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NATIONAL RADIO ASTRONOMY OBSERVATORY

QUARTERLY REPORT

July 1, 1986 - September 30, 1986

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A. TELESCOPE USAGE

The following telescopes have been scheduled for research and maintenance in the following manner during the third quarter of 1986.

	140-ft	300-ft	12-m	VLA
Scheduled observing (hrs)	1604.75	1813.00	645.00	1651.80
Scheduled maintenance and equipment changes	309.00	171.75	1322.75	214.60
Scheduled tests and calibrations	210.25	47.50	238.25	347.70
Time lost	90.00	129.50	80.75	
Actual observing	1514.75	1683.50	564.25	1569.05

B. 140-FOOT OBSERVING PROGRAMS

The following line programs were conducted during this quarter.

No.	Observer(s)	Program
A-83	Anantharamaiah, K. Bhattacharya, D. (Raman) Payne, H.	Observations over the range of 147-153 MHz to search for low-frequency recombination lines toward the Galactic Center.
A-84	Anantharamaiah, K. Erickson, W. (Maryland) Payne, H.	Observations in the range of 60-65 MHz for H and C recombination-lines toward Cas A.
B-440	Bell, M. (Herzberg) Avery, L. (Herzberg) Matthews, H. (Herzberg)	Search at 4.927 and 9.170 GHz for H_2CC, an isomer of acetylene.
B-457	Bell, M. (Herzberg) Matthews, H. (Herzberg) Sears, T. (Brookhaven)	Observations at 9.71 GHz to identify the carrier of a linear molecule detected in TMC-1.
C-235	Crutcher, R. (Illinois) Heiles, C. (Berkeley) Kazes, I. (Meudon) Troland, T. (Kentucky)	Observations at 18 cm of the OH Zeeman effect.
E-48	Erickson, W. (Maryland) Payne, H.	Observations at 400 cm to search for low-frequency absorption lines in the Center region.

No.	Observer(s)	Program
E-49	Elvis, M. (CFA) Wrobel, J. (NMIMT) Lockman, F. J.	Observations of HI toward extragalactic X-ray sources.
G-282	Gordon, M.	Observations at 21 cm for interstellar hydrogen in the Bootes Void.
L-195	Lockman, F. J. Hobbs, L. (Chicago) Jahoda, K. (Goddard) McCammon, D. (Wisconsin)	Observations of HI in low column density directions.
L-205	Likkel, L. (UCLA) Morris, M. (UCLA)	Observations of OH at 1612 and 1667 MHz toward stars with dense cold circum-stellar shells.
M-245	Magnani, L. (Maryland) Blitz, L. (Maryland) Lada, E. (Texas) Sandell, G. (Helsinki)	Observations at 3335 MHz to study CH emission from IRAS "Cirrus."
M-258	Mirabel, I. (Puerto Rico)	Observations at 4.8 GHz to search for "intelligent," narrow frequency-band carriers.
P-134	Payne, H.	Observations at 5 cm of rotationally excited OH in the young planetary nebula NGC 6302.
T-192	Turner, B. Ziurys, L. (Massachusetts)	Observations at 9 cm to study the exci-tation of ground-state interstellar CH.
V-57	Verschuur, G. (Unaffiliated) Schmelz, J. (Penn State)	Observations at 21 cm to search for the Zeeman effect in Galactic HI clouds at $Z < 100$ pc.
W-201	Walmsley, C. (MPIR, Bonn) Batrla, W. (Illinois)	Observations at discrete frequencies over the range of 5816-9979 MHz and at 12 GHz for methanol in absorption in interstellar clouds.
W-215	Wootten, H. A. Loren, R. (Texas)	Observations at 2 cm of H_2CO in dense, star-forming clumps in the ρ Oph molecular cloud.
W-218	Walker, H. (Leiden) Burton, W. B. (Leiden)	Observations of HI in nearby IRAS dust clouds.

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

B - Effelsberg, MPIR 1000 m	Lm - Medicina 32 m
F - Fort Davis 85 ft	N - NRL Maryland Pt. 85 ft
G - Green Bank 140 ft	O - Owens Valley 130 ft
H - Hat Creek 85 ft	Sn - Onsala 20 m
I - Iowa 60 ft	Wn - Westerbork n=1-14x26 m
Jb - Jodrell Bank Mk II 25 m	Yn - Socorro n=1-27x25 m
Km - Haystack 120 ft	

No.	Observer(s)	Program
B-70V	Barthel, P. (Caltech) Lonsdale, C. (Penn State)	Observations at 18 cm of the small-scale, hotspot morphology in 3C 205 with telescopes B, G, Jb, Km, O, Wn and Yn.
D-12V	Diamond, P. (MPIR, Bonn) Nyman, L. (Goddard)	Observations at 18 cm of the proper motion of the masers in W 43 with telescopes B, G, Jb, Km, O, Sn, and Yn.
H-18V	Hodges, M. (Caltech) Mutel, R. (Iowa)	Mapping at 18 cm of the compact double DA 344 with telescopes F, G, H, I, Km, N, O, and Yn.
M-80V	Marscher, A. (Boston) Bartel, N. (CFA) Padrielli, L. (Bologna) Rickett, B. (San Diego) Romney, J.	Observations at 18 cm of the low-frequency variable NRAO 140 with telescopes B, F, G, H, I, Jb, Km, N, O, and Yn.
P-75V	Phillips, R. (Haystack) Mutel, R. (Iowa)	Observations at 18 cm to obtain an astrophysically incisive map of CTD 93 with telescopes B, F, G, H, I, Jb, Km, Lm, N, O, Sn, Wn, and Yn.
S-65V	Spangler, S. (Iowa) Cordes, J. (Cornell) Mutel, R. (Iowa) Benson, J.	Observations at 18 cm of the interstellar scattering of 2013+370 with telescopes F, G, H, I, Km, N, O, and Yn.
X-43V	Bartel, N. (CFA) Unger, S. (Manchester)	Observations at 18 cm of a newly discovered SNR found in NGC 891 with telescopes B, G, O, Wn, and Yn.

C. 300-FOOT OBSERVING PROGRAMS

The following continuum programs were conducted during this quarter.

No.	Observer(s)	Program
A-82	Aller, H. (Michigan) Aller, M. (Michigan) Payne, H.	Observations at 880, 1400, and 2700 MHz of low-frequency variable sources.
B-412	Burke, B. (MIT) Carilli, C. (MIT) Heflin, M. (MIT) Langston, G. (MIT)	Observations at 6 cm to continue the MIT-Green Bank survey at $\delta = 20° < \delta < 45°$.
G-290	Gregory, P. (British Columbia) Picha, J. (British Columbia) Xu, H. (British Columbia)	Galactic survey at 6 cm for transient and highly variable radio sources.
O-32	O'Dea, C. Balonek, T. (Colgate) Dent, W. (Massachusetts) Kinzel, W. (Massachusetts)	Polarization and flux-density measurements of variable sources at 2695 MHz.

The following line programs were conducted during this quarter.

No.	Observer(s)	Program
K-297	Kerr, F. (Maryland)	Pilot search for galaxies behind the Milky Way by the study of HI.
R-234	Richter, O. (STScI)	Survey of HI at $0^h < \alpha < 24^h$ and $-19° \lesssim \delta \lesssim 0°$.

The following pulsar programs were conducted during this quarter.

No.	Observers	Program
B-442	Backer, D. (Berkeley) Clifton, T. (Berkeley) Foster, R. (Berkeley) Heiles, C. (Berkeley) Kulkarni, S. (Caltech) Rand, R. (Caltech) Werthimer, D. (Berkeley)	Real-time, fast pulsar search of the Galactic plane at 825 MHz.

No.	Observer(s)	Program
D-139	Dewey, R. (Cornell) Stokes, G. (Princeton) Taylor, J. (Princeton) Weisberg, J. (Princeton)	Monitoring at 390 MHz of the timing of pulsars discovered in the Princeton-NRAO pulsar survey.

The following VLB program was conducted during this quarter.

No.	Observer(s)	Program
B-455	Briggs, F. (Pittsburgh) Wolfe, A. (Pittsburgh)	Very long baseline observations at 452 MHz to measure the absorption of highly redshifted 21-cm radiation from QSOs.

The following "piggy back" program was conducted during this quarter.

No.	Observer(s)	Program
B-454	Bowyer, S. (Berkeley) Backer, D. (Berkeley) Buhse, R. (Berkeley) Kulkarni, S. (Caltech) Werthimer, D. (Berkeley)	Observations at 825 and 1421 MHz for narrow-band radio signals of extra-terrestrial origin simultaneous with B442, K297, and R234.

D. 12-METER OBSERVING PROGRAMS

The following line programs were conducted during this quarter.

No.	Observer(s)	Program
C-239	Combes, F. (Meudon) Encrenaz, T. (Meudon) Gerin, M. (Meudon) Wootten, H. A. Bogey, M. (Lille, France) Demuynca, C. (Lille, France) Destombes, J. (Lille, France)	Verification of interstellar C_3H_2: search for isotopic variants.
D-146	Dent, W. (Massachusetts) Balonek, T. (Colgate)	Study of the evolution of extragalactic radio sources at millimeter wavelengths.
D-147	Dickinson, D. (Lockheed) Jewell, P.	Study of SiO masers in short-period Mira variables.

No.	Observer(s)	Program
F-91	Feldman, P. (Herzberg) Matthews, H. (Herzberg) Saito, S. (Nagoya, Japan)	Further observations of interstellar oxophosphine (HPO).
F-92	Feldman, P. (Herzberg) Matthews, H. (Herzberg)	Search for C_5H radical in circumstellar envelope of IRC+10 216.
G-294	Gordon, M.	Survey of 3-mm recombination lines from selected HII regions.
L-199	Liszt, H. Wolfe, A. (Pittsburgh)	Search for redshifted CO absorption toward A0235+164.
T-209	Turner, B. Ziurys, L. (Massachusetts)	Study of the new interstellar molecular ion $NCNH^+$.
T-214	Turner, B.	Completion of a spectral survey in the 3-mm window.
W-212	Wootten, H. A. Loren, R. (Texas) Wilking, B. (Missouri)	DCO^+ in star-forming clumps in rho Oph molecular cloud.
W-217	Wolf, G. (Arizona) Lada, C. (Arizona)	Study of the structure and kinematics of molecular disks in SF Regions II.
W-219	Wootten, H. A. Greason, M. (Virginia)	Study of the chemical ancestry of DCN and HCN in molecular clouds.

E. VLA OBSERVING PROGRAMS

The following research programs were conducted with the VLA during this quarter.

No.	Observer(s)	Program
AA-57	Anantharamaiah, K. Shaver, P. (ESO) van Gorkom, J. (Princeton) de Bruyn, A. (NFRA)	Search for redshifted recombination-lines towards 3C 286. 90-cm line.
AA-58	Anantharamaiah, K. Bagri, D.	Search for OD towards W49 and W3. 90-cm line.
AB-129	Burke, B. (MIT) Hewitt, J. (MIT) Roberts, D. (Brandeis)	Time variations in lensed quasar 0957+561. 6 cm.

No.	Observer(s)	Program
AB-340	Becker, R. (Calif., Davis) White, R. (STScI)	Scaled-array observations of Lick Hα 101. 20 cm.
AB-357	Becker, R. (Calif., Davis) White, R. (STScI)	Monitoring radio flux of HD 193793. 6 cm.
AB-369	Browne, I. (NRAL) Bridle, A. Burns, J. (New Mexico) Dreher, J. (MIT) Hough, D. (Caltech) Laing, R. (RGO) Owen, F. Readhead, A. (Caltech) Scheuer, P. (MRAO) Wardle, J. (Brandeis) Lonsdale, C. (Penn State)	Sidedness of jets in high-luminosity sources. 6 cm.
AB-376	Baum, S. Bridle, A. Heckman, T. (Maryland) Miley, G. (STScI) van Breugel, W. (Berkeley)	Complete sample of equatorial, extra-galacic radio sources. 2, 6, 18, and 20 cm.
AB-387	Becker, R. (Calif., Davis) Helfand, D. (Columbia)	Composite remnant G24.7+0.6. 90 cm.
AB-389	Baum, S. Bridle, A. Heckman, T. (Maryland) Miley, G. (STScI) van Breugel, W. (Berkeley)	Multifrequency mapping of 1717-00 = 3C 353. 2, 6 and 20 cm.
AB-392	Branch, D. (Oklahoma) Cowan, J. (Oklahoma)	Spectral index measurement of the radio source at the site of SN 1961v in NGC 1058. 6 cm.
AB-394	Bastian, T. (Colorado) Dulk, G. (Colorado) Bookbinder, J. (JILA)	dMe flare stars. 6 and 20-cm line.
AB-395	Brown, A. (Colorado) Drake, S. (Goddard) Mundt, R. (MPI-Heidelberg)	Inner emission regions of HL Tau and XZ Tau. 2 and 6 cm.

No.	Observer(s)	Program
AB-396	Braun, R. Walterbos, R. (Leiden) Brinks, E. (ESO)	Interstellar medium of M31. 20-cm line.
AB-398	Burns, J. (New Mexico) Moody, J. (New Mexico) Zhao, J. (New Mexico) Gregory, S. (New Mexico)	Survey of supergiant cD galaxies. 6 cm.
AB-400	Brinks, E. (ESO) Klein, U. (Bonn U.) Weiland, H. (Bonn U.)	HI and radio-continuum observations of blue, compact dwarf galaxies. 20-cm line.
AB-401	Baum, S. O'Dea, C.	Search for molecular gas in cluster accretion flows: OH absorption in NGC 1275. 20-cm line.
AB-403	Baum, S. Bridle, A. Heckman, T. (Maryland) Miley, G. (STScI) van Breugel, W. (Berkeley)	3C 98: A radio galaxy with associated extra-nuclear, optical, emission-line gas. 18 and 21 cm.
AB-405	Brown, A. (Colorado)	Bipolar flow source IRS7 and other PMS radio sources in Corona Australis. 2, 6, and 18 cm.
AB-406	Bookbinder, J. (Colorado) Lamb, D. (Chicago)	Radio emission from AE Aqr. 6 and 20 cm.
AB-408	Bookbinder, J. (Colorado) Caillault, J. (Colorado) Gary, D. (Caltech) Giampapa, M. (NOAO) Golub, L. (SAO) Linsky, J. (Colorado) Gibson, D. (NMIMT)	A first epoch, volume-limited, multi-frequency survey of M dwarf stars. 1.3, 2, 6 and 20 cm.
AB-410	Broderick, J. (VPI & SU) Condon, J. Jauncey, D. (CSIRO) Nicolson, G. (Hartebeesthoek) Preston, R. (JPL)	2300-189, a quasar with a well-modeled jet. 4-cm, single-antenna VLB.
AB-416	Brown, R.	Extended radio structure of 0235+164. 6, 18, and 20 cm.

No.	Observer(s)	Program
AC-138	Christiansen, W. (North Carolina) Stocke, J. (Steward Obs.)	Study of helical jet in 3C 436. 6 and 20 cm.
AC-146	Churchwell, E. (Wisconsin) Felli, M. (Arcetri) Massi, M. (Arcetri)	High, dynamic range, continuum mapping of Orion A. 2, 6 and 20 cm.
AC-149	Clarke, D. (New Mexico) Burns, J. (New Mexico) Norman, M. (Los Alamos) Christiansen, W. (North Carolina)	Search for active magnetic field effects in extragalactic radio sources: 3C 219 and 3C 388. 6 and 20 cm.
AC-153	Cooke, B. (Leicester) Ponman, T. (Birmingham) McHardy, I. (Leicester)	A source in the error box of the X-ray source GX349+2. 6 and 20 cm.
AC-158	Cowan, J. (Oklahoma) Branch, D. (Oklahoma)	Observations of the historical supernova 1959d in NGC 7331. 6 cm.
AC-163	Crane, P. Dahari, O. (STScI) Ford, H. (STScI) Jacoby, G. (NOAO) Ciardullo, R. (STScI)	Radio jets and the emission-line regions of active galaxies. 20 cm.
AC-164	Carilli, C. (MIT) van Gorkom, J. (Princeton) Langston, G. (MIT)	Search for neutral-hydrogen absorption along the line of sight to PKS 2020-370. 20-cm line.
AC-166	Carilli, C. (MIT) Dreher, J. (MIT) Perley, R.	Further studies of Cygnus A. 1.3, 20 and 90 cm.
AC-169	Cordes, J. (Cornell) Clegg, A. (Cornell) Heiles, C. (Berkeley) Kulkarni, S. (Caltech) Simonetti, J. Stevens, M. (Berkeley)	Faraday rotation measure toward the inner galaxy. 20 cm.
AC-170	Chance, D. (STScI) Yusef-Zadeh, F. (Columbia)	Orion Nebula. 20 cm.
AC-171	Cameron, R. Bicknell, G. Ekers, R.	Twin jet source PKS 2104-25. 90 cm.

No.	Observer(s)	Program
AC-174	Conway, J. (NRAL) Wilkinson, P. (NRAL) Cornwell, T.	Multifrequency synthesis of 3C 179. 2 and 6 cm.
AC-175	Clarke, D. (New Mexico) Burns, J. (New Mexico) Feigelson, E. (Penn State)	Multi-configuration mapping of the inner lobes of Centaurus A. 18 and 20 cm.
AD-160	de Pater, I. (Berkeley)	Jupiter Patrol. 6 and 20 cm.
AD-176	Davies, R. (NRAL) Hummel, E. (MPI, Bonn) Pedlar, A. van der Hulst, J. (NFRA) Wolstencroft, R. (Royal Obs.)	Nuclei of Sbc galaxies. 6 cm.
AD-180	Dickel, H. (Illinois) Goss, W. M.	H_2CO towards W 49A. 6-cm line.
AD-181	de Pater, I. (Berkeley) Dickel, J. (Illinois)	Saturn. 6 cm.
AD-182	Dahari, O. (STScI) Brosch, N. (Wise Obs.)	Interacting, elliptical, irregular galaxy pairs. 20 cm.
AD-186	de Pater, I. (Berkeley) Gulkis, S. (JPL)	Neptune. 6 and 20 cm.
AD-187	Drake, S. (Goddard) Linsky, J. (Colorado)	Radio emission in B-type magnetic helium stars. 2, 6 and 20 cm.
AD-188	Drake, S. (Goddard) Simon, T. (Hawaii) Florkowski, D. (USNO) Stencel, R. (Colorado) Bookbinder, J. (Colorado) Linsky, J. (Colorado)	Long-term variability in M supergiants: Alpha Ori, Alpha Sco A, and Alpha 1 Her. 2 and 6 cm.
AE-47	Eales, S. (Hawaii) Devereux, N. (Hawaii)	Observations of the 50 nearest starburst galaxies. 6 and 20 cm.
AF-125	Feretti, L. (Bologna) Giovannini, G. (Bologna) Gregorini, L. (Bologna)	The NAT galaxy in Abell 115. 6 cm.
AF-128	Fiedler, R. (NRL) Dennison, B. (VPI & SU) Johnston, K. (NRL)	Search for refractive scintillation in CTA 26. 20 and 90 cm.

No.	Observer(s)	Program
AG-145	Geldzahler, B. (NRL) Schwartz, P. (NRL) Gear, W. (Queen Mary College) Ade, P. (Queen Mary College) Robson, E. (Preston Polytech) Nolt, I. (Oregon) Smith, M. (Royal Obs.)	Simultaneous multifrequency observations of blazers. 1.3, 2, 6, 20, and 90 cm.
AG-181	Giovannini, G. (Bologna) Feretti, L. (Bologna)	High-resolution observation of NGC 4869. 6 cm.
AG-189	Glendenning, B. (Toronto) Kronberg, P. (Toronto)	Peculiar spiral NGC 2146. 6 and 20 cm.
AG-220	Garrington, S. (NRAL) Conway, R. (NRAL) Leahy, J. (NRAL) Laing, R. (RGO)	Depolarization asymmetries and jet sidedness. 6 and 20 cm.
AG-222	Gaume, R. (Michigan)	Investigation into the nature of OH 340.78-0.10. 6 and 18-cm line.
AG-224	Gaume, R. (Michigan) Mutel, R. (Iowa)	Evidence of supernova induced star formation? 18-cm line.
AG-225	Garwood, R. (Minnesota) Dickey, J. (Minnesota) Perley, R.	Continuum survey of the galactic plane. 20 cm.
AG-226	Gunn, J. (Princeton) Knapp, G. (Princeton) van Gorkom, J. (Princeton)	Measurement of the thickness of the HI disks in the edge-on spiral galaxies NGC 891, NGC 4565, NGC 7814. 20-cm line.
AH-195	Hjellming, R. Davis, R. (NRAL)	Recurrent Nova RS Oph. 1.3 cm.
AH-227	Hjellming, R.	1741-038: a rapid "scintillator." 2, 6, and 90 cm.
AH-228	Henkel, C. (MPIR, Bonn) Wilson, T. (MPIR, Bonn) Mauersberger, R. (MPIR, Bonn) Walmsley, M. (MPIR, Bonn) Johnston, K. (NRL)	Ammonia masers in hot molecular clouds. 1.3-cm line.
AH-230	Hummel, E. (MPIR, Bonn) Kotanyi, C. (ESO) van Gorkom, J. (Princeton)	Peculiar radio features in NGC 4388 and NGC 4438. 6 cm.

No.	Observer(s)	Program
AH-231	Hummel, E. (MPIR, Bonn) Jorsater, S. (ESO) Lindblad, P. (Stockholm Obs.) Sandqvist, A. (Stockholm Obs.)	Central region of NGC 613, a peculiar radio source. 2 and 6 cm.
AH-234	Heeschen, D. Wrobel, J. (NMIMT)	Clumpy irregular galaxies. 2 cm.
AH-235	Henkel, C. (MPIR, Bonn) Ho, P. (CFA) Martin, R. (Steward Obs.) Turner, J. (CFA)	Extragalactic H_2O maser in IC 10. 1.3-cm line.
AH-236	Hughes, V. (Queen's) MacLeod, G. (Queen's)	Star-forming regions. 6 cm.
AH-238	Hooimeyer, J. (Leiden) Barthel, P. (Caltech) Schilizzi, R. (NFRA) Miley, G. (STScI)	Comparison of large and small-scale structure in extended quasars. 2 and 6 cm.
AH-239	Hewitt, J. (MIT) Turner, E. (Princeton) Langston, G. (MIT) Burke, B. (MIT)	Two gravitational lens candidates. 2 cm.
AH-240	Habbal, S. (CFA) Withbroe, G. (CFA) Gonzalez, R.	Solar coronal bright point emission. 20 and 90 cm.
AH-241	Heaton, B. (Kent, UK) Little, L. (Kent, UK)	Disk-outflow source G35.2N. 2 and 6 cm.
AI-24	Irwin, J. (Toronto) Seaquist, E. (Toronto) Duric, N. (British Columbia) Taylor, A. (Groningen)	Neutral-hydrogen observations of NGC 3079. 21-cm line.
AI-27	Israel, F. (Leiden Obs) Skillman, E. (NFRA)	NGC 2403. 20 cm.
AI-28	Irwin, J. (Toronto) Seaquist, E. (Toronto) Duric, N. (British Columbia)	Four edge-on spiral galaxies. 20 cm.

No.	Observer(s)	Program
AJ-135	Johnston, K. (NRL) Bowers, P. (NRL) Florkowski, D. (USNO) de Vegt, C. (Hamburger Sternwarte) Lestrade, J. (Bureau de Longitude)	Hipparcos reference stars. 6 cm.
AJ-138	Jorsater, S. (ESO) van Moorsel, G. (ESO) Lindblad, P. (Stockholm Obs.)	High-resolution, HI study of the barred spiral galaxy NGC 1365. 20-cm line.
AJ-140	Jaffe, W. (Leiden) Owen, T. (SUNY) Caldwell, J. (SUNY)	Thermal radiation from Titan. 2 cm.
AJ-141	Jauncey, D. (CSIRO) White, G. (Royal Obs) Savage, A. (Royal Obs) Condon, J.	Positions of southern flat-spectrum sources. 6 cm.
AJ-144	Jackson, P. (Maryland) Kundu, M. (Maryland)	Survey of Hyades Cluster. 20 cm.
AK-144	Kronberg, P. (Toronto) Sramek, R.	Monitoring M82. 1.3 and 2 cm.
AK-147	Kulkarni, S. (Caltech) Djorgovski (Harvard)	Deep radio map of IE 0630+178 Geminga field. 20 cm.
AK-150	Kundu, M. (Maryland) Jackson, P. (Maryland) White, S. (Maryland)	Synoptic observations of a complete sample of nearby flare stars. 6 and and 20 cm.
AK-151	Kundu, M. (Maryland) Jackson, P. (Maryland) White, S. (Maryland)	Observations of narrow-band flares on red dwarf stars. 6 and 20 cm.
AK-152	Kundu, M. (Maryland) Jackson, P. (Maryland) White, S. (Maryland)	Observations of narrow-band flares on red dwarf stars. 6 and 20 cm.
AK-153	Killeen, N. O'Dea, C. Bridle, A.	Extragalactic radio jets. 90 cm.
AK-154	Keto, E. (Harvard) Ho, P. (CFA) Haschick, A. (Haystack)	Temperature map of collapsing molecular core G10.6-0.4 at 0.01 PC resolution. 1.3-cm line.

No.	Observer(s)	Program
AK-159	Kassim, N. (Maryland) Baum, S.	Two peculiar SNRs with evidence for steep spectrum components. 2, 6, 20, and 90 cm.
AL-113	Leahy, J. (NRAL)	Faraday rotation and depolarization in classical double radio sources. 6, 18, and 20 cm.
AL-122	Leahy, D. (Calgary) Kwok, S. (Calgary)	Einstein galactic plane X-ray sources. 20 cm.
AL-123	Langston, G. (MIT) Carrilli, C. (MIT) Burke, B. (MIT)	Radio cluster 1355+083. 6, 20, and 90 cm.
AL-124	Leahy, J. (NRAL) Muxlow, T. (NRAL) Stephens, P. (NRAL) Morison, I. (NRAL)	Spectral mapping of classical doubles. 20 cm.
AL-125	Leahy, J. (NRAL) Muxlow, T. (NRAL) Shone, D. (NRAL)	Bridges of distant radio sources. 20 cm.
AL-126	Lang, K. (Tufts) Willson, R. (Tufts)	Coordinated observations of the quiet sun. 2 and 6 cm.
AM-166	Mahoney, M. (Maryland) Erickson, W. Becker, R. (Calif., Davis) Helfand, D. (Columbia)	Pulsar candidate in the globular cluster M 28. 20 and 90 cm.
AM-174	Miley, G. (STScI) van Breugel, W. (Berkeley) Chambers, K. (Johns Hopkins)	Properties of ultra-steep-spectrum radio sources. 6 cm.
AM-179	Muhleman, D. (Caltech) Berge, G. (Caltech) Grossman, A. (Caltech)	Saturn: properties of the atmosphere and rings. 6 cm.
AM-180	Maslowski, J. (Jagellonian) Kellermann, K.	Mapping MPWK weak sources. 6 cm.
AM-182	Masson, C. (Caltech)	Expansion of planetary nebulae. 2 and 6 cm.
AM-183	Meurs, E. (Cambridge)	Radio properties of double nucleus galaxies. 6 cm.

No.	Observer(s)	Program
AM-184	Meurs, E. (Cambridge)	Radio cores in Seyfert galaxies. 1.3 and 2 cm.
AM-186	Muhleman, D. (Caltech) Berge, G. (Caltech) Linfield, R. (JPL)	Astrometric measurements of the Neptune/ Triton system. 2 cm.
AM-190	Muhleman, D. (Caltech) Berge, G. (Caltech) Grossman, A. (Caltech)	Saturn: properties of the atmosphere and rings. 2 cm.
AN-40	Norris, R. (CSIRO) Allen, D. (AAO) Whiteoak, J. (CSIRO) Gardner, F. (CSIRO)	The new Megamaser galaxy 11506-3851. 18-cm line.
AO-62	O'Donoghue, A. (NMIMT) Owen, F. Eilek, J. (NMIMT)	Wide angle tail sources. 6 cm.
AO-72	Odegard, N. (Toronto) Seaquist, E. (Toronto)	Polarization mapping of the galaxy NGC 3631. 20 cm.
AO-73	Ondrechen, M. (Minnesota) McElroy, D. (Comp Sci Corp) van der Hulst, J. (NFRA)	Barred spiral galaxies. 20 cm.
AP-116	Pottasch, S. (Groningen) Bignell, R. C. Zijlstra, A.	Survey of planetary nebulae. 6 cm.
AP-121	Pottasch, S. (Groningen) Zijlstra, A. Bignell, R. C.	Relationship between OH/IR stars and planetary nebulae. 2 and 6 cm.
AP-122	Pedlar, A. Perley, R. Crane, P. Davies, R. (NRAL)	NGC 1275 (3C 84, Perseus A). 90-cm line.
AP-123	Pedlar, A. Anantharamaiah, K. van Gorkom, J. (Princeton) Ekers, R.	Continuum and recombination-line observations of the galactic center. 90 cm.

No.	Observer(s)	Program
AR-131	Rodriguez, L. (UNAM) Torrelles, J. (UNAM) Canto, J. (UNAM) Curiel, S. (UNAM) Ho, P. (CFA) Pravdo, S. (JPL)	Herbig-Haro 1 and 2 region. 60 and 20 cm.
AR-141	Rao, A. (TIFR) Ananthakrishnan, S. (TIFR) Ulvestad, J. (JPL)	Structure of compact sources in the galactic plane. 2, 6 and 20 cm.
AR-147	Rucinski, S. (David Dunlap) Gibson, D. (NMIMT)	Survey of evolved W Ursa Majoris stars. 2, 6 and 20 cm.
AR-148	Rudnick, L. (Minnesota) Pedelty, J. (Minnesota) Chan, V. (Minnesota)	Structural details of extragalactic radio source hot spots: 3C 33. 2 cm.
AR-152	Roeser, H. (MPI-Heidelberg) Perley, R.	Observations of the hot spot in Pictor A. 2, 6 and 20 cm.
AS-80	Sramek, R. van der Hulst, J. (NFRA) Weiler, K. (NRL)	Monitoring SN1980 in NGC 6946 and SN 1979c in M100. 6 and 20 cm.
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-262	Saripalli, L. (TIFR) Subrahmanya, C. (CSIRO) Gopal-Krishna (TIFR)	Giant radio galaxy 0503-286. 20 cm.
AS-263	Subrahmanyan, R. (TIFR) Gopal-Krishna (TIFR) Swarup, G. (TIFR) Thum, C. (IRAM, Spain)	Orion A and Orion B. 90 cm.
AS-264	Swarup, G. (TIFR) de Serego Alighieri, S. (ESO)	Search for a radio jet associated with the optical jet in 3C 227. 2 and 6 cm.
AS-265	Schwartz, P. (NRL)	Ionized bright rims. 6 cm.
AS-266	Skillman, E. (NFRA)	A super-bubble in IC 10. 20 cm.

No.	Observer(s)	Program
AS-267	Sanders, D. (Caltech) Helou, G. (Caltech) Soifer, B. (Caltech)	Complete sample of the most luminous IRAS galaxies. 20 cm.
AT-64	Taylor, A. (Groningen) Pottasch, S. (Groningen) Seaquist, E. (Toronto)	Monitoring nova Vulpeculae 1984 No. 2. 2, 6 and 20 cm.
AT-74	Turner, J. (CFA) Ho, P. (CFA) Martin, R. (Steward Obs.) Henkel, C. (MPIR, Bonn)	Extragalactic H_2O masers in NGC 253 and M51. 1.3-cm line.
AT-75	Taylor, A. (Groningen) Seaquist, E. (Toronto) Bode, M. (Manchester)	Radio and optical interferometry of symbiotic variables. 2, 6 and 20 cm.
AT-76	Taylor, A. (Groningen) Waters, L. (LSR-Utrecht) Lamers, H. (LSR-Utrecht)	IRAS selected Be stars. 6 cm.
AT-77	Turner, E. (Princeton) Langston, G. (MIT) Hewitt, J. (MIT) Burke, B. (MIT)	Gravitationally lensed pair of quasar images with a separation of 2.6 arcminutes. 6 cm.
AT-78	Turner, J. (CFA) Ho, P. (CFA) Beck, S. (Northeastern)	Spectral-index maps of Brackett line galaxies. 6 cm.
AU-25	Unger, S. (NRAL) Axon, D. (NRAL) Pedlar, A. (NRAL) Taylor, K. (RGO) Wolstencroft, R. (ROE)	Gas ejection in the hot-spot galaxy NGC 1808. 6 and 20-cm line.
AV-96	van der Hulst, J. (NFRA) Sramek, R. Weiler, K. (NRL)	Radio supernova in NGC 4258. 6 and 20 cm.
AV-127	van Breugel, W. (Berkeley) McCarthy, P. (Berkeley) Heckman, T. (Maryland) Miley, G. (STScI)	Three radio galaxies with extended emission line. 2, 6, and 21 cm.
AW-158	Wood, D. (Wisconsin) Churchwell, E. (Wisconsin)	Ultracompact HII regions. 1.3 and 2 cm.

No.	Observer(s)	Program
AW-160	Wootten, H. A.	Search for an ionized component in the L1689N bipolar flow. 2 and 6 cm.
AW-162	Whiteoak, J. (CSIRO) Wood, P. (Mt. Stromlo) Bessell, M. (Mt. Stromlo)	OH/IR stars in M31. 18-cm line.
AW-163	Welch, D. (DRAO) Duric, N. (British Columbia)	Search for emission from Cepheid variable stars. 6 cm.
AZ-30	Zijlstra, A. Bignell, R. C.	Identification of a suspected radio galaxy. 20 cm.
VAH-48	Bartel, N. (CFA) Unger, S. (NRAL)	Supernova in NGC 891. 18-cm phased array VLB.
VP-75	Phillips, R. (Haystack)	18-cm phased array VLB.
VS-65	Spangler, S. (Iowa) Benson, J. Cordes, J. (Cornell) Mutel, R. (Iowa)	Interstellar scattering of 2013+370.

F. SCIENTIFIC HIGHLIGHTS

Saturn's Atmosphere and Rings

Multi-configuration, 20, 6, and 2-cm VLA observations of the Saturn system have recently been completed during the current phase of maximum ring opening angle. The observations will be combined with maps made at other ring opening angles to learn more about the distribution of particle sizes in the three principal rings of Saturn, supplementing the information already obtained from IR, visual, and radar earth-based observations, and Voyager UV stellar occultation experiments.

The most recent 6-cm maps show three aspects of the Saturn system that have not been previously observed: (1) A wide band about 5 K warmer than the surrounding disk occurs between 30 and 50 degrees North latitude--evidence of a zonal clearing that enables deeper, warmer parts of the atmosphere to be seen. (2) Flux from the sides of the rings is linearly polarized as it scatters perpendicularly into the line of sight. (3) The brightness difference between the front and rear of the ring system clearly demonstrates that forward scattering dominates.

Optically Obscured Galaxies

Neutral hydrogen has been clearly detected from four recently discovered galaxies that are seen towards the "Zone of Avoidance," the heavily obscured region associated with the plane of the Milky Way. A pilot program on the 300-foot telescope observed approximately 300 arbitrarily selected beam areas near the galactic equator, out to 7000 km/sec. Two of the galaxies appear to be in the IRAS point source catalog, and all four appear to be either spiral or irregular. New galaxies found in the uninvestigated 20 percent of the sky may be important additions to the Local Group or they can provide additional data for studies of the large-scale structure of the extragalactic universe.

New Maser Transition in Megamaser Galaxies

A new maser transition at 6035 MHz from the $^2\Pi_{3/2}$, J = 5/2 excited rotational state of OH was successfully detected with the 140-foot telescope from the megamaser galaxy IC 4553. There are seven known megamaser galaxies as defined by the detection of 18-cm OH Λ doublet transitions, and the $^2\Pi_{1/2}$, J = 1/2 excited rotational state transitions at 6 cm have also been detected in a few of these. Now that centimeter-wave lines (5 cm and 6 cm) have been seen from two excited rotational states of OH in a megamaser galaxy, other lines are also being sought from higher rotational levels. Knowledge of these transitions potentially provides important constraints on the physics of the excitation process and the physical parameters of the emitting gas. For IC 4553, detection of the 5-cm absorption line, velocity shifted by ~4500 km/sec, was a noteworthy technical achievement. Maintenance of a baseline ripple of less than 1 mK over the 40-MHz bandwidth was required in order to detect the 300 km/sec wide, weak line.

Supernova

A previously unrecognized supernova was identified on a recent VLA image of the edge-on spiral galaxy NGC 891. Twenty-one centimeter absorption confirms the object to be located in the disk of the galaxy. Discovery observations in August locate the object 1.5 arcminutes from the nucleus, with a radio power that outshines the nucleus by more than an order of magnitude. It is five times more powerful than any known radio supernova. Recently obtained optical spectra show Hydrogen Balmer-line ratios reminiscent of those in Lk Hα 101 or η Car, although no Paschen α is present. With line widths as narrow as 750 km/sec, the object may be a Class V supernova. Maximum optical light output may have occurred as early as 1982 since the rise to maximum radio flux is normally much delayed. Prediscovery elevated radio flux levels have been measured on VLA images from 1984 and 1985, and prior to that the region showed characteristics of a normal HII region.

UV Ceti Flares

Two extremely unusual flares from the late-type dwarf star UV Ceti were recently observed with the VLA in spectral-line mode. At least one of the flares, reaching a peak 20-cm flux of 220 mJy, is believed to be the most intense microwave flare ever recorded. During its one minute duration, it was equally intense in all channels and 100 percent LH circularly polarized. The second, less intense but longer-lasting flare (150 mJy, 15 minutes) exhibited complex temporal variations and was predominantly RH circularly polarized. Most noteworthy, however, were the frequency features of the latter flare. The flare was generally characterized by irregularly distributed features in frequency space, some of which slowly drifted toward higher frequencies at rates of 1 to 2 MHz/sec. Frequency drifting is a clear signature that coherent emission mechanisms are operative in stellar microwave flares. At the moment, however, the observations cannot clearly differentiate the root cause of the stellar flare activity to be either cyclotron maser emission or unspecified plasma radiation effects.

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

On June 1, 1985 work began on the further development and construction of thirty 8.4-GHz receivers for use on the VLA for reception of telemetry signals from the Voyager 2 spacecraft. The VLA will be used for reception of television pictures of Neptune during a brief period centered on August 24, 1989. Construction of the front-ends has begun. The first unit utilizing FET amplifiers was delivered to the VLA in February 1986, and the construction schedule will be completed by the end of 1987.

Receiver noise temperatures of ~14 K and 32 K have been measured on several systems utilizing HEMT and FET amplifiers. Adding ~15 K for antenna temperature, a system S/N improvement of 2.1 dB is achieved with HEMT's. A decision to use these devices in the front-ends has been made.

During this quarter three front-ends (S/N's 3-5) were shipped to the VLA.

23 GHz HEMT/FET Amplifier Development

Two four-stage FET amplifiers giving ~120 K average noise temperature from 22 to 25 GHz have been delivered to the VLA and have been incorporated in a front-end upgrade. Two additional FET amplifiers and two additional amplifiers with GE HEMT first-stages are in the final testing period. The HEMT units are giving 40 K minimum noise temperature and 60 K average in the 22-25 GHz range.

The present plan is to upgrade the VLA with amplifiers at a rate of one antenna per month using HEMT amplifiers if devices are available and FET's if they are not. At a later date the FET's would be upgraded to HEMT's.

Hybrid-Spectrometer

A spectrometer, which is a hybrid of analog-filter and digital-correlator techniques, is under construction for providing 1536 channels and 2.4 GHz bandwidth on the Tucson 12-meter telescope. It is shown in NRAO Electronic Division Internal Report No. 248 that this hybrid approach gives much lower cost than an all-digital or all-analog system; this is very important for future millimeter-wave astronomy arrays.

The prototype one-eighth of the system was completed and tested on the 12-meter telescope this quarter. The performance was good (see HYSPEC Memo No. 8) and construction of the final system has started, with an expected completion date of December 1987.

Superconducting (SIS) Millimeter-Wave Mixer Development

Theoretically, SIS mixers have noise temperatures many times lower than Schottky diode mixers, and experiment has already demonstrated a factor of two advantage in sensitivity at 115 GHz. It is believed that most future spectral-line astronomy in the range 50 to 500 GHz will be performed with SIS mixer receivers. This development involves design and testing of SIS mixers and junctions at NRAO, and SIS device fabrication through contracts with the University of Virginia and the National Bureau of Standards.

Recent studies have shown that SIS <u>direct detectors</u> for millimeter wavelength continuum astronomy should have extremely good sensitivity, and may have saturation power levels far above those of SIS mixers. It is planned to conduct tests of SIS direct detectors to see if a suitable post-detector amplifier can be found which will result in low overall NEP.

Receiver noise temperatures below 100 K SSB at 115 GHz are now routinely obtained in the laboratory using Pb-alloy junctions operated at 2.5 K and all-niobium junctions at 4.2 K. Mixers using Nb junctions manufactured by Hypres are now installed on the 12-meter Kitt Peak telescope and give receiver noise temperatures between 90 K and 126 K SSB, depending on IF bandwidth and which receiver channel is used. These numbers include all input optics losses (beam-splitter, lens, and vacuum window). Close collaboration with the Semiconductor Device Laboratory at the University of Virginia continues as we develop refractory SIS junctions incorporating on-chip microwave tuning circuits for operation up to 360 GHz. The first mask set has been designed using the GE-Calma CAD system at the University. The Calma tape is now being processed at Tau Laboratories which will produce the final five-level mask set using e-beam lithography. Critical dimension tolerances on these masks will be within $\pm$ 0.05 µm (500 Å). In addition to SIS mixers for 2.6 and 1.3 millimeter wavelength, the mask set includes special long, thin junctions for Fiske-step measurements, SQUID's, and a parallel-plate capacitor. These will help us to characterize the junction and material properties.

Experimental mixer junctions for 70-120 GHz are being fabricated to our design by IBM (Watson Research Laboratory) under a joint study agreement and should be delivered soon.

Schottky-Diode Millimeter-Wave Mixer Development

Cryogenically cooled Schottky-diode mixers have been in use for almost all millimeter-wave astronomy for the past ten years. NRAO has pioneered the development of the mixers, both in circuit design and, by contract to the University of Virginia, in the development of the diode devices.

We have experienced great difficulty in obtaining reproducible performance from Schottky diode mixers in the shorter millimeter bands, and believe the problem lies in the mechanical differences between the mixer blocks, and even in the differences between successive "whiskers" used in the same mixer. During this quarter, we have assembled or re-contacted ~30 mixers, mostly in the 200-240 GHz and 240-270 GHz bands, in attempting to optimize performance. We have started using the large-chamber scanning electron microscope at UVA Semiconductor Device Laboratory for contacting diodes and making accurate photographs of mixers every time they are contacted. Servo-mechanisms in the SEM allow positioning of the diode whisker within a fraction of a micron.

The first of four compact, room-temperature, 225-GHz radiometers for millimeter array site testing has been delivered to the VLA, with a noise temperature of 1500 K DSB. The three remaining units are under construction.

A number of 200-240 GHz mixers are being fabricated for the four-beam (eventually eight-beam) 230-GHz receiver on the 12-meter telescope and for the 225-GHz site testing receivers. The mixers with the best cryogenic performance are being kept for the multi-beam receiver, and the weaker ones are being used for the site-testing receivers.

Planar Mixer-Antenna Development

The goal of this research is to develop compact, multi-beam receivers using planar arrays of closely spaced antenna feed elements coupled to SIS junctions. The receivers can be designed to operate either as direct detectors or in heterodyne mode. With direct detectors, the receiver array is located at the focal plane of the telescope and gives a "photographic" image with one output for each pixel. With heterodyne receivers, the array is located either in the focal plane or at a virtual (i.e., transformed) aperture plane of the telescope, in which case it operates as a phased array, forming many beams simultaneously by appropriate combining and phasing of the individual IF signals. This "multi-beaming" would greatly advance the speed or sensitivity of millimeter-wave astronomy. The planar, log-periodic antenna has been studied using lower-frequency scale models, and appears suitable as the basic element of an array.

This work is of low priority at present because of the heavy burden of servicing existing Tucson equipment and developing new SIS and Schottky receivers. Questions needing answers before committing ourselves to further work on planar multi-beam receivers are: (i) If our hybrid back-end can only handle eight IF's, will the planar array be in any way superior to eight conventional SIS receivers? (ii) How do we connect IF and bias to an array of, say, 50 mixers in an area 5 mm x 5 mm? (iii) What is the best way to make an IF processor to give correct gain and phasing in 50 channels and produce eight IF outputs? (iv) How can we achieve LO injection with sufficient uniformity to drive SIS mixers? (v) Can we realize an SIS direct detector with sufficient sensitivity to make an array of direct detectors useful?

Millimeter Local Oscillator Sources

Millimeter-wave frequency multipliers developed at NRAO are now used as local oscillators for virtually all observations on the 12-meter telescope. Planar (whiskerless) Schottky diodes, being developed under the University of Virginia contract, promise improved performance and reliability in the future.

We have designed, but not yet tested, a waveguide tripler for the new 290-310-GHz receiver at Kitt Peak. We hope this will cover 280-360 GHz, thereby superceding the old quasi-optical tripler.

We have fabricated three new 200-280 GHz triplers for use on the 230 GHz multi-beam receiver and the site-testing receivers. Using the scanning electron microscope at the University of Virginia, we have been able to achieve good reproducibility from one tripler to the next.

I. GREEN BANK ELECTRONICS

6-cm, 7-Feed Receiver

Initial observations were made with the new 6-cm, seven-feed receiver at the 300-foot telescope during the period 27 August to 29 September. From the observational data obtained during this run, along with results of other tests, the following conclusions regarding receiver performance may be made:

1. Sensitivity: Tests indicate that all channels except three are theoretically noise limited. The noise fluctuations of one channel appear to be two to three times higher than theoretical, a second exhibits refrigeration modulation three to four times the noise level, and a third channel is unstable about one percent of the time but noise limited the remainder of the time.

2. Gain Stability: Except for the channels described above, the gain stability with time, telescope position, and motion appears excellent.

3. Noise Temperature: Noise temperatures of the channels on the telescope are 65 ± 5 K. This is 10 to 15 K above original estimates. Since the original calibrations were done, a waveguide liquid nitrogen termination has been constructed and more careful calibration of the

system will be done. Investigations into other possible causes of the high noise temperature will also be done.

Work will continue to correct these problems, but the system is now considered ready for use on a scheduled basis.

Adaptive Array Receiver

The 400-500 MHz adaptive array receiver is expected to increase the useful hour-angle coverage of the 300-foot telescope. A properly designed feed array should permit tracking of a source over the full 46 feet of the traveling feed track with minimal loss in gain; currently, only about half of the track can be effectively used.

Computer programs have been developed to calculate the primary antenna beam for various array configurations and scan angles. Given that beam pattern, the resulting antenna gain can be determined. Linear eight-element and two-dimensional 4 x 4 arrays have been analyzed. The two-dimensional array seems to give superior results, but more work needs to be done to optimize the array phase and amplitude adjustments.

Two prototype, low-noise, room-temperature GaAs FET amplifiers have been constructed. The phase and amplitude match of these amplifiers is adequate, but more work is required to improve the amplifier VSWR.

140-foot Beam Splitter

Two cassegrainian upconverter-maser systems are available on the 140-foot telescope, but until recently observations using both receivers simultaneously were not possible. During this quarter, several years of work culminated with the installation of a beam splitter on the telescope that allows dual-polarization observations. The splitter works by illuminating a grid of wires with the offset subreflector. Angled reflectors behind the grid direct the two polarizations to separate ellipsoid reflectors that in turn illuminate the receiver feeds. The ellipsoids can be removed from the beam path, allowing single-channel observations in the usual way.

This system is usable with any combination of feeds above 8 GHz, allowing either dual-polarization measurements at a single frequency or observations at two separate frequencies. Initial tests indicate good results, but further testing is scheduled for this winter.

J. TUCSON ELECTRONICS

Schottky Mixer Receivers

70-120 GHz Receiver

During the shutdown period the klystron, local oscillator system in this receiver was replaced with Gunn oscillators. The phase-locking circuits perform well, and this modification should increase the reliability of the receiver and greatly reduce operating costs.

200-270 GHz Receiver

This receiver is also being modified to replace the klystrons with Gunn oscillators. The receiver will be installed on the telescope in November, with two channels covering 200-270 GHz. The noise temperature of the receiver varies from 500 K SSB to 1100 K SSB over this frequency range.

270-310 GHz Receiver

A mixer and tripler for this band are being developed in the Central Development Laboratory. Due to limitations in LO power, we intend to support this band with a single-channel receiver for the next observing season. During next summer shutdown, we hope to add this band to the 200-270 GHz receiver in dual-channel forms.

330-360 GHz Receiver

The local oscillator in this receiver is being replaced with a Gunn oscillator and quadrupler. The receiver is a single channel at the present time and expansion to two channels may be possible in the future if sufficient LO power is available.

Eight-Feed, 230-GHz Receiver

The construction of the four-feed, prototype receiver for this project is almost complete, and we hope to test it on the telescope early next year. The receiver is designed to cover the frequency range 220-230 GHz and will have four beams in a line with a beam separation of 80 arc seconds. A single Gunn oscillator provides LO power for the four feeds, and expansion to eight feeds will simply consist of duplicating the existing system.

SIS Receiver

The new niobium junctions fabricated by the Central Development Laboratory have been incorporated into this receiver during the quarter. The noise temperature is now less than 100 K SSB at 115 GHz, with an image rejection of about 20 dB. The aperture efficiency is now around 45 percent, a similar value to the Schottky receiver.

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.

When the VLA antennas are heated by the sun at low-elevation angle, differential temperatures of up to 5°C have been observed across the antenna structure. Under these conditions the pedestal and yoke of the antenna can bend significantly and cause pointing errors of up to one arcminute. This problem is being cured by coating the critical parts of the antenna structure with insulation to reduce the temperature differentials. Currently, twenty-four antennas have insulation installed, and coating of all antennas will be finished in 1987.

Another, lesser, 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.

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-meter antennas with simple dipole-type feeds. If modest efficiency results (anything more than 15% will be adequate), we should be able to collect sufficient data from the 25-meter antennas at this frequency for testing purposes. Note that if every 25-meter 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.

Four antennas now have 75-MHz receivers and a log-periodic antenna outrigged on the side of the 25-meter reflectors. Two new dipole feeds have been designed; one a crossed dipole type, the other a quad dipole type. These were installed on two antennas and testing is to continue during the next quarter. With the new feeds installed near the focus of the antenna, locally generated radio-frequency interference became a significant problem (see RFI Improvements).

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-meter 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.

Fifteen antennas now have 327-MHz receivers installed, and this system is undergoing test and evaluation. The final feed configurations has been determined. To reduce local RFI, two RFI enclosures for the vertex mounted "B" racks in antennas 20 and 21 have been installed (see RFI Improvements).

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. Finally, the 8.4-GHz front-ends would enable the VLA to be used in planetary radar experiments with the Goldstone transmitter. The NRAO Central Development Laboratory has developed this front-end which is presently using GaAs FET amplifiers. Improved HEMT (High Electron Mobility Transistor) amplifiers were incorporated into the third system this quarter.

Four 8.4-GHz front-ends have been received from the Central Development Laboratory in Charlottesville and have been installed on six 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 25 X-band systems will continue through 1988.

RFI Improvements

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

Two RFI enclosures for the vertex mounted "B" racks have been installed and tested, eliminating 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. Two more RFI enclosures have been ordered this quarter. It is expected that they will be installed the first quarter of 1987.

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 half 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 NH3. 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 Green Bank Electronics Division will be used to replace present 5-GHz paramps. The prototype "A" rack has been installed on Antenna 25. Testing of this system to continue during the next quarter.

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 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 a separate, optimized receiver. 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, with testing of this receiver to continue during the next quarter.

L. AIPS

An IVAS television display was purchased from International Imaging Systems for use with AIPS. It has memory for two 12-bit deep images 1024 on a side, giving both wider dynamic range and more pixels than our older IIS Model 70 displays. The IVAS was initially installed on the VAX and the AIPS Y routines to drive it were written and debugged. In the process, the AIPS model for TV displays was improved, which should make it easier to port AIPS to still more display devices. The IVAS will now be moved to the Convex after certain host software problems are resolved.

During this quarter two new map/deconvolution tasks were released: BSMAP performs mapping, self-convolution, and cleaning on date of low signal to noise in small fields and SDCLN performs a variation of the Steer-Dewdney-Ito deconvolution. New verbs include ones to set and to clear the output image name, TV display annotation, and an interactive split-screen TV display for comparing images. Significant improvements include support for "tape" IO to disk files and a revised tables format which allows a column to consist of arrays. Antenna files were converted into this format. These developments were part of the work on a package of calibration tasks which is now progressing well. The Cookbook was updated (particularly in the machine-specific Appendix) and changed to chapter-based page numbering. At this writing, it is being reproduced in Green Bank and three-ring binders are being prepared.

M. VERY LONG BASELINE ARRAY

Project Management

A further shift in the order of station construction has been made to concentrate construction and antenna erection activities in southerly locations in wintertime. The order now is: (1) Pie Town, NM, (2) Kitt Peak, AZ, (3) Los Alamos, NM, (4) North Liberty, IA, (5) Fort Davis, TX, (6) Brewster, WA, (7) St. Croix, USVI, (8) Owens Valley, CA, (9) Mauna Loa (probably), HI, (10) Northeast site, not yet fixed.

Systems Engineering

This Project-wide technical oversight function has been assumed, during the construction phase, by a Committee which includes senior members of different Project Groups, working closely with the Project Manager.

Sites/Stations

At Pie Town, the antenna foundation is complete, the alidade track has been aligned and grouted in place, and the pintle bearing has been set. Much of the antenna structure is on site, and assembly is proceeding on schedule. The control building is under roof, and partitions and shielding are being installed.

At Kitt Peak, pouring of the antenna foundation is in progress. The control building walls are up, and plumbing is being installed, ready for pouring of the floor slab.

For Los Alamos, the construction contract is in place, excavation is starting, and concrete pouring will begin in mid-October.

North Liberty construction drawings are complete, the pre-bid conference is scheduled for October 8, and bids for the foundation will be due October 28.

The Fort Davis site has been bought, and the survey and soils tests are nearly complete.

A good site for the St. Croix station has been found on land owned by Fairleigh Dickinson University, and negotiations for its purchase or long-term lease are under way.

Antennas

At the Pie Town Station, progress indicates that this antenna will be ready for acceptance tests by mid-December. Manufacture of the next three antennas has begun on schedule.

Contracts have been let for feed cones, focus rotation mounts (FRM) and subreflectors for the first several antennas, and design and manufacturing activities are progressing well. The Pie Town feed cone was delivered and is now being outfitted with electronics and feeds in the VLA antenna assembly building. It is scheduled for installation at Pie Town in November. The first FRM is expected late this year, and will also be outfitted at the VLA.

Electronics

The three electronics racks for the Pie Town station were completed and shipped in late September to the VLA for overall system tests in conjunction with the Station computer and other elements of the Monitoring and Control (M/C) system. These include Rack "C", the Master LO Rack, to be located in the control building, and Racks "A" and "B", located in the antenna vertex room and containing the front ends, converters, LO synthesizers, etc. Front end prototypes shipped include 15-, 10.7-, 4.8- and 1.5-GHz cooled units, and the 330/610-MHz room temperature unit. All of the above equipments have been satisfactorily tested prior to shipment. Tests included monitoring and controlling of the modules through the Monitor/Control (M/C) interfaces, using a personal computer to simulate the station computer.

Racks for the Kitt Peak electronics are in hand, and building is in progress. Construction of electronics for the later stations will be paced by funding limitations. While receivers are provided for Pie Town at most of the planned frequencies in order to prove out the antenna and other equipment designs, later stations will initially have receivers only at 1.5, 4.8 and 23 GHz.

Data Recording

Prototyping of the Data Acquisition System (DAS) at Haystack Observatory is behind schedule as a result of some problems in meeting VLBA specifications, particularly with regard to the 12-hour continuous recording time between tape changes, and the flexibility required in the formatter design. A solution has been agreed upon, and the first prototype electronics rack (DAR1) and its accompanying recorder (REC1), now under construction, are scheduled to be available to NRAO in January, 1987 for test and installation at Pie Town. Additional units DAR2 and REC2 are also to be furnished under the prototype phase of the contract.

A proposal from Haystack covering some additional, partially optional, development work, plus the first phase of the production program, is under study at NRAO. This first production phase will include three DAR's and three REC's, sufficient to support the checkout and initial operation of Kitt Peak, Los Alamos, and North Liberty. NRAO plans to negotiate a contract change order authorizing a part of this work under 1986 funding, and the remainder in 1987.

Effort on the Data Playback System (DPS) has been reduced temporarily to provide additional effort to prevent further schedule slippage of the data acquisition equipment. The Correlator program should not require these for some time in any event.

Monitoring and Control

Assistance was provided to the antenna contractor's servo design group in tests of their control system in conjunction with NRAO's monitoring and control equipment. Equipment provided included a standard VLBA interface board and a Compaq microcomputer, together with an appropriate software system with documentation.

The Pie Town Station computer was delivered to the VLA on September 2, and previously developed software for the VLBA system tests was brought up on this processor.

A preliminary version of a general-purpose screen display (for handling devices for which a special display has not been written) has been completed, and work has begun on specialized screens. The subroutine package that handles screen displays was further refined for improved maintainability.

Software has been written which converts the ASCII text string prepared by an observer into the internal constructs used by the station computer while observing. Work continues on the part of the monitor data handling system needed for stand-alone pointing observations and on an internal time-keeping system for the station computer.

Reliability problems continued with the Alcyon C compiler and accompanying subroutine libraries.

Detailed specifications for the weather stations were completed and the first procurement were initiated.

Correlator

Refinement of the conceptual design of a spectral-domain correlator for the VLBA continued, toward the complete characterization necessary for deciding whether to adopt such an architecture. The many possible modes, representing tradeoffs among the available options and features, were specified in greater detail. The transform length was fixed, provisionally, at 2048 samples. The choice between a radix-2 or -4 FFT implementation, on the other hand, became less clear upon further investigation of cost, and plans for both versions are being carried at present. Number representation schemes and ranges of allowable values were optimized throughout the system. Numeric precisions were also specified -- subject, however, to later ratification based on simulation results.

Analytic studies of finite-precision sample weighting and multi-level fringe rotation, while not yet complete, have shown that both can be accomplished satisfactorily and without serious degradation from quantization effects. Analysis of quantization noise in the FFT computation suggested a minimum numeric precision required there, but the complexity of this operation is such that potential systematic effects will only be revealed by simulations.

Work continued on the development of a large-scale computer simulation of the entire spectral correlator data path. This program has now been generalized to allow tests of various number representations and precisions, and several large data sets of 0.5 megasamples each, appropriately filtered to simulate different spectral characteristics, have been constructed. The detailed, bit-level simulation employed is unavoidably compute-intensive; runs on the Observatory's Convex C-1 computer have been restricted to 32 megasamples by practical limitations on computing time. This level suffices for verifying the accuracy of simulation and for some studies of specific quantization effects in the sample weighting and FFT sections, but cannot reach the extremes of dynamic range necessary to detect the systematic problems which may occur with real data. Time for more extensive runs has been arranged on the Cray-XMP at the Pittsburgh Supercomputing Center, and adaptation of the simulation program to this system is in progress.

In one new area of FX study, the configuration and specifications are being developed for the major computer hardware elements throughout the correlator system. These support the correlator control function, post-correlation processing, archive management and translation to distribution format, and fringe fitting for array calibration. This study will form an essential part of the eventual cost comparison of the FX scheme with lag correlation.

A second new area is the development of a preliminary gate-array design which would be used both for the FFT butterfly stages and for the baseline cross-multiplication. The preliminary logic design is now complete, and a breadboard version using MSI components is being developed. A detailed design is vital both for cost estimation and realistic simulations.

Data Processing

Most of the software needed for normal processing of astronomical data from the VLBA is already in routine production use. Development is needed in three general areas: (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).

1) A preliminary version of the distribution tape has been designed. Software has been written to convert data from the NRAO MkII VLBI correlator into the form of the proposed VLBA distribution tape. This software is partly operational, and is being used to read data for developing item 2), below.

2) The preliminary design of the calibration software has been done and is now being implemented. The continuum calibration routine has been written and is in the advanced stages of debugging.

3) The concerns of geometric accountability are being included in the design of all software and data structures, although little direct effort in this area has as yet been possible.

N. PERSONNEL

Appointments

Thomas H. Troland	Visiting Scientist	07/11
Patrick E. Palmer	Visiting Scientist	07/18
John F. Dowling	VLBA Contract Administrator	08/18
Jozef Maslowski	Visiting Scientist	08/27
Eric R. Wollman	Visiting Scientist	09/01
William M. Goss	Scientist	09/01

Terminations

Gary A. Fickling	Sci. Programming Analyst	07/25
Wei-Hwan Chian	Visiting Asst. Scientist	07/31
Thomas H. Troland	Visiting Scientist	08/08
J. Thomas Armstrong	Research Associate	08/23
Geoffrey V. Bicknell	Visiting Scientist	08/29
Allan Pedlar	Visiting Scientist	08/29

Changes in Status

Felix J. Lockman	to Scientist	07/01
Juan Uson	to Associate Scientist	07/01
Jacqueline van Gorkom	to Associate Scientist	07/01

Other

Larry D'Addario	Leave of Absence	07/01
Phillip M. Dooley	Return from Leave of Absence	09/01
Jacqueline van Gorkom	Return from Leave of Absence	09/01

APPENDIX A

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