

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

Quarterly Report
April 1 - June 30, 1970

RESEARCH PROGRAMS

Interferometer

	<u>Hours</u>
Scheduled observing	807.25
Scheduled maintenance and equipment changes	775.75
Time lost due to: equipment failure	28.75
power	2.00
weather	29.00
interference	0.25

In early April, G. Miley conducted 11-cm observations of small-scale source structure with the 42-foot telescope at the Spencers Ridge site (100,000 wavelengths to 85-1), 85-1 and 85-2.

At the end of that series of observations the interferometer was shut down for approximately two months to undergo major modifications which included the installation of a dual frequency 2695-MHz and 8085-MHz observing system, the painting of the 85-foot telescopes to minimize thermal effects, the resetting of 85-1 and 85-3 reflector surfaces to improve the efficiency and reduce the sidelobes at the shorter wavelength and an 8K memory expansion of the DDP-116 computer.

Observations for the remainder of the quarter, using the three 85-foot telescopes at 2695 and 8085 MHz, were conducted as follows:

<u>Observer</u>	<u>Program</u>
R. Hjellming, C. Wade, and R. Brown	Two-frequency interferometric observations to search for radio emission from normal stars and X-ray sources.
D. DeYoung and D. Hogg	Two-frequency interferometric observations to search for secular intensity variations in Virgo A and Cygnus A and for variations in the structure of Cassiopeia A.
G. Miley and J. Wardle	Two-frequency observations to investigate the angular structure of quasars that are partially resolved or

ObserverProgram

G. Miley and J. Wardle (continued)

unresolved at 2695 MHz; the angular separation-redshift relation of these sources; and the frequency dependence of their structure.

D. Hogg and C. Wade (testing)

Determination of beamwidth, instrumental phase stability, and instrumental polarization.

140-foot TelescopeHours

Scheduled observing	1939.00
Scheduled maintenance and equipment changes	223.00
Time lost due to: equipment failure	95.50
power	1.75
weather	22.25
interference	3.25

Line observations were conducted as follows:

ObserverProgram

F. Kerr (Maryland) and P. Jackson (Maryland)

5-GHz observations to attempt to detect H109 α radiation from distributed ionized hydrogen in the spiral arms of the Galaxy.

M. Gordon

5-GHz recombination line observations of 109 α and 137 β of hydrogen and helium in W3 and W49.

M. Roberts

5-GHz line observations in an attempt to detect recombination or other lines in external galaxies.

J. Ball (Harvard), A. Dupree (Harvard), A. E. Lilley (Harvard), L. Goldberg (Harvard), and D. Cesarsky (Harvard)

6-cm line observations as follows: 1) observations of recombination lines in H II regions searching for structure in the line profiles which will be interpreted in terms of stimulated emission from H I regions; 2) a search for He⁺; and 3) a search for CH₃OH.

B. Zuckerman (Maryland), P. Palmer (Chicago), L. Snyder (Virginia), and D. Buhl

Continued 6-cm line observations of H₂C¹²O¹⁶ and H₂C¹³O¹⁶.

T. Wilson (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany)

4830-MHz line search for formaldehyde in Perseus A and in faint sources within the Galaxy, including supernova remnants.

<u>Observer</u>	<u>Program</u>
R. Rubin (Illinois) and B. Turner	5008-MHz recombination line observations in K3-50, H2-3, H2-6, G48.62+0.1 and G35.58-0.1.
P. Solomon (Columbia) and P. Thaddeus (Columbia)	4830-MHz line studies of formaldehyde.
L. Snyder (Virginia) and D. Buhl	5625-MHz search for H ₂ O ¹⁸ .
M. Roberts and K. Kellermann	600-MHz search for hydrogen in several radio sources.
P. Palmer (Chicago), B. Zuckerman (Maryland), J. Yen (Toronto, Canada), and C. Gottlieb (Harvard)	6017, 6031, 6035, and 6049-MHz observations of the hyperfine split lambda doublet lines ($^2\pi_{3/2}$, J=5/2) of OH in known OH sources.
J. Dickel (Illinois), R. Rubin (Illinois), and B. Turner	Search for 22-GHz water vapor emission in newly found OH sources.
L. Snyder (Virginia), D. Buhl, and J. Edrich	22-GHz line observations to monitor polarization and time variations and to search for fine structure in water vapor sources.
R. Rubin (Illinois) and B. Turner	Observations in the 23.7 to 23.9-GHz range to search for the recombination lines H81 β , He ⁺ 103 α , He65 α and H65 α in K3-50.
A. Barrett (M.I.T.), and P. Schwartz (M.I.T.)	22-GHz survey of water vapor emission from infrared stars.

Continuum observations were conducted as follows:

<u>Observer</u>	<u>Program</u>
C. Mayer (N.R.L.) and T. McCullough (N.R.L.)	6-cm observations to determine the brightness temperature spectra of Neptune and Uranus.
D. Morrison (Hawaii)	6-cm observations of the brightness temperature of Venus to obtain phase effects and the mean brightness temperature and a comparison of brightness temperatures of Venus and Mercury.
M. Davis, I. Pauliny-Toth, and K. Kellermann	6-cm source survey to provide a uniform survey down to about 0.5 flux units of

<u>Observer</u>	<u>Program</u>
M. Davis, <u>et al.</u> (continued)	the entire region of the sky between the celestial equator and +35 degrees declination; to obtain the number of radio sources at various flux density levels, and determine the characteristics of sources with flat and normal spectra; and to search for new sources with opaque components which would be candidates for subsequent VLB and time variation studies.
H. J. Wood (Virginia), J. Trasco (Virginia), and M. Roberts	6-cm survey of optical magnetic stars.
H. Johnson (Lockheed Research Laboratory)	6-cm observations of X-ray and related sources in the Crab Nebula, YM29, HD16523, 3C 123, and Orion A.
M. Davis	6-cm flux density measurements of 200 sources selected from the Davis 300-foot source survey.
A. Witzel (Observatoire de Paris, Meudon, France) and P. Veron (Observatoire de Paris, Meudon, France)	6-cm observations to measure the spectra and investigate the log N/log S relationship of approximately 400 sources.
M. Kundu (Maryland)	6-cm observations of the polarized brightness distribution of supernova remnants.
K. Kellermann and I. Pauliny-Toth	3-cm observations of the fluxes of approximately 500 sources to complement source spectral data collected at 40, 20, 11, and 6 cm.

The following very long baseline observations were conducted during this quarter:

<u>Observer</u>	<u>Program</u>
M. Cohen (Calif. Inst. of Tech.), J. Broderick, and K. Kellermann	10.7-GHz very long baseline observations between the CalTech Owens Valley 130-foot telescope and the NRAO 140-foot telescope.
I. Shapiro (M.I.T.), D. Thacker (M.I.T.), P. Schwartz (M.I.T.), D. Papa (M.I.T.), B. Burke (M.I.T.),	22-GHz water vapor line observations utilizing the Haystack 120-foot telescope, the NRAO 36-foot telescope, and

<u>Observer</u>	<u>Program</u>
(continued)	
G. Papadopoulos (M.I.T.), W. Sullivan III (Maryland), K. Johnston (N.R.L.), S. Knowles (N.R.L.), J. Moran (Lincoln Lab.), M. L. Meeks (Lincoln Lab.), and W. Welch (Berkeley)	the NRAO 140-foot telescope.
D. Jauncey (Cornell) and J. Broderick	606-MHz observations utilizing the Arecibo 1000-foot telescope and the NRAO 140-foot telescope.

The following pulsar observations were conducted during this quarter:

<u>Observer</u>	<u>Program</u>
J. Pfleiderer (ESRO Fellow)	256 and 405-MHz observations of the Crab Nebula pulsar.
M. Ewing (M.I.T.), R. Batchelor (M.I.T.), and D. Staelin (M.I.T.)	256-MHz high-frequency resolution, long time base observations of known pulsars.

Two special tests were conducted at the 140-foot telescope this quarter. A pilot test was made of a radar measuring system to measure off-axis deflections of points on the reflector in relation to the focal point. The second test was of two devices: 1) a spillover shield at the focal point to minimize ground effects, and 2) a vertex cone to minimize energy radiated back to the focal point.

300-foot Telescope

	<u>Hours</u>
Scheduled observing	1502.75
Scheduled maintenance and equipment changes	313.25
Time lost due to: equipment failure	34.00
power	3.00
weather	48.25
interference	0.00

The following line observations were conducted during this quarter:

<u>Observer</u>	<u>Program</u>
S. Gottesman	1420-MHz neutral hydrogen observations of galactic systems to determine the congruence of optically defined spiral arms and neutral hydrogen emission and high angular and frequency resolution observations of the Cygnus X complex.

<u>Observer</u>	<u>Program</u>
G. Westerhout (Maryland)	1420-MHz observations to map the distribution of neutral hydrogen in the plane of the Galaxy.
R. Harten (Maryland)	1420-MHz study of the local structure of neutral hydrogen gas.

The following pulsar observations were conducted during this quarter:

<u>Observer</u>	<u>Program</u>
R. Manchester	410-MHz observations of the positions, Stokes parameters, timing, dispersion, and Faraday rotation of pulsars.
M. Ewing (M.I.T.), M. Price (M.I.T.), D. Staelin (M.I.T.), and R. Batchelor (M.I.T.)	100-200 MHz observations of pulsars to investigate their spectra and sub-pulse structure and to search for slow periodicities.
G. R. Huguenin (Massachusetts) and J. Taylor (Massachusetts)	74, 111, 147, and 234-MHz observations of the dynamic spectra and frequency variations of pulsars.

J. Maslowski (Jagellonian University, Poland) surveyed the sky from $+48^\circ$ to $+51^\circ$ declination at 1400 MHz to collect data for the support of cosmological investigations and evolutionary investigations of radio sources.

On June 9, the 300-foot telescope was shut down to install an improved reflector surface.

36-foot Telescope

	<u>Hours</u>
Scheduled observing	1404.00
Scheduled maintenance and equipment changes	291.00
Time lost due to: equipment failure	85.00
power failure	4.50
weather	91.50
interference	2.00

The capability of the 36-foot telescope was expanded this quarter with the following new receivers: 20-mm continuum; 13.5-mm continuum and spectral line (for VLB work); 3.5-mm spectral line; and 2.6-mm spectral line.

<u>Observer</u>	<u>Program</u>
A. Penzias (Bell Labs.), R. Wilson (Bell Labs.), K. Jefferts (Bell Labs.)	Observations of CO and CN molecules and their isotopes at 2.6 mm.

<u>Observer</u>	<u>Program</u>
H. Schmidt (Sacramento Peak), A. Penzias (Bell Labs.), R. Wilson (Bell Labs.), and K. Jefferts (Bell Labs)	Attempt to detect CN in Comet Bennett (1970).
K. Kellermann and I. Pauliny-Toth	Continuum observations of various sources at 20 mm, to establish a standard flux-density scale.
E. Conklin	Observations at 9.5 and 3.5 mm of sources from the Ohio State Catalog having unusually flat spectra.
Y. Terzian (Cornell) and A. Parrish (Cornell)	Investigation of the Cygnus X region at 9.5 and 3.5 mm.
S. Gorgolewski (Calif. Inst. of Tech. and Torun, Poland)	Observations of the Galilean sat- ellites of Jupiter at 3.5 mm.
D. Buhl and L. Snyder (Virginia)	Observations of HCN and other lines at 3.5 mm.
C. Gottlieb (Harvard) and D. Dickinson (Smithsonian Astrophysical Observatory)	An attempt to detect SiO in various sources at 3.5 mm.
S. Knowles (N.R.L.), G. Papadopoulos (M.I.T.), W. Welch (Berkeley), I. Shapiro (M.I.T.), D. Thacker (M.I.T.), P. Schwartz (M.I.T.), D. C. Papa (M.I.T.), B. Burke (M.I.T.), W. Sullivan III (Maryland), K. Johnston (N.R.L.), S. Knowles (N.R.L.), J. Moran (Lincoln Lab.), and M. L. Meeks (Lincoln Lab.),	Very-long baseline interferometry at 22 GHz on galactic H ₂ O sources (with the Haystack 120-foot and the Green Bank 140-foot telescopes).

ELECTRONICS DIVISION--EQUIPMENT DEVELOPMENT

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

Interferometer Development	12%
Interference Protection	2%
Millimeter Receiver Development	3%
Very Long Baseline Interferometer	8%
24-GHz Receiver	3%
Pulsar Receiver Construction	5%
6-cm Receiver	3%
3-cm Receiver	3%

(continued)

413-Channel Correlator	10%
Visitor Support and Routine Maintenance	32%
21-cm Cooled Paramp	4%
5-10 GHz Receiver	6%
Tourist Telescope	2%
Homology Optical Position Servo	4%
45-GHz Receiver	3%

A new spectral-line front-end for the 36-foot telescope has been completed and successfully used for detection of new spectral lines. The receiver consists of a phase-locked local oscillator system, a parametric IF amplifier, and an easily changed RF section for adaptation to different frequencies. The receiver was developed with cooperation with Bell Telephone Laboratories.

Development of parametric amplifiers at 23 and 45 GHz is continuing. An amplifier tunable from 22 to 24 GHz and a 1 GHz bandwidth amplifier centered at 45 GHz have been operated in the laboratory.

The construction of the 5.2-10.4 GHz front-end has been completed. This receiver was used on the 140-foot telescope during June.

The 3-cm/11-cm interferometer front-ends and delay line systems have been installed and the complete system was operational again during June.

Work has been continuing on the optical position reference system for the homology telescope. Some work has been necessary to remove mechanical resonances in the servo loop. The system will be used to determine the effects of air turbulence, etc., on the stability of the platform.

The VLB recording and playback systems were delivered in June. Leach Corporation personnel are spending some time at Green Bank in order to get the equipment completely up to specification.

The IF section of the new 400-channel autocorrelation receiver is nearly completed.

ENGINEERING DIVISION

During the second quarter of 1970 areas of major effort by the Engineering Division have been the following:

1. The 300-foot telescope resurfacing program which, during the last month of the quarter, saw the erection contractor, Micro-T, start the removal of existing mesh and the installation of saddle supports for the new panels. Panel manufacturing difficulties have been resolved, equipment altered and manufacturing is progressing. The contractor has established an accelerated manufacturing schedule and is confident that the completion date for installation of panels will be met.

2. The three 85-foot telescopes of the interferometer system were removed from service during the early part of the quarter for panel adjustment and painting. The surface panels of telescopes 85-1 and 85-3 were set to an installation rms of 0.027 inches and 0.025 inches, respectively, to secure better performance at the new 3.75-cm operating frequency. Painting of 85-2 and 85-3 telescopes has been essentially completed while 85-1 has received the prime and intermediate coats.

3. The design of a tracking, polarizing and focusing feed system for the 300-foot telescope has been completed and specifications have been prepared. This new feed mount is now in the procurement stage.

4. Design of modifications to the rigid door section of the 36-foot telescope dome have been completed and hardware manufacture is underway in the Green Bank shops.

5. The design and evaluation of a new variable speed drive system for the 300-foot telescope is underway.

COMPUTER DIVISION

Hardware

Central processing units (computer "mainframes") operated by NRAO now include one IBM 360/50 batch processor at Charlottesville; four Honeywell (Computer Control Division) DDP-116 realtime processors located, respectively, at the 140-foot telescope, at the 300-foot telescope, at the Green Bank interferometer, and at the Tucson 36-foot telescope, and one Varian Data 620/i minicomputer used only with VLB tape processing. Of these six CPU's the last three currently are not operated nor programmed by the computation's division, but rather by the special users group which they serve. The VLB (Varian) processor utilizes an inexpensive minicomputer as a special-purpose computer, so as to relieve the IBM 360 of processing which could overload it.

Software--realtime (DDP-116)

Work has begun on additions to the computer program at the 300-foot telescope, where new features in the program will be available for use after the telescope focal-point work has been completed. In particular, the program changes will accommodate box rotation and box movement along an east/west great circle segment.

Work has continued on making the 140-foot and 300-foot telescopes' computer programs as nearly compatible as possible. For example, to satisfy the user's need for immediate monitoring of his data additional on-line displays have been added to several data-taking programs.

Software--system (IBM 360)

Implementation of the HASP package has been completed. Its use of queuing ("Automatic Spooling") of all input/output records, a technique which can greatly reduce the number of waits previously required for synchronization

of various computational processes, has resulted in some improvement in throughput. The I/O units (especially the line-printer and card-reader) now can remain in continuous motion. The core-memory regions are now negligible compared to the sizes of these regions which the original operating system required.

Software--user

Work has continued on the IBM 360 programs which will edit and reduce data from the new Model III autocorrelator.

A survey has begun on the future workloads anticipated by NRAO computer users. Users interviewed have included members of the VLB, interferometer, and spectral-line (autocorrelator) groups. The Division has estimated the computer time which is likely to be required when each experiment goes into full production. From this the Division is able to estimate the point at which the current computer will become totally saturated.

NRAO SUMMER STUDENT PROGRAM

Each summer the NRAO accepts undergraduate juniors and seniors and graduate students for its summer student program. Over 135 students in physics, astronomy, electrical engineering, and computer sciences responded to announcements distributed last December to more than 200 college departments throughout the United States. A committee of three scientists selected 17 graduate students and 22 undergraduates who are each assigned to a member of the scientific staff, the electronics or the computer division as a research assistant. Twenty-five students are based in Charlottesville, 13 in Green Bank, and one in Tucson. Besides assisting the NRAO staff in their research, the students attend 26 lectures on various topics in radio astronomy as well as the regular Observatory colloquia. Three of the Green Bank-based students spend part of the summer as tour guides for the tourists who visit Green Bank at rates that exceed 1000 per week. Many NRAO summer students return as Ph.D. thesis students and a few have joined the staff later as full-time employees.

The following list shows the 1970 summer students, their college and academic year just completed and hometown.

Graduate Students

<u>Name</u>	<u>Year</u>	<u>College</u>	<u>Hometown</u>
Braly, Kenneth	1	Calif. Inst. of Tech.	Pikesville, Md.
Gallagher, John	1	Wisconsin	Columbus, Ohio
Giovanelli, Riccardo	1	Indiana	Gattatico, Italy
Hemenway, Paul	2	Virginia	Charlottesville, Va.
Jacobs, Fred	1	Harvard	Brooklyn, N. Y.
Johnson, Keith	1	Luther	Joliet, Ind.
Leung, Chun-Ming	1	Berkeley	Ann Arbor, Mich.
Mottmann, John	4	U. Calif., Los Angeles	Pasadena, Calif.
Nam, Chong-Woo	2	U. Calif., Berkeley	Seoul, Korea
Pankonin, Vernon	2	Cornell	Grant, Neb.

<u>Name</u>	<u>Year</u>	<u>College</u>	<u>Hometown</u>
Peters, William	4	Texas	Memphis, Tenn.
Pettersson, Bengt	1	Chalmers Univ. of Tech.	Göteborg, Sweden
Predmore, Read	3	Rice	Houston, Texas
Rosenberg, Fred	3	Virginia	Charlottesville, Va.
Rots, Arnoldus	3	Kapteyn	Groningen, Netherlands
Sengupta, Uday	1	Ohio State	Barrackpore, India
Wallace, David	2	Cornell	Silver Springs, Md.

Undergraduate Students

Allen, Michael	2	Ohio State	Mansfield, Ohio
Born, Gary	3	Chicago	Broadview, Ill.
Bromberg, Kevin	3	Cornell	Livingston, N. J.
Chu, Steven	4	Rochester	Orange, Calif.
Cooper, Fred	3	Lincoln Memorial	Middlesboro, Ky.
Cox, Charles	4	Pennsylvania	Pittsburgh, Pa.
Daniell, Robert	4	Purdue	Lexington, Ky.
Day, Christopher	3	Pittsburgh	Wayne, Pa.
Deniston, Dale	4	Carnegie	Winter Haven, Fla.
D'Ippolito, Daniel	3	Chicago	Hyattsville, Md.
Donley, Shawn	3	Lehigh	Pittsburgh, Pa.
Gonzales, Juan	3	Manhattan	New York, N. Y.
Green, Fred	4	VPI	Elkins, W. Va.
Levine, Alan	3	MIT	Pittsburgh, Pa.
McDonald, Lee	4	Arizona	Tucson, Ariz.
Neuffer, David	4	Rochester	Clayton, N. Y.
Schommer, Robert	4	Chicago	Chicago, Ill.
Sonnanstine, Alan	3	Michigan	W. Carrollton, Ohio
Wantzelius, Paul	3	Carnegie	Roanoke, Va.
Williams, Diane	3	Cornell	Long Valley, N. J.
Williams, Theodore	3	Purdue	Youngstown, Ohio
Yau, Lawrence	3	Princeton	Hong Kong

PERSONNEL

Appointments

Thomas R. Cram	Scientific Prog. I	May 4, 1970
Richard A. Sramek	Research Associate	May 13, 1970
A. H. Bridle	Visiting Asst. Scientist	May 18, 1970
Victor Herrero	Research Associate	June 1, 1970
George H. Conant, Jr.	Head, Computer Division	June 1, 1970

Terminations

John M. Sutton	Research Associate	May 8, 1970
Ivan Pauliny-Toth	Assoc. Scientist	June 26, 1970
Courtney P. Gordon	Asst. Scientist	June 26, 1970
Kurtiss J. Gordon	Research Associate	June 26, 1970
May B. Daw	Librarian	June 30, 1970

OBSERVATORY COLLOQUIA

The NRAO colloquium program for the past fiscal year is outlined below. Speakers are usually invited by our scientific staff and generally talk on topics of current interest in radio astronomy or closely allied fields. The Astronomy Department of the University of Virginia 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
Jet Merkelijn	Commonwealth Scientific and Industrial Research Organization, Australia	July 28, 1969
R. Wielebinski	University of Sydney, Australia	August 18, 1969
James Lequeux	California Institute of Technology	August 21, 1969
Donat G. Wentzel	University of Maryland	August 28, 1969
John Shakeshaft	Mullard Radio Astronomy Observatory	September 2, 1969
Fred Hoyle	University of Cambridge	September 22, 1969
James A. Roberts	University of Toronto	September 25, 1969
William J. Quirk	Columbia University	October 23, 1969
Nikolai Kardashev	Institute for Cosmic Space Research, Moscow	December 2, 1969
Kurt W. Weiler	California Institute of Technology	December 16, 1969
Cyril Hazard	Institute of Theoretical Astronomy, Cambridge, England	December 19, 1969
Joseph Silk	Princeton	January 22, 1970
James M. Moran, Jr.	Lincoln Laboratory, Massachusetts Institute of Technology	January 29, 1970
James H. Hunter	Yale University	February 5, 1970
Robert Bless	University of Wisconsin	February 26, 1970
Sidney van den Berg	University of Toronto, Canada	March 5, 1970
G. M. Frye, Jr.	Case Western Reserve University	March 12, 1970
Bruce Ulrich	University of Texas	March 13, 1970
Martin Rees	Princeton	March 26, 1970
Harm Habing	University of California, Berkeley	April 9, 1970
J.W.M. Baars	Dwingeloo Observatory, Holland	April 16, 1970
Halton C. Arp	Hale Observatories	April 28, 1970
Peter Stumpff	Max-Planck-Institut für Radioastronomie	June 18, 1970
Michal Simon	State University of New York at Stony Brook	June 25, 1970

A list of Observatory reprints issued since June 30, 1969.

No.	Title	Author	Reference
<u>Series A</u>			
109	A Novel Way of Beam Switching, Particularly Suitable at Millimeter Wavelengths	Neil Albaugh and Karl H. Wesseling	<u>IEEE Trans. on Ant. & Prop.</u> , <u>AP-17</u> , 98-100, 1969
110	High Resolution Observations of a High Latitude Neutral Hydrogen Concentration	G. L. Verschuur	<u>Astron. & Astrophys.</u> , <u>1</u> , 473-475, 1969
111	Fast Folding Algorithm for Detection of Periodic Pulse Trains	David H. Staelin	<u>Proc. IEEE</u> , <u>57</u> , 724-725, 1969
112	Passive Remote Sensing at Microwave Wavelengths	David H. Staelin	<u>Proc. IEEE</u> , <u>57</u> , 427-439, 1969
113	Clipping Loss in the One-Bit Auto-correlation Spectral Line Receiver	W. R. Burns and Stanton S. Yao	<u>Radio Science</u> , <u>4</u> , 431-436, 1969
114	Properties of Interstellar Clouds and the Inter-Cloud Medium	R. M. Hjellming, C. P. Gordon and K. J. Gordon	<u>Astron. & Astrophys.</u> , <u>2</u> , 202-208, 1969
115	Pulsar Search Techniques	W. R. Burns and B. G. Clark	<u>Astron. & Astrophys.</u> , <u>2</u> , 280-287, 1969
116	The Neutral Hydrogen Distribution in the Neighborhood of the Region of Anomalously Low Polarization at $\ell^{\text{II}} = 137^\circ$, $b^{\text{II}} = +7^\circ$	G. L. Verschuur	<u>Astron. J.</u> , <u>74</u> , 597- 603, 1969
117	Further Measurements of Magnetic Fields in Interstellar Clouds of Neutral Hydrogen	G. L. Verschuur	<u>Nature</u> , <u>223</u> , 140-142, 1969
118	Search for Microwave Emission from the $^2\pi_{1/2}$, $J=3/2$ State of OH	B. E. Turner	<u>Astron. & Astrophys.</u> , <u>2</u> , 453-457, 1969
119	Radio Observations of the Supernova Remnant HB 21	J. W. Erkes and J. R. Dickel	<u>Astron. J.</u> , <u>74</u> , 840- 845, 1969
120	Search for a Neutral-Atomic-Hydrogen Link Between M31 and M33	K. J. Gordon	<u>Astrophys. Letters</u> , <u>4</u> , 47-49, 1969
121	A Search at 15 GHz for Compact H II Regions in Regions of Possible Star Formation	E. Churchwell, M. Felli and P. G. Mezger	<u>Astrophys. Letters</u> , <u>4</u> , 33-41, 1969

No.	Title	Author	Reference
<u>Series A</u> , continued			
122	An Intermediate Velocity Cloud Showing a Velocity Bridge to Local Matter	G. L. Verschuur	<u>Astron. & Astrophys.</u> , <u>3</u> , 77-82, 1969
123	Integral Properties of Spiral and Irregular Galaxies	M. S. Roberts	<u>Astron. J.</u> , <u>74</u> , 859-876, 1969
124	The Low Energy Cosmic Ray Spectrum	R. M. Hjellming	<u>Astrophys. Letters</u> , <u>4</u> , 81-84, 1969
125	Some Very Cold H I Clouds Found in Emission	G. L. Verschuur	<u>Astrophys. Letters</u> , <u>4</u> , 85-87, 1969
126	A Survey for Galactic OH Emission Sources	B. E. Turner	<u>Astron. J.</u> , <u>74</u> , 985-993, 1969
127	The Radio Structure of Tycho's Supernova Remnant	J. R. Dickel	<u>Astrophys. Letters</u> , <u>4</u> , 109-112, 1969
128	Recombination Lines in Thermal and Non-Thermal Galactic Sources	D. K. Milne, T. L. Wilson, F. F. Gardner, and P. G. Mezger	<u>Astrophys. Letters</u> , <u>4</u> , 121-127, 1969
129	Helium Abundances and the Sizes of He II and H II Regions	R. H. Rubin	<u>Astron. J.</u> , <u>74</u> , 994-998, 1969
130	Intensities of Radio Recombination Lines (II)	M. H. Andrews and R. M. Hjellming	<u>Astrophys. Letters</u> , <u>4</u> , 159-164, 1969
131	An Analysis of Radio Recombination Lines Emitted by the Orion Nebula	R. M. Hjellming and E. Churchwell	<u>Astrophys. Letters</u> , <u>4</u> , 165-171, 1969
132	A Comparison of the Radial Velocities of the Neutral Hydrogen Gas and H II Regions Within 60 Degrees of the Galactic Center	P. G. Mezger, T. L. Wilson, F. F. Gardner and D. K. Milne	<u>Astron. & Astrophys.</u> , <u>4</u> , 96-100, 1970
133	H109 α Line Observations of Six Planetary Nebulae, DR 21 and IC 410	Y. Terzian and B. Balick	<u>Astrophys. Letters</u> , <u>4</u> , 195-198, 1969
134	The Structure of 3C 9	B. G. Clark and G. K. Miley	<u>Astrophys. Letters</u> , <u>4</u> , 207-210, 1969

No.	Title	Author	Reference
Series A, continued			
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