NATIONAL RADIO ASTRONOMY OBSERVATORY

Quarterly Report

April 1, 1989 - June 30, 1989

TABLE OF CONTENTS

A. TELESCOPE USAGE

The NRAO telescopes have been scheduled for research and maintenance in the following manner during the second quarter of 1989.

	140-ft	12-m	VLA
Scheduled observing (hrs)	1699.00	1785.50	1603.8
Scheduled maintenance and equipment changes	151.25	95.00	237.4
Scheduled tests and calibrations	333.75	302.75	347.8
Time lost	79.75	65.97	89.8
Actual observing	1619.25	1719.53	1514.0

B. 140-FT OBSERVING PROGRAMS

The following continuum program was conducted during this quarter.

No.	Observers	Program
C-255	Condon, J. Broderick, J. (VPI & SU) Seielstad, G.	Sky survey at 4.85 GHz covering $-45° <= \delta <= +5°$.

The following line programs were conducted during this quarter.

No.	Observers	Program
H-262	Heiles, C. (Berkeley) Reach, W. (Berkeley) Koo, B. (Berkeley) Tamanaha, C. (Berkeley)	Hydrogen mapping of interstellar shells.
K-321	Kassim, N. (NRL) Magnani, L. (Arecibo) Anantharamaiah, K.	Survey near 220 MHz for hydrogen recombination lines in the inner galaxy.
K-322	Kerr, F. (Maryland) Henning, P. (Maryland)	Studies of galaxies behind the Milky Way identified by their HI features.
L-220	Lubowich, D. (Hofstra) Turner, B. Hobbs, L. (Yerkes)	Search at 803.5 MHz for ^{7}Li (lithium) in the Galactic Center.

No.	Observers	Program
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) Godfrey, P. (Monash) 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.
M-296	McCammon, D. (Wisconsin) Jahoda, K. (NASA) Snowden, S. (MPIR, Bonn) Lockman, F. J.	Search for HI "edges."
P-148	Pauls, T. (NRL) Fiedler, R. (NRL) Schwartz, P. (NRL)	HI absorption measurements of a possible high latitude SNR at G159.6-18.5.
T-246	Turner, B. Lanping, X. (Beijing) Rickard, L. J (NRL)	Observations at 18.1, 18.3, and 23.7 GHz of IRAS/Cirrus cores to obtain gas temperatures and chemical properties.
T-261	Turner, B.	Search at 17.6 GHz for C_4D in TMC-1.
W-252	Wootten, H. A.	Monitor at 22.135 GHz of H_2O in the ρOph Cloud.
W-257	Wootten, H. A. Langer, W. (Princeton) Glassgold, A. (NYU) Wilson, R. (Bell Labs)	Observations at 3.335 GHz of CH in diffuse clouds.
W-261	Wilson, T. (MPIR, Bonn) Bania, T. (Boston) Martin-Pintado, J. (IRAM)	Search at discrete wavelengths near 1.2 cm for hot NH_3 in the Galactic Center.
W-262	Wootten, H. A. Mangum, J. (Virginia)	Search at 14.7 GHz for c-C_3H in the interstellar medium.

The following pulsar programs were conducted during this quarter.

No.	Observers	Program
B-484	Backer, D. (Berkeley) Foster, R. (Berkeley) Taylor, J. (Princeton)	Timing observations at 1330 MHz of PSR 1821-24 and other millisecond pulsars.
T-265	Taylor, J. (Princeton) Stinebring, D. (Princeton) Dewey, R. (JPL) Nice, D. (Princeton) Thorsett, S. (Princeton)	Pulsar timing observations over the range 110-250, 390-500, and 1300-1400 MHz.

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

A - Arecibo 1000 ft	Mb - Itapetinga 20 m
B - Effelsburg, MPIR 100	N - NRL Maryland Pt. 85 ft
E - Hartebeesthoek 26 m	O - Owens Valley 130 ft
F - Fort Davis 85 ft	Pt- Pietown 25 m
G - Green Bank 140 ft	R - Crimea USSR 30 m
H - Hat Creek	So - Onsala 25 m
Jb - Jodrell Bank MKII 25	T - Torun 15 m
Km - Haystack 120 ft	Wn - Westerbork n = 1-14x26 m
Kp - Kitt Peak 25 m	Yn - Socorro n = 1-27x25 m
Lm - Medicina 32 m	

No.	Observers	Program
A-24V	Abraham, Z. (Itapetinga) Zensus, A. Kaufman, P. (Itapetinga) Cohen, M. (Caltech) Scalise, E. (Itapetinga) Schaal, R. (Itapetinga) Unwin, S. (Caltech) Nicolson, G. (Hartebeesthoek)	Monitor of the superluminal quasars 3C 273 and 3C 279 at 2.8 and 6 cm with telescopes B, Lm, Km, G, F, O, N, Pt, Mb, and E.
AH43V	Alef, W. (MPIR) Benz, A. (SFIT, ETH)	Observations at 2.8 cm of two sources to be used for phase reference with telescopes B, Lm, Km, G, O, F, and Pt.
AH44V	Porcas, R. (MPIR, Bonn) Alef, W. (MPIR, Bonn)	High resolution observations at 1.3 cm of the BL Lac object OJ287 with telescopes B, Lm, So, Jb, Km, G, N, O, Y_1 ,Pt, and Kp.

No.	Observers	Program
AH45V	Feigelson, E. (Penn State) Lonsdale, C. (MIT) Phillips, R. (MIT)	Observations at 18 cm of pre-main sequence stars with telescopes G, Y_{27}, and Pt.
B-92V	Briggs, F. (Pittsburgh) Garwood, R. (Pittsburgh)	Study at 2.8 cm of an exotic radio jet in the high redshift quasar PKS 0458-020 with telescopes B, Lm, Km, G, F, O, H, N, Pt, Mb, and E.
B-95V	Biretta, J. (CfA) Harris, D. (CfA) Stern, C. (CfA)	Measurements at 90 cm of the structure of the M87 Jet with telescopes Jb, Wn, Z, G, H, F, O, I, N, Y_{27}, Pt, and A.
B-97V	Briggs, F. (Pittsburgh) Garwood, R. (Pittsburgh)	Studies at 90 cm of a promising z = 3, 21 cm absorption candidate with telescopes Jb, Wn, G, H, F, O, I, N, Y_1, Pt, and A.
F-20V	Fiedler, R. (NRL) Simon, R. (NRL) Johnston, K. (NRL) Dennison, B. (VPI & SU) Hjellming, R.	Observations at 6 cm of compact sources experiencing extreme scattering events with telescopes B, Lm, So, Wn, Km, G, F,N, I, O, H, Y_1, and Pt.
F-21V	Fanti, C. (Bologna) Fanti, R. (Bologna) Parma, P. (Bologna) Venturi, T. (Bologna) Schilizzi, R. (NFRA) Spencer, R. (Manchester) van Breugel, W. (Berkeley) Ren-Dong, N. (Beijing)	Studies at 18 cm of compact steep spectrum radio sources with telescopes Jb, Lm, So, Wn, Km, G, O, F, I, Y_1, Pt, and Kp.
G-60V	Giovannini, G. (Bologna) Wehrle, A. (Caltech) Comoretto, G. (Arcetri) Feretti, L. (Bologna) Venturi, T. (Bologna)	Observations at 6 cm of a sample of Fanaroff-Riley Type I radio galaxies with telescopes at B, Jb, So, Lm, Wn, Km, G, F, O, Y_{27}, and Pt.
H-47V	Hough, D. (JPL) Readhead, A. (Caltech)	Measurements at 2.8 cm of superluminal motion in weak nuclei of the double lobed quasars 3C 207 and 3C 245 with telescopes B, Lm, Km, G, F, O, H, and Pt.

No.	Observers	Program
H-48V	Hough, D. (JPL) Readhead, A. (Caltech)	Measurements of superluminal motion at 2.8 cm in weak nuclei of double-lobed quasars 3C 190, 3C 208, 3C 249.1, and 3C 247 with telescopes B, Km, G, O, and Pt.
H-50V	Hough, D. (JPL) Zensus, A. Porcas, R. (MPIR, Bonn)	Mapping at 2.8 cm of the superluminal core in the double-lobed quasar 3C 263 with telescopes B, Km, G, O, and Pt.
K-25V	Kapahi, V. (TIFR) Hough, D. (JPL)	Observations at 18 cm of the cores of double lobed quasars having misaligned outer lobes with telescopes Jb, So, Lm, Wn, Km, G, O, H, F, N, Y_{27}, and A.
L-49V	Lestrade, J-F. (JPL) Boloh, R. (JPL) Mutel, R. (Iowa) Niell, A. (Haystack) Preston, R. (JPL)	Observations at 6 cm of 15 RS CVn binaries for mapping and astrometry with telescopes B, Lm, G, O, and Y_{27}.
L-56V	Lestrade, J-F. (JPL) Niell, A. (MIT) Preston, R. (JPL) Phillips, R. (MIT) Hodges, M. (Caltech)	Measurements at 6 cm to determine the radio emitting region in close binaries with telescopes G, O, H, and Y_{27}.
M-105V	Miley, G. (Leiden) Chambers, K. (John Hopkins) Schilizzi, R. (NFRA) Roland, J. (Leiden)	Study at 90 cm the fine structure in the most distant radio galaxies with telescopes Jb, Wn, T, N, G, O, Y_{27}, and R.
P-82V	Pauliny-Toth, I. (MPIR, Bonn)	Monitor at 2.8 cm of 2134+004 with telescopes B, Lm, Km, G, F, O, H, Pt, and Mb.
P-83V	Pauliny-Toth, I. (MPIR, Bonn) Porcas, R. (MPIR, Bonn) Zensus, A. Kellermann, K. Wu, S. (Beijing) Mantovani, F. (Bologna) Kaufman, P. (Itapetinga)	Monitor at 2.8 cm of 3C 454.3 with telescopes B, Lm, Km, G, F, O, H, Pt, and Mb.
P-84V	Phillips, R. (MIT) Lestrade, J-F. (JPL)	Preliminary observations at 1.3 cm of the exotic binary LSI+61°303 with telescopes B, Km, G, O, Y_{27}, and Pt.

No.	Observers	Program
P-88V	Preuss, E. (MPIR, Bonn) Alef, W. (MPIR, Bonn) Hai, Q. (Beijing) Kellermann, K.	Studies at 6 cm of structural variability in 3C 111 and 3C 390.3 with telescopes B, So, Lm, Wn, Km, G, F, O, Pt, E, and R.
P-91V	Phillips, R. (Haystack) Titus, M. (Haystack) Lestrade, J-F. (JPL)	Studies at 18 cm of the compactness of the radio-emitting regions of three O giant stars with telescopes G, Y_{27}, and Pt.
R-48V	Roberts, D. (Brandeis) Cawthorne, T. (Brandeis) Wardle, J. (Brandeis) Gabuzda, D. (Simmons College)	Survey at 6 cm of the linear polarization structures of BL Lac Objects with telescopes B, Lm, Wn, Km, G, F, O, Y_{27}, and Pt.
S-80V	Simon, R. (NRL) Johnston, K. (NRL) Spencer, J. (NRL) Porcas, R. (MPIR, Bonn)	Superluminal monitoring at 6 cm of 3C 395 with telescopes B, Lm, So, Jb, Wn, Km, G, N, F, O, H, and Pt.
W-52V	Wehrle, A. (Caltech) Unwin, S. (Caltech) Cohen, M. (Caltech)	Monitor at 1.3 cm of the superluminal motion in 3C 345 with telescopes B, So, Lm, Jb, Km, G, N, O, Y_{27}, and Pt.
W-53V	Wrobel, J. (NMIMT)	Observations at 6 cm of NGC 3894 with telescopes B, So, Lm, Wn, Jb, Km, G, F, O, Y_{27}, and Pt.
Z-19V	Zensus, A.	Observations at 1.3 cm of the quasar 3C 273 with telescopes B, So, Lm, Km, G, O, N, and Pt.

C. 12-M TELESCOPE

The following line programs were conducted during this quarter.

No.	Observers	Program
B-516	Brown, R.	Kinematics of ionized gas at the galactic center.
B-519	Barnes, P. (CITA, Toronto) Crutcher, R. (Illinois) Pratap, P. (Illinois)	Multi-transition observations of Orion B.
B-520	Balonek, T. (Colgate) Robson, E. (Lancashire, UK) Hughes, D. (Lancashire, UK)	Study of simultaneous millimeter-submillimeter-infrared-optical spectra of a small sample of blazars to test specific relativistic jet emission models.

No.	Observers	Program
B-521	Blitz, L. (Maryland)	CO observations of high-latitude galactic clouds.
D-162	Dent, W. (Massachusetts) Balonek, T. (Colgate)	Study of the evolution of extragalactic radio sources at millimeter wavelengths.
G-307	Green, D. (DAO, Canada) Dewdney, P. (DAO, Canada)	Study of shocked CO associated with G33.6+0.1.
H-257	Heiles, C. (Berkeley) Glassgold, A. (NYU)	The DCO^+/HCO^+ ratio in Cas A: A cosmologically important observation.
H-264	Hogg, D. Roberts, M.	Study of interstellar matter in early-type galaxies.
K-315	Koo, B-C. (Berkeley) Heiles, C. (Berkeley)	Investigation of the structure of neutral stellar wind in HH7-11.
K-316	Kastner, J. (UCLA) Zuckerman, B. (UCLA)	Study of CO from red giant stars.
K-318	Kenney, J. (Caltech) Scoville, N. (Caltech) Wilson, C. (Caltech)	Study of molecular gas complexes in M101.
L-124	Liszt, H. Burton, W. B. (Leiden)	^{13}CO (J=1-0) mapping of Sgr C.
L-235	Liszt, H.	Study of high-velocity phenomena near Sgr A.
L-236	Lord, S. (NASA-Ames) Smith, B. (Texas)	An investigation of the molecular disks of a complete, flux-limited sample of interacting galaxies.
M-298	Mangum, J. (Virginia) Wootten, H. A.	A multi-transition molecular line study of the pre-stellar condensations in DR21(OH) and Orion-KL.
S-326	Szczepanski, J. (MIT) Ho, P. (CFA - Harvard)	Study of gas feeding of the galactic center region.
S-327	Sage, L. (NMIMT) Isbell, D. (NMIMT)	Study of ^{13}CO emission from a sample of nearby galaxies.
S-328	Smith, B. (Texas) Lord, S. (NASA-Ames)	A CO (J=1-0) map of the Ripple Galaxy Arp 215.

No.	Observers	Program
S-331	Schwartz, P. (NRL) Pauls, T. (NRL)	Observations of deuterated ammonia in dark dust clouds.
T-251	Turner, B.	A test of Bates' Theory of Dissociative Electron Recombination by a search for the Vinoxy radical (CH_2CHO).
T-256	Turner, B. Lubowich, D. (Hofstra)	Study of mass loss from super Li-rich stars and the galactic lithium problem.
T-258	Turner, B. Wootten, H. A.	A search for the chloronium ion H_2Cl^+.
T-264	Turner, B. Rickard, L. J (NRL) Lanping, X. (Beijing)	Study of CO in cirrus molecular cloud cores.
T-266	Thronson, H. (Wyoming)	Study of star formation and the ISM in SO galaxies.
V-69	Verter, F. (NASA) Rickard, L. (NRL) Verschuur, G. (unaffiliated) Leisawitz, D. (NASA)	Study of CO emission associated with high-latitude cloud complex MBM 15.
V-70	Vallee, J. (NRC, Canada) Avery, L. (NRC, Canada)	Further study of a possible new bipolar outflow in the nearby cloud MBM55.
W-255	Walker, C. (Arizona) Carlstrom, J. (Berkeley) Martin, R. (Arizona) Jackson, J. (MPIfEP)	A CS (J=2-1) study of infrared bright galaxies.
W-256	Walker, C. (Arizona) Carlstrom, J. (Berkeley) Martin, R. (Arizona)	A fully-sampled (half-beam spacing) CO J=1-0 study of IR bright galaxies.
W-260	Walker, C. (Arizona) Carlstrom, J. (Berkeley) Martin, R. (Arizona)	CO (J=1-0) study of IR bright galaxies.
W-263	Wilson, C. (Caltech) Scoville, N. (Caltech)	Study of star formation and interstellar medium in M33.
W-264	Wootten, H. A. Mangum, J. (Virginia) Butner, H. (Texas)	Study of H_2CO in pre-star-forming clumps in the rho Oph molecular cluster.

No.	Observers	Program
W-265	Walker, C. (Arizona) Sage, L. (NMIMT) Martin, R. (Arizona) Carlstrom, J. (Berkeley)	Study of CS (J=2-1) emission from nearby galaxies.
W-266	Wannier, P. (JPL) Andersson, B. (JPL)	Study of a possible outflow source in L637.
Y-8	Yun, M. (CFA - Harvard) Ho, P. (CFA - Harvard)	Study of high-temperature and high-density molecular gas in M82.
Z-79	Ziurys, L. (Arizona State) Steimle, T. (Arizona State)	A search for interstellar CaOH.
A-80	Ziurys, L. (Arizona State)	Study of SiS in outflow regions.

D. VLA OBSERVING PROGRAMS

Second quarter 1989 was spent in the following configurations:

B configuration from:	April 1 to May 3
BC configuration from:	May 9 to June 30,

and the following research programs were conducted with the VLA.

No.	Observers	Program
AA-99	Appleton, P. (Iowa State) Basart, J. (Iowa St Siqueira, P. (Iowa State)	Continuum structure of the elliptical galaxy NGC 5903. 6 and 20 cm.
AA-102	Allen, J. (Iowa) Molnar, L. (Iowa) Mutel, R. (Iowa)	Monitoring and mapping of Cygnus X-1. 1.3, 2, 3.6, 6, 18, and 20 cm.
AB-414	Becker, R. (Calif., Davis) White, R. (STScI)	Monitoring the radio flux of radio stars HD193793 and P Cygni. 2 and 6 cm.
AB-456	Burke, B. (MIT) Hewitt, J. (Princeton) Roberts, D. (Brandeis)	Time variation of 0957+561. 6 cm.
AB-492	Bloeman, J. (Leiden) Duric, N. (New Mexico)	A detailed spectral index study of four edge-on galaxies. 6, 20 and 90 cm.

No.	Observers	Program
AB-515	Becker, R. (Calif., Davis) Helfand, D. (Columbia) Zoonematkermani, S. (Columbia) White, R. (STScI)	Imaging of weak extended galactic sources. 6 and 20 cm.
AB-517	Biretta, J. (CFA) Owen, F.	Proper motion of M87 jet. 2 cm.
AB-525	Braun, R. van Gorkom, J. (Columbia) Walterbos, R. (Berkeley) Kennicutt, R. (Steward Obs.) Norman, C. (STScI)	The interstellar media of nearby galaxies. 20 cm.
AB-530	Burton, W. B. (Leiden) Dickey, J. (Leiden)	HI absorption through galactic "Cirrus" clouds. 20 cm line.
AB-531	Becker, R. (Calif., Davis) Helfand, D. (Columbia) White, R. (STScI)	Survey of the Galactic plane. 20 cm.
AB-532	Bridle, A. Fomalont, E.	Polarimetry of lobes of 3C 288. 2, 3.5 cm.
AB-534	Baum, S. (NFRA) Leahy, P. Perley, R. Riley, J. (MRAO) Scheuer, P. (MRAO)	A survey of nearby hotspots. 3.5 cm.
AB-536	Bosma, A. (Obs. Marsielle) Athanassoula, E. (Obs. Marsielle)	Flaring HI disks of edge-on galaxies. 20 cm line.
AB-540	Birkinshaw, M. (Harvard) Davies, R. (Oxford)	Elliptical galaxies. 6 cm.
AB-544	Becker, R. (Calif., Davis) Helfand, D. (Columbia) Zoonematkermani, S. (Columbia) White, R. (STScI)	A search for new galactic SNR. 6 cm.
AB-545	Becker, R. (Calif., Davis) Helfand, D. (Columbia) Zoonematkermani, S. (Columbia) White, R. (STScI) Keto, E. (Lawrence Livermore)	A search for ultracompact HII regions in the galaxy. 6 cm.

No.	Observers	Program
AB-547	Buta, R. (Alabama) Higdon, J. (Texas)	HI in ringed barred spiral NGC 5850. 20 cm line.
AC-231	Claussen, M. (NRL) Gaume, R. (NRL) Johnston, K. (NRL) Wilson, T. (MPIR, Bonn)	Study of the W3 star forming region. 1.3, 2, 6 and 18 cm line.
AC-244	Carilli, C. Perley, R. Dreher, J. (MIT) Bridle, A. Cotton, W.	Cygnus A. 3.6 cm.
AC-246	Carilli, C. van Gorkom, J. (Columbia) Stocke, J. (Colorado)	Quasar-galaxy pair 3C 232, NGC 3067. 20 cm.
AC-247	Cordes, J. (Cornell) Hankins, T. (NMIMT) McKinnon, M. (NMIMT)	A search for pulsars. 20 cm.
AC-248	Clegg, A. (Cornell) Cordes, J. (Cornell)	Rapid intensity variation from interstellar OH masers. 18 cm line.
AD-160	de Pater, I. (Berkeley)	Jupiter patrol. 6 and 20 cm.
AD-188	Drake, S. (SASC) Simon, T. (Hawaii) Florkowski, D. (USNO) Stencel, R. (Colorado) Bookbinder, J. (Colorado) Linsky, J. (Colorado)	Variability of the radio emission in M Supergiant Alpha Ori. 2 and 6 cm.
AD-220	Dubner, G. (IAFE) Arnal, E. (IAR) Winkler, F. (Middlebury College) Goss, W. M.	The SNR Puppis A. 20 and 90 cm.
AD-222	de Pater, I. (Berkeley) Gulkis, S. (JPL) Romani, P. (NASA) Atreya, S. (Michigan)	Uranus. 1.3, 2, 6 and 20 cm.
AD-223	Dickel, H. (Illinois) Goss, W. M. van der Werf, P. (Kapteyn Lab)	HI observations of DR21. 20 cm line.

No.	Observers	Program
AD-231	Dahlem, M. (MPIR, Bonn) Wielebinski, R. (MPIR, Bonn) Klein, U. (Bonn) Mebold, U. (Bonn)	Peculiar filaments in the halo of NGC 1808. 6 and 20 cm.
AD-234	Dulk, G. (Colorado) Kucera, T. (Colorado) Bastian, T. Rottman, G. (Colorado) Orrall, F. (Hawaii)	Solar coronal abundances: Heavy elements to hydrogen via X-ray to radio flux ratios at the limb. 20 cm.
AE-60	Elias, N. (Pennsylvania) Koch, R. (Pennsylvania)	Close binary star evolution: Serpentids. 3.6 and 6 cm.
AF-73	Fomalont, E. Geldzahler, B. (NRL)	Core of Fornax A. 2 cm.
AF-167	Frail, D. (Toronto) Seaquist, E. (Toronto) Bode, M. (Lancashire, UK) Roberts, J. (Lancashire, UK)	Second epoch of the Nova remnant GK Persei. 6 and 20 cm.
AF-174	Frail, D. (Toronto) Cordes, J. (Cornell) Hankins, T. (NMIMT) Seaquist, E. (Toronto) Weisburg, J. (Carleton College)	HI absorption measurements against pulsars in the inner galaxy. 20 cm line.
AF-175	Fischer, M. (Silver High School) Gibson, D. (Lincoln Lab) Gonzalez, P. (La Plata Jr. High)	176-day cycle of 4U1820-30. 6 and 20 cm.
AF-182	Fruchter, A. (DTM/Carnegie) Goss, W. M. Stinebring, D. (Princeton) Taylor, J. (Princeton)	Eclipsing millisecond pulsar. 90 cm.
AF-183	Fruchter, A. (DTM/Carnegie)	Integrated radio flux from millisecond pulsars in globular clusters. 20 cm.
AG-267	Gottesman, S. (Florida) Hawarden, T. (UKIRT)	HI observations of NGC 5291. 20 cm line.
AG-269	Ge, J. (NMIMT) Owen, F.	High Faraday rotation in cooling flow clusters. 3.6, 6 and 20 cm.
AG-277	Gussie, G. (Calgary) Taylor, A. (Calgary)	Survey of circumnebular neutral hydrogen absorption in planetary nebulae. 20 cm line.

No.	Observers	Program
AG-278	Garcia-Barreto, J. (UAEM)	Barred galaxies NGC 1022 and NGC 1326. 2, 6 and 20 cm.
AG-280	Ge, J. (NMIMT) Owen, F.	Faraday rotation measure in A1795. 3.6 cm.
AG-282	Gopal-Krishna (TIFR) Subrahmanya, C. (TIFR) Steppe, H. (IRAM) Swarup, G. (TIFR)	Ultra-steep spectrum radio sources. 6 and 20 cm.
AG-284	Garwood, R. (Pittsburgh) Dickey, J. (Minnesota)	A galactic absorption survey at low latitudes. 20 cm line.
AG-285	Gomez, Y. (UNAM) Moran, J. (CFA) Rodriguez, L. (UNAM)	Angular expansion of NGC 6302. 3.5 cm.
AG-287	Gaume, R. (NRL) Claussen, M. (NRL) Goss, W. M.	H and He recombination lines in Sgr B2. 1.3 cm line.
AG-289	Ge, J. (NMIMT) Owen, F. O'Dea, C. (NFRA)	Survey at Abell distance class 4 clusters. 20 cm.
AH-295	Habing, H. (Leiden) Goss, W. M. Winnberg, A. (Onsala) van Langevelde, H. (Leiden)	Monitoring OH, IR stars at the galactic center. 18 cm line.
AH-299	Helfand, D. (Columbia) Becker, R. (Calif., Davis)	Survey of the galactic plane. 90 cm.
AH-345	Hjellming, R. McKinnon, M. (NMIMT) Hankins, T. (NMIMT) Han, X. (NMIMT/Beijing)	A search for quasi-periodic radio emission components in X-ray binaries. 3.5 and 20 cm.
AH-346	Helfand, D. (Columbia) Becker, R. (Calif., Davis) Zoonematkermani, S. (Columbia)	A 327 MHz survey of the galactic plane. 90 cm.
AH-354	Hurford, G. (Caltech) Gary, D. (Caltech)	Optically thin solar burst sources. 1.3 and 2 cm

No.	Observers	Program
AH-355	Hewitt, J. (Princeton) Cappallo, R. (Haystack) Corey, B. (Haystack) Lonsdale, C. (Haystack) Niell, A. ((Haystack) Phillips, R. (Haystack) Lestrade, J-F. (JPL) Preston, R. (JPL)	VLBI reference sources near dMe stars. 3.5 and 20 cm.
AH-357	Habbal, S. (CFA) Gonzalez, R. Harvey, K. (Solar Phys. Research)	Solar activity. 2, 3.5 and 6 cm.
AH-362	Hines, D. (Texas) Wills, B. (Texas)	IRAS quasars-radio structure and optical polarization. 6 cm.
AH-363	Hennessy, G. (Virginia) Owen, F. Eilek, J. (NMIMT) Sarazin, C. (Virginia)	A search for depolarization in sources behind Abell clusters. 20 cm.
AH-365	Howarth, I. (Colorado) Brown, A. (Colorado)	Mass loss rates for O-type stars. 3.5 cm.
AH-366	Hjellming, R. Han, X. (NMIMT/Beijing)	X-ray nova V404 Cyg: Monitoring Cyg X-3. 3.5, 6 and 20 cm.
AI-35	Inoue, M. (Nobeyama) Perley, R. Carilli, C. Kato, T. (Utsunomiya) Tabara, H. (Utsunomiya) Aizu, K. (Rikkyo)	High quality mapping of large Faraday rotation source Hyd A. 2 and 6 cm.
AI-37	Impey, C. (Steward Obs.) Foltz, C. (MMT Obs.) Weymann, R. (Mt. Wilson) Hewett, P. (Cambridge)	Survey of optically selected quasars. 6 cm.
AK-216	Kulkarni, S. (Caltech) Hester, J. (Caltech) Evans, C. (Caltech)	Search for emission nebula surrounding PSR 1957+20. 20, 6 and 3.5 cm.
AK-220	Kristian, J. (Mt. Wilson) Windhorst, R. (Arizona State) Fomalont, E. Kellermann, K.	Deep VLA survey: positions and structures. 6 cm.

No.	Observers	Program
AK-222	Kundu, M. (Maryland) White, S. (Maryland) Gopalswamy, N. (Maryland)	Solar continuum and coronal magnetic structure. 20 and 90 cm.
AK-224	Kameya, O. (Nobeyama) Kawabe, R. (Nobeyama) Morita, K. (Nobeyama) Ishiguro, M. (Nobeyama) Campbell, B. (New Mexico)	Search for OH maser and continuum counterparts of new H_2O masers in the NGC 7538 region. 6 and 18 cm line.
AK-227	Kucera, T. (Colorado) Kiplinger, A. (Colorado) Dulk, G. (Colorado) Bastian, T.	Fine structures in solar flares. 2, 3.5 and 6 cm.
AL-150	Lestrade, J-F. (JPL) Preston, R. (JPL)	Statistical properties of RSCVn stars. 6 cm.
AL-154	Langston, G. (MIT) Heflin, M. (MIT) Burke, B. (MIT) Lawrence, C. (CIT)	Time variation of 2016+112. 6 cm.
AL-184	Linsky, J. (Colorado) Bookbinder, J. (Colorado) Brown, A. (Colorado) Skinner, S. (Colorado) Butler, J. (Armagh Obs.) Doyle, J. (Armagh Obs.)	Flare star G1644; observations with IUE and ginga. 2, 6 and 20 cm.
AL-190	Leckband, J. (Iowa) Spangler, S. (Iowa)	Compact radio sources near and behind the Cygnus loop. 2 and 6 cm.
AL-191	Luttermoser, D. (Colorado) Judge, P. (Colorado) Linsky, J. (Colorado)	Survey of cool N-type carbon stars. 3.5 cm.
AL-192	Langston, G. (NRL) Heflin, M. (MIT) Lehar, J. (MIT) Burke, B. (MIT) Lawrence, C. (Caltech)	Variations of gravitational lens 2016+112. 3.5 and 6 cm.
AL-195	Lang, K. (Tufts) Willson, R. (Tufts) Trottet, G. (Obs. Paris) Kerdroan, A. (Obs. Paris)	Solar radio bursts-observations with Nancay. 90 cm.

No.	Observers	Program
AL-204	Lustig, A. (Sydney) Hunstead, R. (Sydney)	Extended cluster sources. 6 and 20 cm.
AL-208	Lang, K. (Tufts) Willson, R. (Tufts)	The final SMM-VLA collaboration. 20 and 90 cm.
AM-206	Molnar, L. (Iowa) Reid, M. (CFA) Johnston, K. (NRL)	Scattering size of Cygnus X-3. 20 and 90 cm.
AM-270	Morganti, R. (ESO) Fosbury, R. (ESO) Alighieri, S. (ESO) Tadhunter, C. (ESO)	The radio structures of Parkes 2 Jy radio sources. 6 cm.
AM-271	Morris, M. (UCLA) Yusef-Zadeh, F. (Northwestern)	Proper motion of the galactic center threads. 20 cm.
AM-272	Meaburn, J. (Manchester) Pedlar, A. (NRAL) Hummel, E. (NRAL)	Dwarf galaxy IC 1613. 6 and 20 cm.
AM-276	Muhleman, D. (Caltech) Grossman, A. (Caltech) Slade, M. (JPL) Jurgens, R. (JPL) Ostro, S. (JPL)	Radar echoes from Titan. 3.5 cm.
AN-52	Nitta, N. (NAO, Japan) Kai, K. (NAO, Japan) Nakajima, H. (NAO, Japan) Kosugi, T. (Tokyo) Bastian, T. Dennis, B. (NASA)	Separation of thermal and nonthermal components in solar flares. 1.3, 2, and 3.6 cm.
AO-86	Owen, F. Perley, R.	B3 classical doubles. 3.6 cm.
AO-87	Owen, F. Eilek, J. (NMIMT) Cornwell, T.	M87. 90 cm.
AO-88	Owen, F. Eilek, J. (NMIMT)	M87. 3.6 cm.

No.	Observers	Program
AP-164	Palmer, P. (Chicago) Yusef-Zadeh, F. (Northwestern) Goss, W. M. Lasenby, A. (Cambridge) Lasenby, J. (Cambridge)	Sgr B1/Sgr B2 complex of HII regions. 2, 6 and 20 cm.
AP-166	Pottasch, S. (Kapteyn Lab) Zijlstra, A. (Kapteyn Lab) Ratag, M. (Kapteyn Lab) Bignell, R. C.	Very young planetary nebulae. 2 and 6 cm.
AP-170	Perley, R. Taylor, G. (UCLA) Inoue, M. (Nobeyama) Kato, T. (Utsunomiya) Tabara, H. (Utsunomiya) Aizu, K. (Rikkyo)	Very large Faraday rotation in Hydra A. 3.5 cm.
AP-171	Penninx, W. (Amsterdam) van der Klis, M. (Exosat) Lewin, W. (MIT) Makishima, K. (Tokyo) van Paradijs, J. (Amsterdam)	Low mass X-ray binary 4U1820-30. 2, 6 and 20 cm.
AR-196	Roberts, D. (Brandeis) Brown, L. (Brandeis) Kollgaard, R. (Brandeis) Wardle, J. (Brandeis) Perley, R.	High dynamic range structure of the quasar 3C 345. 3.5 cm.
AR-204	Riley, J. (MRAO) Warner, P. (MRAO)	The jet and dynamics of 4C74.26. 20 and 90 cm.
AR-205	Reynolds, S.(NC State)	Small-scale structure in young supernova remnants. 6, 20 and 90 cm.
AR-208	Rudnick, L. (Minnesota) Anderson, M. (Minnesota) Wang, Y. (Minnesota)	3C 33 north. 6 and 20 cm.
AR-209	Reipurth, B. (ESO, Chile) Rodriguez, L. (UNAM)	Herbig-Haro objects 80 and 81. 2, 3.5, 6 and 20 cm.

No.	Observers	Proposers
AS-331	Sahai, R. (Chalmers) Claussen, M. (NRL)	The enigmatic radio source in IRC+10216. 1.3, 2, 3.5 cm.
AS-333	Sramek, R. (Australia Telescope) Weiler, K. (NRL) van der Hulst, J. (Westerbork) Panagia, N. (STScI)	Statistical properties of radio supernovae. 2, 6 and 20 cm.
AS-355	Sumi, D. (Illinois) Burns, J. (New Mexico) Zhao, J. (New Mexico)	3C 317, the central galaxy in the cooling flow cluster Abell 2052. 6, 20 and 90 cm.
AS-356	Surdej, J. (Liege) Kellermann, K. Borgeest, U. (Hamburg Obs.) Kayser, R. (Hamburg Obs.) Magain, P. (ESO) Refsdal, S. (Hamburg Obs.) Swings, J. (Liege)	Highly luminous quasars as gravitationally lensed objects. 2 cm.
AS-358	Saikia, D. (NRAL) Garrington, S. (NRAL)	Depolarization and viewing angles of one-sided radio sources. 6, 18 and 20 cm.
AS-365	Sumi, D. (Illinois) Burns, J. (New Mexico) Zhao, J. (New Mexico) Sulkanen, M. (New Mexico)	Central galaxies in the Arnaud X-ray sample of clusters of galaxies. 6 cm.
AS-366	Stocke, J. (Colorado) Foltz, C. (Arizona) Morris, S. (Mt. Wilson) Weymann, R. (Mt. Wilson)	The radio properties of the "broad absorption line" QSOs. 6 cm.
AS-380	Singal, A. (TIFR) Salter, C. (TIFR)	1331-09, a giant radio galaxy. 6, 20 and 90 cm.
AS-382	Schmelz, J. (Lockheed) Gonzalez, R.	Coronal magnetic structures. 3.5, 6 and 20 cm.
AS-387	Schmahl, E. (Maryland) White, S. (Maryland) Kundu, M. (Maryland)	Flare energetics with the SMM X-ray polychromator. 3.5, 6 and 20 cm.
AT-102	Torbett, M. (Kentucky) Campbell, B. (New Mexico)	Radio survey of interacting binary stars. 3.5 cm.
AU-35	Ulvestad, J. (JPL)	Thermal emission from Markarian 231. 2, 6 and 20 cm.

No.	Observers	Program
AV-157	van Breugel, W. (Berkeley) McCarthy, P. (Mt. Wilson) Lilly, S. (Hawaii) Spinrad, H. (Berkeley)	B2 1 Jansky radio sources. 20 cm.
AV-163	van Gorkom, J. (Columbia) Goss, W. M. Leahy, P.	A search for strong magnetic fields in Sgr A West-- Zeeman splitting in H92α. 3.5 cm line.
AV-164	van Breugel, W. (Berkeley) Dey, A. (Berkeley) Spinrad, H. (Berkeley) McCarthy, P. (Mt. Wilson)	Misaligned radio galaxies at high redshift. 2, 3.5, 6 and 20 cm.
AW-230	Wrobel, J. Unger, S. (RGO)	Monitoring of the Seyfert NGC 5548. 3.5 cm.
AW-231	Witzel, A. (MPIR, Bonn) Zensus, A. Quirrenbach, A. (MPIR, Bonn) Krichbaum, T. (MPIR, Bonn) Schalinski, C. (MPIR, Bonn) Hummel, C. (MPIR, Bonn)	Investigation of rapid variability in extragalactic radio sources. 2, 3.6, 20 and 92 cm.
AW-236	Wieringa, M. (Leiden) Katgert, P. (Leiden)	WSRT steep spectrum sources. 20 cm.
AY-23	Yusef-Zadeh, F. (Northwestern) Bally, J. (Bell Labs)	G359.54+0.18 and Sgr C. 2, 6 and 20 cm.
AY-33	Yin, Q. (Peking Univ.) Heeschen, D. Saslaw, W. (Virginia)	Nine starburst galaxies. 6, 20 and 90 cm.
AZ-42	Zhao, J. (New Mexico) Ekers, R. (Australia Telescope) Goss, W. M. Lo, K. (Illinois) Narayan, R. (Steward Obs.)	Long-term flux variations of Sgr A. 6 cm.
EVN-8840	Felli, M. (Arcetri) Massi, C. (Arcetri)	Theta 1 Orionis. 6 cm phased array MK III VLB.
VZ-19	Zensus, A.	3C 273. 1.3 cm single dish VLB.

E. SCIENTIFIC HIGHLIGHTS

The VLA successfully observed a radar bounce from Saturn's largest satellite, Titan. The experiment follows along in the recent series of highly successful planetary observations which have included Saturn's rings and Mars. A 360 kW 8.6 GHz signal was transmitted continuously during three 5.5 hour sessions from the 70-meter DSN Goldstone antenna and received 2.5 hours later at the VLA. The radar echo from Titan is the weakest such echo that has ever been measured. Real differences in surface reflectivity from day to day were seen and interpreted to indicate the presence of a highly variable surface on Titan. Low reflectivity could be consistent with the presence of a deep ethane ocean. The reflectivity during one of the observing days, however, was so high that it is inconsistent with a uniformly spread ocean of ethane. Further radar experiments to validate some of the initial conclusions are planned during the annual passage of Saturn to the Earth.

Investigators: D. Muhleman, A. Grossman, and B. Butler (Caltech)

C. Impey and G. Bothun reported HI observations made with the Arecibo and 140-ft telescopes of the galaxy Malin 1. The two telescopes were needed because of their vastly different beamwidths at 21 cm. The much bigger 140-ft beam detected greater integrated hydrogen emission, indicating that the extent of the galaxy was very large.

The unique feature of Malin 1 is an enormous HI disk, diameter > 240 kpc. Its observed HI mass is 1.1×10^{11} solar masses, the largest HI mass of any galaxy known. The optical surface brightness of Malin 1 is exceptionally low--$M_{HI}/L_B \approx 3$.

One interpretation is that Malin 1 has extremely inefficient star formation. It appears to be an unevolving disk galaxy, where the surface mass density is so low that the chemical composition and mass fraction in gas change very slowly over Hubble times.

An intriguing aspect is that the galaxy was found accidentally. Since there are strong selection effects against finding gas-rich galaxies that are both massive and diffuse, the statistics of occurrence of like galaxies is diffcult to estimate.

Investigators: C. Impey, U. Arizona and G. Bothun, U. Michigan

Molecular Gas in the Nearby Galaxy M33

A comparison of the structure, gas content, and resultant star formation of various types of galaxies is receiving considerable emphasis at the 12-m telescope. An interesting result of late has come from a study of the nearby Sc galaxy M33. This galaxy is close enough so that arm and interarm regions can be resolved with the 12-m, which is also sensitive to the extended, low-brightness emission that characterizes this source. Although M33 has been known to contain HI for some time, previous studies suggested that the molecular gas content was quite low. Using the 12-m, investigators have recently found considerable CO emission from this galaxy, and have performed a half-beam-spacing map out to a radius of 3.5′. Several large, unbound, molecular clouds were found, which are probably comprised of agglomerations of smaller, bound systems. The investigators concluded that the *relative* content of molecular to atomic gas in M33 was comparable to that in our own galaxy. However, the total mass of M33 is considerably less than the Galaxy, which accounts for the weak CO emission.

Investigators: C. D. Wilson and N. Scoville (CalTech)

F. PUBLICATIONS

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

G. CENTRAL DEVELOPMENT LABORATORY

Cooled HEMT Amplifier Development

An additional five K-band HEMT amplifiers have been built and delivered to the VLA. These will replace some of the earlier units using GaAs FET's that have considerably higher noise than the current HEMT amplifiers.

Two new design 22-25 GHz HEMT amplifiers with improved performance have been built and installed in a VLBA receiver. The overall receiver temperature is in the range 26-35 K over the frequency range 21.4-24.5 GHz. We will install amplifiers in a second VLBA receiver in the near future.

The first five-stage 41-45 GHz VLBA amplifier has been completed and a second is almost complete. Using linear monolithic 0.1x100 μm HEMT's in the first two stages and three GE devices in the last three stages, we have obtained an average noise temperature of 48.6 K and a low of 32.9 K at 41.3 GHz.

An amplifier covering 25-34 GHz is being constructed and should be completed by the end of the next quarter. This will give the Green Bank 140-ft telescope the capability to cover the 26-34 GHz range.

Superconducting (SIS) Millimeter-Wave Mixer Development

We are now testing a new modular SIS receiver developed in close collaboration with Tucson. Initial tests using Hypres junctions with integrated tuning structures gave overall receiver noise temperatures $19 \leq T_R \leq 30$ K DSB over most of the range 90-120 GHz. A similar receiver for 68-90 GHz gave $46 \leq T_R \leq 70$ K DSB, which we hope to improve. In the 230 GHz band, using our old laboratory test receiver, we have obtained $65 \leq T_R \leq 140$ K DSB over 200-230 GHz. The receiver noise temperature increases rapidly with frequency above 230 GHz, and we are now investigating the cause of this.

Encouraged by the initial results obtained with the fixed-tuned Hypres mixer at 100 GHz (see October-December 1988 Quarterly Report), we have included some similar circuits on the mask set just completed for SIS mixers to be fabricated at UVA. The excellent $Nb/Al\text{-}Al_2O_3/Nb$ trilayer junctions fabricated at UVA were described in an earlier quarterly report.

Our millimeter-wave research collaboration with IBM Watson Research Center continues. The excellent performance of our IBM SIS mixers at 3 mm was described in an earlier quarterly report. We are still awaiting delivery of a new set of mixers for 115 and 230 GHz.

Collaboration continues with the University of Illinois (UI) at Urbana and UC Berkeley to produce mixers for the 70-260 GHz bands for use on the BIMA at Hat Creek and the NRAO 12-m telescope at Kitt Peak. UI workers have developed a process for making extremely small area Nb/Al-Al_2O_3/Nb trilayer junctions. We have designed SIS mixers compatible with the UI process which will be fabricated at UI. The masks, fabricated using the UI e-beam lithography facility, should be delivered shortly, and the first mixers should be delivered by the end of the summer.

During this quarter we have tested a total of 17 SIS mixers operating from 68-260 GHz.

Schottky Diode Millimeter-Wave Mixers and Multipliers

This quarter, in support of the 12-m telescope and millimeter-array site testing radiometers, we have built (or re-built) and tested a total of 17 Schottky mixers and multipliers in the 230, 300, and 345 GHz bands.

Acousto-Optical Spectrometer

During this quarter, the design of the integrator electronics was further refined, the laser diode controller was transferred from a breadboard to a wirewrap board, a printed circuit board for the fast A to D converter was designed and fabricated, and the board containing most of the digital electronics was released for wirewrapping by an outside vendor. All of the electronics are being packaged into one 2-wide VLA/VLBA module.

At the end of the quarter, all necessary components are in hand and await final assembly and wiring. This should be completed early in the next quarter, to be followed by testing of the hardware and programming of the microprocessor. This should allow us to begin tests of the complete spectrometer toward the end of next quarter. At that point we can evaluate the optical system and begin the refinements which will no doubt be necessary to achieve the performance needed on the telescope.

H. GREEN BANK ELECTRONICS

140-ft Cassegrain Receivers

The current 140-foot 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.

During this quarter, many of the components for the LO system were purchased. Testing of components for, and the design and development of, the LO system continues.

S/X Receivers

The USNO is funding the design and construction of new cryogenic receivers for the Green Bank three-element interferometer. The 85-3 telescope will be operated as a VLBI terminal in conjunction with other USNO antennas. The 85-1 and 85-2 antennas will be operated as a connected interferometer to continue a long-term flux monitoring program.

The construction of components and sub-systems for the second and third S/X receivers continued during the quarter. Feeds and most other components are assembled and tested. Installation of both receivers is anticipated early in the next quarter.

Spectral Processor

The spectral processor is a high time resolution spectrometer capable of producing two 40 MHz spectra each 25.6 μs. A fair amount of flexibility, in terms of bandwidth, number of channels, and averaging time is included to make the instrument useful for spectroscopy. It has special signal averaging capabilities built-in to facilitate its use as a pulsar back-end.

During this quarter, the processor was tested in-house as well as by two outside pulsar groups. Timing observations of several pulsars were performed at the 140-ft with repeatability in the few microsecond range. Sensitivity of the processor relative to an ideal filter bank ranges from 77 percent to 95 percent; approximately 95 percent of the power for a given frequency is confined to the five channels surrounding the frequency. Tests with a strong CW signal showed that spurious responses were down at least 40 dB.

A second IF to baseband converter has been constructed and tested. A third converter is under construction. Digital cards for the second half of the system and for spares are all assembled and a few have been tested.

Seven-Feed, 5 GHz Receiver

The upgrade of this receiver, which consisted primarily of substituting HEMT amplifiers for GaAs FET amplifiers, was completed during this quarter. Tests on the 140-ft gave the following results:

- Mean system temperature at zenith 41 K.
- The receiver is noise limited in 0.2 sec integrations.
- Efficiency of the center feed: 55%.
- Efficiency of outer feeds: 49%.
- HPBW center feed: 6.2 arc min.
- HPBW outer feeds: 6.3 arc min.

System noise temperatures with the old FET amplifiers measured at the 300-ft telescope prior to its collapse were 64 ± 4 K (channel to channel variations). Because of the improvement in receiver noise temperature, the absence of ground radiation through the reflector surface (approximately 8-10 K at the 300-ft telescope at 5 GHz) and an approximate two-fold increase in efficiency at the 140-ft telescope at 5 GHz, future measurements made with the upgraded 7 feed/5 GHz receiver at the 140-ft telescope should be comparable in sensitivity with those obtained previously at the 300-ft telescope

Miscellaneous

Design of the 43 GHz receiver for the VLBA continues. Construction of L-band VLBA receivers and 2 to 16 GHz VLBA local oscillators continues.

I. 12-M ELECTRONICS

New Instruments

Hybrid Spectrometer

In this quarter, two major, long-term development projects, the hybrid spectrometer and the eight-beam receiver, have come to fruition. The hybrid spectrometer, the next-generation spectral line backend, has been installed and tested at the telescope. The system is performing extremely well, and will be made available to astronomers on a routine basis in the autumn when the telescope resumes operation after the annual, two-month summer shutdown period.

The spectrometer provides excellent capabilities for both dual-channel, single-beam and 8-beam mapping modes. The spectrometer is a combination of analog filter and digital autocorrelation technology. It has a total of 1536 display channels, which can be divided among one to eight I.F.'s. The bandwidth for a single I.F. can range from a maximum of 2400 MHz (although the present generation of receivers has only a 600 MHz bandwidth) to a minimum of 37.5 MHz. In the 8-beam mode, the maximum and minimum bandwidths are 300 MHz and 37.5 MHz. A 4x600 MHz mode also exists.

Ultimately, it will be possible to configure the I.F.'s to have different center frequencies within the front-end bandwidth. This will allow observers to center the I.F.'s upon several different lines within the band and observe them simultaneously. Because of the current severe budget constraints, this feature could not be afforded this year.

Eight-Beam, 230 GHz Receiver

With the completion of the hybrid spectrometer, it has been possible to use for the first time the 230 GHz, eight-beam receiver in full 8-beam mode. This receiver consists of a 2 x 4 array of Schottky mixers, with each beam separated by 87" on the sky. The receiver and spectrometer combination was tested twice this spring, and used by a visiting team of astronomers for one run, albeit in a test mode. The system will be available for routine use by observers in the autumn.

This receiver system dramatically increases the efficiency of mapping in the 1.3 mm band, both for external galaxies and for objects in our own galaxy. In a 10-minute test observation of the Galactic Center in May, the staff obtained a 72 point map, with each spectrum in the map containing 192 spectral channels. Each position was observed for a one-minute integration, and had good signal-to-noise.

The 8-beam receiver also has a rotation mechanism that allows the 2x4 array to be rotated to any position angle to take advantage of source geometry. From that position, the rotator can then track parallactic angle so as to keep the array position angle fixed in the RA-DEC frame as the AZ-EL telescope tracks the source across the sky.

Status of Other Receivers

New SIS Receivers

Development of the next generation of SIS receivers has continued. Small, self-contained, modular receivers have been developed for the 70-90 GHz and 90-115 GHz bands and have been tested in a laboratory dewar using a closed-cycle 4.2 K refrigerator. Over the 70-90 GHz band, noise temperatures of around 100 K SSB are obtained for the complete receiver, and over the range 90-115 GHz noise temperatures of 50 K SSB across the band are obtained. A dewar suitable for telescope use that will house up to eight of these modules is nearing completion. Fabrication has started on a receiver module for 200-240 GHz, and we hope to test this module within the next three months.

70-115 GHz Schottky Mixer Receiver

The high frequency dewars on this receiver (90-115 GHz) have been dismantled as this frequency range is covered by the SIS receiver. The low frequency (70-90 GHz) dewars will be kept in service until the completion of the new SIS receiver.

200-360 GHz Schottky Receiver

This receiver is unchanged in the last year and continues to give reliable performance.

90-115 GHz SIS Receiver

This receiver is unchanged since the last report and continues to give unmatched performance in this frequency range.

J. 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 affected directly. For example, at 44 GHz a 20" pointing error causes a 30 percent change in amplitude. Solar-induced tilts, which used to dominate our pointing errors, have been greatly reduced through external insulation of the antenna yoke and base support.

An important pointing problem which is being investigated now 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 believed to be 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. Testing of the stability of two redesigned tilt-meter units showed that the temperature control of the tiltmeter meter unit is now adequate and the components for several more tilt-meter units were on order, with fabrication completed during the second quarter of 1989. Further testing will continue into the third quarter of 1989.

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 and 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 have been procured, and one more system has been installed.

VLA 327 MHz Receiver

This project has been completed. (See RFI improvements.)

VLA 8-GHz Receivers

This project has been completed.

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 most of the coherent RFI between antennas. However, the remainder still limits use of the 327 MHz system, so enclosing the radiating components with RFI shields is necessary.

Four prototype 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 RFI enclosures eliminate the remaining antenna-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 this 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).

1.3 cm 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 three means a tremendous boost in speed and sensitivity. Experiments will be ten times faster. Eight hour experiments will then take less than one hour. Instead of one region per u-v track, approximately ten 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 contains a new 1.3 cm 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 HEMT being developed in the Green Bank Electronics

Division will be used to replace present 5 GHz paramps. Twenty-seven antennas have been equipped with this receiver upgrade, and installation of the remaining system is scheduled to be completed by the start of the third quarter, 1989.

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.

The VLA 18-21 cm wavelength feed currently has system temperatures of approximately 60 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 VLBA, 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 Green Bank 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 resulting in a system temperature of about 35 K. Two more systems modifications of this type are scheduled for this year.

High Time Resolution Processor

We have been planning for some time to instrument the VLA with a high time resolution pocessor (HTRP). The system is planned for observations of the time varying phenomena like flare stars, pulsars etc., and monitoring radio frequency interference (RFI). As an intermediate step, a system has been designed that will utilize existing components such as the analog sum phase array outputs of the VLA, and VLBI MKIII IDF-Video converter system, used as tunable filters with selectable bandwidths. This would provide 14 pairs of RCP and LCP frequency signals from the phased array VLA. Total power detectors and cross multipliers are used to measure all four products with integration period of 25 micro sec to 5 msec. Prototypes of these circuits have been tested and components for the mass production are on order. The data acquisition system is a 64 channel multiplexer and a 12 bit analog to digital converter with maximum sampling rate of 100,000 samples/sec, installed in a 386 based 20 MHz clock speed personal computer with 140 MB hard disk. The data acquisition system has been used to obtain 2-channel phased array VLA signals for developing software and understanding the system stability problems. Fabrication of the interfacing sub-system was started in the second quarter of this year.

K. AIPS

The AIPS code overhaul is essentially complete except for a few severely non-standard tasks which may be removed from the system. We expect to release this code as the 15JUL89 version of AIPS. However, this may be delayed pending legal arrangements related to the export of the code.

Much of the quarter was devoted to cleaning up the last of the overhaul, to correcting minor bugs caused by the overhaul, and to completing the new capabilities described last quarter. The most important new task this quarter is MK3IN which translates Haystack format "A" MKIII VLBI correlator data tapes into AIPS. When fully debugged, AIPS will be able to do the fringe fitting and calibration of MKIII data. Fringe fitting with multiple IFs was corrected. All calibration tasks became able to handle more than one frequency/bandpass combination in the same UV data file, through the introduction of FQ tables. FILLM can now read in a VLA observation to one or more disk files in a single execution. More simultaneous interactive AIPS users are now allowed if the local manager permits. A variety of other improvements to calibration and display programs were made.

L. VLA COMPUTER

During this quarter, the NRAO discovered two minor design flaws in the ModComp operating system that had been causing the tasks in the computers to be scheduled incorrectly. This was fixed by NRAO programmers. The on-line software was frozen on June 8, as per the agreement with NASA for an unchanging operational environment during the Voyager II fly-by of Neptune. An acceptance run performed by JPL on June 12 worked flawlessly. Subsequent Voyager passes provided data of high quality with all software functioning satisfactorily. The operational spares of all hardware components in the on-line computers have now been constructed and tested. The final check-out of the on-line clock was in progress at the end of the quarter.

The new Convex C1-XP computer (now known as Yucca) was successfully installed as planned. Unfortunately, problems with the peripherals have delayed its full use as an image processing system. Only three of the six tape drives are currently usable. Some image displays should be functional by mid July, although the main image display will not be installed before the end of August. The disks on Yucca may be accessed from the older Convex (Cholla) using the Network File System. It is therefore possible, in the interim, to use the image device on Cholla to display images from Yucca.

The decommission of the DEC-10 and Pipeline can now proceed as planned. The Pipeline computers will be removed from the maintenance contract on June 30, the DEC-10 on July 31. The observation preparation program (OBSERVE) is now usable, but users will require some more time to become fully familiar with it. Most of the data calibration functions have already been implemented in the AIPS software. The spectral line calibration, imaging, and display functions have been largely implemented in both AIPS and ISIS.

M. VERY LONG BASELINE ARRAY

Antennas and Site Preparation

The Pie Town antenna participated in the March-April Network run at 1.3, 2.8, and 6 cm for both MKII and MKIII observing. It also participated in the June Network run at 18 and 90 cm. Pie Town also participated in a March 27-28 Crustal Dynamics run. The Kitt Peak VLBA site performed its first Network observations during June 13-19 at 18 cm, using MKII recording. Simultaneous with the Pie Town antenna, the Kitt Peak antenna was remotely controlled from the Socorro Array Operations Center.

Investigation of a problem with the azimuth drive system at Los Alamos led to the discovery of a design error in the gear boxes used for both the azimuth and elevation drives. The gear boxes are multi-stage planetary devices manufactured by Sumitomo Machinery Corporation. The problem is one of accelerated wear in the box. Sumitomo has identified the cause, and has designed and tested a fix which can be installed in the gear boxes without removing them from the antennas. Sumitomo will install the fixes, at their expense, at Pie Town and Kitt Peak by the end of July and at other antennas by the end of August.

Final outfitting of the Los Alamos antenna is underway, and is expected to be completed in July. The Fort Davis antenna is scheduled to be outfitted beginning in August. (This is a return to an earlier outfitting sequence, necessitated by delays in completing the erection of the North Liberty antenna.) The North Liberty antenna is scheduled for outfitting to begin in January 1990. The Owens Valley antenna is virtually assembled. Brewster, WA is scheduled for antenna erection to start imminently. At St. Croix site preparation by the general contractor began in mid-June. At Hancock, NH final permits are being sought to allow site preparation to start in July. Soil tests at the Mauna Kea site are scheduled for completion in July, which will allow architect-engineers to start preparation of drawings for construction bidding in the fall.

Electronics

The electronics construction plan outlined in the last quarterly report is proceeding as planned, and most of the components required have now been received. Tests of the HEMT amplifiers for the 43 GHz front end indicate noise temperatures in the range 35-65 K over the frequency range 41-45 GHz can be achieved. This performance is a little better than anticipated, and should allow the frequency coverage to be increased from 42.3-43.5 GHz, as listed in the project book, to perhaps as much as 41-45 GHz. The first front end will be ready for testing towards the end of the year. All hydrogen masers through serial No. 9 have now been received. Maser No. 5 is presently back at Sigma-Tau for repair, under warranty, of a vacuum leak. Testing of the first data acquisition rack constructed at Charlottesville is continuing, and has concentrated on the individual modules, including the formatter. System testing of the full rack, which may take several weeks, will be started during the first week of June. Testing of future data acquisition racks should proceed much more rapidly, since experience with this one will establish the procedures required.

Data Recording

Prototype playback drives (PBD's) Nos. 1 and 2 were completed except for the parallel bit synchronizer and read boards, and data buffer. The first was shipped to Charlottesville for use in developing control software. The second remains at Haystack for development and checkout of the remaining playback hardware. Data acquisition rack (DAR) 1 has been retrofitted, tested with formatter 4, and shipped to Los Alamos for that site's recent electronic outfitting.

The program of experimental measurements and theoretical models characterizing the sensitivity of tracking performance on critical machine alignments and mechanical tape defects is nearly completed. The results are described in a series of about 20 VLBA acquisition memos. Testing of new thin tapes on the VLBA recorder has started.

Monitor and Control

During second quarter 1989 our primary concern has been with the conversion of the array control software to run under the VxWorks operating system. We have completed the port of the operating system to the MVME 121 CPU boards of the station computer. We have received the SUN computer host for the development system and have the SUN up, running and accessible to the AOC's network, and have the SUN in production for VxWorks code development. Some effort has gone into device driver writing--the MVME-121 and MVME-050 serial ports are up and running. The major job of writing the disk driver is yet to be done. A preliminary version of the MVME 131 monitor-control bus interface is now operating (additional work remains). The TDC tape drive control operator interface program is nearly working under VxWorks.

Work continued on the currently existing, VersaDos, station computer software, primarily in the elimination of bugs, although an appreciable effort had to be mounted in responding to requests to changes in hardware control or observing control protocols. In particular, the allocation algorithm for tracks in MKIII emulation mode was changed, and support was added for simultaneous use of the both polarization channels to utilize the full bandwidth of the X-band front end. Assistance was provided in the design of a combined VLA/VLBA maintenance database, and we are providing active help for establishing the system.

Correlator

An initial "place-and-route" layout of the correlator "FX" chip was completed by LSI Logic Corp., but was determined to perform unsatisfactorily during re-simulation at the Hall-Mark Electronics design center. Further analysis by NRAO engineers revealed numerous flaws arising, evidently, from faulty communications between these two vendors. A second iteration of the process, including several false starts, was necessary before a satisfactory layout was achieved. This marked the completion of the final design phase. On 1989 May 26, NRAO authorized fabrication of prototype chips, which are now scheduled for delivery on June 29.

Finalization of printed-circuit board layout specifications for the two major correlator modules had been delayed pending completion of the FX chip final design and pin configuration. In the meantime, design of the two playback interface modules had been finished. Accordingly, it was decided to abandon the favorable bid for layout and manufacture of the correlator PC boards in the interest of having all four modules fabricated by the same vendor. A revised RFP was issued on 1989 June 1. Tri-Circuits Inc., of Knightdale NC, was again the lowest bidder, again at a substantial savings compared to budget estimates. A purchase order for these four sets of boards was issued on June 22.

Architectural design of the correlator software was completed, as were the model-computation and the control-script interface tasks. Specification of requirements for the database management system which will become an integral part of the correlator software was finalized, and a short list of acceptable vendors was qualified. The DBMS will be procured from among these vendors on the basis of life cycle cost.

The first designated correlator playback drive was received from Haystack Observatory on 1989 May 17. Although actually configured as a data-acquisition recorder drive, pending the design and prototyping of two signal-path modules unique to the playback application, this unit nevertheless allows work to begin on the playback control software. The recorder controller hardware and firmware already include those specialized functions required for playback, and the two-channel decoder provided in the VLBA formatter for diagnostic purposes will suffice for early tests of the correlator playback interface.

The second VLBA Correlator Design Review was held in the final week of the quarter. This meeting, originally planned for January, had been delayed until final design of the FX chip was complete. The two primary foci of the review were (1) function of the chip in the context of each of the two modules in which it is the essential component, and (2) the correlator software architecture, where the meeting represented a final opportunity to debate these plans before they are committed to implementation.

Data Processing

The bulk of the software needed for the normal processing of astronomical data from the VLBA is currently available and in routine production use. There are three general areas which need to be developed: 1) the interface to the correlator and monitor data base, 2) calibration and editing of correlator output and 3) geometric analysis of the data (i.e., astrometry and geodesy).

Software development until recently was largely a major revision of the AIPS software system. Improvements in the calibration software have been made, especially in the areas of spectroscopic calibration and plotting. This effort will be continued through the end of the year. An additional programmer is expected to be added to the staff in September.

It has been decided to postpone the purchase of major computer hardware until 4th quarter 1990, when we should be able to get a third generation minisupercomputer.

N. PERSONNEL

<u>New Hires</u>

Senter, Robert	Business Manager - CV	4/03/89
Calder, Robert	Electronic Engineer II	5/22/89
Heatherly, Sue Ann	Public Education Officer	6/15/89

Terminations

Ananthramiah, K.	Research Associate	4/03/89
Xu, Changlong	Visiting Electronic Engineer I	4/07/89
Weber, David	Electronic Engineer I	6/15/89

Other

Stidstone, Robert	to Chief Engineer/VLBA Antennas	5/08/89
King, Lee	transfer to Charlottesville	5/08/89
Uson, Juan	return from leave of absence	6/01/89

PREPRINTS RECEIVED, APRIL - JUNE, 1989

BOWERS, P.F.; KNAPP, J.R. A Study of OH/IR Stars and Planetary Nebula Formation.

BREGMAN, J.N.; BOISSEAU, J.R. The Radiative Signature of the Shock Acceleration Process in Active Galactic Nuclei.

CORNWELL, T.J. The Applications of Closure Phase to Astronomical Imaging.

CORNWELL, T.J. Atmospheric Effects and the Design and Operation of Radio Telescopes.

CORNWELL, T.J.; ANATHARAMAIAH, K.R.; NARAYAN, R. Speckle Phenomena in Inter-Planetary Scintillation.

COTTON, W.D. JR Polarimetry.

DALLACASA, D.; FERETTI, L.; GIOVANNINI, G.; VENTURI, T. Multifrequency Observations of the Tailed Radiosource NGC 4869 in the Coma Cluster.

DE PATER, I.; RICHMOND, M. Neptune's Microwave Spectrum from 1 mm to 20 cm.

DIAMOND, P.J.; GOSS, W.M.; ROMNEY, J.D.; BOOTH, R.S.; ET AL. The Structure of the Interstellar Medium at the 25 AU Scale.

DICKEL, H.R.; GOSS, W.M. VLA Observations of the 6 cm and 2 cm Lines of H2CO in the Direction of W 49.

GEZARI, D.; BLITZ, L. 1.0-mm Continuum 12CO, 13CO and C18O Mapping of the NGC 6334 Complex and Comparison with IRAS Observations.

GOSS, W.M.; ANANTHARAMAIAH, K.R.; VAN GORKOM, J.H.; EKERS, R.D.; ET AL The Nature, Location and Environment of Sgr A East.

GREEN, D.A. Observations of 11 Small-Diameter Galactic Plane Radio Sources: A Search for Young SNRs.

GRIFFITHS, R.E.; WILSON, A.S.; WARD, M.J.; TAPIA, S.; ULVESTAD, J.S. 4U1722+11: The Discovery of an X-Ray Selected BL Lac Object.

HENNESSY, G.S.; OWEN, F.N.; EILEK, J.A. Faraday Rotation from Abell Clusters of Galaxies.

HOLLIS, J.M.; JEWELL, P.R.; LOVAS, F.J. A Search for Methylene in the Orion Nebula.

JOHNSTON, K.J.; LAMPHEAR, E.J.; WEBSTER, W.J. JR; LOWMAN, P.D. JR; ET AL The Microwave Spectra of Asteroids Pallas, Vesta, and Hygiea.

JOHNSTON, K.J.; STOLOVY, S.R.; WILSON, T.L.; HENKEL, C.; MAUERSBERGER, R. VLA Observations of the 15NH3 Maser Associated with NGC7538-IRS1.

KASHLINSKY, A. On the Coherence Length of Large Scale Peculiar Velocities and Gravitational Clustering.

KELLERMANN, K.I.; SRAMEK, R.; SCHMIDT, M.; SHAFFER, D.B.; GREEN, R. VLA Observations of Objects in the Palomar Bright Quasar Survey.

KETO, E.R. Collapse of Self-Gravitating Protostellar Condensations in DR21.

KETO, E.R.; HO, P.T.P. NH3 Observations of Compressed Post-Shock Molecular Gas in Ionization-Shock Fronts around W33.

LASENBY, J.; LASENBY, A.N.; YUSEF-ZADEH, F. HI Absorption Measurements over the Galactic Centre Radio Arc and Arches Regions.

LASENBY, J.; YUSEF-ZADEH, F.; LASENBY, A.N. HI Absorption Against the 40KMS-1 Cloud and the Circum-Nuclear Disk in Sgr A.

LIKKEL, L. OH and H2O Observations of Cold IRAS Stars.

LIND, K.R.; PAYNE, D.G.; MEIER, D.L.; BLANDFORD, R.D. Numerical Simulations of Magnetized Jets.

LIU, R.; RILEY, J.; WARNER, P.; POOLEY, G.; ALEXANDER, P. The Structure and Dynamics of Two Tailed Sources in Cluster 0648+19.

MADDEN, S.C.; IRVINE, W.M.; MATTHEWS, H.E.; FRIBERG, P.; SWADE, D.A. A Survey of Cyclopropenylidene (C3H2) in Galactic Sources.

MASSON, C.R. The Structures and Distances to BD+30deg3639 and NGC 6572.

NARAYAN, R.; CORNWELL, T.J.; GOODMAN, J.; ANANTHARAMAIAH, K.R. Radio Scattering and Imaging.

OWEN, F.N.; HOGG, D.E. The NRAO Millimeter Array Site Survey.

PREPRINTS RECEIVED, APRIL – JUNE, 1989

PEDELTY, J.A.; RUDNICK, L.; MCCARTHY, P.J.; SPINRAD, H. Strong Asymmetries in the Radio Galaxy 3C337 and Its Large-Scale Emission-Line Gas.

POSPIESZALSKI, M.W. Modeling of Noise Parameters of MESFET's and MODFET's and Their Frequency and Temperature Dependence.

RODRIGUEZ, L.F.; REIPURTH, B. Detection of Radio Continuum Emission from the Herbig-Haro Objects 80 and 81 and Their Suspected Energy Source.

SANDQVIST, AA. 2-mm H2CO Emission in the Sgr A Molecular Cloud Complex at the Galactic Center.

SCHNEIDER, S.E. Neutral Hydrogen in the M96 Group: The Galaxies and the Intergalactic Ring.

SCHWAB, F.R.; HOGG, D.E. Analysis of Radiosonde Data for the MMA Site Survey and Comparison with 'Tipping Radiometer' Data.

SRÁMEK, R.A. Atmospheric Phase Stability at the VLA.

SWADE, D.A. The Physics and Chemistry of the L134N Molecular Core.

SWADE, D.A. Radio Wavelength Observations of L134N Molecular Core.

TORRELLES, J.M.; HO, P.T.P.; RODRIGUEZ, L.F.; CANTO, J.; VERDES-MONTENEGRO, L. VLA Observations of Ammonia and Continuum in Regions with High-Velocity Gaseous Outflows. II.

TURNER, B.E.; AMANO, T.; FELDMAN, P.A. Searches for the Protonated Interstellar Species HC3NH+, CH3CNH+ and HOCS+: Implications for Ion-Molecule Chemistry.

WANNIER, P.G.; SAHAI, R.; ANDERSSON, B-G.; JOHNSON, H.R. Mass Loss from Red Giant Stars: II Carbon Stars.

WEHRLE, A.E.; COHEN, M.H. VLBI Imaging of CTA 102.

WILKING, B.A.; MUNDY, L.G.; BLACKWELL, J.H.; HOWE, J.E. A Millimeter-Wave Spectral-Line and Continuum Survey of Cold IRAS Sources.

WOOTTEN, A. The Structure of Dense Cloud Cores.

WROBEL, J.M. Current Star Formation in S0 Galaxies: NGC 4710.

YUSEF-ZADEH, F.; BALLY, J. G359.3-0.82: An Unusual Radio Source.

ZHAO, J.-H; BURNS, J.O.; OWEN, F.N. A 20 cm VLA Survey of Abell Clusters of Galaxies. I. Distance Class < or = 3 Clusters.

ZHOU, S.; WU, Y.; EVANS, N.J. II; FULLER, G.A.; MYERS, P.C. A CS Survey of Low Mass Cores and Comparison with NH3 Observations.