NATIONAL RADIO ASTRONOMY OBSERVATORY

QUARTERLY REPORT

October - December 1986

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A. TELESCOPE USAGE

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

	140-ft	300-ft	12-m	VLA
Scheduled observing (hrs)	1706.50	1942.75	1920.00	1597.40
Scheduled maintenance and equipment changes	138.00	209.25	91.75	220.20
Scheduled tests and calibrations	281.50	0.00	132.50	341.40
Time lost	110.50	119.75	266.00	
Actual observing	1632.00	1823.00	1654.00	1542.80

B. 140-FOOT OBSERVING PROGRAMS

The following continuum program was conducted during this quarter.

No.	Observer(s)	Program
U-23	Uson, J.	Observations of the Sunyaev-Zeldovich effect at 19.5 GHz.

The following line programs were conducted during this quarter.

No.	Observer(s)	Program
B-443	Bania, T. (Boston) Rood, R. (Virginia) Wilson, T. (MPIR, Bonn)	Observations at 3.5 cm of $^3He^+$ emission in HII regions and planetary nebulae.
B-460	Bell, M. (Herzberg) Seaquist, E. (Toronto)	Observations at 18.34 GHz of C_3H_2 in emission in Centaurus A.
C-240	Combes, F. (Meudon) Bogey, M. (de Lille) Butner, H. (Texas) Destombes, J. (de Lille) Demuynck, C. (de Lille) Encrenaz, P. (Meudon) Gerin, M. (Meudon) Wootten, H. A.	Observations at 1.5 cm to verify the detection of interstellar C_3H_2 and to search for isotopic variants.

No.	Observer(s)	Program
D-152	de Geus, E. (Leiden) Burton, W. B. (Leiden)	Observations of HI in the Ophiuchus star-forming region.
F-89	Fuller, G. (Berkeley) Ziurys, L. (CFA) Heiles, C. (Berkeley)	Observations at 700 MHz in an attempt to measure Zeeman splitting of a recently discovered transition of CH.
L-205	Likkel, L. (UCLA) Morris, M. (UCLA)	Observations of OH at 1612 and 1667 MHz toward stars with dense cold circum-stellar shells.
L-206	Lehto, H. (Virginia) Saslaw, W. (Virginia) Valtonen, M. (Turku) Heeschen, D. Seielstad, G.	Simultaneous observations of OJ 287 at 20 GHz with the VLA and Metsahovi.
M-265	Matthews, H, (Herzberg) Avery, L. (Herzberg) Bell, M. (Herzberg) Feldman, P. (Herzberg) Irvine, W. (Massachusetts) Madden, S. (Massachusetts)	Observations at 18.3 and 19.4 GHz to study (C_3HD).
P-135	Payne, H. Briggs, F. (Pittsburgh)	Observations of HI clouds toward NGC 628.
R-231	Rood, R. (Virginia) Mangum, J. (Virginia) Wilson, T. (MPIR, Bonn) Wadiak, E. J.	Observations at 3.3 and 3.4 cm to determine the value of ^{13}C in HC_3N and to establish evidence for isotopic fractionation.
R-235	Rodriguez, L. (Mexico) Canto, J. (Mexico) Mirabel, I. (Puerto Rico) Torrelles, J. (Inst. of Astrophy., Spain) Ho, P. (CFA)	Mapping at 18.343 GHz of C_3H_2 in selected bipolar outflows.
W-208	Wadiak, E. J. Rood, R. (Virginia) Wilson, T. (MPIR, Bonn) Mangum, J. (Virginia)	Observations at 13.7 cm of $H_2{}^{13}CO$ in molecular clouds.
W-211	Wootten, H. A. Butner, H. (Texas) Loren, R. (Texas)	Observations at discrete frequencies between 18.5 and 24.3 GHz to determine the complex molecular chemistry in a compression front in Rho Oph.

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

A - Arecibo 1000 ft	Lb - Bologna 25 m
B - Effelsberg, MPIR 1000 m	Lm - Medicina 32 m
E - Hartebeesthoek, South Africa 26 m	N - NRL Maryland Pt 85 ft
F - Fort Davis 85 ft	O - Owens Valley 130 ft
G - Green Bank 140 ft	R - Crimea USSR 30 m
H - Hat Creek 85 ft	Sn - Onsala 20 m
I - Iowa 60 ft	So - Onsala 25 m
Jb - Jodrell Bank Mk II 25 m	Wn - Westerbork n=1-14x26 m
Jm - Jodrell Bank 250 ft	Yn - Socorro n=1-27x25 m
Km - Haystack 120 ft	Z - Torun 15 m

No.	Observer(s)	Program
A-11V	Alef, W. (MPIR, Bonn) Gotz, M. (MPIR, Bonn) Preuss, E. (MPIR, Bonn) Kellermann, K.	Observations at 6 cm of the structural variability in 3C 390.3 and 3C 111, with telescopes B, F, G, Km, Lm, O, and Yn.
B-73V	Backer, D. (Berkeley) Marr, J. (Berkeley) Plambeck, R. (Berkeley) Readhead, A. (Caltech) van Breugel, W. (Berkeley) Wright, M. (Berkeley)	Observations at 1.35 cm of the structure of compact components in NGC 1275, with telescopes B, G, Km, Lm, N, O, Sn, and Yn.
B-74V	Barthel, P. (Caltech) Pearson, T. (Caltech) Readhead, A. (Caltech)	Third-epoch observations at 6 cm of a complete sample of compact sources, with telescopes B, F, G, H, I, Jb, Km, Lm, O, So, Wn, and Yn.
D-12V	Diamond, P. (MPIR, Bonn) Nyman, L. (Goddard)	Observations at 1.35 cm of the proper motion of the masers in W 43, with telescopes B, G, Km, N, O, So, and Wn.
G-47V	Gwinn, C. (CFA) Backer, D. (Berkeley) Bartel, N. (CFA) Cordes, J. (Cornell) Mutel, R. (Iowa) Wolzscan, A. (Arecibo)	Observations at 49 cm of pulsar interstellar scattering, with telescopes A, F, G, I, Jm, O, and Wn.

No.	Observer(s)	Program
G-51V	Gurvits, L. (IFSR, USSR) Kardashev, N. (IFSR, USSR) Pauliny-Toth, I. (MPIR, Bonn) Popov, M. (IFSR, USSR) Kellermann, K.	Studies at 6 cm of the radio structure of quasars which are ten times younger than the universe, with telescopes B, G, Km, Lm, O, So, Wn, and Yn.
J-42V	Jones, D. (JPL)	Observations at 6 cm of the changing structure in the nuclei of NGC 4278 and NGC 4552, with telescopes B, F, G, N, O, and Yn.
L-39V	Linfield, R. (JPL) Porcas R. (MPIR, Bonn)	Observations at 6 cm to map the core of Cygnus A, with telescopes B, F, G, Jb, Km, Lm, N, O, So, Wn, and Yn.
L-44V	Lestrade, J-F. (Bureau des Longitudes) Mutel, R. (Iowa) Niell, A. (JPL) Preston, R. (JPL)	Differential astrometry at 6 cm of the stellar system Cyg XI and determination of the component masses, with telescopes B, G, Km, O, Wn, and Yn.
M-70V	Mutel, R. (Iowa) Cordes, J. (Cornell) Spangler, S. (Iowa)	Observations at 49 cm of angular broadening in the vicinity of the Cygnus Superbubble, with telescopes A, B, F, G, I, Jm, O, and Wn.
M-79V	Marecki, A. (Torun)	Search at 49 cm for a counter-jet and for superluminal motion in 3C 286, with telescopes A, F, G, I, Jb, O, R, Wn, and Z.
P-74V	Padrielli, L. (Bologna) Bartel, N. (CFA) Fanti, R. (Bologna) Ficarra, A. (Bologna) Gregorini, L. (Bologna) Mantovani, F. (Bologna) Nicolson, G. (Hartebeesthoek) Weiler, K. (NRL) Romney, J.	Observations at 6 cm of the quasar 0605-085, with telescopes B, F, G, E, Jb, Km, Lm, O, So, and Wn.
S-64V	Spencer, R. (Manchester) Junor, W. (Manchester) Muxlow, T. (Manchester)	Submilliarcsecond mapping at 1.35 cm of the nucleus of M87, with telescopes B, G, Jb, Km, Lm, N, O, Sn, and Yn.

No.	Observer(s)	Program
S-67V	Simon, R. (NRL) Hall, J. (NRL) Johnston, K. (NRL) Spencer, J. (NRL) Waak, J. (NRL)	Superluminal monitoring at 6 cm of 3C 395, with telescopes B, F, G, H, I, Jb, Km, Lm, N, O, So, Wn and Yn.
W-42V	Walker, R. C. Unwin, S. (Caltech) Benson, J.	Observations at 6 cm of superluminal motons in 3C 120, with telescopes A, B, F, G, H, I, Km, Lm, O, So, and Yn.
X-44V	Pauliny-Toth, I. (MPIR, Bonn)	Observations at 49 cm of 3C 454.3, with telescopes B, E, F, G, I, Jb, O, R, and Wn.
X-45V	Briggs, F. (Pittsburgh)	Observations at 49 cm of 0458-02, with telescopes B, E, F, G, I, Jb, O, R, and Wn.
X-46V	Schilizzi, R. (Leiden)	Observations at 49 cm of CSS sources, with telescopes B, F, G, Jb, I, O, Wn, and Z.
X-47V	Pauliny-Toth, I. (MPIR, Bonn) Porcas, R. (MPIR, Bonn) Mantovani, F. (Bologna) Zensus, A. (Caltech) Kellermann, K.	Monitor of 3C 454.3 at 6 cm, with telescopes B, F, G, H, Km, Lb, and O.
Z-13V	Zensus, A. (Caltech) Baath, L. (Chalmers) Biretta, J. (CFA) Cohen, M. (Caltech) Unwin, S. (Caltech)	Monitor at 1.35 cm of the superluminal motion in 3C 273 and 3C 345, with telescopes B, G, Jb, Km, N, O, Sn, and Yn.
Z-14V	Zensus, A. (Caltech) Biretta, J. (CFA) Cohen, M. (Caltech) Unwin, S. (Caltech)	Observations at 6 cm of the superluminal motion in 3C 273 and 3C 345, with telescopes B, G, H, I, Jb, Km, Lm, N, O, So, 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 of low-frequency variable sources at 880, 1400, and 2700 MHz.
C-238	Condon, J. Broderick, J. (VPI & SU) Seielstad, G.	Sky survey at 4.8 GHz covering -2° << 77°.
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
F-94	Fisher, J. R.	Search for intergalactic hydrogen having quantized redshift characteristics.
K-301	Kerr, F. (Maryland) Henning, P. (Maryland)	Pilot search for galaxies behind the Milky Way by the study of HI.
P-136	Payne, H. Briggs, F. (Pittsburgh)	Observations of extended HI around NGC 2146.
R-234	Richter, O-G. (STScI)	Survey of HI at all right ascensions between -19° << 0°.

The following pulsar program was conducted during this quarter.

No.	Observer(s)	Program
B442	Backer, D. (Berkeley) Clifton, T. (Berkeley) Foster, R. (Berkeley) Heiles, C. (Berkeley) Kulkarni, S. (Caltech) Rand, R. (Caltech) Werthimer, D. (Berkeley)	Real-time pulsar search of the Galactic plane at 825 MHz.

The following very long baseline program was conducted during this quarter.

No.	Observer(s)	Program
B-455	Briggs, F. (Pittsburgh) Wolfe, A. (Pittsburgh)	Very long baseline observations at 452.3 452.3 MHz to measure absorption of highly red-shifted 21 cm radiation from QSOs, with the Arecibo 1000 ft telescope.

D. 12-METER OBSERVING PROGRAMS

The following line programs were conducted during this quarter.

No.	Observer(s)	Program
B-450	Blitz, L. (Maryland) Heckman, T. (Maryland)	Search for broad line CO emission from Seyfert nuclei.
B-456	Blitz, L. (Maryland) Wandel, A. (Maryland)	Study of evaporative outflows from high latitude clouds.
B-465	Brown, R.	Study of redshifted CO toward 3C 196.
B-468	Loren, R. (Texas) Butner, H. (Texas)	Observation of the cold shrouds of protostellar dense cores with 72 GHz J=1-0 DCO^+ emission.
D-149	Gordon, M. Dulk, G. (Colorado, JILA)	Search for mm-wave emission from giant and supergiant stars.
D-153	Dent, W. (Massachusetts) Balonek, T. (Colgate)	Study of the evolution of extragalactic radio sources at millimeter wavelengths.
F-98	Fuller, G. (Berkeley) Myers, P. (CFA)	CS mapping of dense cores.
G-295	Gordon, M. Jewell, P. Salter, C. (IRAM, France)	Observations of dust emission in HII regions.
H-220	Ho, P. (CFA) Turner, J. (UCLA) Keto, E. (CFA) Gottesman, S. (Florida)	J=2-1 CO study of barred spiral galaxies.
H-221	Huggins, P. (New York) Healy, A. (New York)	Study of CO in planetary nebulae.

No.	Observer(s)	Program
J-116	Jewell, P.	Study of gas outflows in evolved bipolar nebula OH 231.8+4.2.
K-298	Knapp, G. (Princeton) Bowers, P. (NRL) Long, K. (Princeton)	Study of CO (J=2-1) line profiles for interstellar cloudlets near Alpha Ori.
K-299	Kutner, M. (Rensselaer) Evans, N. (Texas) Mundy, L. (Caltech)	Study of the clumping structure in the S140 molecular cloud.
K-303	Kutner, M. (Rensselaer) Evans, N. (Texas)	CS J=5-4 observations of the bipolar flow in NGC 2071.
L-209	Lubowich, D. (Hofstra)	Observational tests of deuterium nucleosynthesis: DCO^+ and DCN in the shocked molecular cloud associated with the IC 443 SNR.
L-210	Lubowich, D. (Hofstra)	Observational tests of lithium nucleosynthesis: LiOH in the galactic center.
L-212	Lada, C. (Arizona) Walker, C. (Arizona) Adams, F. (Berkeley)	Continuum observations at 1 mm of selected protostars.
M-259	Maloney, P. (Arizona) Black, J. (Arizona)	Isotopic CO studies of edge-on spiral galaxies.
M-262	Maloney, P. (Arizona) Latter, W. (Arizona) Black, J. (Arizona)	CO J=1-0 observations of NGC 5128 (Centaurus A).
M-266	Muhleman, D. (Caltech) Dulk, G. (Colorado) Berge, G. (Caltech) Spencer, M. (Caltech)	Study of CO isotope ratio in the atmosphere in Venus/Saturn.
M-267	Martin, R. (Arizona) Walker, C. (Arizona) Ho, P. (CFA) Emerson, D.	1 mm continuum observations of external galaxies.
O-29	Owen, F. White, R. (Goddard)	Study of Sunyaev-Zeldovich effect in clusters and quasars.

No.	Observer(s)	Program
R-228	Rickard, L. J (NRL) Verter, F. (Rensselaer)	Proposal to test the CO-Far IR correlation at high luminosities.
R-237	Rickard, L. J (NRL) Schwartz, P. (NRL)	Studies of high-frequency thermal emission from galaxies with IR emission.
S-298	Sanders, D. (Caltech) Soifer, B. (Caltech) Scoville, N. (Caltech)	CO (1-0) observations of most luminous IRAS galaxies at Z < 0.
T-208	Thronson, H. (Wyoming)	Study of J=1-0 emission from small galaxies.
T-212	Terebey, S. (High Alt. Obs.) Fich, M. (Washington)	Study of the nature of moderate to massive star formation in outer galaxy.
T-216	Turner, B.	Study of vibrational excitation of CS in IRC 10216 to test chemical freeze-out models.
T-220	Turner, B. Steimle, T. (Arizona State)	Search for interstellar MgO.
W-214	Walker, C. (Arizona) Lada, C. (Arizona) Young, E. (Arizona) Maloney, P. (Arizona) Wilking, B. (Missouri)	Proposal to study the cloud rotation in the region of IRAS 1629A.
W-220	Wiklind, T. (Chalmers, Onsala) Rydbeck, G. (Chalmers, Onsala)	Study of CO (J=2-1) emission in NGC 185.
Y-1	Young, E. (Arizona) Walker, C. (Arizona) Lada, C. (Arizona)	CO mapping of the northern loop of the Rho Ophiuchi cloud.
Z-59	Zuckerman, B. (UCLA) Dyck, H. (Hawaii)	Search for VHya CO maser.

E. VLA OBSERVING PROGRAMS

No.	Observer(s)	Program
AA-60	Ambruster, C. (JILA) Bookbinder, J. (JILA)	Flare star EV Lac. 6 and 20 cm.
AA-62	Anantharamaiah, K.	Recombination line and continuum towards W44. 20 and 90 cm line.
AA-63	Appleton, P. (Iowa State) van Gorkom, J. Ghigo, F. (Minnesota) Struck-Marcell, C. (Iowa State)	HI observations of Arp 143 (NGC 2445/4) and NGC 2793. 20 cm line.
AB-129	Burke, B. (MIT) Hewitt, J. (MIT) Roberts, D. (Brandeis)	Monitoring time variations in 0957+561. 6 cm.
AB-324	Blaha, C. (Minnesota) Pedelty, J. (Minnesota) Dickey, J. (Minnesota) Kennicutt, R. (Minnesota)	Hot spot nuclei. 2 and 20 cm.
AB-339	Becker, R. (Calif., Davis) Helfand, D. (Columbia)	Detailed studies of G5.3-1.0 and G357.7-0.1. 6 and 20 cm.
AB-343	Bosma, A. (Obs. Marseille) Carignan, C. (Montreal) Marcelin, M. (Obs. Marseille) Athanassoula, E. (Obs. Marseille)	HI in the ScIII galaxy NGC 300. 20 cm line.
AB-360	Burns, J. (New Mexico) Eilek, J. (NMIMT) Christiansen, W. (North Carolina) Clarke, D. (New Mexico)	Polarization mapping of the turbulent lobes in 0816+526. 2 cm.
AB-387	Becker, R. (Calif., Davis) Helfand, D. (Columbia)	Composite remnant G24.7+0.6. 90 cm.
AB-396	Braun, R. Walterbos, R. (Leiden) Brinks, E. (ESO, Garching)	Interstellar medium of M31. 20 cm line.
AB-399	Becker, R. (Calif., Davis) Helfand, D. (Columbia)	Two possible plerions. 6 and 20 cm.
AB-400	Brinks, E. (ESO) Klein, U. (Univ. Bonn) Weiland, H. (Univ. Bonn)	HI and radio continuum observations of blue compact dwarf galaxies. 6 and 20 cm line.

No.	Observer(s)	Program
AB-403	Baum, S. (Maryland) 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. 6, 18, and 21 cm.
AB-405	Brown, A. (JILA/Colorado)	Bipolar flow source IRS7 and other PMS radio sources in Corona Australis. 1.3, 2, 6 and 18 cm.
AB-407	Bally, J. (Bell Labs) Stark, A. (Bell Labs) Wilson, R. (Bell Labs) Yusef-Zadeh, F. (Columbia)	Survey of 10 degrees near the galactic center. 6 and 20 cm.
AB-408	Bookbinder, J. (JILA/Colorado) Caillault, J. (JILA/Colorado) Gary, D. (Caltech) Giampapa, M. (NOAO) Golub, L. (SAO) Linsky, J. (JILA/Colorado) Gibson, D. (NMIMT)	A first epoch, volume-limited, multi-frequency survey of M dwarf stars. 1.3, 2, 6 and 20 cm.
AB-412	Broderick, J. (VPI & SU) Condon, J.	Radio identification of UGC galaxies. 20 cm.
AB-414	Becker, R. (Calif., Davis) White, R. (STScI)	Monitoring the flux of HD193793 and P Cygni. 2 and 6 cm.
AB-417	Barvainis, R. Antonucci, R. (STScI)	Spectra of IRAS radio quiet quasars. 6 and 20 cm.
AB-418	Bosma, A. (Obs. Marseille) Athanassoula, E. (Obs. Marseille)	Rotation curves of early type spirals. 20 cm line.
AB-419	Braun, R. Liszt, H.	Wide-field imaging of four galactic HII region complexes. 20 cm.
AC-146	Churchwell, E. (Wisconsin) Felli, M. (Arcetri) Massi, M. (Arcetri)	High dynamic range mapping of Orion A. 6 and 20 cm.
AC-149	Clarke, D. (New Mexico) Burns, J. (New Mexico) Norman, M. (LANL) Christiansen, W. (North Carolina)	Search for active magnetic field effects in extragalactic sources. 6 cm.

No.	Observer(s)	Program
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. 6 cm.
AC-165	Cawthorne, T. (Glasgow)	Spectral studies of 3C 280.1. 2 cm.
AC-166	Carilli, C. (MIT) Dreher, J. (MIT) Perley, R.	Further studies of Cygnus A. 1.3, 2, 20 and 90 cm.
AC-168	Casertano, S. (Princeton) van Gorkom, J.	Search for late-type disk galaxies with extended HI envelopes. 20 cm line.
AC-170	Chance, D. (STScI) Yusef-Zadeh, F. (Columbia)	Structural details of filamentary features in Orion nebula. 20 cm.
AC-172	Caganoff, S. (Mt. Stromlo) Bicknell, G. (Mt. Stromlo) Ekers, R.	Relationship between optical and radio properties of powerful extragalactic radio sources. 6 and 20 cm.
AC-173	Cameron, R. (Mt. Stromlo) Parma, P. (Bologna) de Ruiter, H. (Bologna)	PKS 2149-158, a binary radio jet system. 6, 18 and 21 cm.
AC-174	Conway, J. (NRAL) Wilkinson, P. (NRAL) Cornwell, T.	Complementary VLA/Merlin observations of 3C 179. 2 cm.
AC-175	Clark, D. (New Mexico) Burns, J. (New Mexico) Feigelson, E. (Penn State)	Inner lobes of Centaurus A. 18 and 20 cm.
AC-176	Crane, P. Dahari, O. (STScI) Ford, H. (STScI) Jacoby, G. (NOAO) Ciardullo, R. (STScI)	Anomalous spiral arms of NGC 4258. 6 and 20 cm.
AD-181	de Pater, I. (Berkeley) Dickel, J. (Illinois)	Saturn. 2 cm.
AD-182	Dahari, O. (STScI) Brosch, N. (Wise Obs)	Interacting elliptical-irregular galaxy pairs. 6 cm.
AD-185	Dickel, H. (Illinois) Goss, W. M.	An H_2CO absorption and H76α recombination line study of NGC 6334. 2 and 6 cm line.

No.	Observer(s)	Program
AD-187	Drake, S. (SASC Technologies) Linsky, J. (JILA/Colorado)	Properties and extent of emission in B-type magnetic Helium stars. 2, 6, and 20 cm.
AD-188	Drake, S. (SASC Technologies) Simon, T. (Hawaii) Florkowski, D. (USNO) Stencel, R. (Colorado) Bookbinder, J. (JILA/Colorado) Linsky, J. (JILA/Colorado)	Variability of radio emission in three M supergiants: Alpha Ori, Alpha Sco A, and Alpha 1 Her. 2 and 6 cm.
AD-189	Dewdney, P. (DRAO) Roger, R. (DRAO)	HI near compact HII regions. 20 cm line.
AE-48	Evans, N. (Texas) Kutner, M. (Rensselaer) Mundy, L. (Caltech)	Embedded continuum sources in the S140 molecular cloud. 6 cm.
AE-50	Ekers, R. Morris, M. (UCLA) Yusef-Zadeh, F. (UCLA)	Sgr A West. 1.3 and 2 cm.
AF-104	Felli, M. (Arcetri) Massi, M. (Arcetri) Persi, P. (IAS) Ferrari-Toniolo, M. (IAS)	Star-forming regions in NGC 63357. 2 and 6 cm.
AF-108	Fomalont, E. Ekers, R. van Breugel, W. (Berkeley)	Fornax A. 20 cm.
AF-115	Feigelson, E. (Penn State) Schwartz, D. (CFA) Madejski, G. (CFA)	Radio structures of X-ray BL Lac objects. 20 cm.
AF-123	Fomalont, E. Sanders, W. (New Mexico State)	Stellar radio luminosity function. 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.
AF-132	Fischer, J. (NRL) Rickard, L. (NRL)	Search for central driving source in Lynds 1592/93 and three others with similar morphology. 6 cm.
AF-133	Fich, M. (Washington)	The unusual object S266. 6 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 blazars. 1.3, 2, 6, 20, and 90 cm.
AG-220	Garrington, S. (NRAL) Conway, R. (NRAL) Leahy, J. (NRAL) Laing, R. (RGO)	Depolarization asymmetries and jet sidedness. 6 cm.
AG-224	Gaume, R. (Michigan) Mutel, R. (Iowa)	Evidence of supernova induced star formation? 20 cm line.
AG-226	Gunn, J. (Princeton) Knapp, G. (Princeton) van Gorkom, J.	Measurement of the thickness of HI disks in the edge-on spiral galaxies NGC 891, 4565 and 7814. 20 cm line.
AG-227	Gwinn, C. (CFA) Linfield, R. (JPL) Ma, C. (NASA/Goddard)	VLBI millisecond pulsar astrometry. 18 cm phased array MK III VLB.
AG-228	Gregorini, L. (Bologna)	Sample of dust lane galaxies observed at infrared wavelengths. 6 cm.
AG-230	Gottesman, S. (Florida) Hunter, J. (Florida) Hawarden, T. (Royal Obs.)	Peculiar ellipsoidal galaxy NGC 660. 21 cm line.
AG-232	Gottesman, S. (Florida) Hunter, J. (Florida) Erickson, L. (Florida)	HI observations of NGC 3893 and NGC 4111. 20 cm line.
AG-233	Gottesman, S. (Florida) Hunter, J. (Florida) Erickson, L. (Florida)	HI observations of NGC 4258 and NGC 4303. 20 cm line.
AG-239	Gioia, I. (CFA)	0839+29. 6 cm.
AG-240	Gopal-Krishna (TIFR)	CTD 93. 2 and 6 cm.
AH-195	Hjellming, R. Davis, R. (NRAL)	Recurrent Nova RS Oph. 2, 6, and 20 cm.

No.	Observer(s)	Program
AH-206	Helfand, D. (Columbia) Becker, R. (Calif., Davis) Zoonematkermani, S. (Columbia)	Field surrounding G12.0-0.1: a cluster of supernova remnants? 20 cm line.
AH-211	Ho, P. (CFA) Turner, J. (CFA)	HI synthesis mapping of NGC 253. 21 cm line.
AH-227	Hjellming, R.	1741-038: a rapid scintillator. 1.3, 2, 6, 20 and 90 cm.
AH-240	Habbal, S. (CFA) Withbroe, G. (CFA) Gonzalez, R.	Spatial and temporal variations in solar coronal bright point emission. 2, 6, and 20 cm.
AH-242	Henkel, C. (MPIR, Bonn) Mauersberger, R. (MPIR, Bonn) Wilson, T. (MPIR, Bonn) Wadiak, E. J. Walmsley, C. (MPIR, Bonn) Johnston, K. (NRL)	The $^{15}NH_3$ maser and the velocity of the ionized gas toward NGC 7538 - IRS1. 1.3 cm line.
AH-244	Huang, Y. (Massachusetts) Claussen, M. (Massachusetts)	Search for remnants of three possible historical supernovae. 2, 6, and 20 cm.
AH-245	Hankins, T. (Dartmouth) Horton, E. (Dartmouth)	Measurements of the Crab pulsar average profile. 6 cm.
AH-246	Hummel, E. (MPIR, Bonn) Harnett, J. (Sydney) Beck, R. (MPIR, Bonn) Larsean, N. (MPIR, Bonn)	Search for linearly polarized emission in four spiral galaxies. 20 cm.
AH-247	Hummel, E. (MPIR, Bonn) Dettmar, R. (Bonn) Bajaja, E. (Inst. Rad., Argentina) Wielebinski, R. (MPIR, Bonn)	Large and small scale structures of M104. 20 cm.
AH-248	Hummel, E. (MPIR, Bonn) Grave, R. (MPIR, Bonn) Krause, M. (MPIR, Bonn) Beck, R. (MPIR, Bonn)	High resolution polarization observations of IC 342. 20 cm.
AH-250	Helfand, D. (Columbia) Becker, R. (Calif., Davis)	A 327-MHz survey of the galactic plane: test fields. 90 cm.

No.	Observer(s)	Program
AH-254	Hjellming, R. Gehrz, R. (Minnesota) Taylor, A. (Groningen) Seaquist, E. (Toronto)	Three pre-1097 and bright 1987 novae to complement extensive infrared observations. 1.3, 2, 6, and 20 cm.
AJ-135	Johnston, K. (NRL) Bowers, P. (NRL) Florkowski, D. (USNO) de Vegt, C. (Hamburger Sternwarte) Lestrade, J-F. (B. des Longitudes)	Hipparcos reference stars. 6 cm.
AJ-138	Jorsater, S. (ESO) van Moorsel, G. (ST-ECF) Lindblad, P. (Stockholm Obs.)	High resolution HI study of the barred spiral galaxy NGC 1365. 20 cm line.
AJ-141	Jauncey, D. (CSIRO) White, G. (Royal Obs.) Savage, A. (Royal Obs.) Condon, J.	Positions of southern flat-spectrum sources. 6 cm.
AJ-143	Johnston, K. (NRL) Molnar, L. (CFA) Mason, K. (Univ. College London) Reid, M. (CFA) Hjellming, R.	Coordinated observations of Cyg X-3. 1.3, 2, 6, 18, 20, and 90 cm.
AK-140	Kailey, W. (Steward Obs.) Elston, R. (Steward Obs.)	Search for supernova remnants near the nucleus of M33. 20 cm.
AK-149	Knapp, G. (Princeton) Bowers, P. (NRL)	Search for protoplanetary nebuale associated with OH/IR stars. 6 cm.
AK-150	Kundu, M. (Maryland) Jackson, P. (Maryland) White, S. (Maryland)	Complete sample of nearby flare stars. 6 and 20 cm.
AK-151	Kundu, M. (Maryland) Jackson, P. (Maryland) White, S. (Maryland)	Narrow band flares on red dwarf stars. 6 and 20 cm.
AK-157	Kutner, M. (Rensselaer) Mead, K. (Rensselaer) Evans, N. (Texas)	HII regions in outer galaxy molecular clouds. 20 cm.
AK-158	Kogut, A. (Berkeley) Smoot, G. (Berkeley) Petuchowski, S. (Goddard) Bennett, C. (Goddard)	Formaldehyde absorption in W51. 6 cm line.

No.	Observer(s)	Program
AL-111	Lake, G. (Bell Labs) Schommer, R. (Rutgers) van Gorkom, J.	The rotation curve of NGC 5666. 20 cm line.
AL-112	Lake, G. (Bell Labs) Schommer, R. (Rutgers) van Gorkom, J.	Rotation curves of dwarf galaxies. 20 cm line.
AL-113	Leahy, J. (NRAL)	Faraday rotation and depolarization in classical double radio sources. 6 cm.
AL-124	Leahy, J. (NRAL) Muxlow, T. (NRAL) Stephens, P. (NRAL) Morison, I. (NRAL)	Spectral mapping of classical doubles. 6 cm.
AL-127	Lang, K. (Tufts) Willson, R. (Tufts)	Narrow band emission from the dwarf M flare stars: AD Leo. 6 and 20 cm.
AL-128	Lang, K. (Tufts) Willson, R. (Tufts)	Simultaneous VLA/IUE observations of RS CVn stars. 6 and 20 cm.
AL-130	Lehto, H. (Virginia) Heeschen, D. Seielstad, G. Valtonen, M. (Turku) Saslaw, W. (Virginia)	Simultaneous observations of OJ287. 1.3 and 2 cm.
AM-187	Maccacaro, T. (CFA) Gioia, I. (CFA) Wolter, A. (CFA) Morris, S. (Steward Obs.) Stocke, J. (Colorado)	Extragalactic component of the Expanded Medium Sensitivity Survey. 6 cm.
AM-189	Miley, G. (STScI) Chambers, K. (Johns Hopkins) van Breugel, W. (Berkeley)	Study of ultra-steep spectrum radio sources. 2 and 6 cm.
AN-41	Nakai, N. (Nobeyama) Tsuboi, M. (Nobeyama) Inoue, M. (Nobeyama) Morimoto, M. (Nobeyama) Miyamoto, M. (Tokyo Obs.) Yoshizawa, M. (Tokyo Obs.)	Linkage of optical reference frame with radio reference frame by use of H_2O maser stars. 1.3 cm line.

No.	Observer(s)	Program
AN-43	Neff, S. (Goddard) Joseph, R. (Imperial College) Rickard, L. J (NRL) Johnston, K. (NRL)	Merging galaxies. 2 and 6 cm.
AO-62	O'Donoghue, A. (NMIMT) Owen, F. Eilek, J. (NMIMT)	Wide angle tail sources. 20 cm.
AO-75	Odegard, N. (Toronto) Seaquist, E. (Toronto)	Polarization mapping of the galaxy NGC 3631. 6 cm.
AO-76	O'Dea, C. Gregorini, L. (Bologna) Feretti, L. (Bologna) Giovannini, G. (Bologna)	Complex radio emission in Abell 568. 6 cm.
AO-77	O'Dea, C. Owen, F.	Brightest cluster members in Abell clusters. 20 cm.
AP-108	Phillips, J. (Queen Mary College) Mampaso, A. (IAC, Tenerife)	Core mapping of post-main-sequence bipolars. 2, 6 and 20 cm.
AP-114	Pedelty, J. (Minnesota) Rudnick, L. (Minnesota) Spinrad, H. (Berkeley) van Breugel, W. (Berkeley)	Extended extranuclear emission-line gas in 3C 337. 2 cm.
AP-123	Pedlar, A. (NRAL) Anantharamaiah, K. van Gorkom, J. Ekers, R.	Continuum and recombination line observations of the galactic center. 90 cm.
AP-124	Puxley, P. (Edinburgh) Hawarden, T. (Royal Obs.) Mountain, C. (Royal Obs.) Leggett, S. (Edinburgh)	Circumnuclear star formation in barred spiral galaxies. 6 cm.
AP-125	Pottasch, S. (Groningen) Zijlstra, A. Bignell, R. C.	Spatial distribution of planetary nebulae near the galactic center. 6 cm.
AR-131	Rodriguez, L. (UNAM) Torrelles, J. (UNAM) Canto, J. (UNAM) Curiel, S. (UNAM) Ho, P. (CFA) Pravdo, S. (JPL)	Multiconfiguration mapping of the Herbig-Haro 1 and 2 region. 6 cm.

No.	Observer(s)	Program
AR-143	Rodriguez, L. (UNAM) Roth, M. (UNAM) Tapia, M. (UNAM)	Compact HII region associated with GM24. 2 cm line.
AR-149	Roberts, D. (Brandeis) Lazzarin, A. (Brandeis) Wardle, J. (Brandeis) Dreher, J. (MIT) Lehar, J. (MIT) de Bruyn, A. (NFRA)	Rapid variability in OJ 287. 6 cm.
AR-152	Roeser, H. (MPI, Heidelberg) Perley, R.	The hotspot in Pictor A. 2, 6, and 20 cm.
AR-153	Rucinski, S. (Toronto) Seaquist, E. (Toronto)	Orbital phase dependence of emission from contact binary VW CEP. 2, 6, and 20 cm.
AR-154	Rucinski, S. (Toronto)	Coronal emission of late A/early F-type dwarfs. 2, 6 and 20 cm.
AS-80	Sramek, R. van der Hulst, J. (NFRA) Weiler, K. (NRL)	Supernova SN1980 in NGC 6946 and SN1979c in M100. 2, 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-222	Savage, A. (Royal Obs.) Smith, M. (Royal Obs.) Condon, J.	Survey of QSO fields. 20 cm.
AS-262	Saripalli, L. (TIFR) Subrahmanya, C. (CSIRO) Gopal-Krishna (TIFR)	Giant radio galaxy 0503-286. 6 and 20 cm.
AS-263	Subrahmanyan, R. (TIFR) Gopal-Krishna (TIFR) Swarup, G. (TIFR) Thum, C. (IRAM, Granada)	Orion A. 90 cm.
AS-272	Saripalli, L. (TIFR)	Five giant radio galaxies. 6, 20, and 90 cm.

No.	Observer(s)	Program
AS-273	Staveley-Smith, L. (NRAL) Chapman, J. (NRAL) Unger, S. (NRAL) Feast, M. (SAAO)	The peculiar IRAS source 0937+1212. 2, 6 and 20 cm.
AS-274	Seaquist, E. (Toronto) Henriksen, R. (Queen's) Bell, M. (NRC) Odegard, N. (Toronto)	Study of the galactic wind from M82. 20 and 90 cm.
AS-275	Stine, P. (Penn State) Feigelson, E. (Penn State) Myers, P. (CFA) Mathieu, R. (CFA)	Search for continuum flares in windless pre-main sequence stars. 6 cm.
AS-276	Subrahmanyan, R. (TIFR) Swarup, G. (TIFR)	Search for protoclusters at z = 3.35. 90 cm line.
AS-277	Snell, R. (Massachusetts) Strom, S. (Massachusetts) Strom, K. (Massachusetts) Morgan, J. (Massachusetts) Bally, J. (Bell Labs) Campbell, B. (Mt. Wilson)	Continuum emission from young stellar objects in Orion. 6 cm.
AS-278	Staveley-Smith, L. (NRAL) Axon, D. (NRAL) Davies, R. (NRAL) Hurley, S. (Manchester)	HI observations of the emission line galaxy MICH-160 and the dwarf irregular galaxy MAI-017. 21 cm line.
AS-279	Schmahl, E. (Maryland) Kundu, M. (Maryland) White, S. (Maryland)	The emergence of new solar cycle bipolar regions. 2, 6 and 20 cm.
AS-292	Simon, M. (SUNY)	A peculiar IRAS galaxy.
AT-60	Taylor, A. (Groningen) Seaquist, E. (Toronto) Kenyon, S. (SAO)	Radio-optical-uv monitoring of symbiotic stars. 1.3, 2, 6, and 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-78	Turner, J. (UCLA) Ho, P. (CFA) Beck, S. (Northeastern)	Spectral index maps of Brackett line galaxies. 2 cm.

No.	Observer(s)	Program
AT-79	Thuan, T. (Virginia) Schneider, S. (Virginia) Loose, H. (Gottingen)	HI distribution and kinematics of Haro 2, an extreme example of a star-forming, young elliptical galaxy. 21 cm line.
AU-23	Unger, S. (NRAL) Pedlar, A. (NRAL) Wolstencroft, R. (Royal Obs.) Savage, A. (Royal Obs.) Leggett, S. (Royal Obs.)	Complete far-infrared selected sample of galaxies. 6 and 20 cm.
AU-27	Umana, G. (Catania) Catalano, S. (Catania) Gibson, D. (NMIMT)	Survey of nearby Be stars. 2 cm.
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 line emission. 21 cm.
AW-48	Wade, C. Johnston, K. (NRL) Seidelmann, P. (USNO) Kaplan, G. (USNO)	Astrometric observations of minor planets. 2 and 6 cm.
AW-137	Wrobel, J. (NMIMT) Heeschen, D.	Survey of a volume-limited sample of bright E/SO galaxies. 6 cm.
AW-142	Wills, B. (Texas)	Radio beaming and quasar emission lines. 6 cm.
AW-157	Williams, B. (Delaware) van Gorkom, J.	HI study of 2 compact groups of galaxies. 20 cm line.
AW-160	Wootten, H. A	Search for ionized component in the L1689N bipolar flow. 2 and 6 cm.
AW-167	White, R. (STScI) Becker, R. (Calif., Davis)	Spectra of point sources near Lk Hα101. 2 and 6 cm.
AW-170	Weinberg, D. (Princeton) Guhathakurta, P. (Princeton) van Gorkom, J.	HI rotation curve of UGC 12591. 20 cm line.

No.	Observer(s)	Program
AY-15	Yusef-Zadeh, F. (Columbia) Morris, M. (UCLA) Seiradakis, J. (Thessaloniki) Lasenby, A. (MRAL) Weilebinski, R. (MPIR, Bonn)	Polarized lobe near the galactic center below the plane. 6 and 20 cm.
AZ-29	Zensus, A. (Caltech) Cohen, M. H. (Caltech) Readhead, A. (Caltech)	Radio galaxies 3C 123 and 3C 303. 2 and 6 cm.
V8652	Pauliny-Toth, I. (MPIR, Bonn)	3C 454.3. 6-cm single antenna VLB.

F. SCIENTIFIC HIGHLIGHTS

Extragalactic Occultation Events?

Monitoring observations of 36 extragalactic sources with the Green Bank interferometer over the course of the past seven years have revealed several unusual minima in the light curves that do not follow typical source variations. Daily flux density measurements at 2695 and 8085 MHz were carried out as part of the extensive USNO geodesy program. The most unusual U-shaped event was seen in the source 0954+658 in all 12 parallel polarization correlators for the four antennas. A brief rise to maximum flux density was followed by an abrupt drop to a prolonged minimum of duration ~0.2 years and a steep rise to a trailing maximum and gradual return to the original baseline level. If the occulation interpretation is correct, refraction through a compact ionized component of the ISM is one likely explanation for the light curve signatures. If local to the Galaxy, the occulter's inferred mass and number density would contribute significantly to the mass of the galaxy. Investigators: R. L. Fiedler, B. K. Dennison, and K. J. Johnston (all NRL).

OJ 287 Variability

Recent simultaneous VLA-Westerbork 5 GHz observations of the BL Lac object OJ 287 have confirmed intensity fluctuations reported earlier. Several 1 percent amplitude variations have been repeatedly observed on a slow 2 to 3 hour time scale. More noteworthy, however, has been the identification of a particular time frame during which both telescopes detected sharp flickers--brief non-simultaneous 15 minute events when a 1/2 percent variation appeared, once at the VLA and twice at Westerbork. Although it is still not clear whether the fluctuations were the result of interstellar scintillation, all possible interpretations, including intrinsic source variability, point to the existence of a micro-arcsecond core source in the galaxy. The resultant high brightness temperature, well in excess of the Compton limit, suggests the existence of coherent emission mechanisms and/or a high degree of Doppler boosting for this source component. Investigators: J. D. Dreher, J. Lehar (MIT), D. H. Roberts (Brandeis), and A. G. de Bruyn (NFRA).

HI in Compact Groups

A large quantity of neutral hydrogen gas in the G18 compact group of galaxies (Hickson, 1982) has been mapped with the VLA. The gas cloud extends over an area twice as large as that occupied by the group members and is not directly identifiable as connected to any specific galaxy. While the galaxies in the group are co-aligned with their individual major axes, the major axis of the HI cloud deviates by 120°. In spite of common systemic velocities (~4100 k/s), the galaxies and the gas cloud display oppositely directed velocity gradients. Total HI mass estimates are $\sim 10^{10}$ $M_{\odot}$, with a central density of order 4×10^{-2} H/cm^3. Further clues are being sought to understand the dynamic history of the gas. Investigators: B. Williams (Delaware) and J. van Gorkom (NRAO).

Pictor A Hot Spot

The bright radio hot spot in the western lobe of Pictor A (giant Class II radio galaxy similar to Cyg A) is known to exhibit bright unresolved optical emission with a degree of polarization exceeding 30 percent. Recent VLA 20 and 6 cm observations of the hot spot have revealed radio structure nearly identical to the optical and with a high degree of polarization (55 percent). Additionally, a radio jet was found linking the central unresolved emission with the bright hot spot. The linear spectrum of the emission extending from the radio into the optical and possibly to the X-ray makes a pure synchrotron interpretation very likely. The regions of optical synchrotron emission clearly delineate the locations where the electrons are accelerated since their lifetimes and acceleration time scales are less than 100 years. Investigators: R. Perley (NRAO) and H. Roeser (Max Planck).

Fast Pulsar Candidate in M28

VLA 327 MHz observations of the suspicious compact radio source within one core radius of the center of the globular cluster M28 now strengthen the case that it may be a millisecond pulsar. Until recently the source had distinguished itself as the only 1465 MHz continuum source to be detected in a VLA survey of 12 globular clusters, chosen for their containment of low mass binary stars. A non-detection at 5 GHz with the VLA implied a spectral index less than -1. Very low resolution Clark Lake telescope measurements at 30.9 and 57.5 MHz verified that there was a source of index -2.4 in the general direction of the cluster.

The 327 MHz detection is unambiguously identified with the M28 source and confirms the steepness of the spectrum. Maps of the linearly polarized intensity imply a very high fractional polarization (~35%). The combination of a steep radio spectrum, substantial linear polarization, and compact configuration are properties unique to radio pulsars and certainly warrant future intensive searches for short-period pulsations from the source. Investigators: W. Erickson, M. Mahoney (Maryland), R. Becker (California, Davis), and D. Helfand (Columbia).

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 seven front-ends (S/N's 6-12) were completed.

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. During this quarter, eight amplifiers were shipped to the VLA.

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.

Tests continued on the prototype one-eighth of the system during this quarter. Construction of the final system is well underway, with expected completion by 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. We believe 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 a contract with the University of Virginia and a joint study agreement with IBM (Watson Research Laboratory).

Recent studies have shown that SIS direct detectors 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 using all-Nb junctions manufactured to our design by Hypres, Inc. These junctions are now in use 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 five-level mask set was designed using the GE-Calma CAD system at the University and fabricated by Tau Laboratories using electron-beam lithography. Critical dimensional tolerances on these masks are ± 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.

We have just received some experimental mixer junctions for 70-120 GHz fabricated to our design by IBM. These $Nb/Nb_2O_5/Pb(InAu)$ edge-junctions incorporate integrated tuning structures. Initial measurements appear encouraging.

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 these mixers, both in circuit design and, by contract to the University of Virginia, in the development of the diode devices.

Two mixers have been completed for the new 280-320 GHz receiver on the 12-meter telescope. As it is not possible to cover the full frequency range with these fixed-tuned mixers, it will be necessary to change the backshort when changing frequency range. This entails warming up the refrigerator.

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 (see below). The mixers with the best cryogenic performance are being kept for the multi-beam receiver, and the weaker ones are being used for site-testing receivers.

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

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 (whisker-less) Schottky diodes, being developed under the University of Virginia contract, promise improved performance and reliability in the future.

We are evaluating a new tripler design 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

140 Foot Surface Measurements

During this quarter, a holography technique was used to generate maps of the 140 foot main reflector surface, as a preliminary step toward the goal of improving the high frequency observing efficiencies of this telescope. During a five-day observing run in November, the hardware and observing technique were checked and several data sets were taken. From these sets of data, at least two usable surface maps have been generated, and these appear to be consistent within the measurement accuracy. A geosynchronous satellite broadcasting in the downlink band of 11.7 to 12.2 GHz was used as the test signal source.

In order to minimize the costs of this project, existing hardware was used whenever possible. A two-channel, prime-focus receiver was constructed using inexpensive commercial low-noise block converters modified for our purposes. One channel was connected to a feed that illuminated the main reflector, and the second to a feed mounted on the top of the front-end box that viewed the satellite directly. Phase-locked LO and IF systems from retired systems were used in the receiver. The correlator that was constructed for measurements of the new 12 meter telescope surface was adapted for interface with the 140 foot control computer and used.

This measurement system should prove to be an extremely useful system, and an observing run to check the measurement repeatability is scheduled in the upcoming quarter.

300-1000 MHz Receiver Upgrade

The 300-1000 MHz receiver is the primary observational receiver in that frequency range on both the 140 foot and 300 foot telescopes. Presently, this receiver uses cooled parametric upconverters followed by cooled 4.8 GHz FET amplifiers. A group of balanced FET amplifiers using octave bandwidth stripline hybrids has been developed and constructed to replace the upconverters and 4.8 GHz FET amplifiers. The performance achieved by these amplifiers is:

Freq.(MHz)	Noise (K)	Gain (dB)
300 - 400	< 30	25
500 - 750	< 25	25
750 - 1000	< 30	25

While the maximum noise temperature of these balanced amplifiers is roughly equivalent to the best noise temperature obtained by the upconverters, there is much less variation across the frequency range. Replacement of the upconverters with these amplifiers should yield a more stable receiver and a much more simple system.

The receiver will be retrofitted as soon as the observing schedule allows.

300 Foot Offset Feed System

Certain classes of observing programs are harmed by stray radiation caused primarily by scattering off of the antenna feed-support structures. This effect can be eliminated by using an offset feed system and a non-parabolic main reflector. An investigation into ways to minimize this stray radiation using our existing parabolic reflectors is underway at Green Bank. An approach that looks feasible is to offset a feed axis by some angle from the telescope axis so that the feed illuminates only a portion of the main reflector with a clear sky view. A theoretical analysis of the 300 foot has shown that such an arrangement, using a practical feed design, can yield a beam efficiency of 98.5% within a five degree solid angle of the main beam axis. This efficiency compares to 81.5% using the standard, center-fed antenna.

The most desirable frequency for implementing this type of system seems to be 21 cm, and we plan to do this in the coming months. As a first step, we will construct a manageable, scaled model of the feed in order to optimize its design, and then will construct a 21 cm feed that can be used with the 1.3-1.8 GHz receiver on the 300 foot telescope.

HEMT Amplifiers

High-Electron-Mobility Transistors have been under development in semiconductor labs over the last few years. Tests on sample quantities at NRAO and other labs have shown that these devices show promise as low-noise, cooled amplifiers, rivaling maser noise performance at some frequencies. Recently, versions usable at cryogenic temperatures have appeared on the commercial market. As availability allows, these devices will be incorporated into our FET amplifier receiving systems, where suitable.

HEMT devices have been installed in the 4.6-5.1 GHz amplifiers in the 2-5 GHz receiver. This has resulted in a decrease in the receiver noise temperature of approximately seven degrees, compared with the receiver using FET amplifiers. The system temperature with this receiver on the 140 foot at zenith is expected to be 25 to 28 K. A tests period on the telescope is scheduled this quarter; barring problems, the receiver should then be available for scheduled use.

J. TUCSON ELECTRONICS

Schottky Mixer Receivers

Work on the mixer receivers has been mainly directed at improving the performance of the receivers and replacing the klystron L.O. systems with Gunn oscillators. The status of the various receivers is summarized below.

1. 70-115 GHz Receiver

This receiver has performed well during the quarter. The Gunn oscillator L.O. system is less troublesome than the klystron system and will enable us to reduce operating costs considerably. The receiver uses two pairs of dewars; one for 70-95 GHz, the other for 90-115 GHz. Although the high frequency dewars effectively have been made obsolete by the new SIS receiver, we have elected to retain them as a back-up system.

2. 90-115 GHz Receiver

This new receiver has given excellent performance during the quarter. Noise temperatures of between 100 K SSB and 150 K SSB, with image rejection of 15-20 dB, are routinely obtained although the tuning can be tricky at certain frequencies. The receiver is filled with helium three times a week and a fill takes about an hour. The aperture efficiency obtained with the receiver is around 45%, although one channel is slightly lower than this. Some redesign of the optics is taking place to fix this problem. Towards the end of the last observing period a fault developed in the helium reservoir, and this will be redesigned before the receiver is used again.

3. 200-270 GHz Receiver

This receiver has, at the present time, two pairs of mixers. One pair covers the range 200-240 GHz, the other 240-270 GHz. The performance of the high frequency pair has been improved, and we now have two channels giving less than 1000 K SSB over the 240-270 GHz range. The performance of the low frequency pair is unchanged at 500-600 K SSB across the band. The receiver is now equipped with Gunn oscillators over the entire frequency range and, although difficult to tune at some frequencies, the performance seems quite satisfactory.

4. 270-310 GHz Receiver

Work on this frequency band is continuing, and we expect to be able to support the band with a single channel receiver for the high frequency observing session in February and March. If this single channel receiver is successful, we plan to incorporate a dual channel version in the 200-270 GHz receiver.

5. 330-365 GHz Receiver

Work on this receiver is directed towards replacing the klystron/tripler L.O. system with a Gunn oscillator/quadrupler system. We hope to have the modified receiver ready for February/March 1987. The receiver is single channel at the present time and will be expanded to two channels if sufficient L.O. power is available. The performance will be unchanged from last season, namely 1500 K SSB at 345 GHz.

6. Eight Feed, 230 GHz Receiver

Laboratory tests of the four feed prototype of this receiver are now complete, and we hope to test the receiver on the telescope in the first quarter of 1987. The receiver is designed to cover the frequency range 220-230 GHz and will have four feeds in a line, with a beam separation of 80 arcseconds. A single Gunn oscillator powers the four feeds, and expansion to eight feeds will simply consist of duplicating the present system.

7. Bolometer Receiver

A new bolometer element is being installed in the bolometer receiver. The system will be tested on the telescope early in 1987 and if sensitivities of better than 2 Jy in one second in the 1 mm window are not obtainable routinely, the bolometer receiver will no longer be supported.

Progress has been made in other areas of instrumentation for the 12 meter telescope.

Digital Continuum Backend

A digital, two channel, continuum backend for the 12 meter telescope has been used for observing during the last quarter. The signal from the digital backend is accumulated in the telescope control computer and passed over the data link to the analysis computer for final signal processing. During the next quarter this device will be expanded to accommodate four channels.

Hybrid Spectrometer

Work continues on the hybrid spectrometer. The digital part of the instrument is being constructed at the Central Development Laboratory and is scheduled for completion in May 1987. The analog filters and IF processor are being constructed in Tucson with an uncertain time scale, although our hope is to complete the system by the summer of 1987.

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% 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. Twenty-four antennas currently 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 arc min 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 interferency, 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 have 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 useable 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 1/2 hour. Instead of one region per u-v track, 20-30 regions can be studied at once. This is a very significant step forward.

The extension of the frequency coverage to 25.1 GHz is of particular interest because of the (J,K) = (6,6) line of 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 NH3. Because of their different excitation and radiative lifetimes, the ortho and para species of NH3 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 degrees Kelvin and increase the bandwidth above and below the current bandwidth of 22.0-24.0 GHz. Also a 5 GHz GaAs FET being developed in the GB Electronics Division will be used to replace present 5 GHz paramps. The 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 degrees Kelvin. 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

The main developments in AIPS during the present quarter concerned the package of calibration tasks. The package was installed in AIPS during the previous quarter, except for the new LISTR, but was not tested by users until the current one. Needless to say, there were many changes, corrections and improvements made. At this writing, the package works for continuum, total intensity data, and some high quality images have been produced starting with raw data from the VLA Modcomp tapes. Specialized polarization and spectral bandpass calibration tasks remain to be written.

Other areas also received attention. The new verbs SHOW and TELL allow the user to change the parameters of cooperating tasks while they are running. This is particularly useful in the deconvolution tasks and is available for some other tasks as well. Tape input-output has been separated into its own machine-specific subroutines and the tape programs revised to use them and to handle blocked FITS tapes (an international standard beginning January 1, 1987). Fast, machine-specific backup tasks, BAKTP and BAKLD, have been written for VMS and UNIX systems. The geometry tasks were cleaned up and HGEOM acquired the ability to convert between celestial, galactic, and ecliptic coordinates. Two new taks were also received to support Imagen laser printers.

M. VLA COMPUTER DIVISION

On-Line System

The 32 bit upgrade continued with only minor problems and development of the new software proceeded. A backup ModComp 32/85 system was acquired with funding provided by JPL through the Voyager project.

DEC-10 System

A third RP07 disk drive (used) was installed on the DEC-10, doubling the amount of disk space available for databases.

VAX Systems

The two VAX 11/780 systems were extensively reconfigured and the machine room rearranged to allow for the new CONVEX C-1 computer. The IIS image computer was moved from VAX 3 to the CONVEX, leaving VAX3 without an image display device. It will be used primarily as a general-purpose computer and network model, although batch AIPS processing will be possible.

The VAX 11/750 (OUTBAX) continues in use for display of pipeline images as well as for AIPS. The Groningen Image Processing System (GIPSY) was installed on OUTBAX during the quarter. This system is an interactive image software processing package designed especially for analysis of spectral-line images.

CONVEX System

A new CONVEX C-1 mini-supercomputer (named CHOLLA) was acquired and installed at the VLA. Similar to the computer installed earlier in Charlottesville, the CONVEX C-1 is a 64 bit vector processor which runs under the UNIX operating system. It will be used primarily for AIPS processing of VLA data but will also serve for development of image processing and enhancement algorithms. The installation of the CONVEX required extensive rearrangement of the VAX machine room and user work areas. It took approximately three weeks.

N. VERY LONG BASELINE ARRAY

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.

Status of Site Preparation

<u>Pie Town</u>: The control building and all other site preparation items are complete.

<u>Kitt Peak and Los Alamos</u>: The antenna foundations are finished, and utilities are in at both sites. Both control buildings and all other site preparation work should be complete by the end of January, 1987.

<u>North Liberty</u>: The site has been acquired, a contract for site preparation (not including a control building) has been signed, and preliminary on-site work has started. Budget restrictions may make it necessary to defer construction of

the control building. Temporary space in an existing building could house sufficient equipment to permit checkout and acceptance of the completed antenna.

Fort Davis: The pre-bid conference with potential bidders for the site preparation job was held on 16 December. It is expected that a contract for the work will be in place by the end of February.

Brewster: Nothing new. The site preparation job will be bid early next year.

St. Croix: Negotiations continue with Fairleigh Dickinson University for purchase of the site.

Owens Valley: A site has been chosen, with Caltech approval, on land leased by Caltech from the City of Los Angeles. Formal acquisition is expected early next year.

Hawaii: A good site has been located on the north flank of Mauna Loa. Formal application to the State of Hawaii for use of the land will be made early in 1987.

Northeast: A final location for this Station has still not been determined.

Antennas

Antennas #1 through #4 are currently under contract. A proposal from Radiation Systems, Inc. for construction and erection of #5 through #10, at the revised rate of two antennas per year, has recently been received and is under study.

Antenna #1 (Pie Town): Installation of the surface panels has begun. The major remaining erection tasks are the alignment of the elevation gears and, most demanding, the setting of the precision surface panels.

All feeds have been successfully tested save the L-band feed, which is in the final stages of fabrication. The first feed cone has been outfitted with feeds, receivers and cabling and is ready for installation by the Contractor. NRAO personnel will install the first subreflector and its focusing and rotation mount (FRM), scheduled to be ready by February 25, 1987. Arrangements have been made to have the subreflector surface checked by an independent group prior to installation.

An 18 week schedule for "outfitting" the completed antenna for operation has been developed.

Antenna #2 (Kitt Peak): The major structural items are complete at the fabricator's plant. The surface panels await inspection. The servo system is complete and successfully tested. Erection of the antenna will begin January 15, 1987.

Antenna #3 (Los Alamos): The heavy structural items are about 50% completed, and the first tier of surface panels is finished. The servo system is complete and tested.

Antenna #4 (North Liberty): Fabrication of the structure began in November.

Electronics

Electronics equipment for the Pie Town antenna was shipped to the VLA site during September. Included are the front ends for 330 MHz, 610 MHz, 1.5 GHz, 4.8 GHz, 10.76 GHz and 15 GHz, as well as the racks containing the associated converters, LO related and control electronics, plus all power supplies. Laboratory testing of this equipment, as part of a working system which also includes the station computer and the Data Acquisition Rack (see below), was started in October, and will continue until the installation at the antenna is started in February 1987. Engineers from Charlottesville have made several trips to the VLA site to participate in this testing program.

Construction of the electronics for antennas 2 and 3 is progressing well. Their initial outfitting will include front ends for only 1.5 GHz, 4.8 GHz and 23 GHz. Front ends for 1.5 and 4.8 GHz are now being completed, as are some parts of the local oscillator system. Racks, bins, metal parts and electronic parts are mostly on hand, and assembly of racks and modules has begun. The electronics for antenna 2 will be ready for shipment to the VLA site for system tests by the end of April 1987.

A visit to Sigma Tau Standards Corporation in Tuscaloosa in December showed that the hydrogen maser contract is on schedule and no significant technical difficulties have been encountered. The three masers which are to be delivered in July 1987 under Phase I of the contract have been largely completed with regard to the main mechanical assembly, and the physics packages are under vacuum. Current work is concentrated on the electronics parts, and first tests of oscillating systems are expected early in the new year.

Data Recording

In response to Haystack's recent proposal, a change order to Subcontract AUI-216 is in preparation, which will fund some additional development effort, field engineering support in connection with prototype testing and installation at Pie Town, plus a "station computer" (see below) for use at Haystack in verifying proper monitoring and control of data recording elements built at Haystack prior to shipment to the field.

The first Data Acquisition Rack (DAR#1), including IF processing components but less Formatter, is undergoing system tests at the VLA with other subsystems destined for Pie Town. The Formatter and the Recorder proper (REC#1) are scheduled for delivery mid-February, 1987.

Haystack's proposed preproduction program comprising three additional pairs of units requires further study and consultation with Haystack prior to the writing of a further change order committing the required funds.

Monitoring and Control

It was decided to continue buying Motorola System 1121 computers for station computers. This System costs only about 3% more than a board-level minimum system, and affords some options that may be useful. Its use also permits deferring some effort on system booting. A requisition for the Kitt Peak and Los Alamos computers was completed.

As system tests of the equipment for Pie Town progress, special operator/technician interface programs for the various devices are being written. A major effort is under way to coordinate general screen appearances of interface screens for both the VLBA and the VLA. Sensible control functions are available for the synthesizers, the front end and oscillator switch module, and the front end interface modules themselves, while work has started on the control functions for the baseband converter modules.

Most astronomical observing programs are now available in preliminary form, including: 1) Text string interpreter for observation description; 2) Fundamental timing system, including an internal 20 Hz software execution rate and synchronization to the 1/sec station tick; 3) Antenna pointing; 4) Monitor data logging (for stand-alone pointing observations only--the VLBI observation variant is still under development); 5) New source setup of standard interfaces, receivers, local oscillators, baseband converters (partially complete).

The weather station for Pie Town has been ordered.

A MicroVax II has been ordered to serve as the main Monitor/Control computer in the Array Operations Center. The system consists of CPU, memory, disk, cabinets and connectors ordered from Digital Equipment Corporation, and tape transports, a laser printer, and terminals ordered from other vendors. The system ordered is adequate for software development and initial operation; it will need further expansion before the Array is in full-time operation.

Correlator

Analytic studies of finite-precision sample weighting and multi-level fringe rotation in an FX correlator were completed. Both operations can be accomplished satisfactorily and without serious degradation from quantization effects. Tables of fringe-rotator coefficients optimized for several different cases of input and output precision were developed for use in simulations. The effects of the initial signal quantization at the array elements were also studied, and were shown to be insignificant in all but a very few cases. Post-correlation correction appears impossible, however--for both spectral-domain and lag correlation--and for extraordinary observations special pre-whitening measures may be required before recording. No further analytic work is planned, as the complexity of the operations and of the statistical distributions of the signals in other areas of the correlator preclude effective use of such techniques.

Development of the large-scale computer simulation of the entire FX correlator has been completed, although the system is still frequently being modified to incorporate new features suggested by study of its results. A comprehensive experimental base has now been accumulated, including runs of up to 64 Megasamples. Some results have revealed weak spurious signals and spectral distortions which appear to arise from the finite quantization of signals in the FFT operation. These would limit the spectral dynamic range to less than the goal of about 40 dB, and it may be necessary to increase the length of data words beyond the provisional specifications based on earlier, very coarse analysis. Extensive further runs with the simulator are planned to study these effects and to explore the multiplier/accumulator sections of the correlator design.

The earlier plan to build a breadboard version of the FFT/multiplier gate array with MSI components has been abandoned. Instead, work has started on a system to simulate the chip using a digital signal processor (DSP) programmed to replicate exactly the gate-array functions at the bit level. This simulator will provide a parallel but essentially independent realization of the most critical parts of the FX correlator, so that comparison of results between it and the computer simulation system will greatly enhance our confidence in the conclusions drawn. Like the computer system, the DSP simulator will generate test data with various spectral characteristics, and can be changed easily to determine the influence of particular features. However, it will be more exact in many details, such as number representation and truncation, and may be able to process more samples.

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) The 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).

2) Considerable progress has been made in this area. The preliminary design of the calibration software is now being implemented. The continuum calibration routines have been written and are in limited production use. There were also signifigant new software developments to allow editing of data.

3) The concerns of geometric accountability are being included in the design of all software and data structures.

O. PERSONNEL

New Hires

Darrel Emerson	Assist. Director/Tucson Operations	11/10/86
Kevin Lind	Research Associate	11/24/86
Dennis Newell	Electronics Engineer I	10/20/86

Terminations

Patrick Palmer	Visiting Scientist	10/15/86
Patrick Moore	Scientific Programming Analyst	11/17/86
Davuluri Narayana	Visiting Electronic Engineer I	10/27/86
Jozef Maslowski	Visiting Scientist	11/25/86

Other

David Hogg	Transfer to Charlottesville	10/01/86
Morton Roberts	Leave for Professional Advancement	11/01/86
Charles Broadwell	Transfer to Charlottesville	12/01/86

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