NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

Telescope Operations Division Report No. 5

INTERFEROMETER USERS' GUIDE

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INTERFEROMETER USERS' GUIDE

Jonathan Spargo

Introduction

This report is intended to supplement the more detailed reports on the three-element interferometer system. It gives a general description of the system, of the data, and of the configuration of the electronics on the telescopes and in the control center.

1.0 Observing Time

1.1 Scheduled Downtime

1.1.1 Normal Maintenance

Normal maintenance is undertaken each Tuesday beginning at 0800 local time, and lasting until 1600 local time, or until the completion of major maintenance. Exceptions to the normal maintenance schedule must be cleared through the Telescope Supervisor or the Head of Telescope Operations Division. Maintenance is co-ordinated by the telescope supervisor.

1.1.2 Telescope Moves

Telescope moves are normally begun at 0800 local time on the day scheduled for the move. Pointing corrections and phase calibration are begun at the conclusion of the move and system checkout.

1.1.3 Holidays

The interferometer is normally shut down for 3 - 24 hour periods each year which are currently Thanksgiving, Christmas and Easter.

1.2 Unscheduled Downtime

1.2.1 Equipment Failure

The normal procedure for both major and minor equipment failures is for the operator to determine the nature of the difficulty, and either attempt to fix it himself or call for help should he need it.

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1.2.2   Trouble Shooting Procedures

If the trouble is system-wide, for example, in the DDP-116 computer, the system is shut down until repair is made. If the trouble is confined to one telescope, observations may continue with the other two. Minor troubles can usually be corrected immediately; if they require some time to fix, and can be tolerated during the observing period, they are usually carried to the next maintenance day before repair is attempted.

1.2.3   Weather Conditions

Operators are instructed to shut down the system if one or more of the following situations occur: steady wind velocities of 30 mph or frequent gusts of 35 mph; a temperature of -10 degrees F or lower; or heavy, wet snows, with little or no wind, under which conditions snow will accumulate in the dishes. The telescopes will be shut down upon accumulation of 1/4" ice load (average) or an equivalent snow load.

2.0   Telescope Drive Rates

2.1   Drive Package Configuration

The drive packages of each 85 foot telescopes (polar and dec) are equipped with a slew motor and 3 scan motors.

2.2   Slew Rate

The slew rate in right ascension and declination is 20 degrees per minute.

2.3   Scan Rates

The scan rate can be varied by calling up various motors in either direction.

2.4   Scan Rate Tables

Tables 1A and 1B below give current possible rates right ascension and declination.

2.4.1   Right Ascension Scan Rate Table * * * * * * * * * * * TABLE - 1A

(Sky Rate)   (Current Hour Angle Rates) *

W - 3.0 **	-------------	4 min/min W
W - 2.0	-------------	3 min/min W
W - 1.0	-------------	2 min/min W
W - 0.6	-------------	1 min 36 sec/min W
W - 0.4	-------------	1 min 24 sec/min W
W - 0.2	-------------	1 min 12 sec/min W
Track - 0.0 **	-------------	1 min/min W
E - 0.2	-------------	48 sec/min W
E - 0.4	-------------	36 sec/min W
E - 0.6	-------------	24 sec/min W
E - 1.0	-------------	0
E - 2.0	-------------	1 min/min E
E - 3.0	-------------	2 min/min E
E - 4.0	-------------	3 min/min E
E - 5.0 **	-------------	4 min/min E

2.4.2   Declination Scan Rate Table * * * * * * * * * * * * TABLE - 1B

(Sky Rate)   (Current Declination Rates) *

N - 4.0 **	-------------	1° /min N
N - 3.0	-------------	45' /min N
N - 2.0	-------------	30' /min N
N - 1.0	-------------	15' /min N
N - 0.6	-------------	9' /min N
N - 0.4	-------------	6' /min N
N - 0.2	-------------	3' /min N
0.0 **	-------------	0
S - 0.2	-------------	3' /min S
S - 0.4	-------------	6' /min S
S - 0.6	-------------	9' /min S
S - 1.0	-------------	15' /min S
S - 2.0	-------------	30' /min S
S - 3.0	-------------	45' /min S
S - 4.0 **	-------------	1° /min S

2.4.3   Manual Rates

    * These are the rates at which the telescope may be run now manually
by the operator, from the control center. Other combinations are possible
but not currently available.

2.4.4   Computer Rates

    ** In addition to the slew rate, the computer can call up these rates
only for fine positioning of the telescopes.

2.4.5 Additional Computer Rate

The computer has one additional rate that it uses for position touch up after observation has begun. This equals 1.4 sky rate on either axis. This is available to the computer only and can not be run manually.

3.0 Telescope Limits

3.1 Limit Configuration

The three 85-ft antennas are equipped with a set of primary and backup limits for hour angle and declination. The limits are reasonably uniform for all three telescopes. However, the limits may vary from telescope to telescope by as much as two degrees and are somewhat susceptible to thermal situations. In general the limits are as follows:

South limit - about -46 degrees

North limit - about +84 degrees

3.2 Approximate Limit Values

East limit north of 0 degrees dec. - about 5 hrs 54 min H.A.

West limit north of 0 degrees dec. - about 5 hrs 55 min H.A.

East limit south of 0 degrees dec. - about 4 hrs 54 min H.A.

West limit south of 0 degrees dec. - about 4 hrs 55 min H.A.

3.3 Computer Limits

In addition, limits are programmed into the computer and are slightly less than the actual limits of the telescopes. For example, the east limit in the computer is about 5 hrs 50 min north of zero, and 4 hrs 50 min south of zero. The computer is only programmed for east and west limits. If a telescope should be driven into a limit, it is stopped and it automatically reverts to manual control. The operator then must manually back the telescope out of the limit and place it again in computer control. If the computer

decides the source it is going to is beyond the east limit, it will position

the scopes just short of the limit and wait for the source to come out of the

limit. It will then set up the scopes and continue normal observation. If the

source being observed goes into the west computer limit the computer will stop

observation and position the scopes on the next source in its list and begin

observing again. A current listing of all actual telescope limits is kept on

hand at the operator's console in the control center.

4.0   Observing Instructions

4.1   Instructions For Operators

Observers should leave a detailed set of instructions about their

programs with the operators. These instructions should include places, times,

and phone numbers where the observer or his designated assistant can be reached

in case of equipment trouble or down time. A standard form is now available

at the control console for this purpose. The observer may want to know, for

example, the exact amount of time lost and sources missed, so that he can

change and update his program for the following day.

4.2   Program Planning Consultation

Observers may find it useful in the planning of their programs to

consult with the interferometer scientific supervisor or other staff astron-

omers having knowledge about the system.

5.0   Processing the Data

5.1   Data at the Control Center

5.1.1   Data Outputs Available

The data available for the instrument include a magnetic tape, con-

taining up to about 29 hours of observation, two copies of the teletype print-

out from the computer, two copies of the observing log, and an analog record

of the corresponding data. One copy of the printout, log, and record go to the observer. The carbon copy of the log is kept as a permanent record at the Control Center for one year at which time it is placed in storage at the Green Bank Laboratory Building. The copy of the teletype printout is kept for seven days, and then thrown away.

5.1.2   Maintenance Logs

As with the observing logs, the telescope operators keep a maintenance log, showing all system failures and the corrective actions taken. These logs are available for inspection at the control center, and in the Green Bank Laboratory Office of Telescope Operations Division.

5.2   Operator Notes on the DDP-116

5.2.1   Operator System Monitoring Procedures

In addition to the usual data which are recorded, there are also the very useful comments which are intercalated by the operators. As each shift begins, the operator on duty identifies himself to the computer by means of a programmed interrupt called XOPID (operator identification), which he initiates himself. The computer then calls for the initials of the operator and of the observer (See Appendix A). This information is stored along with source data for use in data reduction. At approximately the same time the operator will, if requested, type in the current local oscillator frequency for the phase locked oscillator system. In addition there is on hand a graph depicting the predicted sidereal clock error in milliseconds. At the start of each shift the operator takes a reading from this graph and enters it on the observing log. This clock correction is then available, on the log, for data reduction and then can be entered in the IBM 360 in Charlottesville.

5.2.2   Computer Interrupt "XNOTE"

During the time that the computer is taking data on a given source, the operator may write on the data disk using the programmed interrupt called "XNOTE". This allows the operator to note on the disk any information about the data, such as equipment malfunction. This note is then printed out during the subsequent stages of the data reduction.

5.3   Subsequent Data Processing

5.3.1   Data Pickup (shuttle)

The Green Bank to Charlottesville shuttle driver makes a stop at the control building each day between 8 and 8:30 A.M. to pick up any data going to Charlottesville. This usually includes the magnetic tape with a punched IBM card for "INTREAD" as instruction for the IBM 360 in Charlottesville, the remaining copies of the observing log and teletype printout, and the analogue data.

5.3.2   Special Data Arrangements for the Green Bank Observer

If the observer decides to remain in Green Bank while his program is being run, he may upon request have all the data, excluding the magnetic tape, retained at the control building for him. He may also arrange to have the printed results of the data reduction by the 360 in Charlottesville delivered to his office or to the control center.

5.3.3   Final Data Processing

Final data processing is done in Charlottesville on the IBM 360 computer. Schedules for processing have been set up by the staff at Charlottesville. Programs are in existence for interferometer data processing. Observers should consult scientific staff and computer staff in Charlottesville to arrange for the desired information from data reduction.

6.0   The Interferometer System

6.1.0   The Individual Telescopes

6.1.1   Electronic Subsystems

A detailed description of the receiver front ends, and the local oscillator system, has been given in the Interferometer Group Memoranda by Pasternak (IG No. 1367, August 1967) and by Wesseling (IG 1867, September 1967; IG 1967, October 1967). A monitor of all of the important receiver and telescope functions is maintained in the control center, as described below.

6.1.2   Focus - Polarization

The focus position and polarization angle of the front end boxes of all three telescopes are read by optical position encoders and are displayed on a binary readout on the control console. A subroutine is available for the computer which gives a decimal printout of the box positions and allows positioning of the boxes. Current standard positions for focus and polarization are:

6.1.3   Focus - Polarization Tables

	Binary	Computer Readout	Scale
85-1 Focus	06431 ± 10	167.60 ± .5	35.2 ± .1 cm
2 "	06520 ∓ 10	170.40 ∓ .5	35.0 ∓ .1 cm
3 "	07141 ∓ 10	184.10 ∓ .5	37.3 ± .1 cm

	Binary	Computer Readout	Degrees
85-1 Polarization	01142 ± 10	30.5 ± .5	30.5 ± .5
2 "	04540 ∓ 10	120.0 ∓ .5	120.0 ∓ .5
3 "	04072 ± 10	105.3 ± .5	105.3 ± .5

The numbers in the decimal printout are degrees for polarization, units of about 2 mm in focus. The polarization angles are those which by test have shown the minimum ellipticity residual.

The standard procedure is to check these readouts once per 24 hours and note

the readings by entering them into the computer by XNOTE (see above). They can be checked more frequently if requested.

6.1.4   Telescope Control

The telescopes are operated from the control center. There are provisions, however to operate each telescope at its location for testing and repair situations.

6.2   The Control Center

6.2.1   Building Arrangement

The main floor of the control center has the control room and receiver rooms, described below; a visitors' office, containing a desk, filing cabinets, and an IBM card punch (Model 026) and the telescope supervisor's office. The basement of the building contains the cable bulkheads, RF cable pressurizing equipment, cable distribution equipment, and the interfacing between computer, telescopes, and receivers. There is a limited amount of shop room and storage area.

6.3   The Control Room

The principal monitoring information is presented in the control room, in three consoles:

6.3.1   Unit 100 Antenna Console

Unit 100, the antenna console. There are four control panels (one for each telescope, and one spare) which allow for manual or computer operation of the telescopes. These panels also provide information about motor speed and direction, status of the brakes, and whether the telescope is in a limit situation. An emergency stop is on each control panel. Above the control panels are the telescope position displays, one a cathode-ray tube system, the other a digital system.

6.3.2   Unit 130   System Console

Unit 130, the system console. This unit contains the audio monitor and communications system that will communicate with several points on all three telescopes, as well as several points in the control building. This system can be used to monitor the telescopes, and to assist in the isolation of mechanical troubles on a particular telescope. The CRT unit displays data from the computer. The manual focus and polarization control is located beneath the binary display of these quantities.

6.3.3   Unit 180   Analog Display Console

Unit 180, the analog display console. The four-channel Sanborn recorder which displays the output of the correlators is located in this console. The meteorological equipment, including wind speed and direction indicators for two positions on the baseline (85-1 and control center), a recording thermometer and dewpoint indicator, a standard barometer, and a recording microbarograph, is also included.

6.3.4   Clocks

In the control room are a digital sidereal clock, a digital calendar display, and an EST clock. The sidereal time is derived from the Observatory master clock, which is in the main laboratory. However, a WWV receiver is available for clock checks, and is in fact automatically switched on each hour for this purpose.

6.4   The Receiver Room

6.4.1   Detailed Description of Receiver

A detailed description of the three element interferometer receiver back end is given in the Electronic Division Internal Report No. 73, June 1968, by J. Coe. This portion of the system is comprised of three units:

6.4.2   Unit 300 Back End Unit

Unit 300, the back end unit. This unit is the heart of the inter-
ferometer, containing the delay lines, the IF level monitor and control, the
correlator output monitor, the synchronous detectors, and the front end
switch controls.

6.4.3   Unit 330 Analog Monitor

Unit 330, the analog monitor. By means of a versatile patch panel,
any receiver function can be displayed on one of the two four-channel Sanborn
recorders, or on the oscilloscope, or on the audio monitor.

6.4.4   Unit 400 L. O. Distribution Rack

Unit 400, the local oscillator distribution rack. In this rack are
the master oscillator, phase controllers, and PLO remote monitors for each
telescope. The displays include the LO frequency, the sine and cosine compo-
nents of the phase error in the LO paths to the individual telescopes, and the
PLO level and phase at each telescope.

6.5.0   The Computer

6.5.1   Description

The computer is a Honeywell (3C) DDP-116 computer, located in the
control room. The machine and the programs have been described in detail in
the report "Programs for the Interferometer DDP-116 Computer" by B. G. Clark
(September 1968).

6.5.2   Machine Orientation

The DDP-116 computer is a general purpose digital, solid state, par-
allel entry, 16-bit binary computer, with an internally stored program. It
has a core memory of 8192 (8K) 16-bit words which is paged in 512 word blocks,

with a memory cycle time of 1.7 μsec. Cycle time for some basic operations include, ADD 3.4 μsec., SUBTRACT 3.4 μsec., DIVIDE, with hard-wired hardware option 16.67 μsec. max., MULTIPLY, with hard-wired hardware option 9.18 μsec. max.

The computer has been equipped with the following input/output (I/O) devices:

6.5.3   Teletype

ASR-35 Teletype unit which will read and punch paper tapes at 10 characters per second, print at 10 characters per second. It also features a keyboard input, and can be used for off-line paper tape preparation.

6.5.4   Card Reader

A 200 card per minute card reader (no punch).

6.5.5   Tape Transport

A magnetic tape transport operating at 45 inches per second, writing a seven track magnetic tape at densities of either 200 or 556 bits per inch.

6.5.6   Disk Memory

Disk drive (flat drum) which serves as both program memory and data storage units. There are 192 tracks containing 1536 words each for a total capacity of 294,912 words.

6.5.7   Direct Multiplexed Channel (DMC)

6.5.8   A-D Converter

6.5.9   Cathode Ray Tube Display

The cathode ray tubes. These devices display alpha-numeric characters at fixed gridpoint intervals. The CRT has its own memory and reviews its image automatically. Its memory can be accessed by the computer or its own keyboard.

7.0   Operation of the Interferometer System

7.1   Entering the Observing Program

7.1.1   Computer Memory Resident Program

The basic program for computer operation of the system is resident on one of the memory disks in the computer. Although it is nondestructible during normal operation, it can be accessed and updated under certain circumstances. A copy of the current disk program is made on magnetic tape and kept on hand in the control room in case a malfunction of the disk program occurs. This program contains all the instructions necessary for computer control of the system, excluding optional subroutines. It also contains all the parameters such as baseline constants and current telescope position correction factors necessary for computer operation. The computer uses this program by transferring the data it needs from the master program in the disk to its core memory which it then uses for execution of the observing program.

7.1.2   Program Execution

Program execution is controlled basically by the input of IBM punch cards, with supplemental data typed in on the teletype by the operator when called for. The operator follows prescribed routines for getting the computer on the air to the point of entering the observer's deck of punched cards containing source data and operating instructions for the observer's program. When the source cards have been entered the computer will proceed to the first source and begin the observation. Since the computer is dependent upon the source cards for all the information it needs to know about a source, the information on the card must be carefully planned and follow a rigid format. If the format is not followed, the computer will simply reject the card, and time will be

lost while the card is corrected or a new one is punched. Specific instructions for entering source data on the card as well as what that data means to the computer and how it will affect computer and system operation, will be found on pages 5-1 through 5-4 of the report "Programs for the Interferometer DDP-116 Computer."

7.1.3   Readying the Observing Program

Once the operator has brought the computer to the point of readiness for observing, the computer will ask (via the TTY) for a source list to be put into the reader. Before reading them it will check to see if it has the correct Besselian day numbers in its memory. If not, it will ask the operator for them. It also checks to see if it has a program in memory. If so, it will ask if the cards to be entered should precede, follow, or replace the existing list in its memory. The operator then types in the appropriate entry. The source list card deck, with up to 100 cards, is now loaded. With sense switch 4 in the set position the computer will read the entire list in the card reader with no printout on the TTY. With the same switch in the reset position it will read a card and pause before reading the next card in order that the TTY may printout the source name and position or the card just read. This is a lengthy process and is usually skipped by most observers. As the computer reads the source cards it checks them, and if any given card or cards contain an error, or contain any information exceeding programmed parameters, the computer will stop the reading process and print one of several warnings. If the problem is serious enough, the computer will ask permission to begin observing while the error in the card is being corrected. A complete listing of all possible computer outputs on the TTY, such as warnings, malfunction codes, and operator instructions can be found in the Message Dictionary, Chapter IX, of the report by Clark.

7.1.4   Start Observing

As soon as the source deck has been read the computer will type--
"RETURN TO OBSERVING." At this point the operator places all telescopes
under computer control and the computer proceeds to the first source in the
deck. It then slews the telescopes to a rough position, does fine touchup
on positions and begins taking data. Note that the computer will check each
telescope at 5 minute intervals to insure proper telescope positions.

7.5   Recording the Data

7.5.1   Disk Capacity

During the process of setting up on a source the computer via the
TTY writes a header indicating such things as source name, scan number, pre-
cessed positions, polarization switching mode and gain setting. At the same
time it is writing the same header on the disk memory system provided for data
storage. The disk contains 2379 work sectors for data storage, and at present
levels can hold at maximum about 30 hours of observational data. The computer
keeps a running count of the current disk sector at a rate of two records per
scan header and one record per printed line of data. If the disk should over-
flow (i.e., exceed 2379 records) the computer will stop whatever it is doing
and let the operator know about it. Then the operator must dump the disk to
seven track magnetic tape. After this he must by proper action erase the disk.
Then the observations may continue.

7.6   Teletype Data Display

Display of the data on the typewriter.

7.6.1   Teletype Output

The output of the correlators is printed on the typewriter, as a mon-
itor of the system performance and as an indication of the nature of the infor-
mation being obtained about the source. Sample outputs are included in

Appendix A. Normally six columns are printed out; the local sidereal time of the printout, the real and imaginary components of the source visibility function, the correlator offset, the rms error of a single input point about the mean fringe solution, and the correlator channel which was sampled.

7.6.2   Data Output

The correlators which are to be printed out may be selected by means of the computer sense switches. Correlator 1 (85-1/85-2) is printed if sense switch 1 is set; correlator 2 (85-1/85-3) is printed if SS 2 is set; correlator 3 (85-2/85-3) is printed if SS 3 is set; and correlator 4 (85-1/42 ft) is printed if SS 3 is reset.

7.6.3   Printout Rate

The rate at which printouts are given is determined by SS 4. If If SS 4 is reset, the output of the selected correlators will be printed every minute. If SS 4 is set, the output will be displayed every 15 seconds. Because of the relatively long time required to write with the typewriter, it is necessary to skip every fourth 15-second printout. In normal operation, the display period of one minute is used.

7.6.4   Special Conditions (crossover)

Under certain conditions (for example, near the hour angle of the instrumental pole, 4^h 50^m W) the fringe rates decrease to less than one cycle per 15 seconds. The computer will not try to reduce this data, but rather will wait the required number of integration periods until one full fringe has been completed. Meanwhile, it will write dummy records into the disk and zeros in all four data columns on the typewriter. It is not uncommon to have several minutes of dummy records printed out for the third correlator, if the baseline is expecially short (100 m - 300 m) and if the source is near 5^h W.

7.7   Termination of an Observing Program

7.7.1   Data Transfer and Restart of Observing

When the stop time for a source being observed is reached the computer stops the observation and prints out a line which contains the Greenwich sidereal date, sidereal time, the last disk sector in which a record was written and a return code. After this the computer begins moving the telescopes to the next source while writing a new header for the source. This process is continued until the computer source list is empty. At that point, a new source list can be entered or the operator may enter a routine to dump the disk data onto 7 track magnetic tape for transport to Charlottesville and subsequent processing on the IBM 360 computer. After tape dump the operator loads the computer with the new source list. He then prepares the tape and the necessary data for the shuttle driver. The shuttle driver normally stops by the control center each day between 8 and 8:30 a.m. local time to pick up all data going to Charlottesville. By planning an observing day to begin and end at, say sometime between 6 and 8 a.m., the operator can then dump the disk, with the preceding day's data, and have the data ready for the shuttle driver. This procedure will get the data to Charlottesville for processing quickly.

7.8   Antenna -. Pointing Calibration

Calibration of the antenna pointing can most conveniently be done using the DDP-116 program, as described in Chapter VII of Clark's report.

7.8.1   Computer Program Execution

Currently the computer is able to determine the pointing errors for two telescopes simultaneously. A source list in the same format as for interferometric observations is entered. The computer then determines the position of the gaussian of defined halfwidth which best fits the data, in each

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coordinate. This operation requires typically about five minutes to obtain

one measurement of the error in both right ascension and declination. A

typical teletype output is shown in Appendix A.

7.8.2   Updating Pointing Constants

The pointing errors displayed on the teletype are punched on cards,

which are sent to Charlottesville. There, the cards are used by the program

"MERDE", which uses the observations to determine 16 constants - 9 in hour

angle, 7 in declination - which characterize the pointing behavior of each

telescope. These constants are sent back to Green Bank, usually by phone,

and are entered by card into the DDP-116.

7.9   The 42 Foot Portable Antenna

7.9.1   Description and Use

In addition to the 85-ft telescopes the interferometer has a base-

line provided by 85-1 and a 42-ft telescope mounted on a flatbed trailer. The

42-ft baseline offers extended baseline measurements to supplement regular

interferometer observation. At the time of this writing the 42-ft is being

readied for use at a mountaintop site approximately 22 airline miles to the

southwest of the observatory. When operational this will provide a baseline

of roughly 300,000 wavelengths at 11 cm. The 42-ft is tied into the system

by a microwave link through which phase lock of the L.O. is maintained and

data is conveyed to the DDP-116. The outputs of 85-1 and the 42-ft are cor-

related in the fourth correlator. At present telescope pointing of the 42-ft

must be done by an additional operator at the telescope. However, equipment

is presently in the design and fabrication stage which will provide for remote

telescope control of the 42-ft from the control center. Use of the 42-ft

in conjunction with the interferometer program, requires that arrangements be

made well enough in advance so that operator scheduling details can be worked out. It is suggested that questions concerning 42-ft operation be directed to the Scientific Supervisor and or/the Telescope Supervisor.

8.0   Miscellaneous

8.1   Records of Modifications and Technical Assistance

It is hoped that this guide will be useful to you in planning your program for the interferometer. It is impossible to cover all aspects of the instrument in such a guide as presented here. Hardware and software are in a constant process of updating. Records of all modifications to equipment are available in the control center for information and use. Normal operation parameters for all electronic equipment including front ends, receivers, correlators, phased locked local oscillator system and the computer can be found in miscellaneous publications kept on hand at the control center. The systems engineer, and the technicians are available to discuss operation of the electronic equipment. Again the Scientific Supervisor can discuss observing techniques and data reduction programs on the IBM 360/50 with those concerned.

APPENDIX A

SAMPLE COMPUTER OUTPUTS VIA

THE ASR-35 TELETYPE

A1.   STANDARD OBSERVING FORMAT

1/   CTA 102   SCAN 16282

2/   22 31 03.537   11 34 12.446

3/   OBSERVE UNTIL   19 36

4/   MODE Q   GAIN 0

5/   192602 CTA 102

192621	01243	-00092	00222	00462	1
192625	00802	-00775	-00012	00453	2
192630	-00935	-00994	00233	00462	3

6/ is at line 192625.

7/   2446721   193635   SECT   00650   RETURN   00001

- -

NOTES:

1/   Source and scan number.

2/   Precessed coordinates.

3/   Sidereal stop time for this scan.

4/   Polarization switching mode and correlator gain setting.

5/   Observation begins.

6/   These three lines of six columns are the principal data output:
      Column 1 = Sidereal time at printout (local).
      Column 2 = Cosine component (real).
      Column 3 = Sine component (imaginary).
      Column 4 = Correlator DC offset.
      Column 5 = RMS of the fit to the fringe function.
      Column 6 = Correlator channel being sampled.

7/   This line says that the observation for this scan is terminated.
      It contains, in order, the Greenwich sidereal day number, local
      sidereal time, disk sector, and return code.

```
         SOURCE LIST EMPTY.
         READY PROGRAM IN CARD READER.
1/       RETURN TO OBSERVING.
             2446720   105311 SECT 00000 RETURN 00002
2/       SCAN 16880?
         YES.

         W 16                              16880
             06 30 15.391 04 56 22.005 . . .
         OBSERVE UNTIL 12 23
         MODE          GAIN 0

         105816 W16
         105836 -00010     00021      00622     00000    1
         105840 -00062    -00014     -00086     00476    2
         105845  00023    -00015      00182     00000    3
         1
3/       +167.72
         +030.73
         2
         +170.37
         +120.08
         3
         +183.95
         +105.27
             2446720 110515 SECT 0005 RETURN       00006
         110525 W16
         110536 -00027     00031      00646     00000    1
         110536  00000     00000      00000     00000    2
         110540  00000     00000      00000     00000    3
         XNOTE 85-1 F = +167.72, P = +030.73
4/       XNOTE 85-2 F = +170.37, P = +120.08
         XNOTE 85-3 F = +183.95, P = +105.27
         110836  00028     00027      00661     00119    1
         110840  00000     00000      00000     00000    2
         110845  00000     00000      00000     00000    3
         XOPID
         ENTER OPERATOR ID % 2 CHARACTERS.
         JS
         OK JS LETS GET TO WORK.
5/       ENTER OBSERVERS INITIALS
         DH
         SLAVEDRIVER DH
         111036  00034     00027      00021     00000    1
         111040  00000     00000      00000     00000    2
         111045  00000     00000      00000     00000    3
```

(continued)

A2. - (continued)

NOTES:

1/   The observing list has been called for and entered. In this case everything is OK, with no mistakes in card format. If something was wrong a warning would have appeared here.

2/   The computer asks if this is the correct scan number with the answer being yes; observing begins.

3/   Observing has been interrupted to permit measuring focus and polarization of the front-end box of each telescope.

4/   The results of focus and polarization measurements are here entered on the data disk for future use by the observer.

5/   This is the operator identification routine normally used at the beginning of each shift.

A3.   DATA TRANSFER FROM DISK TO 7 TRACK MAGNETIC TAPE
        (TAPE OR DISK DUMP)

1/   2446721. . . 110810. . . SECT. . . 01785. . . RETURN. . . 00001

2/   SOURCE LIST EMPTY.

3/   READY PROGRAM IN CARD READER.

4/   ENTER TAPE NUMBER -- NNNN

5/   0461

6/   TRANSFER COMPLETE. PRESS CR TO CLEAR DISK.

- -

NOTES:

1/   Scan terminator - same as in observing format.

2/   Computer has exhausted its observing list.

3/   Asks for new observing list.

4/   Here instead of an observing list, the operator has entered the
        program for data transfer. The computer now requests the serial
        number of the magnetic tape being used for this particular transfer.

5/   The operator complies following the requested format in line 4.

6/   Data transfer has been completed and the disk may be erased. After
        this has been completed the computer will again ask for a new ob-
        serving list.

A4.   COMPUTER AID ANTENNA POINTING

          3C218   SCAN   00000
            09 16 36.350 - 11 57 39.165
          OBSERVE UNTIL   05 00
          MODE   GAIN 0

          TELESCOPE   COORD   HA   ERROR   CHANGE   AMPL

            85-2   RA   -4H40M   -06.7   0.7   0199
            85-3   RA   -4H39M   -06.4   0.0   0170
            85-2   DEC   -4H35M   03.3   -0.9   0189
            85-3   DEC   -4H35M   04.0   1.7   0168

          -

NOTES: The above is a sample of the TTY output for the computer directed
        antenna pointing program. The columns of this output have the
        following meaning.

Column 1. The telescope which is being pointed.

Column 2. The coordinate for which the error is being measured.

Column 3. The hour angle at which the observation was made.

Column 4. The dial error.

Column 5. The difference between Column 4 and the dial error predicted
           by the previous pointing curve.

Column 6. The magnitude of the peak deflection, in arbitrary units.