NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

Quarterly Report

July 1 - September 30, 1970

RESEARCH PROGRAMS

Interferometer

		Hours
Scheduled observing		2060.75
Scheduled maintenance and equipment changes		147.25
Time lost due to:	equipment failure	86.25
	power	1.50
	weather	2.25
	interference	4.25

During this quarter interferometer observations at 2695 MHz and 8085 MHz were conducted, as follows:

Observer	Program
J. Wardle and G. Miley	Observations to investigate the angular structure of quasars that are partially resolved or unresolved at 2695 MHz, to explore the angular separation-redshift relation, and to detect emission from "radio-quiet" quasi-stellar objects.
B. Balick	Observations to study condensations in the H II regions DR 21, W51, W33, and IC 410.
J. Wardle	Observations of the polarization of radio sources and monitoring the polarizations of variable sources.
R. Hjellming and C. Wade	Study of time variations in the radio flux from novae.
D. Hogg and D. DeYoung	Observations of the polarization structure of eight double sources in order to investigate magnetic field geometry.
B. Balick and S. Gottesman	Observations to attempt to measure emission from the supernova in M101.

140-foot Telescope

		Hours
Scheduled observing		1781.50
Scheduled maintenance and equipment changes		426.50
Time lost due to:	equipment failure	43.75
	power	2.00
	weather	0.00
	interference	8.00

Line observations, except for very long baseline programs, were conducted as follows:

Observer	Program
M. Roberts	Search for 21-cm hydrogen absorption in several prominent galaxies and 1159-MHz recombination-line observations of H178α in the direction of the galactic center.
J. Ball (Harvard) and B. Zuckerman (Maryland)	1-GHz carbon recombination-line observations.
T. Menon (Hawaii), B. Turner and J. Payne	Search for new molecules and atomic lines in the 1 to 4-GHz range.
B. Turner	Search for seven new molecules with laboratory measured frequencies in the range 8.06 to 9.40 GHz.
M. Gordon and S. Gottesman	18-cm search for recombination lines from diffuse ionized hydrogen in the galaxy.
L. Snyder (Virginia), D. Buhl, and M. Roberts	2.395, 2.887, 2.961, and 3.045-GHz search for deuterated water (HDO).
L. Snyder (Virginia) and D. Buhl	1.0465-GHz search for interstellar thioformaldehyde (H_2CS).
L. Snyder (Virginia), D. Buhl, and M. Roberts	12-GHz search for new molecules, with particular emphasis on the OCS molecule.
E. Churchwell, P. Mezger (Max-Planck-Institut für Radioastronomie, Bonn, Germany), and J. Maslowski (Jagellonian University, Poland)	11-cm line observations to study Stark broadening of higher order recombination lines of hydrogen; search in dark clouds with molecular line emission and in a dark cloud containing T Tauri stars for radio recombination lines; search for line emission

Observer	Program
E. Churchwell et als. (continued)	of the general galactic background in the galactic plane toward a region where no discrete sources appear; and search the dark bay of the Orion Nebula for carbon-line emission.
G. Verschuur	Additional 21-cm Zeeman-line measurements in previously studied radio sources in order to reduce the magnetic field limit and an attempt to detect magnetic fields in very cold H I clouds.
J. Knapp (Maryland)	High resolution 21-cm line observations of absorption spectra in the directions of continuum sources near the galactic center.
J. Ball (Harvard), A. E. Lilley (Harvard), C. Gottlieb (Harvard), H. Penfield (Harvard), H. Radford (Smithsonian), and J. Onello (Harvard)	834-MHz search for CH_3OH in formaldehyde sources, especially Sgr A and B2, NGC 2024, and W3.
C. Heiles (Arecibo), B. Turner, and W. Brundage	Search for new molecules in the frequency interval 100 to 500 MHz.
F. Kerr (Maryland) and W. Sullivan (Maryland)	1667-MHz observations to measure the Stokes parameters in all four OH lines with special emphasis on time variations and correlations between the intensities of OH and H_2O.
B. Turner	1667-MHz OH-line observations to map and measure the polarization of new OH sources, continue a survey of OH sources, and search for weak OH emission near continuum sources.
C. Townes (Berkeley), N. Evans (Berkeley), R. Hills (Berkeley), and O. Rydbeck (Chalmers Univ., Onsala, Sweden)	1667-MHz observations of strong OH sources to determine whether such emission has the characteristic of random or non-random noise.
W. Wilson (Aerospace Corp.) and A. Barrett (MIT)	18-cm observations of OH emission associated with infrared stars to investigate time variations and other physical properties of the radiation and to search for new OH/IR sources.

Continuum observations were conducted as follows:

Observer	Program
J. Dickel (Illinois) and W. Warnock (Illinois)	Measurements of the spectrum of Venus at 7.5, 9.3, 12.5, and 15.0 cm.
K. Kellermann	4.995 and 15.375-GHz measurements of the flux densities of variable sources.
J. Dickel (Illinois) and W. Warnock (Illinois)	11-cm observations to search for polarization in the supernova remnant CTB 1.

Very long baseline observations were conducted as follows:

Observer	Program
P. Palmer (Chicago), T. Clark (NASA Goddard), B. Zuckerman (Maryland), O. Rydbeck (Chalmers Univ., Onsala, Sweden), B. Ronnang (Chalmers Univ., Onsala, Sweden), J. Moran (Lincoln Lab), J. Ball (Harvard), A. Yen (Toronto), C. Gottlieb (Harvard), and M. L. Meeks (Lincoln Lab)	5-cm OH-line observations involving the Chalmers University 84-foot telescope, the Haystack 120-foot telescope, and the NRAO 140-foot telescope.
O. Rydbeck (Chalmers Univ., Onsala, Sweden), B. Ronnang (Chalmers Univ., Onsala, Sweden), J. Ball (Harvard), J. Moran (Lincoln Lab), and M. L. Meeks (Lincoln Lab).	Observations involving the Chalmers University 84-foot telescope, the Haystack 120-foot telescope, and the NRAO 140-foot telescope for the purpose of precisely measuring the relative position of individual OH emission features at 1665 MHz and 1667 MHz in W3, W49, and NGC 6334 and searching for relative proper motion among the group of emission points in W3 at 1665 MHz.

18-cm observations were conducted by R. Manchester to measure the four Stokes parameters as a function of pulse phase for pulsar radiation.

300-foot Telescope

During this quarter the 300-foot telescope was being resurfaced.

36-foot Telescope

		Hours
Scheduled observing		759.00
Scheduled maintenance and equipment changes		1380.25
Scheduled tests and calibration		170.00
Time lost due to:	telescope and receiver failure	24.75
	digital system failure	4.00
	power	0.00
	weather	131.25
	interference	0.00

No observing was scheduled for July and August due to anticipation of adverse weather conditions. During that period, three major overhaul and maintenance programs were carried out:

1. The dome door, which had given considerable trouble, was completely overhauled, and new rollers were installed.

2. The dome azimuth track was releveled.

3. The control room was completely reorganized and rewired to accommodate more receivers and peripheral systems.

As of August 31, 1970, the telescope is staffed and available for observing 24 hours per day.

Observer	Program
E. Conklin	Continuing observations of sources with flat spectra from the Ohio State catalog at 31 and 85 GHz.
C. Wade and R. Hjellming	Search for emission from novae and red giant stars at 21 and 85 GHz.
W. Dent (Massachusetts) and R. Hobbs (NASA Goddard)	Continuing study of variable sources at 31 and 85 GHz.

ELECTRONICS DIVISION—EQUIPMENT DEVELOPMENT

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

Interferometer Development	9%
Interference Protection	2%
Very Long Baseline Interferometer	8%
24-GHz Receiver	4%
Pulsar Receiver Construction	3%
6-cm Receiver	3%
413-Channel Autocorrelation Receiver	12%
Visitor Support and Routine Maintenance	23%
21-cm Cooled Paramp	4%
Homology Optical Position Servo	2%
45-GHz Receiver	3%
Local Oscillator Development	10%
18-cm Receiver Improvements	3%
11-cm Receiver Construction	3%
Antenna Feed Development	3%

Three projects concerned with local-oscillator development were active this quarter. These were a phase-stable 1-2 GHz synthesizer, a millimeter-wave phase-

lock system, and an inexpensive digital synthesizer for second L.O. use. This equipment is needed for VLB experiments, for observations of millimeter-wave spectral lines, and for use with the new autocorrelation receiver.

Very Long Baseline recording and playback systems were delivered by Leach Corporation but did not meet specifications. A contract change has been negotiated and NRAO will complete the system. Several identical units are on order by other organizations; these will also be modified by NRAO.

The 18-cm cooled paramp receiver was modified to reduce noise temperature, improve calibration accuracy, and provide convenient variation and calibration of polarization. A 3-feed, 4-channel, 11-cm receiver is under construction for use on the 300-foot telescope.

The IF section of the 384-channel autocorrelation receiver has been completed; the digital portion should be complete by February. Development of parametric amplifiers at 22 and 45 GHz and a cooled-diode switch at 1.4 GHz is continuing.

ENGINEERING DIVISION

During the third quarter of 1970 the 300-foot telescope resurfacing program consisted of the removal of the mesh, the completion of installation of the saddle supports for the panels, and the installation of 739 panels out of a total of 1308. The manufacturer has completed the assembly of approximately 1200 of the surface panels. Some difficulties were experienced by the manufacturer in the painting and shipping of the panels, but these apparently have been resolved and the manufacturer assures us that shipment will be complete by October 15. At the present rate of installation, the panel erection subcontractor anticipates completion of installation by October 18. Panel adjustment and final alignment will start immediately following completion of installation.

Other projects by this Division included:

1. The completion of painting on telescope 85-1 and application of intermediate and finish coats of paint on the 140-foot telescope. The repainting of the 140-foot telescope foundation was also performed at this time. Nighttime observing was not interrupted.

2. Bids were received and evaluated for the purchase of a tracking, polarizing and focussing feed-mount system for the 300-foot telescope. Recommendations for bid award have been made.

3. Major overhaul at the 36-foot telescope (see page 5, this report).

4. A new variable-speed drive for the 300-foot telescope has been procured and pit alterations for installation of this drive have been made.

5. An oil separation unit has been designed and installed at the 300-foot telescope to clean up discharge from the telescope sump.

6. Design work on the 65-meter homology antenna is continuing. Areas of effort include the azimuth and tower structure, connection details for the reflector structure, panel structure and tower structure, design of panels, and the focal point cabin. Experimental panels have been manufactured and measurements have been made of their accuracy and thermal behavior.

COMPUTER DIVISION

Hardware

A new mini-computer configuration has been selected. Intended for installation at the 36-foot telescope site, it will act as a spectral-line processor and will enhance the observational facilities for detection of new molecular spectra.

Software - User

IBM 360 programs for editing the new autocorrelator data and for subsequent mapping are being developed.

Software - System

A "checkpoint/restart" capability was locally designed and implemented. It allows interruption of any long-running program so that the program can be removed to a disc file and brought back later, to be resumed from the interrupted point without loss of time. This interruption capability will give us greater flexibility for the many types of long runs which previously could only be started on the 12-8 a.m. shift, or on weekends, but which now can be started at any time and continued in segments whenever time permits.

Software - Realtime

Extensive reprogramming of the 36-foot telescope software has begun. Initial emphasis is directed toward making the software match the servo-loop hardware for maximum pointing accuracy.

New routines for the autocorrelator programs on the realtime computers are being developed, both for the Model III correlator now under construction and improvement of the existing Model II correlator.

ANTENNA DESIGN STUDIES

The Homology Telescope (The present status and future work on the design of the 65-meter homology telescope.)

The following have been chosen as the design goals for the telescope:

1. The telescope will be an altitude-azimuth instrument 65 meters in diameter.

2. Wheel and track azimuth bearings and conventional elevation bearings will be used.

3. Elevation range - from the horizon to a few degrees beyond the zenith.

4. Azimuth range - a total of 420°.

5. Reflector system - to be used as either a prime-focus instrument with f/D = 0.42 or as a Cassegrain telescope

6. Short wavelength limit - the goal is to have operation at 3.5 mm wavelength with an rms surface accuracy of 0.22 mm. This goal may be met only under calm wind and temperature conditions.

7. Pointing precision - this should achieve 3 arc seconds under calm atmospheric conditions.

8. The design should ensure no permanent deformation or damage to the telescope in winds of 100 mph at the dish center.

9. Equipment rooms, each about 10x10x12 feet, will be supplied at the vertex of the dish and just outside the prime focus.

Steady progress in design of the dish, the tower and details of the member joints has been made. A re-design of the azimuth structure to stiffen the tower and increase the natural frequency has resulted in an increase in tower weight but has made possible the elimination of two of the azimuth trucks and their associated mechanical components. Test surface panels have been fabricated at Green Bank and measurements have been made of their surface accuracy. A study of selected existing panel manufacturing techniques is being made to determine their suitability and adaptability to produce panels of the required accuracy at a reasonable cost. Work on the design of the drive and control servo has started and the first outline of the design is expected in about six weeks. An equipment layout and preliminary design study is being made of the focal point cabin to assure satisfactory location of projected equipment. An experimental and test platform with which to examine problems arising in the concept of the stable reference platform has been designed and built. Tests of this platform have been carried out at Green Bank since mid-July and they are continuing. They give essential information on the effects of the atmosphere on the principle of stabilizing a reference platform by locking it to the ground using the rays of light from optical autocollimators. Measurements and calculations are being made on the thermal properties of our existing telescopes as a guide to the thermal limits to be expected from the new design.

A rather complete and widespread site survey and site test program is needed. Dr. C. M. Wade has joined the project to lead this work. Draft site criteria have been set up and a first survey of areas in the southwest has been made. Since the scientific problems of siting this telescope are very similar to those for infrared telescopes, we have discussed our work with Prof. J. Westphal of CalTech and with a number of other optical and infrared astronomers. Professor Westphal is leading the work for NASA on the search for an infrared telescope site.

The design group has developed an optical system for measuring the 140-foot telescope surface and has recently tested a novel radio method which might give the added accuracy needed. Carl Zeiss in W. Germany has provided information on a good optical system they have used, and a good collaboration has developed with the Max-Planck Institut in Bonn on this subject. Studies are continuing to find even more precise methods for surface measuring.

The main preliminary design problems are expected to be worked out by the summer of 1971. To do this, the services of the quite considerable number of NRAO staff who are devoting part of their time to the project will be used.

We shall at this point, have completed the feasibility design phase. We shall know that the telescope will meet its design goals, and we shall have determined that all component parts of the telescope can be built and will work. We shall have a good estimate of its cost, and we shall be prepared to recommend either the exact site or, what is more probable, to be able to give a comparative judgment on various possible sites.

We shall be ready at this time to enter the final stage of engineering which would lead to a sufficiently detailed set of design drawings, specifications, and other material for a bid package to be prepared and bids solicited from an approved list of contractors.

The final engineering design phase would take about one year. It would, in our view, be performed by a firm specializing in antenna design to carry the major effort. Our own engineering staff would work with the chosen firm, and special contractors would be selected to work on elements such as the position reference system and the servo control design and evaluation.

TOURIST PROGRAM

During this quarter a more comprehensive program for the benefit of tourists was introduced. The program includes graphic displays with descriptions of the instruments, and a small 2-foot diameter radio telescope which monitors the sun. Approximately 19,000 visitors came to the Observatory this summer.

PERSONNEL

Appointments

Collins E. Yang	Structural Engineer	July 1, 1970
Stanley D. Shawhan	Vis. Asst. Scientist	July 2, 1970
William F. del Guidice	Mechanical Engineer	August 3, 1970
Eugene H. Tademaru	Research Associate	August 4, 1970
Charles H. Moore, Jr.	Scientific Prog. Analyst I	August 10, 1970
Bert I. Hansson	Electronic Engineer	September 8, 1970
Robert N. Whitehurst	Visiting Scientist	September 10, 1970
Edward B. Fomalont	Assistant Scientist	September 18, 1970

Terminations

Peter G. Mezger	Scientist	July 14, 1970
W. Bruce McAdam	Visiting Scientist	July 29, 1970
Cary A. Young	Electronic Engineer	July 31, 1970
Edward B. Churchwell	Research Associate	August 24, 1970
Stanley D. Shawhan	Vis. Asst. Scientist	August 28, 1970

Leave of Absence

David S. De Young	Assistant Scientist	July 1-31, 1970
Gerrit L. Verschuur	Assistant Scientist	Returned July 1, 1970