NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

Quarterly Report

October 1 - December 31, 1965

RESEARCH PROGRAMS

Interferometer

		Hours
Scheduled		1734.00
Equipment installation and scheduled maintenance		186.25
Time lost due to:	equipment failure	39.75
	weather	0.50
	interference	0.75

The interferometer operated for the major portion of the time with a 2700 meter baseline. On December 8, 85-2 was moved to give a baseline separation of 1200 meters. The commentary below reflects the use of the interferometer during this quarter.

I. 2700 m Separation

Visibility survey. Approximately 40 unidentified sources listed in the Revised 3C catalog were observed to determine which were unresolved. Accurate position measurements will be made for the unresolved sources in order to facilitate optical identifications.

Position Measurements. Observations continue on all unresolved sources previously unidentified. A positional accuracy of 1" to 1".5 of arc is attainable for most sources.

Planets. Measurements were made of the second maximum of the fringe visibility function for Venus in order to gain further information about the limb darkening of the planet. Attempts were made to detect Mercury and additional observations were made of Saturn in order to measure the angular diameters of that planet.

Instrumental Phase. Several identified sources were observed continuously in order to determine the phase stability characteristics of the interferometer. Several unresolved and unidentified sources at low declinations were also included to obtain accurate positions for these sources.

Extragalactic Source Survey. Observations of a large number of extragalactic sources were continued by F. Bash (University of Virginia) in his dissertation work for the determination of one dimensional brightness distributions.

Survey of Planetary Nebulae. Observations of seven planetary nebulae were made for the determination of the angular diameters of these sources. This information will be used to give a distance estimate for these nebulae.

Long Integrations. Observations were made of two regions of sky--one which includes the BSO 1 and another with no known source in the beam. The purpose of this work is to determine the faintness limit for the instrument.

One faint 4C object was detected and it has been determined that the interferometer can work to the limit of the 4C survey for unresolved sources.

II. 1200 m Separation

Baseline calibration. The end of the quarter was devoted to the calibration of the baseline parameters for the 1200 m separation immediately following observations at the individual telescopes for the determination of antenna pointing correction data.

300-foot Telescope

		Hours
Scheduled		1959.75
Equipment installation and scheduled maintenance		79.25
Time lost due to:	equipment failure	52.75
	weather	15.00
	interference	1.75

During this quarter E. McClain, R. Sloanaker and J. Bologna (Naval Research Laboratory) continued a series of observations of polarized emission of discrete radio sources. Observations were first conducted in 1963 and 1964 at a frequency of 1413.5 MHz. During the most recent observing period, observations were conducted at 1175 MHz. At some later date they wish to make observations of the same sources at wavelengths both below 21 cm and above 26 cm.

M. Roberts measured the hydrogen content of a series of galaxies, an investigation that has been in progress for sometime.

Toward the end of the quarter, a moderately severe structural problem was discovered on this telescope. Repairs were made on the immediate problem, and two 8 hour periods each week, instead of the usual one, were used to give the structure a thorough check. These structural maintenance periods will continue for most of the month of January.

140-foot Telescope

	Hours
Scheduled	1837.75
Equipment installation and scheduled maintenance	235.75

(140-foot, continued)

		Hours
Time lost due to:	equipment failure	159.50
	weather	43.50
	interference	.50
	power	.25

The time lost due to weather was due to atmospheric effects related to observing at short wavelengths rather than to weather restrictions on the telescope structure.

Observations were undertaken at a number of frequencies during this quarter beginning with 15.375 MHz. Antenna evaluations at this frequency made by P. Mezger and J. Baars indicate an aperture efficiency of 43 percent. It was also found that the beam switching technique used on this system was very effective in removing sky noise fluctuations. K. Kellermann and I. Pauliny-Toth made flux density measurements of a few discrete sources at this frequency, and M. Kaftan-Kassim observed a planetary nebula.

With the autocorrelation receiver observing the hydrogen line, D. Williams (University of California) and T. Menon made absorption measurements. M. Roberts observed a few extragalactic systems at this frequency, and D. Hogg observed the radio scintillation of sources near the sun.

Equipment at the focal point was set up to measure the OH line. P. Palmer and B. Zuckerman (Harvard University) observed OH line linear polarization. A. Barrett and A. Rogers (Massachusetts Institute of Technology) measured OH line circular polarization of selected sources.

The equipment was temporarily arranged as a switched radiometer system to enable S. von Hoerner and M. DeJong to observe lunar occultations of sources.

R. Hobbs and J. Hollinger (Naval Research Laboratory), using NRL equipment, made polarization measurements of about 50 sources at a frequency of 14.5 GHz.

In order to evaluate the antenna performance at a wavelength near 1 cm K. Kellermann, J. Baars and P. Mezger determined that the telescope has an aperture efficiency of 16 percent near the zenith at 31.4 GHz which is very close to the value predicted from earlier measurements at longer wavelengths.

ELECTRONICS DIVISION--EQUIPMENT DEVELOPMENT

Approximately 30 percent of the effort in the Electronics Division this quarter was spent in routine repair, installation, and minor modification of equipment to support the Observatory's experimental program. Notable items this quarter were an unusual amount of digital equipment repair, minor modification and tune-up of a 20-channel receiver for the 300-foot telescope, and repackaging of front-end boxes for the 140-foot and 300-foot telescopes.

The status of new equipment development is as follows:

Construction Completed: An automatic phase-measuring or phase-correcting system for use with the interferometer has been completed. This is a prototype system and is currently being evaluated on the interferometer.

A digital clock and computer interface for use in controlling the 36-foot telescope were completed and shipped to the Arizona site.

The 9.5 mm radiometer was completed and installed on the 140-foot telescope.

Construction in Progress: The construction of a new solid-state universal receiver back-end has been started. This universal solid-state receiver will replace the many specialized vacuum-tube receivers now in use and will provide improvements in reliability, performance, and ease of operation. Approximately 10 of these receivers will be constructed in 1966.

-A device to read and print magnetic tapes is being constructed. This piece of equipment is needed to service digital equipment in Green Bank when the computer is moved to Charlottesville.

-The RF portion of the autocorrelation spectral line receiver is being rebuilt in order to remedy several problems which have existed.

-A transistorized receiver for use in performing lunar occultations with the 140-foot telescope is being constructed. This receiver is small enough to remain on the telescope at all times, so no installation time is lost when an occultation occurs.

-New 2 cm and 6 cm receivers utilizing cooled parametric amplifiers are being constructed for use on the 140-foot telescope. These receivers will first be used during winter and spring 1966.

Construction in the Planning Stage: An extremely long baseline interferometer (between Green Bank and Arecibo, Puerto Rico) is being actively planned. This system will utilize an atomic clock for the local oscillator at each location. Data will be recorded at the two locations and later correlated in a computer. This is the first interferometer of this type.

- A new general purpose digital recording system for use at all telescopes is being planned. The goal is to plan a system which has sufficient capability and flexibility to be used for several years. In the past we have continuously built and modified the telescope digital data handling systems.

THE NRAO MILLIMETER WAVE ANTENNA

On-Site Work at Kitt Peak

The site is prepared for the arrival of the reflector from Rohr Corporation.

Telescope Fabrication, Rohr Corporation

Machining of the reflector surface has progressed slowly. Several machining problems which have slowed the work significantly have been encountered:

1) Excessive tool wear caused by silicon-carbide dust imbedded in the dish surface after a dust-blast preparation of the surface. The problem was solved by the use of diamond cutters and slower cutting speeds.

2) Small differential movements between the cutter arm assembly and the reflector mount of the order of 0.002". This was found to be correlated with the tide, and machining and measurements are now being performed during periods of favorable tide conditions only.

These problems have delayed the estimated delivery of the telescope to the middle of January 1966.

Computer

The computer has arrived at Kitt Peak and the hardware has been checked out and found satisfactory.

ANTENNA DESIGN STUDIES

The Largest Feasible Steerable Paraboloid

Work by members of the engineering group has proceeded steadily during the quarter. The floating sphere antenna has been the subject of extensive structural and deflection analyses. The concept still appears to be attractive, but the stresses and deflections in a shell with a circular aperture strengthened by a lantern ring become serious. Shell structures of two steel shells separated by as much as 20 feet have been studied as a possible way of keeping these stresses within reasonable limits. This work has been done by O. Heine, and work on the same concept is also being done by Lear Siegler under NRAO contract.

E. Faelten has made designs for both a spherical surface and a parabolic surface dish mounted on an azimuth rotating support. By moving the feed (spherical surface) on the parabolic surface, a limited but adequate elevation motion is obtained.

The study of homologous structures has been continued by R. Jennings and S. von Hoerner. The intent is to find the structure design whose shape varies as little as possible as deflections take place. Theoretical and computer studies show this to be worthy of continued study.

At a meeting in Green Bank (October 11, 1965) the very interesting ideas of North American Aviation were described by Mr. J. J. Myers, Dr. J. Horsch, and Mr. D. Ulrey. In San Juan, on December 6, 1965, Dr. M. Hoffman and Mr. M. Perry of ITT Federal Laboratories described and discussed large luneberg lens design. This Puerto Rican meeting was also used by the group for a study of the 1000-foot spherical dish antenna of the Arecibo Ionospheric Observatory.

The group will shortly draft its first progress report.

The Very Large Antenna Array Project

The design study to date for the Very Large Array culminated in a VLA (Draft) Report No. 1, dated December 10, 1965, in which the study group summarized the following aspects of the array concept: Need and general performance requirements, various possible systems, a detailed analysis of the correlation array, a study of the array configuration, sensitivity and dish size and finally a suggestion for a specific array. The report also treats

the antenna and track requirements, electronics, data processing, and the monitor and control system for the VLA. Desirable characteristics for the site are also discussed.

Efforts during this quarter were directed toward the problem of choosing an array configuration that will make the most effective use of the earth's rotation in order to minimize the number of antennas necessary to achieve an adequate synthesis of a source brightness distribution. Presently, a 35-37 element array in the shape of a "Y" looks very promising. A computer program has been written that will evaluate objectively the effects of missing fourier components in sampling for various specific array configurations. Other efforts are being made toward formulating the design concepts for the electronics, the individual antenna elements and the movement of the antennas along a track or by other means to achieve maximum array flexibility. The advantages and disadvantages of using railroad-type tracks are being explored and cost studies of the array components are underway.

The computer design and feasibility study by RCA, accomplished under an NRAO contract, has been successfully completed. This study was undertaken to show the feasibility of using digital computers for on-line reduction of the data produced by the VLA. Not only do digital tehniques appear to be a practical way to handle the data, but the cost appears to be a reasonable fraction of the total cost of the array. It is entirely feasible to perform the data-gathering, telescope monitoring and control functions by computer techniques and hardware now available.

The VLA (Draft) Report No. 1 and the subsequent work of the VLA design group will be the primary topic for discussion at the NRAO Users Committee meeting to be held in the Charlottesville laboratory on January 28-29, 1966.

CHARLOTTESVILLE LABORATORY BUILDING

After inspection and approval by the architects, the University of Virginia and the State of Virginia, the new NRAO laboratory building on the University grounds was occupied on December 20, 1965. This three story building has provision for the scientific staff and director's office, that part of the electronics division responsible for new systems design, the computer division, the main library, drafting and photographic services and a few administrative services personnel. By the end of January 1966 the director's office, computer, library and part of the scientific staff will have been transferred to the new laboratory from Green Bank.

Maintenance is being provided through the University of Virginia. The total capacity of the building is about 70 people. Communication between the Charlottesville and Green Bank sites is being accomplished by means of two direct telephone lines, TWX, daily scheduled trips by automobile for mail, passengers, and the transportation of magnetic tapes and data, and by charter aircraft when fast travel is necessary and weather permits.

The address of the new laboratory is Edgemont Dairy Road, Charlottesville, Virginia, 22901; the main telephone number is Area 703, 296-0211.

PERSONNEL

Mr. F. Bash (University of Virginia) rejoined the staff on a graduate student appointment while observing for his doctoral thesis on the interferometer.

Mr. R. Drake was employed by the fiscal division as accountant.

Mr. R. Mauzy joined the electronics division as an electronics engineer during this quarter. His work will be primarily concerned with the NRAO autocorrelation receiver program.

Mr. J. Schraml has joined the basic research staff from Germany, on a one year appointment as research associate. He will collaborate with P. Mezger on galactic source mapping and on the analysis of excited hydrogen line studies.

Dr. Z. Turlo began a one year appointment as research associate. Dr. Turlo has had experience with solar interferometry in Poland and will be working with the interferometer group.

Miss Margaret B. Weems was employed in the new Charlottesville laboratory as technical illustrator. Her previous position was a similar one at the University of Virginia.