnowski	<u>Astrophys. Letters</u> , <u>3</u> , 111-114, 1969

No.	Title	Author	Reference
<u>Series B</u>			
105	Observations of the Angular Structure of Radio Sources	F. N. Bash	<u>Astrophys. J.</u> , <u>152</u> , 375-390, 1968
106	Further Observations of Variable Radio Sources	K. I. Kellermann, I.I.K. Pauliny-Toth	<u>Astrophys. J.</u> , <u>152</u> , 639-646, 1968
107	The Cygnus Region. III. Observations of the NGC 7000 Area at Decimeter Wavelengths	H. Wendker	<u>Z. f. Astrophys.</u> , <u>68</u> , 368-379, 1968
108	Repeated Outbursts in the Radio Galaxy 3C 120	I.I.K. Pauliny-Toth, K. I. Kellermann	<u>Astrophys. J.</u> , <u>152</u> , L169-L175, 1968
109	Intergalactic H I Absorption at 21 centimeters	A. A. Penzias, E. H. Scott, III	<u>Astrophys. J.</u> , <u>153</u> , L7-L9, 1968
110	Radio Interferometry Using a Base Line of 20 Million Wavelengths	B. G. Clark, K. I. Kellermann, C. C. Bare, M. H. Cohen, D. L. Jauncey	<u>Astrophys. J.</u> , <u>153</u> , L67-L68, 1968
111	Radio-Source Spectra and Their Time Variations	K. I. Kellermann, I.I.K. Pauliny-Toth	Perek (ed.), <u>Highlights of Astronomy</u> , New York, Academic, 1968, 371-372
112	Radio and Optical Observations of the Hercules Cluster of Galaxies	T. D. Carr, G. C. Omer, Jr., G. R. Lebo, R. W. Davis	<u>Astrophys. J.</u> , <u>153</u> , L139-L142, 1968
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<u>Series B, cont.</u>			
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