NATIONAL RADIO ASTRONOMY OBSERVATORY

Quarterly Report

April 1, 1988 - June 30, 1988

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A. TELESCOPE USAGE

The following telescopes have been scheduled for research and maintenance in the following manner during the second quarter of 1988.

	140-ft	300-ft	12-m	VLA
Scheduled observing (hrs)	1981.25	2030.00	1926.25	1551.4
Scheduled maintenance and equipment changes	146.75	105.50	93.75	302.3
Scheduled tests and calibrations	56.00	48.50	156.00	335.2
Time lost	25.50	38.50	127.25	-
Actual Observing	1955.75	1991.50	1799.00	1379.5

B. 140-FT OBSERVING PROGRAMS

The following continuum program was conducted during this quarter.

No.	Observer(s)	Programs
B-494	Backer, D. (Berkeley) Bookbinder, J. (Colorado) Dulk, G. (Colorado) Kulkarni, S. (Caltech) McKean, M. (Colorado) Bastian, T.	Observations at 1400 MHz of the dynamic spectra of dMe flare stars and RS CVn binaries.

The following line programs were conducted during this quarter.

No.	Observer(s)	Programs
B-485	Brown, R.	Search at 988 MHz for recombination lines toward quasars showing redshifted HI absorption.
B-501	Baan, W. (Arecibo) Gusten, R. (MPIR, Bonn) Henkel, C. (MPIR, Bonn) Wilson, T. (MPIR, Bonn)	Observations at 2 cm of H_2CO in external galaxies.
B-505	Bell, M. (Royal Observatory) Broten, N. (Herzberg) Watson, J. (Herzberg)	Search at 21 cm for recombination lines of positronium.
C-252	Claussen, M. (NRL) Kleinmann, S. (Massachusetts)	Observations at 18 cm of OH masers from an infrared flux-limited sample of oxygen rich stars.

No.	Observer(s)	Programs
G-302	Giovanelli, R. (NAIC) da Costa, L. (CNPq, Brazil) Ford, V. (Mt. Stromlo) Haynes, M. (Cornell) Mathewson, D. (Mt. Stromlo) Salzer, J. (NAIC)	Hydrogen observations of Sc galaxies in the declination range of -40°- -18°.
I-005	Irvine, W. (Massachusetts) Friberg, P. (Chalmers) Hjalmarson, A. (Chalmers) Madden, S. (Massachusetts) Ziurys, L. (Massachusetts) Turner, B.	Observations at 1.6 cm of molecular clouds, particularly the cold clouds TMC-1 and L134N.
L-220	Lubowich, D. (Hofstra) Hobbs, L. (Yerkes) Turner, B.	Search at 803.5 MHz for ^{7}Li (lithium) in the Galactic Center.
M-227	Matthews, H. (Herzberg) Batrla, W. (Illinois) Caswell, J. (CSIRO) Haynes, R. (CSIRO) Olnon, F. (Leiden) Winnberg, A. (Chalmers) Maddalena, R.	Observations at 1.3 cm for H_2O maser sources in the Galactic Plane.
M-283	Likkel, L. (UCLA) Morris, M. (UCLA) Maddalena, R.	Monitor at 1.3 cm unusual H_2O emission from two IRAS sources.
M-284	Brown, R. (Monash University) Godfrey, P. (Monash University) Henkel, C. (MPIR, Bonn) Irvine, W. (Massachusetts) Madden, S. (Massachusetts) Wilson, T. (MPIR, Bonn) Maddalena, R.	Time variability study at 1.5 cm of ammonia masers.
T-242	Tifft, W. (Arizona)	Refined observations of HI redshifts in about 100 galaxies to verify and enhance data taken at the Bonn 100-m and the NRAO 300-ft telescopes.
T-243	Thuan, T. (UVA) Fouque, P. (Meudon) Schneider, S. (Massachusetts)	Hydrogen survey of dwarf galaxies.

No.	Observer(s)	Programs
T-248	Turner, B.	Search for hyperfine CH lines at 702 and 724 MHz.
W-248	Combes, F. (Meudon) Encrenaz, P. (ENS, France) Gerin, M. (ENS, France) Wlodarczak, G. (de Lille, France) Wootten, H. A.	Search at 1.4 cm for acetic acid in the interstellar medium.
Y-003	Yusef-Zadeh, F. (Goddard) Anantharamaiah, K.	Search at discrete frequencies between 4.7 and 7.2 GHz for recombination lines from the Galactic Center Region.
Z-070	Zuckerman, B. (UCLA)	Search at 18 cm for OH maser emission toward carbon stars.

The following pulsar programs were conducted during this quarter.

No.	Observer(s)	Programs
B-484	Backer, D. (Berkeley) Clifton, T. (Smith Assoc. England) Foster, R. (Berkeley) Kulkarni, S. (Caltech) Taylor, J. (Princeton)	Timing observations at 1400 MHz of PSR 1821-24 and other submillisecond pulsars.
B-500	Backer, D. (Berkeley) Dey, A. (Berkeley) Gorham, P. (Caltech) Kulkarni, S. (Caltech) Middleditch, J. (Los Alamos) Prince, T. (Caltech)	Targeted pulsar search at 20 cm.

The following very long baseline programs were conducted, and the stations used for the observations are coded as follows:

A - Arecibo 1000 ft
B - Effelsburg, MPIR 1000 m
E - Hartebeesthoek 26 m
F - Fort Davis 85 ft
G - Green Bank 140 ft
H - Hat Creek 85 ft
I - Iowa 60 ft
Jb - Jodrell Bank MK II 25 m
Jn - Merlin 25 m
Km - Haystack 120 ft
Lm - Medicina 32m
Mb - Itapetinga 20 m
N - NRL Maryland Pt. 85 ft
O - Owens Valley 130 ft
Sn - Onsala 20 m
So - Onsala 25 m
Wn - Westerbork n=1-14x26 m
Yn - Socorro n=1-27x25 m
Z - Torun 15 m

No.	Observer(s)	Programs
A-18V	Akujor, C. (U. of Nigeria) Wilkinson, P. (Manchester)	Search at 6 cm for superluminal motion in 3C 380 with telescopes B, G, Jb, Km, Lm, O, Wn, and Yn.
A-19V	Andre, P. (IRAM) Lestrade, J-F. (JPL) Montmerle, T. (IRAM) Phillips, R. (Haystack) Mutel, R. (Iowa)	Studies at 6 cm of the magnetosphere of a young radio-emitting magnetic star in the Rho Ophiuchi Cloud with telescopes G, O, and Yn.
B-79V	de Bruyn, A. (Dwingeloo) Brouw, W. (NFRA) Schilizzi, R. (NFRA) Brouwer, F. (NFRA)	Studies at 6 cm of M81 and SS433 with telescopes B, G, Jb, Km, Lm, O, So, Wn, and Yn.
B-83V	Biretta, J. (CFA) Reid, M. (CFA) Junor, W. (Manchester) Spencer, R. (Manchester) Muxlow, T. (Manchester)	Studies at 18 cm of the structure and evolution of the M87 jet with telescopes A, B, F, G, Jb, Km, Lm, N, O, So, Wn, and Yn.
B-85V	Baath, L. (Onsala) Wehrle, A. (Caltech) Cohen, M. (Caltech) Jones, D. (JPL)	Observations at 18 cm to confirm superluminal motion in CTA 102 with telescopes A, B, F, G, I, Jb, Km, Lm, O, So, Wn, and Yn.
B-88V	Biretta, J. (CFA) Zensus, A. (Caltech)	Measurements at 18 and 49 cm of the low frequency structure and spectra of 3C 345 with telescopes B, F, G, H, I, Jb, Km, Lm, N, O, So, Wn, and Yn.
B-90V	Briggs, F. (Pittsburgh) Garwood, B. (Pittsburgh)	Observations at 18 and 49 cm of radio sources behind high redshift galaxies with telescopes A, B, F, G, H, I, Jb, Km, N, O, Wn, and Yn.
B-486V	Backer, D. (Berkeley) Batrla, W. (Illinois) Johnston, K. (NRL) Menton, K. (CFA) Reid, M. (CFA) Moran, J. (CFA)	Observations of methanol masers at 12.178 GHz with telescopes G, H, and N.
C-50V	Cohen, M. (Caltech) Barthel, P. (Caltech) Unwin, S. (Caltech) Wehrle, A. (Caltech) Zensus, A. (Caltech) Aller, H. (Michigan) Aller, M. (Michigan) Aller, H. (Michigan) Nicolson, G. (Hartebeesthoek)	Study at 6 cm high redshift strong sources with telescopes B, E, F, G, I, Jb, Km, Lm, N, O, Sn, Wn, and Yn.

No.	Observer(s)	Programs
F-13V	Fey, A. (Iowa) Spangler, S. (Iowa) Mutel, R. (Iowa) Dickey, J. (Minnesota) Cordes, J. (Cornell)	Measurements at 49 cm of the galactic distribution of angular broadening at low latitudes with telescopes A, B, F, G, H, I, and O.
F-16V	Fey, A. (Iowa) Spangler, S. (Iowa) Mutel, R. (Iowa)	Observations at 18 cm of 2021+317 to test for interstellar scattering with telescopes B, F, G, H, I, Jb, Km, N, O, Lm, So, Wn, and Yn.
H-42V	Hooimeyer, J. (Leiden) Barthel, P. (Caltech) Schilizzi, R. (NFRA) Miley, G. (STScI)	Studies at 6 cm of the core structure of extended quasars with telescopes B, F, G, Km, Lm, O, So, Wn, and Yn.
L-53V	Lonsdale, C. (Haystack) Phillips, R. (Haystack) Barthel, P. (Caltech)	Survey at 18 cm of double hot spots in 5 powerful double sources with telescopes B, G, O, and Yn.
M-98V	Marscher, A. (Boston) Shaffer, D. (Interferometrics) Marcaide, J. (Astrofisica, Spain)	Observations at 6 cm of 4C 39.25 with telescopes B, F, G, H, I, Km, Lm, N, O, So, Wn, and Yn.
O-2V	O'Dea, C. (NRFA) Biretta, J. (CFA)	Studies of the central components of two-sided jets: NGC 1265 with telescopes B, F, G, H, Km, O, and Yn.
P-77V	Padriella, L. (Bologna) Fanti, R. (Bologna) Gregorini, L. (Bologna) Mantovani, F. (Bologna) Spangler, S. (Iowa)	Studies at 49 cm of sources showing low frequency variability with telescopes B, F, G, I, Jb, O, Wn, and Z.
P-83V	Pauliny-Toth, I. (MPIR, Bonn) Porcas, R. (MPIR, Bonn) Zensus, A. (Caltech) Wu, S. (Beijing) Mantovani, F. (Bologna) Kaufman, P. (Itapetinga) Kellermann, K.	Monitoring at 6 cm of 3C 454.3 with telescopes B, F, G, H, Km, Lm, Mb, and O.
R-45V	Roberts, D. (Brandeis) Wardle, J. (Brandeis) Cawthorne, T. (Brandeis) Brown, L. (Brandeis) Gabuzda, D. (Brandeis) Holdaway, M. (Brandeis) Kollgard, R. (Brandeis)	Monitoring of linear polarization of superluminal sources at 6 cm with telescopes B, F, G, Km, Lm, O, Wn, and Yn.

No.	Observer(s)	Programs
S-75V	Simon, R. (NRL) Fiedler, R. (NRL) Johnston, K. (NRL) Spencer, J. (NRL) Dennison, B. (VPI & SU) Phillips, R. (Haystack) Nicolson, G. (Hartebeesthoek) de Bruyn, A. (NFRA) Mutel, R. (Iowa) Booth, R. (Chalmers) van Breugel, W. (Berkeley) Mantovani, F. (Bologna) Spencer, R. (Manchester) Porcas, R. (MPIR, Bonn) Crane, P.	Observations at 6 cm of extreme scattering events in the interstellar medium with telescopes B, F, G, H, I, Jb, Jn, Km, Lm, N, O, So, Wn, and Yn.
S-77V	Simon, R. (NRL) Dennison, B. (VPI & SU) Fiedler, R. (NRL) Johnston, K. (NRL) Phillips, R. (Haystack) Spencer, J. (NRL) Waltman, E. (NRL)	Tests at 18 cm for possible scattering by the ISM in 0954+658, 1502+106, and 1749+096 with telescopes B, F, G, H, I, Km, N, O, and Yn.
W-42V	Unwin, S. (Caltech) Benson, J. Walker, R. C.	Monitor at 6 cm superluminal motions in 3C 120 with telescopes B, F, G, H, I, Jb, Km, N, O, So, Wn, and Yn.
X-37V	Gwinn, C. (CFA)	Search at 18 cm for reference sources with telescopes F, G, and O.

C. 300-FT OBSERVING PROGRAMS

The following continuum programs were conducted during this quarter.

No.	Observer(s)	Programs
A-082	Aller, H. (Michigan) Aller, M. (Michigan) Payne, H.	Observations at 880, 1400, and 2700 MHz of low frequency variable sources.
B-506	O'Dea, C. (NFRA) Balonek, T. (Colgate) Dent, W. (Massachusetts) Kinzel, W. (Massachusetts)	Polarization and flux density measurements of variable sources at 2695 MHz.

No.	Observer(s)	Programs
D-155	Dennison, B. (VPI & SU) Fiedler, R. (NRL) Johnston, K. (NRL) Simon, R. (NRL)	A patrol survey at 2.7 GHz for occultation events.

The following line programs were conducted during this quarter.

No.	Observer(s)	Programs
H-242	Haynes, M. (Cornell) Herter, T. (Cornell)	Hydrogen observations of SO galaxies in the local supercluster.
R-239	Richter, O-G. (STScI) Huchtmeier, W. (MPIR, Bonn) Davis, D. (STScI)	Complete high sensitivity HI survey of SO galaxies contained in the Shapely-Ames Catalog.
T-224	Tifft, W. (Arizona) Cocke, W. (Arizona)	Observations at 21 cm of quantization and time variability in galaxy redshifts.

The following pulsar program was conducted during this quarter.

No.	Observer(s)	Programs
B-442	Backer, D. (Berkeley) Dey, A. (Berkeley) Foster, R. (Berkeley) Werthimer, D. (Berkeley)	Real-time fast pulsar search of the Galactic Plane at 390 MHz.

The following SETI search, commensurate with other programs, was conducted during this quarter.

No.	Observer(s)	Programs
B-454	Backer, D. (Berkeley) Bowyer, S. (Berkeley)	Commensal SETI at any available frequency.

D. 12-M TELESCOPE

The following line programs were conducted during this quarter.

No.	Observer(s)	Programs
B-465	Brown, R.	Search for CO absorption in 3C 196.
B-498	Barvainis, R. (Haystack) Clemens, D. (Arizona) Leach, R. (Arizona)	Study of polarimetry of dust emission at 1 mm.

No.	Observer(s)	Programs
B-502	Black, J. (Arizona) Thorne, L. (Sandia Labs) Saito, S. (Nagoya, Japan)	Continuation of a search for interstellar CP.
B-504	Bregman, J. Hogg, D. Roberts, M.	Search for J=2-1 CO in galactic cooling flows.
C-250	Churchwell, E. (Wisconsin) Diplas, A. (Wisconsin) Koornneef, J. (Johns Hopkins)	Study of gas phase molecular abundance in regions with and without ice mantles on dust grains.
C-251	Clancy, R. (Colorado) Muhleman, D. (Caltech)	Study of Venus and Mars CO.
D-159	Dent, W. (Massachusetts) Balonek, T. (Colgate)	Study of the evolution of extragalactic radio sources at millimeter wavelengths.
G-297	Grabelsky, D. (Northwestern) Ulmer, M. (Northwestern)	Search for CO (J=2-1) emission from cD galaxies at the centers of cooling flows.
H-247	Hunter, D. (Lowell Observatory) Thronson, H. (Wyoming) Bally, J. (Bell Labs)	CO observations of HI complexes in NGC 4449.
H-248	Hunter, D. (Lowell Observatory) Thronson, H. (Wyoming)	CO observations of small galactic HII regions.
H-249	Heiles, C. (Berkeley) Reach, W. (Berkeley) Koo, B. (Berkeley)	^{12}CO mapping and ^{13}CO measurements of molecular shocks.
H-250	Henkel, C. (MPIR, Bonn) Jacq, T. (MPIR, Bonn) Walmsley, C. M. (MPIR, Bonn) Baudry, A. (Bordeaux Obs.) Jewell, P.	Study of $H_2{}^{18}O$ in compact cores -- follow-up observations.
H-251	Hollis, J. M. (Goddard)	Search for CO in R Aquarii.
H-252	Hollis, J. M. (Goddard) Jewell, P. Lovas, F. (NBS)	Search for CH_2 in Orion A.

No.	Observer(s)	Programs
K-306	Kutner, M. (RPI) Evans, N. (Texas) Mead, K. (NRL) Natta, A. (Arcetri)	A study of high density structures in bipolar flows.
K-311	Keto, E. (Berkeley) Klein, R. (Berkeley) Ho, P. (CFA)	Study of HCO^+ in W33-Main and G10.6-0.4 as a tracer of shocked gas.
K-312	Kutner, M. (RPI) Mundy, L. (Caltech)	Confirmation of detection of CS(J=5-4) line in M82.
L-208	Lubowich, D. (Hofstra)	Study of mass loss from super lithium-rich stars from CO J=2-1 line.
L-224	Lewis, B. M. (NAIC)	Study of similarities of DGE stars with/without 1612 MHz masers at 86 GHz SiO.
L-225	Loren, R. (Texas) Wootten, H. A. Wilking, B. (Missouri)	Study of alignment, magnetic fields, and rotation of cold DCO^+ clumps in rho Oph.
L-228	Lada, C. (Arizona) Margulis, M. (Massachusetts)	Search for dense gas in IRAS sources; Monoceros OB1 dark cloud.
L-229	Latter, W. (Arizona) Maloney, P. (Leiden)	CO observations of Malin 1.
M-280	Mirabel, I. (Caltech) Sanders, D. (Caltech) Kazes, I. (Paris Observatory)	CO observations of powerful radio galaxies.
O-38	Odenwald, S. (NRL) Schwartz, P. (NRL)	Observations of CO outflows in the Cygnus-X region.
P-141	Petuchowski, S. (Goddard) Bennett, C. (Goddard)	Study of vibrationally-excited H_2O.
S-318	Schombert, J. (Caltech) Bothun, G. (Michigan) Mundy, L. (Caltech)	Study of CO emission in low surface brightness galaxies.
S-319	Sage, L. (NMIMT)	Study of CO and active star formation in early-type galaxies.

No.	Observer(s)	Programs
T-244	Turner, B. Bally, J. (Bell Labs) Feldman, P. (Herzberg) Amano, T. (Herzberg)	A search for interstellar $HOCS^+$.
T-245	Turner, B. Bally, J. (Bell Labs) Guelin, M. (IRAM, France) Cernicharo, J. (IRAM, France)	Confirmation of HCP in IRC 10216.
V-66	Vallee, J. (Grenoble) Avery, L. (Herzberg)	Study of nearby bipolar outflow in MBM55 at 175 pc, one of the nearest molecular clouds.
V-67	Van Buren, D. (Johns Hopkins) Terebey, S. (Caltech)	CO mapping of cloud cores possibly associated with propagating star formation.
W-239	Walker, C. (Arizona) Lada, C. (Arizona) Young, E. (Arizona)	A proposal to map CS J=2-1 emission around cold IRAS sources that possess dust cores.
W-242	Wilson, C. (Caltech) Scoville, N. (Caltech)	Detailed star formation studies in M33 and M101.
W-244	Wootten, H. A. Wlodarczak, G. (Lille, France) Combes, F. (Meudon) Encrenaz, T. (Meudon) Gerin, M. (Meudon)	Search for acetic acid in the interstellar medium.
W-251	Wright, M. (Berkeley) Meixner, M. (Berkeley) Blitz, L. (Maryland)	Study of CO in Seyfert galaxies.
Y-5	Yusef-Zadeh, F. (Goddard) Hollis, J. M. (Goddard) Bally, J. (Bell Labs)	High resolution CO observations of a galactic center cloud.
Z-64	Ziurys, L. (Massachusetts) Blake, G. (Berkeley)	Confirmation of detection of interstellar vibrationally-excited HCO^+.
Z-66	Ziurys, L. (Massachusetts) Claussen, M. (NRL)	A study of vibrational excitation in HCN.
Z-67	Ziurys, L. (Massachusetts) Hovde, D. (Berkeley) Saykally, R. (Berkeley)	A search for interstellar SH^+.

No.	Observer(s)	Programs
Z-69	Zhou, S. (Texas) Evans, N. (Texas) Mundy, L. (Caltech)	A study of high mass star forming regions.

E. VLA OBSERVING PROGRAMS

Second quarter 1988 was spent in the following configurations:

CD configuration from April 1 to June 30
D configuration from June 30

and the following research programs were conducted.

No.	Observer(s)	Programs
AA-82	Allen, R. (Illinois) Sukumar, S. (Illinois)	The thin and thick radio continuum disks of NGC 891. 90 cm.
AA-85	Alexander, P. (MRAO) Pooley, G. (MRAO) Sopp, H. (MRAO) Wynn-Williams, G. (Hawaii) Green, D. (DRAO)	The dynamics of atomic and molecular gas in interacting galaxies. 20 cm line.
AA-86	Arnal, E. (Ins. Argentino Radio) Dubner, G. (IAFE, Argentina) Braun, R. Goss, W. M.	HI observations of the SNR Puppis A. 20 cm line.
AB-408	Bookbinder, J. (Colorado) Caillault, J. (Georgia) Gary, D. (Caltech) Giampapa, M. (NOAO) Golub, L. (SAO) Linsky, J. (Colorado) Gibson, D. (Lincoln Labs)	A first epoch, volume-limited survey of M dwarf stars. 1.3, 2, 6, and 20 cm.
AB-414	Becker, R. (Calif., Davis) White, R. (STScI)	Monitoring radio flux of HD 193793 P Cygni. 2 and 6 cm.
AB-456	Burke, B. (MIT) Hewitt, J. (Haystack) Roberts, D. (Brandeis)	Time variation of 0957+561 A,B. 6 cm.

No.	Observer(s)	Programs
AB-458	Branduardi-Raymont, G. (Univ. College London) Mason, K. (Mullard Lab)	Radio flux measurements of soft X-ray-selected active galactic nuclei in the field of the Coma cluster. 6 cm.
AB-462	Bandiera, R. (Arcetri) Brinks, E. (RGO)	The optical knots in Kepler's SNR. 2 cm.
AB-468	Bookbinder, J. (Colorado) Bastian, T. Holman, G. (Goddard) Gary, D. (Caltech)	Spectral mapping of solar active region loops. 6 cm.
AB-469	Brown, A. (Colorado) Reimers, D. (InsTheoPhyStern)	Simultaneous radio and ultraviolet variability study of the 4 Draconis system. 6 cm.
AB-471	Bagchi, J. (TIFR) Kapahi, V. (TIFR) Joshi, M. (TIFR)	Survey of a complete sample of distant Abell clusters of BM I classifications. 20 cm.
AB-472	Barsony, M. (Caltech)	HI imaging of molecular outflow sources. 21 cm line.
AB-476	Birkinshaw, M. (Harvard) Davies, R. (NOAO)	Study of the morphologies of bright elliptical galaxies. 6 cm.
AB-482	Bookbinder, J. (Colorado) Linsky, J. (Colorado)	Search for radio emission from K dwarfs. 6 cm.
AB-483	Bookbinder, J. (Colorado) Brown, A. (Colorado) Walter, F. (Colorado)	Study of main sequence evolution via mass loss. 6 cm.
AB-485	Brosch, N. (Wise Obs) Gondhalekar, P. (Rutherford Lab)	Late-type dwarf galaxies in the Virgo cluster. 20 cm line.
AB-486	Bertola, F. (Padova, Italy) Huchtmeier, W. (MPIR, Bonn) Zeilinger, W. (Wien, Austria)	HI mapping of AM 2209-251. 20 cm line.
AB-488	Brissenden, R. (Mt. Stromlo) Bicknell, G. (Mt. Stromlo) Tuohy, I. (Mt. Stromlo) Remillard, R. (MIT)	X-ray selected AGN. 6 and 20 cm.
AB-492	Bloemen, J. (Leiden) Duric, N. (New Mexico)	Spectral index study of 4 edge-on galaxies. 6 cm.

No.	Observer(s)	Programs
AB-494	Bastian, T. Drake, S. (SASC Tech) Bookbinder, J. (Colorado)	Synoptic observations of FF Aquarii. 2, 3.6, 6 and 20 cm.
AB-496	Bastian, T. Cornwell, T. Dulk, G. (Colorado)	High resolution imaging of the Sun: an application of mosaicing. 20 cm.
AB-497	Bastian, T. Bookbinder, J. (Colorado) Linsky, J. (Colorado) Merryfield, W. (Colorado)	Radio and ultraviolet observations of AE Aquarii. 1.3, 2, 3.6 and 6 cm.
AB-498	Braun, R. Hester, J. (Caltech) Cox, D. (Wisconsin) Raymond, J. (CFA)	Direct measurement of magnetic field strength and relativistic ion fractions in SNRs. 4 cm.
AB-500	Bajaja, E. (MIPR, Bonn) Hummel, E. (NRAL)	The large- and small-scale HI structure in NGC 4321. 20 cm line.
AC-207	Cornwell, T. Yusef-Zadeh, F. (Goddard)	A unique HH object. 2 and 6 cm.
AC-216	Campbell, B. (New Mexico) Asbell, J. (New Mexico)	Search for radio emission from new, young stellar objects. 6 cm.
AC-220	Crampton, D. (DAO) Gower, A. (Victoria) Cowley, A. (Arizona)	Survey of an optical cluster of quasars. 20 cm.
AC-221	Carignan, C. (Montreal) Puche, D. (Montreal)	HI studies of the Sculptor group galaxies. NGC 55 and NGC 300. 20 cm line.
AC-222	Caillault, J. (Georgia) Drake, S. (SASC Tech)	Full-phase coverage of BY Dra. 6 cm.
AC-223	Cordova, F. (LANL) Hjellming, R. Mason, K. (Mullard Lab) Middleditch, J. (LANL)	A possible "Ghost" SNR and filiments associated with PSR 0656+14 and the Gem-Mon SN remnant. 6 and 21 cm line.
AC-224	Caillault, J. (Georgia) Patterson, J. (Columbia) Skillman, D. (Goddard)	Radio light curve of V471 Tauri. 6 and 20 cm.

No.	Observer(s)	Programs
AC-226	Carilli, C. van Gorkom, J. (Columbia) Stocke, J. (Colorado)	HI imaging of quasar galaxy pairs. 20 cm line.
AC-227	Casertano, S. (Groningen) van Gorkom, J. (Columbia)	Late-type disk galaxies with extended HI envelopes. 20 cm line.
AC-232	Cordova, F. (LANL) Hjellming, R.	Coordinated, multi-wavelength campaign on Cygnus X-2 from X-ray to radio. 2, 3.6, 6, and 20 cm.
AD-188	Drake, S. (SASC Tech) Simon, T. (Hawaii) Florkowski, D. (USNO) Stencel, R. (Colorado) Bookbinder, J. (Colorado) Linsky, J. (Colorado)	Variability of emission in supergiants Alpha Ori. 2 and 6 cm.
AD-215	de Jong, T. (Amsterdam) van den Broek, A. (Amsterdam) van Driel, W. (Amsterdam)	Southern extreme IRAS galaxies. 6 cm.
AD-216	Dickel, H. (Illinois) Goss, W. M.	Mapping of H_2CO absorption and H76α emission towards component A in NGC 6334. 2 cm line.
AD-218	Dahlem, M. (Univ., Bonn) Klein, U. (Univ., Bonn) Mebold, U. (Univ.. Bonn) Wielebinski, R. (MPIR, Bonn) Dettmar, R. (Univ., Bonn)	Linear polarization and HI observations of peculiar filaments in NGC 1808. 20 cm line.
AD-219	Dewdney, P. (DRAO) McCutcheon, W. (British Columbia) Purton, C. (DRAO)	Early stages of star formation (cool IR/strong CO sources). 6 cm.
AD-220	Dubner, G. (IAFE, Argentina) Arnal, E. (Inst. Argentino Radio) Winkler, F. (Middlebury Coll.) Goss, W. M.	The SNR Puppis A. 20 cm.
AE-28	Escalante, V. (Harvard) Ho, P. (Harvard) Haschick, A. (Haystack) Rodriguez, L. (CFA)	Accurate positions of H2O masers associated with young objects. 1.3 cm line.

No.	Observer(s)	Programs
AE-55	Ekers, R. (AT) Cowan, J. (CFA) Sramek, R. Goss, W. M. Roberts, D. (Oklahoma)	Observations of the young SNR G25.52+0.22. 2 cm.
AG-145	Geldzahler, B. (NRL) Schwartz, P. (NRL) Gear, W. (Royal Obs.) Ade, P. (Queen Mary College) Robson, E. (Lancashire Polytech) Nolt, I. (Oregon) Smith, M. (Royal Observatory)	Simultaneous multifrequency observations of blazars. 1.3, 2, 6, 20 and 90 cm.
AG-259	Goss, W. M. Anantharamaiah, K.	Recombination lines from the external galaxy NGC 253. 6 and 20 cm.
AG-260	Guhathakurta, P. (Princeton) Kim, D. (UCLA) Jura, M. (UCLA) van Gorkom, J. (Princeton) Knapp, G. (Princeton)	HI in the interacting elliptical galaxy NGC 5018. 20 cm line.
AG-261	Green, D. (DRAO)	IR selected candidate new galactic SNRs. 6 cm.
AG-262	Ge, J. (NMIMT) Owen, F.	High Faraday rotation in cooling flow clusters. 3.6 cm.
AG-264	Gavazzi, G. (IFC) Dickey, J. (Minnesota)	Disruption of spiral disks in the cluster A1367. 20 cm line.
AH-265	Hollis, J. M. (Goddard) Yusef-Zadeh, F. (Goddard)	Imaging of M20 and M8. 6 and 20 cm.
AH-269	Hester, J. (Caltech) Braun, R. Cox, D. (Wisconsin) Raymond, J. (CFA)	Relativistically supported recombination regions in the Cygnus Loop. 6 cm.
AH-276	Hanisch, R. (STScI) Batuski, D. (STScI) Burns, J. (New Mexico)	Head-tail radio sources in poor clusters of galaxies. 6 and 20 cm.
AH-292	Hughes, V. (Queen's Univ.) MacLeod, G. (Queen's Univ.)	Star formation in very dense regions. 6 and 20 cm.

No.	Observer(s)	Programs
AH-295	Habing, H. (Leiden) Goss, W. M. Winnberg, A. (Onsala) van Langevelde, H. (Leiden)	Monitoring galactic center OH/IR stars. 18 cm line.
AH-299	Helfand, D. (Columbia) Becker, R. (Calif., Davis)	Survey of the Galactic Plane. 90 cm.
AH-300	Helfand, D. (Columbia) Hamilton, T. (SAO)	In search of the origin of the X-ray background. 6 cm.
AH-301	Hjellming, R. Gehrz, R. (Minnesota) Taylor, A. (Calgary) Seaquist, E. (Toronto)	Systematic observations of two new radio novae. 1.3, 2, 3.6, 6 and 20 cm.
AH-305	Ho, P. (Harvard) Szczepanski, J. (MIT) Pyne, E. (Harvard) Jackson, J. (Berkeley) Armstrong, J. (Cologne)	NH_3 condensations in the neutral ring around the galactic center. 1.3 cm line.
AH-306	Higgs, L. (DRAO) Landecker, T. (DRAO) Wendker, H. (Hamburger Sternwarte)	Sources in Cygnus-X. 20 cm.
AH-312	Hogg, D.	The HI distribution in Wolf-Rayet galaxy He2-10. 20 cm line.
AH-313	Hummel, E. (NRAL) van der Hulst, J. (NFRA)	The B-field structure in the interacting systems NGC 2207/IC2163 and NGC 4038/39. 20 cm.
AH-316	Hjellming, R. Han, X. Johnston, K. (NRL)	Phase dependence of radio spectra of X-ray binaries. 1.3, 2, 3.6, 6, 18, and 20 cm.
AH-318	Higdon, J. (Texas)	Neutral hydrogen observations of the Cartwheel Ring galaxy. 20 cm line.
AI-34	Irwin, J. (Toronto) Seaquist, E. (Toronto)	NGC 4388 and NGC 5775. 20 cm.
AI-35	Inoue, M. (Nobeyama) Perley, R. Carilli, C. Kato, T. (Utsunomiya Univ.) Tabara, H. (Utsunomiya Univ.) Aizu, K. (Rikkyo Univ.)	Large Faraday rotation source Hyd A. 2 and 6 cm.

No.	Observer(s)	Programs
AJ-160	Joshi, M. (TIFR) Bagchi, J. (TIFR) Kapahi, V. (TIFR)	Spectral index mapping of very steep spectrum sources in clusters. 20 cm.
AK-172	Kristian, J. (Mt. Wilson) Windhorst, R. (Mt. Wilson) Fomalont, E. Kellermann, K.	Deep survey in a Space Telescope/ WFPC ultradeep survey area. 6 cm.
AK-193	Kim, K. (Toronto) Kronberg, P. (Toronto)	Polarization observation of S 147 background sources. 6, 18, 20, 21, and 22 cm.
AK-200	Keto, E. (LLNL) Carral, P. (Berkeley) Welch, W. (Berkeley) Reid, M. (CFA) Ho, P. (Harvard)	Structure of recombination line emission in ultracompact HII regions 1.3 cm line.
AK-201	Krause, M. (MPIR, Bonn) Beck, R. (MPIR, Bonn) Hummel, E. (NRAL)	ASS and BSS magnetic field structures of IC 342 and M81. 20 cm.
AL-156	Lind, K. van Breugel, W. (Berkeley)	Further observations of an edge-brightened jet in PKS 0623-206. 6 cm.
AL-166	Loushin, R. (Illinois) Crutcher, R. (Illinois) Troland, T. (Kentucky)	OH observations toward S106. 18 cm line.
AL-169	Liszt, H. Greisen, E. Braun, R.	HI absorption toward W43. 20 cm line.
AL-171	Lang, K. (Meudon/Tufts) Willson, R. (Tufts) Trottet, G. (Meudon)	Simultaneous VLA-Nancay radio-heliographic observations of the sun. 90 cm.
AL-172	Lasenby, A. (Cambridge) Howarth, N. (Cambridge)	Nine edge-on spiral galaxies. 90 cm.
AL-174	Lawrence, C. (Caltech) Davies, R. (Manchester) Lasenby, A. (Cambridge) Myers, S. (Caltech) Readhead, A. (Caltech)	Observations of MWB fields. 6 and 20 cm.

No.	Observer(s)	Programs
AL-176	Langston, G. (MPIR, Bonn)	Ring source at 30 degrees galactic latitude. 2, 6 and 20 cm.
AL-177	Langston, G. (MPIR, Bonn) Burke, B. (MIT) Conners, S. (MIT) Heflin, M. (MIT) Lehar, J. (MIT)	Highly variable radio sources detected in the MG 5 GHz survey. 6 cm.
AL-178	LaViolette, P. (Starburst Found.)	Radio investigation of the compact feature near SW tip of CTB 80. 6 and 20 cm.
AM-233	Muhleman, D. (Caltech) Grossman, A. (Caltech) Goldstein, R. (JPL)	Radar echos from Saturn's rings. 3.5 cm line.
AM-236	MacKenty, J. (STScI) Burg, R. (STScI) Griffiths, R. (STScI)	Starburst and extragalactic HII region galaxies. 6 cm.
AM-237	Montmerle, T. (CEN Saclay) Feigelson, E. (Penn State) Andre, P. (IRAM, Granada)	Embedded infrared sources in the Rho Ophiuchi cloud core. 6 cm.
AO-81	Odenwald, S. (NRL)	Unusual filaments in FIR-21: a galactic center HII region? 1.3, 2 and 6 cm.
AO-82	O'Dea, C. (NFRA) Ge, J-P. (NMIMT) Owen, F.	Distance class 4 Abell clusters. 20 cm.
AP-158	Pooley, G. (MRAO) Riley, J. (MRAO) Liu, R. (MRAO)	Spectral ages of luminous radio sources. 2 and 6 cm.
AP-159	Penninx, W. (MIT) Lewin, W. (MIT) Mitsuda, K. (ISAS, Tokyo) van Paradijs, J. (Amsterdam) Zijlstra, A. (Groningen)	Simultaneous radio and X-ray observations of the low-mass X-ray binary GX 17+2. 6 and 20 cm.
AP-160	Pedlar, A. (NRAL) Yates, G. (NRAL) Saikia, D. (NRAL) Unger, S. (RGO) Axon, D. (NRAL)	Neutral hydrogen in NGC 3227 and NGC 3226. 20 cm line.

No.	Observer(s)	Programs
AR-164	Rodriguez, L. (CFA) Gomez, Y. (CFA) Garcia-Barreto, J. (UNAM) Garay, G. (Chile) Moran, J. (CFA)	Density distance of NGC 6302. 6 cm line.
AR-166	Roeser, H.-J. (MPIA, Heidelberg) Perley, R. Meisenheimer, K. (MPIA, Heidelberg)	Hotspots, jet and lobes of Pictor A. 90 cm.
AR-167	Roeser, H. (MPIA, Heidelberg) Perley, R. Hiltner, P. (MPIA, Heidelberg) Meisenheimer, K. (MPIA. Heidelberg)	Hotspots in classical double radio sources. 2, 6 and 20 cm.
AR-173	Richards, P. (Appleton Lab) Heaton, B. (Univ. Kent)	Ionized gas in compact molecular clouds. 6 cm.
AR-177	Rengarajan, T. (TIFR) Iyengar, K. (TIFR)	Search for continuum emission from unassociated IRAS sources with HII region like colors. 6 and 20 cm.
AR-179	Richter, O. (STScI) van Gorkom, J. (Princeton) Ferguson, H. (Johns Hopkins)	HI survey of the Hydra I cluster of galaxies. 20 cm line.
AR-180	Rudnick, L. (Minnesota) Anderson, M. (Minnesota)	Large scale shock structures driven by the jets of SS 433. 20 and 90 cm.
AR-181	Riley, J. (MRAO) Warner, P. (MRAO)	Radio structure of 4C 74.26 - the largest known quasar. 20 and 90 cm.
AR-184	Roelfsema, P. Seaquist, E. (Toronto)	Recombination line observations of M82. 3.5 and 6 cm line.
AR-185	Roelfsema, P. Goss, W. M.	H, He and C 92 alpha observations of W3. 3.5 cm line.
AS-211	Sramek, R. Weiler, K. (NRL) van der Hulst, J. (NFRA) Panagia, N. (STScI)	Statistical properties of radio supernovae. 2, 6 and 20 cm.
AS-324	Schmahl, E. (Maryland) Kundu, M. (Maryland) Nitta, N. (Maryland)	Quiet sun fine structure variability. 2, 6 and 20 cm.

No.	Observer(s)	Programs
AS-326	Sukumar, S. (Illinois) Allen, R. (Illinois)	NGC 4565. 20 and 90 cm.
AS-327	Stewart, R. (CSIRO) Slee, O. (CSIRO) Dulk, G. (Colorado) McKean, M. (Colorado) Bastian, T. Large, M. (Sydney) Robinson, R. (Anglo-Aust. Obs)	Spectra of active southern stars. 2, 6, 18, 20 and 90 cm.
AS-329	Subrahmanyan, R. (TIFR) Gopal-Krishna (TIFR) Swarup, G. (TIFR)	Orion A and Orion B. 90 cm.
AS-331	Sahai, R. (Chalmers) Claussen, M. (NRL)	The enigmatic source in IRC+10216: spectrum and variations. 1.3, 2, and 3.5 cm.
AS-333	Sramek, R. Weiler, K. (NRL) van der Hulst, J. (NFRA) Panagia, N. (STScI)	Statistical properties of radio supernovae. 2, 6 and 20 cm.
AS-335	Stanford, A. (Wisconsin) Wood, D. (Wisconsin) Code, A. (Wisconsin)	Spatial and kinematic distribution of HI in colliding galaxies. 20 cm line.
AT-94	Taylor, A. (Calgary) Seaquist, E. (Toronto) Kenyon, S. (CFA)	The symbiotic stars Z And and CH Cyg. 6 and 20 cm.
AU-34	Uson, J. Bagri, D.	Search for redshifted emission from Zel'dovich pancakes. 90 cm line.
AV-153	van Breugel, W. (Berkeley) McCarthy, P. (Berkeley) Spinrad, H. (Berkeley)	High redshift radio galaxies with extended optical line emission. 2 and 6 cm.
AV-156	Vader, J. (Yale) Frogel, J. (NOAO)	Dust-embedded AGN in unusually warm IRAS galaxies. 6 and 20 cm.
AW-196	Wicklind, T. (Onsala) Henkel, C. (MPIR, Bonn)	HI in the early type galaxy NGC 404. 20 cm.
AW-211	Williams, B. (Delaware) van Gorkom, J. (Columbia)	HI synthesis of three compact groups of galaxies. 20 cm line.

No.	Observer(s)	Programs
AW-213	Wootten, H. A. Mangum, J. (Virginia)	Study of the pre-stellar condensations in Rho Ophiuchi. 1.3 cm line.
AW-214	Wootten, H. A. Butner, H. (Texas) Loren, R. (Texas)	Structure of a dense star-forming core. 2 cm line.
AW-215	Wootten, H. A. Mundy, L. (Caltech) Wilking, B. (Missouri)	The star-forming center of a proto-stellar disk. 1.3 cm line.
AW-216	Westpfahl, D. (DAO)	HI observations of NGC 5364. 20 cm line.
AW-218	Walter, F. (Colorado) Brown, A. (Colorado) Gibson, D. (Lincoln Labs) Stern, R. (Lockheed)	Simultaneous VLA-GINGA-IUE monitoring of the corona of Sigma 2 CrB. 2, 3.5, 6, and 20 cm.
AY-23	Yusef-Zadeh, F. (Goddard) Bally, J. (Bell Labs)	G359.54+0.18 and Sgr C. 2, 6, and 20 cm.
AZ-31	Zhao, J. (New Mexico) Burns, J. (New Mexico) Owen, F.	Turbulent radio jets in cluster galaxies. 6 and 20 cm.
AZ-35	Zheng, X. (Nanjing Obs.) Reid, M. (CFA) Birkinshaw, M. (Harvard) Ho, P. (Harvard)	Low frequency characteristics of NGC 6251. 90 cm line.
AZ-36	Zijlstra, A. (Kapteyn Lab) Pottasch, S. (Kapteyn Lab) Bignell, R. C.	A rapidly cooling proto-planetary nebula. 1.3, 2, 18 and 20 cm line.

F. SCIENTIFIC HIGHLIGHTS

Neutral Hydrogen with Early-Type Galaxies

The gas content of galaxies increases with type, from early to late. Neutral hydrogen, HI, is an excellent tracer of this gas. Heretofore, attempts to detect HI from SO galaxies have been largely unsuccessful. Now, however, the sensitivity of the 300-ft telescope has been improved to the point where the small amounts of gas present in these SO's can be detected in a recent survey, for example, HI was detected in 50 percent of the 32 SO galaxies searched. As a result, quantitative information exists about the percentage of a galaxy's mass that is gas rather than just upper limits for the earliest galaxy types.

Rule-of-thumb detection rates for galaxies in the Revised Shapley-Ames Catalog using the 300-ft telescope as a "redshift machine" are: 100 percent for Sb's, Sc's and Irr's, 75 percent for Sa's; and 50 percent for SO's.

Investigators: O-G. Richter (STScI), W. K. Huchtmeier (MPIfR)

An Extremely High Velocity Bipolar Outflow

Water maser emission over an exceptionally wide range of velocities has been detected from the cold, stellar, infrared source IRAS 16342-3814. The H_2O emission appears as two distinct features separated by 259 km s^{-1}. For comparison, the next most widely spread H_2O maser emission from a stellar object is 115 km s^{-1}. Several lines of evidence suggest that 16342-3814 is an evolved star that has undergone considerable mass loss. Much of the material lost has been channeled into a bipolar outflow, which must be being viewed almost end on. The star's significance is its high-velocity gas streams, higher than can be accounted for by the stellar wind from a red giant star.

The maser emission is being monitored with the 140-ft telescope to see if, as initial measurements suggest, the features of the H_2O separations grow with time.

L. Likkel (UCLA), M. Morris (UCLA)

DDO 154: A "Dark" Galaxy?

The neutral hydrogen distribution of the gas-rich dwarf irregular galaxy DDO 154 has been investigated with the VLA. DDO 154 was targeted for study on the basis of the very large extent of its HI component, previously known from low resolution, single-dish observations. The rotation curve has been determined unambiguously out to 4 optical radii from the center to a point where the flat portion of the curve is reached. In terms of optical scale lengths, it is one of the longest rotation curves ever measured and provides excellent constraints on the galaxy mass model. At its outermost point (7.6 kpc), 90 percent of the mass of the galaxy is non-visible. Overall the luminous matter (stars and gas) is only a minor component of the total galaxy mass.

Investigators: C. Carignan (Montreal); K. C. Freeman (ANU)

ASM 2080+25

The VLA was used to detect a radio counterpart to the soft X-ray nova discovered with the Ginga X-ray satellite. The VLA search was guided by previous successful observations of the X-ray novae A0620-00 = V616 Mon and Cen X-4 = V822 Cen. Radio images at 1.49 GHz, made from data taken on May 3 and 26, show that a radio source with a strength of 4.4 ± 0.5 mJy appeared in the May 26 image where there was none in the May 3 image (upper limit of 0.5 mJy). Within the 5 arcsecond error box the source position agrees with the position of the X-ray and optical candidates.

Investigators: R. M. Hjellming (NRAO), T. A. Calovini (NMIMT), F. A. Cordova (LANL)

G. PUBLICATIONS

Attached as Appendix A is a tabulation of all preprints received in the NRAO Charlottesville library authored by NRAO staff members or based on observations obtained on NRAO telescopes during the reporting period.

H. CHARLOTTESVILLE ELECTRONICS

Neptune/Voyager Project

The final receiver was delivered to the VLA January 1988. The maintenance of these receivers is being transferred from the CDL to the VLA site. Remaining work includes supplying spare parts and assistance with specialized test equipment for these receivers.

Cooled HEMT Amplifier Development

The upgrade of L-band GASFET amplifiers is going slowly because of manpower limitations and a shortage of good HEMT devices. We expect to get good devices shortly from Mitsubishi.

Production of 8 GHz amplifiers has been restarted to build spare units for the Neptune/Voyager project and also the VLBA project.

Another nine 23 GHz amplifiers built this quarter bring the total to 51 for the VLA and VLBA projects.

The 43 GHz amplifier work has continued slowly again because of manpower limitations. The cryogenic test set has been almost completed this quarter, and a tunable test fixture which facilitates amplifier design has been completed and tested. A second GE HEMT has been incorporated in a one-stage amplifier and gives 7 dB gain at 43 GHz. Work will proceed with tests of additional HEMT devices, including measurements of noise at cryogenic temperatures.

Superconducting (SIS) Millimeter-Wave Mixer Development

Our millimeter wave research collaboration with IBM Watson Research Center continues. A new set of SIS mixers for 115 and 230 GHz have been designed for fabrication by IBM using their $Nb/Nb_2O_5/Pb$-In-Au edge-junction process. Using junctions of this kind, we have obtained mixer noise temperatures less than 6 K DSB in the 85-116 GHz range. Two of these mixers are now operating on the 12-m telescope at Kitt Peak. Because of its high input loss, the noise temperature of the telescope receiver is relatively high: 74 K to 138 K SSB in the better channel, and about 20 K higher in the other channel. We supplied one of these mixers to the Harvard/Smithsonian Sky Survey Telescope which now has an overall receiver noise temperature of 34 K in DSB operation and 52 K when tuned for SSB operation.

We have received an initial batch of mixer junctions from Hypres. Included on this wafer are 115 GHz and 230 GHz mixers with inductive tuning elements, and

some experimental, fully integrated mixers which will require no external tuners. These were fabricated using their Nb/Al-Al_2O_3/Nb trilayer process under a no-cost collaborative agreement. The seven masks for this process were laid out using UVA mask design facilities. Due to difficulties with their fabrication process, most of the mixers on the present wafer are either short-circuits or of poor quality, but Hypres is working on another batch.

The Nb/Al-Al_2O_3/Nb trilayer process for fabricating superconducting circuits appears to be the best available for millimeter-wave SIS mixers. This process is being implemented at UVA as part of a collaborative effort with NRAO to develop better SIS mixers. We expect the UVA collaboration to give us the responsive source of SIS junctions we need to develop mixers for other frequency bands and to explore quasi-optical mixers--e.g., the Phillips planar-spiral mixer--without the great cost and delays of using a commercial source of junctions. The UVA process is producing excellent trilayer material, as is evident from the I-V characteristics of test junctions. However, relatively minor difficulties in the five lithography steps have delayed the production of useful mixer junctions.

Schottky Diode Millimeter-Wave Mixer Development

In support of the 12-m telescope this quarter, we have re-built and tested a total of 16 Schottky mixers in the 230, 300, and 345 GHz bands.

We have now stopped all development of new Schottky diode mixers, and will continue Schottky work only as needed to service receivers for the 12-m telescope and site-testing atmospheric receivers.

I. GREEN BANK ELECTRONICS

300-ft Telescope Spectral Processor

The Spectral Processor project continues. The eleven FFT boards needed for the first phase of the assembly work have all been built, tested, and debugged. The FFT controller, the IF converter controller, and the data capture boards were all completed and tested this quarter. The design of the Accumulator boards is now complete and the boards are under test. An iteration of the memory board design used in the Accumulator will be necessary in order to add some needed functions. A paper design of the circuitry required to interface between the rack controller PC and the hardware control bus was completed, and construction will soon begin.

Wiring of the rack backplanes was completed to the level needed for the upcoming system tests. AC filters and limit protection circuitry was completed and installed in the racks.

Work on the IF/Video converters continued. Adjustment of the SSB network was attempted in order to improve the rejection over the values reported last quarter, but without much success. It has been decided to freeze this design for the moment so that a working prototype of the entire IF chassis can be completed. Integration of the various IF modules into a chassis has begun, and should be ready in September when needed for system tests.

140-ft Cassegrain Receivers

The current 140-ft Cassegrain receiver systems use parametric upconverters and 18-25 GHz masers to cover the 5-25 GHz frequency range. A project is underway to replace the upconverters with HEMT amplifiers and to also extend the frequency range to greater than 30 GHz. The masers will be retained because of their significantly superior noise performance over current HEMT technology. Progress is limited because of the lack of research equipment funds, but a small amount has been used to purchase some needed microwave components to allow prototyping to proceed. It is expected that this fall antenna efficiency measurements at about 32 GHz will be made, using a room-temperature mixer receiver.

S/X Receivers

The USNO is funding the design and construction of new cryogenic receivers for the Green Bank three-element interferometer. The major design tasks under way are:

Receiver Design - All receivers will be dual polarization, dual frequency, prime-focus receivers operating at center frequencies of 2.3 and 8.4 GHz. Cooled HEMT amplifiers of existing designs will be utilized. The receiver will be controlled and monitored by digital signals transmitted over multimode fiber optic cables from the Interferometer control building. The dewar design is finished and the first unit construction is 80 percent complete. The receiver components have all been ordered and most have been received.

Feed Design - A coaxial feed design using a wide-flare horn with dual-depth corrugations and a dielectric cone X-band section has been adopted. The first-cut feed has been constructed and shows encouraging performance. The spill-over temperature of both bands is approximately 3 K, an important quality measure for feeds to be used with ultra-low-noise receivers. Work is under way to improve the cross-polarization performance and to match the T-junctions used to feed the S-band horn.

Control Computer - The 85-3 antenna will be operated as a VLBI antenna in conjunction with other USNO antennas. This necessitated a new control computer, interface, and control program. A fast AT class PC was selected as the control computer, and the control program is 80 percent complete. The antenna will be controlled over a serial bus (with optical fiber link). Inductosyns have been installed for position readouts, and the serial bus to motor interface is under construction. Much work was required because this antenna has been out of service for several years, but it is expected that the antenna will be under computer control by the end of July.

Data Link - The MKIII VLBI terminal located at the 140-ft telescope will be used with the 85-3 observations and a link will be installed between the two telescopes, sending single polarization, S-band and X-band IF signals. The IF signals will be frequency multiplexed onto a wideband, single-mode optical fiber. The fiber cable has been installed and the optical tranceivers have been ordered.

Miscellaneous

Ten 4.8 GHz cooled HEMT amplifiers were completed this quarter for VLA and VLBA receivers. Sundry HEMT devices were evaluated for possible cryogenic use, and a group of Mitsubishi devices were found acceptable.

Construction and testing was completed on the sixth 4.8 GHz VLBA front-end, and construction of two 1.5 GHz front-ends was taken to about 80 percent completion. Ten 2-16 GHz VLBA synthesizers scheduled for completion this year are under construction.

J. 12-M ELECTRONICS

Receiver Status

70-115 GHz Schottky Mixer Receiver - This dual-channel receiver remains unchanged since the last quarterly report. It is the only receiver available for the 70-90 GHz range. We hope to replace this receiver with an SIS within the next year.

200-350 GHz Schottky Mixer Receiver - This dual-channel receiver has been used over the full frequency range over the past high frequency observing season. The receiver performance over the 240-270 GHz range has been improved and no further changes will be made to the receiver. The efforts of the receiver group will be devoted to producing SIS receivers to cover the full operating band of the telescope.

Multi-feed 230 GHz Receiver - This 8-feed receiver is virtually completed and will be made available to observers when the hybrid spectrometer is completed. At that time 8 channels will be available with a 300 MHz bandwidth per channel.

Hybrid Spectrometer - Construction of the hybrid spectrometer is virtually complete. The remaining effort needed is mainly software. We are aiming at telescope tests in the fall.

K. VLA ELECTRONICS

Improvements in Antenna Pointing

Antenna pointing errors degrade the performance of synthesis telescopes at both low and high frequencies. At low frequencies strong background sources are randomly located in the primary beam and pointing errors then limit the achievable dynamic range. At high frequencies the pointing errors become a significant fraction of the primary beam width so the source being imaged is effected directly. For example, at 44 GHz a 20" pointing error causes a 30 percent change in amplitude.

Another pointing problem which will be addressed in the future is the occurrence of tilts of up to 20 arcseconds in the azimuth axis of a few antennas at certain azimuth angles. This effect is presumably caused by deformations or

perturbations in the azimuth bearings. This, and other problems such as an antenna tilt caused by constant wind force, could be corrected in the future by an active correction scheme utilizing electronic tilt-meters mounted on the antenna structure. Some preliminary tests have been completed. Testing of the stability of two redesigned tilt-meter units showed that the temperature control of the tiltmeter meter unit is now adequate.

75 MHz Array Development

The proposed array will provide a major, new observing capability by giving 20" resolution at a frequency where the current best resolutions are many arcminutes. This capability will enable useful observations of thousands of previously unresolved extragalactic, galactic, and solar system objects. Current capabilities at this frequency enable only total fluxes from the stronger objects, so the proposed array will be truly a ground-breaking instrument. In particular, the array will be especially useful in observing the extended steep-spectrum emission associated with extragalactic radio sources, galactic objects such as supernova remnants, and small-scale, time-variable emission from the Sun, Jupiter, and nearby stars.

The single, major obstacle to using such an array lies in the calibration of the data. It is felt that modern computers with self-calibration techniques provide the means to remove the strong phase perturbations introduced by the ionosphere. However, testing of these techniques at these low frequencies is required to better understand the type of algorithm needed. To do this, we wish to equip the current 25-m antennas with simple dipole-type feeds. If modest efficiency results (anything more than 15 percent will be adequate), we should be able to collect sufficient data from the 25-m antennas at this frequency for testing purposes. Note that if every 25-m antenna had such a feed, the entire 3C and 4C catalog could be mapped at 75 MHz with the same resolution as the original 1400 MHz aperture synthesis catalog done at Cambridge. The cost of this outfitting is very modest.

Two new dipole feeds have been designed; one a crossed dipole type, the other a quad dipole type. The crossed dipole was chosen as the easiest to implement. Testing of this feed and its effect on other frequencies will continue into next quarter. With the new feed installed near the focus of the antenna, locally generated radio frequency interference became a significant problem (see RFI Improvements). Four antennas are equipped with the 75 MHz system. NRAO has an agreement with NRL for further outfitting. The first level of funding (for four more systems) has been received and components are being procured.

VLA 300 MHz Receiver

Observations of a large number of astronomical objects would benefit from a lower observing frequency than 1.35 GHz, the lowest frequency currently supported on the VLA. Some objects radiate more strongly at lower frequencies while others are so large that a larger field of view than the 30 arcminutes available at 1.35 GHz is needed.

The receiver will be designed so that observations in the range 300-350 MHz can be made with an instantaneous bandwidth of approximately 5 MHz. At this low

frequency, the VLA 25-m diameter antennas can only be used in prime focus mode. It is known that radio-frequency interference, both locally generated at the VLA and from external sources, will be a significant problem.

Twenty antennas now have 327 MHz receivers installed, and this system is undergoing test and evaluation. The final feed configurations have been determined. To reduce local RFI, RFI enclosures for the vertex mounted "B" racks have been installed on four antennas (see RFI Improvements). Components for the completion of this system are being procured.

VLA 8 GHz Receivers

Feeds and front-ends covering the frequency range 8.0-8.8 GHz will be installed on the VLA primarily to augment the NASA/JPL DSN reception of the Voyager signal from Neptune at 8415 MHz. Other scientific benefits include the provision of an additional frequency for measurements of continuous spectra and joint observations with the VLB array. The 8.4 GHz front-ends enabled the VLA to be used in a successful planetary radar experiment with the Goldstone transmitter. The NRAO Central Development Laboratory has developed this front-end which was using GaAs FET amplifiers. Improved HEMT (High Electron Mobility Transistor) amplifiers have been incorporated into these systems during this quarter.

All thirty 8.4 GHz front-ends have been received from the Central Development Laboratory in Charlottesville and nineteen have been installed on antennas. Interferometer and phased-up sum measurements with these antennas on Voyager II have been completed with the appropriate signal-to-noise ratio, and other test programs are continuing.

JPL has provided funding for this project, and antennas being overhauled will be outfitted with X-band feed towers. Installation of the remaining five X-band systems will continue through 1988.

RFI Improvements

The sensitivity of the 327 MHz and 75 MHz systems will be limited partly by radio-frequency interference locally generated at each antenna. Modifications to various modules to reduce this interference and increase the instantaneous useable bandwidth were investigated. A modification to allow the Monitor and Control system to free run eliminated the coherent RFI between antennas.

Four RFI enclosures for the vertex mounted "B" racks have been installed and tested. The remaining RFI enclosures have not been procured due to an increase in cost by a factor of two. These RFR enclosures eliminate the remaining locally generated interference at 327 MHz. There is still some locally generated RFI noticeable at 75 MHz. A method to reduce this interference is being investigated. No progress has been made during the quarter.

Water-Vapor Radiometers

The development of a system to measure the total precipitable water in a path through the atmosphere will serve three purposes. First, the radiometer developed in this project can be used as a prototype of the device which is

required at each VLBA station. Second, the radiometer can be used at the VLA to provide estimates of the extinction, giving corrections for observations at 1.3 cm and serving as a historical record of the quality of the VLA site. Finally, if a reliable system can be built at a sufficiently low cost, it would be attractive to add them to the VLA itself.

The device will consist of two radiometers; one operating at about 20.5 GHz, the other at about 31 GHz. The radiometers will probably be built around room temperature mixers, with system temperatures of approximately 600 K. The system will be mounted so that it can cover the full range of elevation, and probably the full range in azimuth as well. The concept is straightforward. The engineering effort will concentrate on the problem of achieving high gain stability at a reasonable cost.

The R.F. components for the water-vapor radiometers have been procured and are being assembled for testing. The project is manpower limited (no progress has been completed this quarter).

Receiver Upgrade

Many important ammonia line experiments, such as accretion disks, circumstellar material, distant star-forming complexes, and extragalactic ammonia, will benefit from the upgrade in K-band performance. The projected improvement at 24 GHz by a factor of 5-6 means a tremendous boost in speed and sensitivity. Experiments will be 20-30 times faster. Eight-hour experiments will then take only a little over 1/2 hour. Instead of one region per u-v track, 20-30 regions can be studied at once. This is a very significant step forward.

The extension of the frequency coverage to 25.1 GHz is of particular interest because of the (J,K) = (6,6) line of NH_3. Together with the (J,K) = (3,3) line at 23.9 GHz, this will offer a pair of transitions belonging to the ortho (K=3n) species of NH_3. Because of their different excitation and radiative lifetimes, the ortho and para species of NH_3 are independent of each other, and have been suggested to be representative of conditions at different ages for the molecular material. Hence those ortho lines are particularly important spectroscopic tools for understanding some of the underlying physics.

A new "A" Rack has been fabricated including a revised dewar layout. This new dewar assembly will contain a new 1.3 cm GaAs FET amplifier or HEMT amplifier presently under development at the Central Development Laboratory. This amplifier will reduce the system temperature to 150 K and increase the bandwidth above and below the current bandwidth of 22.0-24.0 GHz. Also, a 5 GHz GaAs FET being developed in the GB Electronics Division will be used to replace present 5 GHz paramps. The new "A" Rack has been installed on eighteen antennas.

1.3-1.7 GHz T_{sys} Improvements

HI imaging is the most important class of spectral line project at the VLA. The observation of HI in emission (either galactic or extragalactic) is almost always sensitivity limited, either because the HI has to be followed to the faint outermost regions of galaxies, or because more angular or frequency resolutions are desirable.

Currently, the VLA 18-21 cm wavelength feed has system temperatures of approximately 60 and 50 K. A significant fraction of this system temperature results from the need to locate all front-ends in the same cryogenic dewar. This results in longer input waveguide runs than would usually be required and prevents the polarization splitters from being cooled.

For example, using similar cryogenically cooled GaAs FET amplifiers as those used on the VLA, it is predicted that the fully optimized receivers on the VLBA will have system noise temperatures of 29 K at 18-21 cm.

Although some effects, such as subreflector diffraction, will prevent VLA noise temperatures from ever being quite as low as these VLBA values, it does seem worthwhile to investigate the possibility of replacing the VLA receivers with separate, optimized receivers. It is planned to use a VLBA front-end to test their performance for use on the VLA. Another worthwhile area of investigation would be a modification to the 18-21 cm feed to improve its spillover performance.

A VLBA front-end receiver dewar assembly has been received from the GB Electronics Division. This dewar assembly along with a VLBA polarizer was installed on VLA Antenna 23. Satisfactory testing of this receiver was completed during the past year. No further investigations are scheduled for 1988.

L. AIPS

During the quarter, we began work on the "code overhaul" in which the AIPS source code is being converted from its old standards to a strict ANSI Fortran 77 standard with certain specific additions. The additions, the use of a HOLLERITH data type and of INCLUDEd files, are all handled by a preprocessor so that the Fortran compilers will be presented only with strictly standard code. Programs to perform the bulk of the transformations have been written and run on the code. The remaining work, which must be done by hand, has been and will be time consuming, and we do not anticipate releasing the overhauled code until April 1989. At the advice of AUI's legal staff, the new AIPS will be protected by copyright and by requiring a license agreement with all recipients. The license will remain free of charge for academic research institutions.

In the meantime, we will issue releases of the old code with various bugs corrected as we find, and have the time to fix, them. New tasks (1) to create a data base with simulated data, (2) to collate slice files and write values to disk, and (3) to merge low and high resolution images by feathering in the Fourier plane were added to 15JUL88 AIPS during the quarter. Tasks FILLM, VLBIN, and BPASS received the bulk of the corrections made to this release. New versions of the mosaicing tasks and new related tasks to display sensitivity in, and to combine, mosaiced images were also added.

M. VERY LONG BASELINE ARRAY

Antennas and Site Preparation

The first VLBA subreflector, and its focus/rotation mount, were installed at Pie Town in mid April, allowing observation with seven receivers covering the 1.5, 2.3, 4.8, 8.4, 10.7, 15, and 23 GHz bands. Pie Town is now operational for the VLBI Network. It participated in the 6 and 18 cm segments of the May - June NUG run.

Preliminary single dish observations were made at Pie Town at nine frequency bands between 327 MHz and 23 GHz. The system temperatures and antenna efficiencies were in rough agreement with expected values. More careful evaluation was scheduled for the next quarter, including the obtaining of holographic images of the antenna surfaces.

The Kitt Peak station was scheduled to receive its subreflector, focus/rotation mount, remaining initial front ends and feeds, and data recording system in early fall. Cryogenic and electronic outfitting were underway at Los Alamos. At Fort Davis, antenna erection was almost complete.

Antenna erection was underway at North Liberty. The Brewster site is ready for the antenna contractor's erection crew. Antenna foundation and control building construction proceeded at Owens Valley. Pre-construction activities continued for the St. Croix, Mauna Kea, and Hancock, NH sites.

Electronics

During the first two weeks of April, most of the VLBA electronics group in Charlottesville moved from the Ivy Road building to the NRAO headquarters building on Edgemont Road. The move included all personnel and laboratories except for one front-end assembly lab. The purpose of the move was to reduce amount of rented space required at Ivy Road. Also during April, the phase-in of the construction of additional Data Acquisition Racks in Charlottesville started with racks serial numbers 5 and 6. All parts for these units are now on order. Construction of other electronics racks, modules and front ends for initial outfitting, through serial 7, is progressing on schedule. Some final design modifications on the 23 GHz front end, involving the additional frequency conversion required for this band, were continued.

Hydrogen maser frequency standards 5 and 6 were delivered on schedule by Sigma Tau Standards Corporation at the end of June. Evaluation of two of the masers at JPL's special facility in Pasadena is continuing. Results to date indicated that the units were performing within specifications. Testing should be completed before the end of the next quarter. The antenna at Pie Town was outfitted with receiving systems for the 1.5, 2.3, 4.8, 8.4, 10.7, 15, and 23 GHz bands. The 330 MHz and 610 MHz front ends were scheduled to be added after measurements on the subreflector positioning are completed.

Data Recording

The first Pie Town VLBA Recorder - VLA Mk III fringes were obtained on 1 June on the Haystack correlator. The recordings were made 17 May observing

3C 84 at 4.8 GHz. Debugging of the station computer's software controlling the VLBA recorder continued. This Data Acquisition System (DAS No. 1) was also utilized for Pie Town's participation in the May - June NUG run, in MK III compatibility mode.

Testing of the recently completed Formatter No. 2, together with Recorder No. 2 was initiated. Additional stability and cross playback error tests between the 1st DAS at Pie Town and the 2nd DAS at Haystack are scheduled. Preproduction Data Acquisition Racks (I.F. Processing) Nos. 3 and 4 at Haystack are almost complete and checkout has started. Most items for preproduction Recorder No. 3, and Playback Drives No. 1 and No. 2 were ordered.

Monitor and Control

During the second quarter of 1988 work continued on the station computer astronomical observing routines, with those corrections and rectifications dictated by actual use of the software for a NUG observing run. The VLBA tape recorder was used for the first time, in a Mk III compatible mode. This effort surfaced many details of driving the VLBA recorder, which are now being incorporated into the station computer software.

Firmware and software for the focus/rotation controller is essentially complete. A preliminary version of the device itself is installed at Pie Town. Modest changes are necessary for the final version of the mount.

The utility monitor interface was designed and the prototype installed at Pie Town. The Pie Town weather station was also installed, following some redesign necessitated by a change in the vendor for the dewpoint sensor, which we believe will result in a much more reliable and maintainable instrument for determining relative humidity.

Work continued on pointing analysis software. It is rapidly becoming reliable. Work resumed on the monitor data checker, which was previously present only in skeleton form. Work continued on a set of programs that will eventually serve to communicate between the VME station computers and the AOC MicroVax that will serve as the array controller.

A set of station monitor data handling programs were written. However, they cannot be fully tested until the networking facilities between the AOC's MicroVax and Pie Town's Motorola VME are available. Development by Motorola of the X.25 hardware-software product that provides our communication protocol interface to the MicroVAX was prolonged. A firm order was finally accepted by the manufacturer, and delivery is now expected in July.

The Kitt Peak and Los Alamos computer systems were installed at the sites. The CPUs for all site computer systems were in hand. The additional parts (the Monitor/Control coprocessor and additional memory) for the Fort Davis computer were purchased, but were loaned to Haystack Observatory for use in testing the interface to the VLBA tape recorder systems.

Correlator

In response to the Request for Proposals for final design, prototyping, and fabrication of the correlator "FX chip," four responsive proposals were received and evaluated. All were significantly above our budgetary cost estimates, primarily because the chip foreseen in the preliminary design encompassed too much logic to be accommodated in the target gate-array product, and forced standard-cell implementations into relatively large, low-yield die sizes. It appeared likely that a revision of the basic specification could nevertheless yield a chip at close to the originally estimated cost, with only a moderate reduction in correlator performance. The bidding process was suspended pending this revision.

The revised specification halves the on-chip memory. Through redesign of the FFT module it will still be possible to perform up to a 2048-point transform (1024-point spectral resolution) by extending the parallel-processing approach, previously used only for the 2048-point case, to the 1024-point transform as well. This requires some modest additional complication in the wiring of the FFT module. The only effect on correlator performance arises in the cross-multiplier/accumulator module, where the limited on-chip storage is used for short-term accumulation. Although the original correlator specifications will still be met, certain new limitations on the baseline/channel/resolution product will be imposed, particularly for polarized correlation.

Bids based on the revised FX-chip specification were opened on the last day of the quarter, and a preliminary inspection confirms that the revised specification has indeed resulted in bids close to, and in fact below, the original cost estimate.

The software system designer completed a graduated transition from his previous assignment within the Observatory to the Correlator Group, and the vacant programmer slot was filled with a new hire, bringing the correlator software team to full strength. Development of the detailed software design is now under way. Action was started on specifying the computer hardware which will support the software development environment and, eventually, the correlator control functions. A competitive procurement is now planned, and preliminary presentations and budgetary quotes were obtained from the three vendors believed to offer the most competitive products. During the quarter the Correlator Division also moved from Ivy Road to NRAO headquarters on Edgemont Road.

Data Processing

Most of the software needed for normal processing of astronomical data from the VLBA is already in routine use. Pending the availability of the VLBA Correlator and computers toward the end of the Project, software development continued at a modest level in the areas of:

1. The interface to the Correlator and monitor data base;
2. Calibration and editing of Correlator output;
3. Geometric analysis of the data -- astrometry and geodesy.

The calibration effort emphasis was on spectral line and atmospheric corrections. Significant further progress in geometric analysis awaited hiring of a suitable person, expected during the third quarter.

Array Operation Center

The building's exterior, driveways, and external lighting were essentially complete. Interior drywall, interior finishing, communications cabling, and HVAC finishing are current primary activities. The current estimate for occupancy is September 15.

N. PERSONNEL

New Hires

Horstkotte, J.	Sr. Scientific Programming Analyst	06/20/88
Biemesderfer, C.	Sr. Scientific Programmer	06/20/88

Terminations

Retallack, D.	Systems Scientist	04/15/88
Sheets, B.	Sr. Administrative Assistant	05/31/88
Arora, R.	Visiting Electronics Engineer I	06/14/88

Promotions

Braun, R.	to Systems Scientist	06/01/88
Morris, G.	to Senior Designer	06/01/88
Ferraro, R.	to Electronics Engineer II	07/01/88

Other

Van Gorkom, J.	return from Leave of Absence	06/09/88

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