Option	Choices	Entered by Card	Entered by Terminal
j) Rest Frequency	Value of rest frequency. Used to calculate center frequency.	'R'	N.A.
k) Center Frequency Formula	Formula describing the ULO setup	'R'	N.A.
2) A/C Configuration	1 Receiver - 1024 chans. 2 Receivers - 512 chans. each 3 Receivers - 512/256/256 chans. 4 Receivers - 256 chans. each 1 Receiver - 512 chans. 80 MHz BW 2 Receivers - 256 chans. ea. 80 MHz BW 3 Receivers - 256/128/128/chans. 80 MHz BW 4 Receivers - 128 chans. each 80 MHz BW 2 Receivers - 256/512 chans. mixed 4 Receivers - 128/128/256/256 chans. mixed	'R' Configuration	= 0 = 1 = 2 = 3 = 4 = 5 = 6 = 7 = 8 = 9
3) Focus (offset)	Value of the focus offset from nominal focus in units of wavelengths (assumes Rest Frequency has been initialized)	N.A.	FOCUS = ####
4) Zenith Focus	Value of focus at zenith	'P'	FØ = ####mm
5) Position Angle	Value of box position angle	'P'	PAØ = #### degrees
6) Sequencing Select	Greenwich Sidereal Time Greenwich Mean Time Local Sidereal Time As-soon-as possible (duration)	'S'	N.A.
7) Integration Period	Time of A/C Dumps	'A'	TINTG = seconds
8) Duration	Duration of a scan	'S'	TDUR = seconds

The following is a list of special conditions that require manual intervention:

Line Special Conditions	
Item	Response
LO Switch	The ULO switch must be set by the telescope operator to Modulate for S-Power, and either f_0, f_1, or f_2 for T-Power.
Deformable Subreflector	A Cassegrain receiver push-button must be selected. Control panel must be powered on and in computer control.

Following is a list of spectral line observing verbs which may be used individually or in procedures.

Verb	Description
SPOBS	Collects frequency switched data at the current telescope position. The scan is marked as an S-Power scan.
ONTPO	Collects non-switched data at the current telescope position. The scan is marked as a T-Power "on" scan.
OFTPO	Collects non-switched data at the current telescope position. The scan is marked as a T-Power "off" scan.
BALANCE	Initiates a command to the A/C to balance the IF levels. This action requires 20 seconds to complete.
MANUALBAL	Default for line programs. The verb BALANCE must be invoked to balance the A/C.
AUTOBAL	The verb BALANCE will be invoked automatically by the Modcomp when the power counters are out of range in the first dump of the first integration of a scan. This action results in the first dump (20 seconds) and the balance time (20 seconds) being lost in the observing time. However, the scan duration will be completed as normal.
MODFOCUS	This verb causes the nominal focus to move ± 1/8 wavelength while observing with T-Power or S-Power. Successive integrations are taken at + 1/8 wavelength and - 1/8 wavelength. The scan duration must be an even multiple of the integration period. This feature helps to cancel standing waves if present in the data.
FIXFOCUS	This verb is the default for line programs. All integrations are observed at the nominal focus.
OVERSAMPLE	Causes the A/C sample rate to be 4* BW. 40 MHz and 80 MHz BW cannot be oversampled.
NORMSAMPLE	Default for line programs. The A/C sample rate will be 2* BW.

Following is a brief description of the spectral line observing procedures in current use. The complete descriptions are given in Section VI. These are standard procedures which are always available at the telescope. For assistance in customizing procedures, contact the telescope programmer before the observing run.

Procedure	Description
SPWR	Positions the telescope and collects frequency switched data (S-Power).
TOFF	Positions the telescope and collects non-switched spectrum that is marked as an "off" scan.
TON	Positions the telescope and collects non-switched spectrum that is marked as an "on" scan.
SMANY	Positions the telescope and collects REPC scans of frequency switched data (S-Power).
TMANY	Moves the telescope to an "off" position and collects one T-Power "off" scan; moves the telescope to the source position and collects REPC T-Power "on" scans.
SFIVE	Collects S-Power scans at the source position and then at offsets in each cardinal direction.

B. Continuum Observing Program

The continuum observing program records radiometer output. Radiometer signals pass through the NRAO Standard Receiver and through signal conditioning cards before being digitized by a 15 bit A/D converter. Samples are collected every 100 milliseconds (Sidereal). Sampling generally starts "as-soon-as-possible" for single sky position observations. For mapping, the sampling begins after the telescope is positioned. The computer averages the 100 millisecond sample over the integration period to form a sky sample which is recorded together with the telescope position at the center of the integration. The program can record up to eight radiometer channels simultaneously.

A number of sky samples, fixed by the buffer size and the number of channels, are grouped together to form a record. Each record is temporarily stored on a magnetic disk file. The records are collected into a logical grouping of records that forms a complete observation and is assigned a five digit identification number. This group of records is called a "scan" and the identification number is called a "scan number". When the disk is filled, the records are transferred to tape. Observing is halted for several minutes during the transfer. The computer also generates a log; a sample copy is given in Appendix K.

Continuum observations at the 140-ft telescope present the observer with some unique problems. None of the continuum observing equipment is interfaced to the computer, and there is no standard equipment setup supported by electronics. Thus, observations have been collected with an expected time constant of 0.2 seconds, but with the equipment set for 2.5 seconds; with the radiometer input expected on A/D channels 8 through 15, but with the equipment cabled for 0 through 7; with the noise tube expected to be controlled by the computer, but in fact controlled by the autocorrelator, etc. If in doubt - check your equipment. If in need of help - contact the receiver engineer, telescope operator, or telescope programmer. It is your responsibility to see that all is done.

The calibration of continuum observations is a two step process. First, the A/D counts are converted to an antenna temperature scale based on a standard noise tube reference (which should be assumed to have an absolute accuracy of $\sim$ 20%).

Then the noise tube temperature scale is converted to a flux density scale by observations of standard sky sources. The first step is done by the procedure CAL. CAL measures the total power with the noise tube turned off, then on, then off again. The calibration (cal) factor is calculated from NOISE TUBE (K) divided by (counts cal on - counts cal off), using the noise tube value entered by the observer. There is no continuous calibration method currently available. The calibration procedure assumes that the combination of noise tube switch time constant and the receiver time constant is less than 0.5 seconds. The analysis system calculates the cal factor and applies it to all subsequent scans until the next CAL scan. The flux density/temperature calibration is done by the observer using the analysis system.

All continuum observations are done as procedures, and therefore the continuum verbs themselves are not directly usable. For reference, we include a list of verbs associated with continuum observing below:

Verb	Description
CDOB	Collects continuum data assuming the telescope is moving within specified position limits. The verbs MOVE and SLEW set the data start and stop collection limits.
CDCL	Collects one continuum scan with the noise source off-on-off for calibration.
CDSIT	Collects continuum data for a specified time duration regardless of telescope position.
OFOB	Collects one sky sample as part of an off-on observation.
OFCL	Collects one sky sample with the noise source on as part of an off-on observation.
START	Prepares for the start of a continuum scan.
STOP	Terminates a continuum scan.

Following is a list of continuum observing procedures for source measuring and mapping. Detailed descriptions are given in Section VI. These are the standard procedures which are always available at the telescope. For assistance in customizing procedures, contact a telescope programmer before the observing run.

Procedure	Description
CAL	Takes a scan with the noise source off-on-off to determine the temperature to counts scale.
OFFON	Performs a series of single integration measurements off and on-source followed by an off-on-off noise source calibration.
PEAK	Determines the Local Pointing Corrections (LPC); moves the telescope to peak position.
POINT	Determines the Local Pointing Corrections (LPC).

C. VLBI

Although none of the VLBI recording equipment is interfaced to the control computer, the 140-foot control system can assist VLBI observers. There are three areas where the computer can be of help: scheduling the telescope moves, peaking up on sources, and calculating system and source temperatures. For the following discussion we will limit our remarks to observer scheduling by cards with emphasis on time scheduling using Greenwich Mean Time (GMT) or Greenwich Sidereal Time (GST). This is the typical VLBI observing technique.

1. Scheduling the Telescope Moves

VOBS is the 140-foot observing procedure that positions the telescope and waits until a specified time before moving to the next source position. VLBI observers use this procedure to create an observing schedule. An example is given below:

Example: Scheduling the Telescope Moves

S NRAO 15Ø	3 Ø3575Ø.7	5Ø54Ø4	GMT 15Ø9ØØ	VOBS
S 3C 84	3 Ø3182Ø.7	412522	GMT 1515ØØ	VOBS
S NRAO 15Ø	3 Ø3575Ø.7	5Ø54Ø4	GMT 1527ØØ	VOBS
S VR42220Ø1	3 22Ø15Ø.Ø	421Ø1Ø	GMT 1543ØØ	VOBS
S NRAO 15Ø	3 Ø3575Ø.7	5Ø54Ø4	GMT 1559ØØ	VOBS
S 3C 84	3 Ø3182Ø.7	412552	GMT 1611ØØ	VOBS

2. Peaking Up on Sources

PEAK is an observing procedure that places the telescope beam at the maximum of the convolution of the telescope beam and source brightness distribution, i.e., for a point source the telescope is "peaked up". The procedure finds the peak by scanning back and forth through the source in right ascension and declination. The resulting profiles are Gaussian fit and averaged. The calculated positional differences replace the local pointing corrections (LPC) so that the next "move to position" brings the telescope beam to the strongest point. The telescope is left on this point.

When using this procedure, the telescope drive rate and offset size must be entered into the computer by the patter 'P' card. Of course these quantities vary with observed wavelength. Either total or switched radiometer output can be used, but switched output works more reliably, because of the reduction of "atmospheric sources". This procedure works well on strong sources, but tends to fail on weak sources or sources with poorly determined positions (relative to the pointing corrections). If the procedure fails to find a peak, the local pointing corrections last found are used. In the following example, PEAK is used for strong six centimeter sources, but is skipped for a weak source. (Peak takes about 3 to 4 minutes to find the peak.)

Example: Peaking Up On Sources

```
A           0.2        5.Ø
S 3C 345          3 164216.5   3951Ø1          SEQ                    PEAK
P 1950.0     1ØØ.Ø     1ØØ.Ø    3 Ø 1   12Ø.Ø  2ØØØ               123.    245
S 3C 345          3 164216.5   3951Ø1          GMT Ø63ØØØ             VOBS
S DR 21           3 2Ø3815.9   421447          GMT Ø72ØØØ             VOBS
S 2134+ØØ         3 213432.4   ØØ36Ø3          SEQ                    PEAK
S 2134+ØØ         3 213432.4   ØØ36Ø3          GMT Ø8Ø4ØØ             VOBS
  RLPC+Ø.Ø;    DLPC+Ø.Ø
S CYG X-3         3 2Ø3Ø37.6   4Ø4712          GMT Ø83ØØØ             VOBS
```

3. Calculating System and Source Temperatures

The observing procedures VSTM and VSRC calculate the system and source temperatures. VSTM determines the system temperature by measuring the change in total power caused by firing the noise tube. VSRC determines the source temperature by performing OFF-ON measurements followed by a measurement of the noise tube. The number of OFF-ON pairs is specified by REPC; must be varied according to the strength of the source. Both procedures display the calculated temperatures on the operators CRT screen and can be obtained from the analysis computer on the line printer.

There is an inherent difference between these two verbs. VSTM requires total power raidometer output. VSRC does not and indeed works best with switched radiometer output. Therefore, these procedures assume their input to be on separate A/D channels; VSRC assumes switch input on A/D channel 8 and VSTM assumes total input on A/D channel 9. At the time of this writing, the change between switch and total power output requires that the telescope operator manually change receiver or back-end switches. Because both procedures are often done in succession, we have combined them into a new procedure called VSST, which prompts the telescope operator to set the appropriate switches prior to observing. Naturally, the timing of this procedure is somewhat variable.

In the following example, the observer peaks up, calculates system and source temperatures, and delays until it is time to change sources. Note how the repeat counter changes with expected source strength.

Example: Peaking Up, System Temperature and Observing

```
A           Ø.2      5.Ø
P  195Ø.Ø    1ØØ.Ø     1ØØ.Ø    3 Ø 1   12Ø.Ø   2ØØØ                 123.   245
S  4C39.25       3  Ø92541.6  39Ø8Ø5          SEQ                      PEAK
S  4C39.25       3  Ø92541.6  39Ø8Ø5          SEQ              3       VSST
S  4C39.25       3  Ø92541.6  39Ø8Ø5          GMT  2259ØØ              VOBS
S  NRAO  15Ø     3  Ø3575Ø.7  5Ø54Ø4          SEQ                      PEAK
S  NRAO  15Ø     3  Ø3575Ø.7  5Ø54Ø4          SEQ              1       VSST
S  NRAO  15Ø     3  Ø3575Ø.7  5Ø54Ø4          GMT  2332ØØ              VOBS
```