NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

Quarterly Report

July 1 - September 30, 1966

RESEARCH PROGRAMS

Interferometer

	Hours
Scheduled	607.00
Equipment changes and scheduled maintenance	53.00
Time lost due to: equipment failure	1.00
interference	8.25

S. Zisk (M.I.T.) finished aperture synthesis measurements for approximately 24 of the strongest radio sources at a frequency of 234 MHz.

W. Cronyn (U. of Maryland) completed scintillation measurements of small diameter sources.

On July 27, the interferometer was shut down to undergo extensive telescope and equipment modifications and to add a third 85-foot telescope to the system. The interferometer is expected to be operational this calendar year as a three element, completely computer controlled system.

300-foot Telescope

	Hours
Scheduled	395.50
Equipment changes and scheduled maintenance	46.00
Time lost due to: equipment trouble	9.00

An extensive strengthening and modification of the 300-foot telescope by Rohr Corporation was completed during this quarter. Rather severe damage to the telescope occurred during this work, and Observatory personnel will repair and adjust the surface during the coming quarter.

Toward the end of the quarter, A. P. Henderson (U. of Maryland) made measurements to evaluate the antenna and conducted neutral hydrogen observations of the galaxy, investigating in further detail deviations of the HI distribution above and below the plane of the galaxy.

R. Davies (U. of Wisconsin) observed neutral hydrogen in selected galactic clusters, and G. Westerhout (U. of Maryland) continued his galactic survey of neutral hydrogen.

140-foot Telescope

	Hours
Scheduled	2051.25
Equipment changes and scheduled maintenance	156.75
Time lost due to: equipment failure	119.25
weather	52.25

140-foot Telescope, continued		Hours
Time lost due to:	interference	11.25
	power	0.75

Time lost due to weather is mainly attributed to detrimental atmospheric observing conditions at short wavelengths.

B. Zuckerman (Harvard) and P. Palmer (Harvard) engaged in two observational programs during this period: (1) a search for an excited OH line at 6 cm and (2) a search for an excited hydrogen line near 400 MHz.

Seventeen days were scheduled for 2 cm observations. K. Kellermann and I. Pauliny-Toth observed a number of sources to check for high frequency flux density variations. P. Mezger used part of that period to test the high frequency characteristics of the telescope.

Five lunar occultations were scheduled to be observed by J. Taylor (Harvard), M. DeJong and S. von Hoerner at 234, 256, and 405 MHz, simultaneously. Change over to the occultation receivers, the observation, and change back to the normal program has now been reduced to three hours, maximum.

The remaining time on the telescope was devoted to research at 2695 MHz. The following observers undertook the following programs:

Observer	Program (11 cm)
W. Altenhoff	Extinction measurements
M. Cohen (Cornell)	Source scintillation measurements
M. DeJong	Mapping normal galaxies
D. Heeschen	Flux density measurements of elliptical galaxies
D. Hogg	Mapping region of Scorpius XR-1 source
M. Kaftan-Kassim	Flux density determinations of planetary nebulae
K. Kellermann, I. Pauliny-Toth and W. Tyler	Flux density determinations of over 400 discrete sources
H. C. Ko (Ohio State)	Mapping clusters of galaxies
P. Mezger	Mapping galactic sources; position measurements
M. Roberts and G. Swenson, Jr. (Illinois)	Mapping near M 31
Z. Turlo	Jupiter occultation by solar corona

ELECTRONICS DIVISION--EQUIPMENT DEVELOPMENT

During the past quarter approximately 10 percent of the Electronics Division's efforts were expended on routine repair and system installation. This relatively low figure is chiefly due to the 300-foot telescope being down for mechanical modifications during the summer months.

The radio frequency system (front end) for the portable 42-foot antenna has been completed. The model for the phase lock loop system for the 42-foot antenna has been completed and work is also progressing on the data link. This work is being done by Airborne Instruments Laboratory on a contract basis.

A dual 11-21 centimeter radiometer has been assembled and was installed on the 140-foot telescope September 29.

The IF amplifier, delay lines, and correlator portion of the three-element interferometer have been constructed and are in a final checkout phase. The interferometer local oscillator system has been designed and a portion of the system has been prototyped. Components for construction of the final system are now on order. The DDP-116 on-line computer for the interferometer has been received, and interface equipment is being checked out.

On-line computers for use at the 140-foot and 300-foot telescope have been ordered, and the development of special input-output equipment has been started.

The construction of an independent local oscillator interferometer system for use between Green Bank and Arecibo is proceeding. Parametric amplifiers and magnetic tape recorders have been received and the IF portion of the receiver has been constructed.

Most of the logic for the planned 416-channel digital correlation receiver has been prototyped and tested. The following major items for the receiver have been ordered: 1) Core memory, 2) about one-third of the required integrated circuits, and 3) the necessary cabinets.

Most of the major components for the universal local oscillator system have been received; assembly and testing of the system is planned during the next quarter.

Four of the eight new solid-state IF amplifiers and phase detector systems have been constructed.

The following Electronics Division Internal Report was issued during the quarter:

No.	Title	Author	Date
57	Characteristics of the Paraboloid Antenna	J.W.M. Baars	August 1966

THE NRAO 36-FOOT MILLIMETER WAVE ANTENNA, KITT PEAK, ARIZONA

A preliminary alignment of the telescope pedestal has been completed. The computer has been moved to the telescope site from the Tucson laboratory and has been interfaced with the telescope control system. Computer programs for the detailed testing of the telescope performance have been developed. The preliminary tests of the servo drive showed unacceptable performance, and the manufacturer (Teledyne) returned the system components to their plant for

modifications. Ninety per cent of the final telescope control program has been written and partly checked on the computer.

Permanent power and telephone have been connected to the site.

300-FOOT TELESCOPE

The modification and improvement work that was started in April was continued through the beginning of the working period. A survey of the reflector support structure after completion of the contractor's (Rohr) part of the work indicates that the 300-foot telescope now is a safe and more rigid structure, and therefore the objections with that part of the program have been accomplished. The reflecting surface is now being readjusted for optimum antenna efficiency by NRAO.

ANTENNA DESIGN STUDIES

The Largest Feasible Steerable Telescope (LFST)

By the end of this report period the work of the group had produced satisfactory studies for the following four antenna concepts:

1. The Floating Sphere Antenna. In this concept, the reflector is carried by a large spherical shell, which in turn floats on water (in one design) or on an air bearing. Three structural possibilities for the spherical shell have been examined, concrete, a double wall of steel plate with a space frame between the walls, and a honeycomb structure. All are feasible structurally. Quite complex calculations were needed to give the stresses and deflections of the spherical shell; the properties of the stiff ring around the shell opening also required considerable study. Enough has been done on drive systems to show how the sphere could be rotated. Some methods of minimizing the effects of the shell deflections on the telescope reflector have been considered. Work on these problems has been done within the group and by two contracts, one with Lear Siegler, Inc., and one with North American Aviation.

2. Azimuth Rotating Telescope with Limited Elevation Motion. Three such instruments have been studied and designs carried through to a point where reasonable weight and size estimates can be made. Two of the designs use a parabolic surface which is moved to give the elevation motion; the third uses a fixed spherical surface and a moving phase -- correcting feed.

All of these design concepts are now to be reviewed to make sure that they are adequate and that they can be used for comparison of the economy of the designs.

The method of computing member sizes in a structure to satisfy the homology principle for a number of points on the surface of the structure has now been tested for several structural shapes. The method has, after a considerable amount of labor, been shown to work in that the solutions for member sizes converge quite rapidly to values which make the chosen surface points behave

correctly. That is, the surface points deflect as the direction of gravity changes, but the shape of the surface defined by the points remains the same.

The Very Large Antenna Array Project (VLA)

All of the programs reported in the last Quarterly Report have continued during this quarter.

Limbaugh Engineers, Inc., of Albuquerque, New Mexico, has mapped and studied three typical sites in the southwest in order to determine approximate costs on developing an array site. After the initial phase of the study, one site was temporarily eliminated as being too similar to one of the others, and further work is being carried on for the remaining two sites. The result of the study will be preliminary architectural and engineering designs for the buildings, roads, utilities, railroad tracks and antenna foundations, and cable trenches.

IT&T and RCA are continuing their studies of the electronic components and antenna structures, respectively. These two contracts are being closely monitored and frequent reassignments of emphasis have been made.

Instruments have been installed for the daily determination of total atmospheric water vapor content at three suitable sites in the southwest. These units have been in operation for about three months. Studies with the interferometer at Green Bank indicate that atmospheric phase instability is correlated with high water vapor content.

Continued study has been devoted to the array configuration and to the performance of various arrays. Computer programs for investigation of the transfer functions of arrays have been in use for over a year. In addition, a program for taking the Fourier transform of the transfer function has been prepared (by B. G. Clark) using the Cooley-Tukey algorithm. This transform is the response of the array to a point source of radiation, and gives directly the side lobe and main beam responses of the array.

A considerable amount of discussion has been devoted to the desirable speed of observations and the number of sources that could profitably be observed in a year, with implications for the number of antennas in the array and the possible use of complementary arrays as the normal mode of operation. There are two schools of thought: One is that the astronomical community can utilize information on only a few hundred new sources per year at most, and that it is therefore uneconomical to provide an array large enough to synthesize a source in a few hours. The other view is that the inconvenience of moving and of waiting, perhaps months, for an "observation" to be completed is such a severe handicap that much more good research per dollar will come out of the instrument if an observer can get his results in a day or so, even if this means that the instrument stands idle some of the time. A variant of the latter view is that a powerful instrument generates its own programs by making new discoveries, and that it is likely that the faster and better the instrument, the busier it will be. Clearly, there is no consensus here, but the subject is important

and the dialogue must be continued. One unanimous view is that mobility of the antennas is very important and must be provided, regardless of what else is decided about the mode of operation.

MISCELLANEOUS

Budget Status

Expenditures for FY 1967 are currently being limited to the fourth quarter level of FY 1966 until final approval of the FY 1967 budget has been obtained from Congress and the N.S.F. All major commitments for equipment and facilities included in the FY 1967 budget are being deferred until the anticipated appropriation of $5.2 million becomes definite. The NRAO budget request for FY 1968 is $6.5 million, down from the $7.9 million originally requested. Major items in the FY 1968 budget (with the corresponding FY 1967 amounts in parentheses) now include: Operations $4.0 million ($3.69 million), LFST Design $100,000 ($100,000), VLA Design $1.0 million ($550,000), Other Observing Equipment $932,000 ($468,000) and Research and Test Equipment $300,000 ($280,000).

Very Long Baseline (VLB) Interferometer

The NRAO has received $52,000 as the Arecibo Ionospheric Observatory's share of the cost for this project. The funds were made available by a direct transfer from the Air Force to the NSF, who in turn amended the AUI contract to reflect the increased available funds.

NRAO Airstrip

A contract was awarded to the General Paving Company, Morgantown, West Virginia, on August 8, 1966, to pave the NRAO's 3500-foot airstrip. Completion was scheduled for 60 days from date of award. Rain has postponed completion beyond October 15, however.

Interferometer Control Building

The construction of this building has progressed to the point where all exterior masonry work is virtually completed. The installation of the roof has just started. It should be under roof by about October 15. Plumbing and electrical work has been started and the internal masonry work has been started.

PERSONNEL

	On Board 6/30/66	On Board 9/30/66	Change
Scientific and Engineering	40	35	- 5
Technical	66	61	- 5
Administrative	14	16	+ 2
Clerical	35	35	-0-
Maintenance	39	40	+ 1
Other (Guards-Food Service)	11	11	-0-

	On Board 6/30/66	On Board 9/30/66	Change
Students	33	5	-28
Part-Time	19	14	- 5
Total	257	217	-40

Scientific and Engineering Personnel Changes During Quarter

Appointments

R. Davies	Junior Research Associate	July 18, 1966
A. Cunningham	Research Associate	Sept. 8, 1966

Terminations

L. Chow	Research Associate	July 8, 1966
C. Sastry	Research Associate	Aug. 31, 1966
M. DeJong	Research Associate	Sept. 7, 1966
M. Kassim	Research Associate	July 1, 1966
W. Weller	Research Associate	Sept. 7, 1966
H. van der Laan	Visiting Research Associate	July 1, 1966
J. Bringe	Electronic Engineer	Aug. 27, 1966

Administrative Appointments During Quarter

J. Findlay*	Assistant Director	Sept. 1, 1966
J. Finks	Budget Officer	July 5, 1966

* Return from year's leave of absence.