NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

Quarterly Report

January 1 - March 31, 1973

RESEARCH PROGRAMS

36-foot Telescope

		Hours
Scheduled Observing		1983.50
Scheduled Maintenance and Equipment Changes		132.75
Scheduled Tests and Calibration		19.75
Time lost due to:	Telescope and receiver failure	111.75
	Digital system failure	63.50
	Power	6.25
	Weather	416.75
	Interference	0.00

During this quarter a new type of superheterodyn bolometer was tested at 112 GHz, yielding very low system temperatures. Further comparison tests of indium antimonide and germanium bolometers were made at 260 GHz, along with antenna and atmospheric evaluations.

Observer	Program
W. Wilson (Aerospace) E. Epstein (Aerospace) P. Schwartz (NRL)	Search for extragalactic CO, HCN, and their isotopes (88 and 115 GHz).
F. Kerr (Maryland) A. Milman (Maryland) G. Knapp (Maryland) S. Knapp (Maryland) E. Epstein (Aerospace) W. Wilson (Aerospace)	Study of carbon monoxide in dense interstellar dust clouds (115 GHz).
W. Wilson (Aerospace) E. Epstein (Aerospace) J. Waters (MIT) F. Shimabukuro (Aerospace) A. Barrett (MIT) D. Staelin (MIT)	Study of CO and HCN emission from infrared stars; study of atmospheric ozone (88, 111, and 115 GHz).
K. Jefferts (Bell Labs) T. Phillips (Bell Labs) P. Wannier (Princeton)	Search for $C^{12}O^{17}$ and deuterated water (HDO) (80 and 112 GHz).

Observer	Program
K. Johnston (NRL) B. Waltman (NRL) P. Schwartz (NRL) W. Wilson (Aerospace)	Study of hydrogen recombination lines in Orion A and M17 (99-106 GHz).
W. Dent (Massachusetts) R. Hobbs (NASA, Greenbelt)	Temporal variations and spectra of variable radio sources (31 and 85 GHz continuum).
G. Macdonald (U. Kent, Canterbury, England)	Search for millimeter-wave emission from UHURU X-ray sources (31 and 85 GHz continuum).
H. Johnson (Lockheed)	Continuum observations of symmetric galactic nebulae and planetary nebulae (31 and 85 GHz continuum).
E. Epstein (Aerospace) W. Fogarty (Aerospace)	Monitoring of 3C120, BL Lac, and OJ 287 for intraday variability (85 GHz continuum).
W. Flygare (Illinois) J. McGurk (Illinois) C. Norris (Illinois) E. Pearson (Southern Illinois) T. Schmoltz (Illinois)	Search for sodium hydroxide, hydrogen peroxide, sulphur oxide, and other molecules (65-101 GHz).
D. Buhl L. Snyder (Virginia) F. Clark (Virginia) P. Giguere (Virginia)	Mapping of HCN, HNC, and HNCO; spectra of CH_3CCH in the galactic center; high resolution spectra of $HC^{13}N$ (85-95 GHz).
L. Snyder (Virginia) D. Buhl R. Gammon C. Gottlieb (Harvard) P. Giguere (Virginia)	Search for ketene (H_2C_2O) (80 GHz).
B. Turner M. Morris (Chicago) P. Palmer (Chicago) B. Zuckerman (Berkeley) L. Rickard (Chicago)	Observations of CS, CH_3OH, H_2CO, HC_3N and other molecules in dust clouds and infrared nebulae; study of HC_3N and its isotopes (85-95 GHz).
B. Turner R. Gammon	Study of the excitation of linear and symmetric top molecules (OCS, SiO, CH_3CN, and others) (85-95 GHz).

Observer	Program
R. Hjellming B. Balick	Study of millimeter-wave radio flares on Cygnus X-3 and Algol (31 and 85 GHz continuum).
E. Conklin	Observation of flat-spectrum sources from the Ohio State catalog; study of short-period variable sources for optical-radio correlations (31 and 85 GHz continuum).
E. Conklin D. Heeschen	Observations of normal elliptical galaxies for time variations (31 and 85 GHz continuum).
J. Rather P. Clegg (Queen Mary College, London) P. Ade (Queen Mary College, London)	Comparison tests of InSb and Ge bolometers; observations of planets, galactic and extragalactic sources (260 GHz continuum).
M. Kundu (Maryland) P. Clegg (Queen Mary College, London) P. Ade (Queen Mary College, London) J. Rather	Brightness distribution of the quiet sun and brightness structure of active regions; study of 300 second oscillations (260 GHz continuum).
P. Encrenaz (NASA, Inst. Space Studies) A. Penzias (Bell Labs) R. Wilson (Bell Labs)	Observations of carbon monoxide in W33; observations of recombination lines in W51 and Orion A (70, 115, and 145 GHz).
A. Penzias (Bell Labs) R. Wilson (Bell Labs) K. Jefferts (Bell Labs) P. Solomon (Minnesota) P. Wannier (Princeton)	Study of interstellar DCN and the deuterium/hydrogen ratio; further study of carbon monoxide and its isotopes (80 and 115 GHz).
F. Gardner (CSIRO) A. Penzias (Bell Labs)	Study of carbon monoxide and its isotopes in the direction of W33 (115 GHz).

Interferometer

		Hours
Scheduled Observing		1612.75
Scheduled Maintenance and Equipment Changes		148.00
Scheduled Tests and Calibration		383.25
Time Lost Due to:	Equipment Failure	29.75
	Power	1.25
	Weather	25.00
	Interference	0.00

Unless otherwise indicated, the following continuum observations were conducted at 2695 and 8085 MHz.

Observer	Program
M. Kaftan-Kassim (SUNY, Albany) G. Sistla (SUNY, Albany)	Observations of planetary nebulae.
M. Kundu (Maryland) R. Becker (Maryland)	Linear polarization measurements of supernova remnants with diameters 3 arc seconds or less.
D. Hogg D. De Young	Observations of the polarization structure in 7-8 double sources in order to investigate magnetic field geometry, the presence of shock fronts, and structural correlation in the overall radio emission.
R. Hjellming B. Balick L. Blankenship	Observations of close binary stars with extremely short periods or period anomalies.
R. Hjellming C. Wade	Measurements of the positions of approximately 200 small diameter sources.
R. Hjellming L. Blankenship	Monitor of known X-ray sources and search for new ones.
H. Palmer (Jodrell Bank, England)	Observations of approximately 35 sources to look for "radio cores".
J. Cuzzi (Massachusetts) W. Dent (Massachusetts)	High-resolution observations of the planets Mercury and Saturn at 8085 MHz.
S. Gottesman (Florida) P. Palmer (Chicago) R. Brown	Attempt to detect radio emission from the supernova in NGC 5253 and other recent supernovae.
R. M. Price (MIT) P. Crane (MIT)	Survey of normal spiral galaxies down to diameters of 2-3 arc minutes and to a magnitude of 12.5.
A. Bridle E. Fomalont	Observations of 21 optical objects near M31 to investigate their radio variability.

The following line observations were conducted.

Observer	Program
E. Greisen	Investigation of very short scale lengths of hydrogen concentrations in the interstellar medium through 1421 MHz absorption measurements.

The following very long baseline observations were conducted.

Observer	Program
M. Ewing (Caltech) A. Moffet (Caltech) R. Walker (MIT) P. Crane (MIT) G. Papadopoulos (MIT) W. Cannon (York University, Canada)	Search at 21-cm wavelength for apparent motions of pulsars using the two OVRO 90-foot telescopes, the OVRO 130-foot telescope, and the three-element NRAO interferometer.

300-foot Telescope

	Hours
Scheduled Observing	1945.00
Scheduled Maintenance and Equipment Changes	159.00
Scheduled Tests and Calibration	40.00
Time Lost Due to: Equipment Failure	56.00
Power	0.00
Weather	39.50
Interference	1.25

The following continuum programs were conducted during this quarter.

Observer	Program
W. Dent (Massachusetts) J. Kapitsky (Massachusetts)	Monitor of the 11-cm flux and polarization of variable radio sources.
M. Kesteven (Queens, Canada) A. Bridle (Queens, Canada) G. Brandie (Queens, Canada)	Observations at 11 cm to study the incidence of variability in a large sample of extragalactic sources and a monitor of known variable sources and other sources not presently known to be variable, in order to test the expanding cloud model of variable sources.
J. Condon	Observations of the extragalactic confusion background at 11 cm to determine radio source number counts in the flux density range 5-100 milliflux units.
D. Pleticha (Cornell) J. Condon	Measurements of 11-cm positions and flux densities of 1500 extragalactic radio sources found in the Arecibo 611-MHz multibeam survey.
N. Sarma (Tata Institute, India) J. R. Fisher	Survey of the region along the path of the moon at 20-cm wavelength.

Observer	Program
W. Erickson (Maryland) J. R. Fisher	Study over the frequency range 110-500 MHz of metric wavelength radio source variability using both the Clark Lake radio telescope and the NRAO 300-foot telescope.
T. K. Menon (Tata Institute, India)	Flux density measurements at 1400 and 2695 MHz of sources measured with the Ooty occultation telescope in India at 327 MHz.

The following line observations were conducted.

Observer	Program
B. Burke (MIT) P. Crane (MIT) J. Spencer (MIT) T. Giuffrida (MIT)	Observations of highly red-shifted neutral hydrogen in absorption against the continuum emission of quasars over the range 250-500 MHz.
S. Peterson (Cornell) G. S. Shostak	Line observations of 21-cm neutral hydrogen in approximately 50 peculiar galaxies selected from the Arp Catalog.
M. Wright (Berkeley)	Search for 21-cm neutral hydrogen absorption in quasars near spiral galaxies.
R. Tully (Maryland) J. R. Fisher	Measurements of dwarf galaxies in the 21-cm line of neutral hydrogen.
D. De Young M. Roberts	Search for 21-cm neutral hydrogen emission from the Coma, Pegasus I, Perseus, and Cancer clusters of galaxies.
M. Roberts G. S. Shostak	Distribution studies of 21-cm neutral hydrogen in approximately 1000 spiral and elliptical galaxies.
G. S. Shostak	Re-observe, at the 21-cm line of neutral hydrogen, Stephan's Quintet to measure the hydrogen absorption within the system and to attempt to detect nearby galaxies that are near the galactic plane in areas obscured by interstellar dust.

The following very long baseline observations were conducted.

Observer	Program
T. Clark (NASA, Greenbelt) W. Erickson (Maryland) L. Hutton (Maryland) R. Perley (Maryland) G. Resch (Maryland) N. Vandenberg (Maryland) J. Broderick (NAIC) S. Knowles (NRL)	Observations at 73.8 and 111.5 MHz to study the Crab pulsar, other pulsars and other extragalactic sources and to search supernova remnants for pulsars using the NAIC 1000-foot telescope at Arecibo, the NRL 150-foot telescope at Sugar Grove, and the NRAO 300-foot telescope

The following pulsar observations were conducted.

Observer	Program
J. Taylor (Massachusetts) R. Hulse (Massachusetts)	High-sensitivity survey for new pulsars over the frequency range 250-500 MHz.

In addition to the above programs, P. Palmer (Chicago) and B. Zuckerman (Berkeley) searched near the 21-cm neutral line of hydrogen for intelligent life in the direction of stars within 20-25 parsecs of the sun.

140-foot Telescope

	Hours
Scheduled Observing	1891.75
Scheduled Maintenance and Equipment Changes	136.50
Scheduled Tests and Calibration	100.50
Time Lost Due to: Equipment Failure	51.00
Power	1.00
Weather	39.00
Interference	0.00

The following line observations were conducted during this quarter.

Observer	Program
G. Verschuur	Observations of the South Pole high-velocity HI cloud at the 21-cm line of neutral hydrogen.
M. Gordon	Observations at 6-cm wavelength of W49 and Ori A to test the weak recombination line theory of Dupree and Goldberg.
C. Heiles (Berkeley) T. Troland (Berkeley) G. Wrixon (Bell Tel. Lab)	Absorption of the linearly polarized galactic background radiation by the 21-cm line of neutral hydrogen.
D. Ball (Maryland)	Absorption studies of 21-cm neutral hydrogen in galactic supernova remnants.

Observer	Program
D. De Young M. Roberts	Search for 21-cm neutral hydrogen in the Coma, Pegasus I, Perseus, and Cancer clusters of galaxies.
P. Solomon (Minnesota) N. Scoville (Minnesota)	Map region of the galactic center at the 2-cm J = 2, K doubling transition of H_2CO (formaldehyde).
P. Thaddeus (NASA Inst. Space Studies) M. Kutner (NASA Inst. Space Studies) P. Encrenaz (NASA Inst. Space Studies)	Observations of the 14.488 GHz H_2CO (formaldehyde) line in HII regions and in diffuse dark nebulae.
P. Palmer (Chicago) L. Rickard (Chicago) B. Zuckerman (Berkeley)	Search for the following molecules: H_2O_2 at 14.829 GHz and CH_3SH at 14.764 GHz. Study of the 2-cm C76α line in NGC 2024 and W3.
L. Snyder (Virginia) F. Clark (Virginia) L. Krisher (Maryland) D. Buhl	Search at 14.803 GHz for interstellar CH_3COOH (acetic acid).
B. Zuckerman (Berkeley) N. Evans (Berkeley)	Search for the 2_{11}-2_{12} transition of H_2CO (Formaldehyde) in IR stars and other sources at 14.488 GHz.
B. Zuckerman (Berkeley) N. Evans (Berkeley) R. Benson (Illinois) H. Tigelaar (Illinois) B. Turner	Study of 2-cm carbon recombination lines in Ori B and other sources.
R. Benson (Illinois) H. Tigelaar (Illinois) B. Turner	Search for the following molecules: $(CH_3)_2O$ (acetone) at 15.076 GHz, $HCOOCH_3$ (A) (methyl formate) at 14.681 GHz, $HCOOCH_3$ (A) (methyl formate) at 14.676 GHz, H_2CO (formaldehyde) at 14.906 GHz, and H_2CO (formaldehyde) at 14.603 GHz.
B. Balick R. Brown	Observations of the 2-cm recombination lines of H, He, and C76α in the direction of the five brightest continuum sources in the galactic center.
R. C. Bignell (NRC Fellow, Canada)	Search for the H76α recombination line at 14.690 GHz in NGC 7027, IC 418, and other planetary nebulae, and for the C76α recombination line at 14.696 GHz in NGC 7027.

Observer	Program
T. Gull (KPNO) M. Smith (Cerro Tololo, Chile) B. Balick	Mapping the 2-cm recombination lines of H76α, He76α and C76α, the velocities and line widths of bright optical nebulae in coordination with optical observations.
F. Clark (Virginia) L. Snyder (Virginia) L. Krisher (Maryland) D. Buhl	Observations of CH_3COOH (acetic acid) at 6.089 and 6.175 GHz.
P. Myers (MIT)	Observations of 4830 MHz H_2CO (formaldehyde) in HII regions and dust clouds.
D. De Young M. Roberts	Attempt to detect the 6-cm H_2CO (formaldehyde) and recombination lines in Perseus A.
E. Chaisson (Smithsonian)	Study of M17 at the H110α recombination line (4874.157 MHz) and H_2CO (formaldehyde) in absorption at 4830 MHz.
M. Kutner (NASA, Inst. Space Studies) P. Encrenaz (NASA, Inst. Space Studies) K. Tucker (NASA, Inst. Space Studies)	Observations at 4830 MHz of H_2CO (formaldehyde) in Ori A, Ori B, and cloud L134.

The following very long baseline observations were conducted.

Observer	Program
A. Niell (JPL) D. Shaffer (Caltech) B. Clark K. Kellermann	Measurements of radio galaxies and quasars at 2-cm wavelength to investigate their small scale structure and time variability using the Goldstone 210-foot telescope and the NRAO 140-foot telescope.
B. Burke (MIT) G. Papadopoulos (MIT) R. Walker (MIT) P. Crane (MIT) J. Moran (Smithsonian) K. Johnston (NRL) S. Knowles (NRL)	Water-vapor VLB at 22 GHz to determine the proper motion of source subcomponents using the Haystack 120-foot telescope, the NRL Maryland Point 85-foot telescope and the NRAO 140-foot telescope.
M. Kundu (Maryland) B. Burke (MIT) G. Papadopoulos (MIT) R. Walker (MIT) P. Crane (MIT) J. Moran (Smithsonian) K. Johnston (NRL) S. Knowles (NRL)	Exploratory observations at 22 GHz to look for fine structure in the sun's emission.

Observer	Program
B. Hansson (Chalmers, Sweden) R. Ronnang (Chalmers, Sweden) M. Cohen (Caltech) K. Kellermann	Observations at 6-cm wavelength, using the Owens Valley Radio Observatory 130-foot telescope, the Chalmers Institute 84-foot telescope, and the NRAO 140-foot telescope.
M. Cohen (Caltech) G. Swenson (Caltech) A. Maxwell (Harvard) J. Yen (Toronto, Canada) K. Kellermann	Observations at 2.8-cm wavelength using the Harvard Fort Davis 85-foot telescope, the Owens Valley Radio Observatory 130-foot telescope, the NRC 150-foot telescope, and the NRAO 140-foot telescope.

The following pulsar observations were conducted.

Observer	Program
D. Backer	Observations to detect pulsar radiation at 14.7 GHz.

ELECTRONICS DIVISION--EQUIPMENT DEVELOPMENT

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

15 GHz Cooled Receiver	4%
0.5-1 GHz Receiver	7%
45-ft Telescope Equipment	10%
VLBI	6%
Interference Protection	5%
Antenna Development	5%
256-Channel Multifilter Receiver	7%
Visitor Support and Routine Maintenance	33%
Improved LO System	5%
7.8 GHz Cooled (Rice) Receiver	2%
Cooled Mixer Receiver	8%
108-116 GHz Receiver	8%

A front-end, data link, and delay system for the 45-foot telescope have been completed.

Work is continuing to improve the beam correlation mode and noise temperature of the 15 GHz cooled receiver. Construction of the 500-1000 MHz receiver is progressing and the highest frequency portion is scheduled on both the 300-foot and 140-foot telescopes in May. Design and construction of an improved LO system to permit computer control of Doppler correction and computer monitoring of output frequency has been initiated.

An 85-95 GHz receiver for the 36-foot telescope has been completed. Work is continuing on a similar 108-116 GHz receiver and on an 85-115 GHz cooled mixer receiver. Final tests are in progress on the first of a series of 256-channel multifilter receivers for Tucson.

ENGINEERING DIVISION

During the first quarter of 1973 the Engineering Division has placed major emphasis on the following projects:

45-foot Transportable Antenna - The Engineering Division has assisted in the completion of the check-out of the antenna and the preliminary planning for the move to Spencer's Ridge near Huntersville, West Virginia.

85-1 Antenna - Engineering assistance has been provided in the installation of shock absorbers on the mechanical steps for the limits of travel for both polar and elevation motions.

140-foot Antenna - A preliminary analysis has been made of the Sterling mount and feed legs prior to designing a mounting for a nutating subreflector for a Cassegrain system. The antenna structure and reflecting surface have been analyzed prior to a design of an equipment building located in the vertex of the antenna, to be used as part of a Cassegrain system.

300-foot Antenna - A study has been completed of the best materials and procedures for cleaning and painting the supporting structure. Drawings have been prepared for improved walkways in the support structure.

Laboratory Building - Green Bank - Preliminary cost estimates have been made for the installation of a sprinkler-type fire protection system in the basement.

Tourist Center - Budget estimates and conceptual drawings have been prepared for a tourist center at the Green Bank site.

36-foot Antenna - Proposals for installation of a new dome cover have been received.

VERY LARGE ARRAY

Land Acquisition

The U.S. Corps of Engineers is proceeding with land acquisition on a schedule which will make the central section available September 1, 1973.

Design Activities

Proceeding on schedule:

Transporter - Specifications and Request for Proposals (RFP) are underway.

Electronics - Design and test of prototypes are well underway.

Computer - Specifications for the continuum hardware system and the preparation of the RFP are underway.

Buildings - Most of the basic requirements for the central control building have been obtained and a study report is being prepared.

Site - Aerial photos have been taken and detail maps are now being prepared.

VLA Antenna Procurement

Five priced proposals were received on March 14, 1973. These proposals are now being evaluated by the Technical and Business Evaluation Subcommittees. The contract target date is mid-July 1973.

Engineer-Architect Selection

Nine detailed proposals were received on March 19, 1973 and are currently under analysis. The target date for the contract is June 1973.

COMPUTER DIVISION

360/50 Computer

256 K bytes of fast core has been added to the IBM 360/50 computer in Charlottesville. The total amount of fast core is now 768 K bytes.

A technical study to make recommendations concerning the replacement of the IBM 360/50 has been started.

Computer Procurements

Technical selection has been made and procurement begun for the following minicomputer systems:

140-foot special processor - Modular Computer Systems - Model II/25

36-foot telescope system - Digital Equipment Corporation - PDP 11/40

Development lab system - Modular Computer Systems - Model II/25

VLBI post post processor - Modular Computer Systems - Model II/25
(option available for procurement at a later time)

140-foot Computer Control

Automatic pointing corrections have now been implemented on the 140-foot computer control system.

PERSONNEL

Appointments

Anthony R. Thompson	VLA Project Engineer	January 1973
Forrest H. Wells	Head, Site & Wye Division, VLA	January 1973
Raymond P. Eschoffier	Electronics Engineer I	February 1973
Bobby L. Ulich	Electronics Engineer I	February 1973
Clarence E. West	Purchasing Officer, VLA	February 1973

Terminations

N.V.G. Sarma	Visiting Electronics Engineer	February 1973