NATIONAL RADIO ASTRONOMY OBSERVATORY

Green Bank, West Virginia

TELESCOPE OPERATIONS DIVISION REPORT NO. 6

# BASIC INSTRUCTIONS FOR OPERATING THE INTERFEROMETER

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MARCH, 1970

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## INTRODUCTION

These instructions include all the basic steps in preparing the telescopes, backend units, and the computer for observing in the interferometer mode or in the switched receiver mode of operation. Most of the technical aspects of the system are not included here, and they can be found in one of a number of publications kept at the control building (see Appendix). The purpose here is to provide instructions for operating the system, not to explain why. It is assumed that required power is being delivered to all equipment and that all equipment is functioning properly. Troubleshooting procedures follow these instructions.

SECTION 1

TELESCOPES AND BACKENDS

Paragraphs 1.0-4.4

Pages 1-6

## 1.0 TELESCOPES

Regardless of the mode of operation to be used, the procedure for preparing the telescope(s) to be operated is the same. The CONSOLE SYSTEM UNIT 130, ANALOG CONSOLE UNIT 160, and the ANTENNA CONTROL UNIT 100 are located in the control building control room.

### 1.1 CONSOLE SYSTEM UNIT 130

1) Place all OFF/MONITOR switches for the telescope(s) to be operated in the MONITOR position (relay shack, polar platform, declination platform, apex, and control room).

2) Make sure the monitor SYSTEM, LOCAL, and LEVEL controls are turned up sufficiently to be able to hear.

### 1.2 PERSONNEL WARNING

Make sure the telescope(s) to be used is clear of all personnel and is ready to be operated.

### 1.3 ANALOG CONSOLE UNIT 160

1) Check wind speed monitors to ascertain the wind is below a steady 30 mph and there are no frequent gusts above 35 mph.

2) Check outside temperature to assure it is above $-10^{\circ}$F.

3) Check relay shack temperatures. Safe operating limits are +40 to +100 degrees F.

### 1.4 ANTENNA CONTROL UNIT 100

1) Make sure the green emergency stop reset button at the top of the telescope control panel is IN.

2) Push ACCEPT COMMAND switch.

3) Push BRAKES ON/OFF switch. The light should come on and the hydraulic pump will be audible over the monitor.

4) When the brakes are released, POL BRAKES OFF, DEC BRAKES OFF, and MANUAL CONTROL switch will be lit.

5) Telescope(s) should be run manually to insure all scan and slew motors are functioning properly.

2.0 BACKEND PREPARATION FOR ALL MODES

Regardless of the mode of operation to be used, the following checks and adjustments are required on the L O DISTRIBUTION UNIT 400 and the BACKEND UNIT 300 (both units located in the control building equipment room) and the ANALOG DISPLAY UNIT 160 (located in the control room).

2.1 MASTER OSCILLATOR (UNIT 400)

1) The frequency counter should indicate 47499.000 to 47501.000 kHz. (To obtain this frequency indication, the switches on the COUNTER SELECT panel below the frequency counter must be set so that only the green LO switch is glowing.)

2) The SAMPLE RATE switch should be in the HOLD position.

3) Press the ALC-LOOP CHECK switch located under the PLO LEVEL meter. It should be set to mid-range using the micrometer-type potentiometer. (If it is not possible to obtain this mid-range setting, check with the proper engineer or technician to insure there is no malfunction.)

4) Press the ALC-LOOP CHECK switch under the IF LEVEL meter. It should be on scale. (If it is not on scale, check with the proper engineer or technician.)

2.2 PHASE SHIFTER SERVO CONTROL (UNIT 400)

1) The AUTO/MONITOR switch should be in AUTO position.

2) The SIN meter should read 0± 1 ua.

3) The COS meter should read +45 to +50 ua.

2.3 PHASE LOCKED OSCILLATOR (UNIT 400)

Press the ALC-LOOP CHECK switch. The PLO LEVEL meter above it should be at mid-scale (30-80). If it is not, check with the proper engineer or technician. NOTE: There is a PLO for each telescope.

2.4 IF MONITOR (UNIT 300)

Set the LEVEL meters for the telescopes to be used so that they indicate between 17-22. Use the ATTENUATOR controls to get this reading.

2.5 IF LEVEL CONTROL (UNIT 300)

1) Press ALC ON/OFF switch so that it indicates OFF. (The RECEIVER CONTROL on the POWER CONTROL panel must be pressed so that it indicates MANUAL position before the ALC can be turned OFF.)

2) Set the METER FUNCTION switch to the IF LEVEL position.

3) Using the IF LEVEL control, adjust the meter to read 27.5±.5.

4) Turn the ALC ON/OFF switch to ON.

2.6 BOX TEMPERATURE (UNIT 160)

85-1, 2, and 3 meters should read between .3-.7 ma.

2.7 MIXER CURRENT (UNIT 160)

85-1, 2, and 3 meters should read between .5-1.0 ma.

3.0 BACKEND PREPARATION FOR INTERFEROMETER MODE

The following checks and adjustments are required for the Interferometer Mode of operation.

3.1 CORRELATOR (UNIT 300)

1) Press CORRELATOR control switch so that it indicates MANUAL control.

2) Press switch labeled 1250.

3) Adjust the attenuator control until the CORRELATOR OUT meter reads zero.

3.2 POWER CONTROL (UNIT 300)

1) Press RECEIVER CONTROL switch so that it indicates COMPUTER position.

2) Press DELAY CONTROL switch so that it indicates COMPUTER position.

3) Press CORRELATOR CONTROL switch so that it indicates COMPUTER position.

3.3 NRAO SYNCHRONOUS DETECTOR (UNIT 300)

1) Set GAIN MODULATOR RANGE switch to OFF position.

2) Set SYNC DETECTOR FUNCTION switch to $>10\sim$ position.

3) Set FULL SCALE TEMPERATURE switch to 30.

4) Set METER-MONITOR switch to ANALOG position.

5) Set ANALOG OUTPUT CONTROLS as follows:

SCALE EXPAND to X3 position

OFFSET RANGE to OFF position

6) Set TIME CONSTANT switch to 3.

3.4 ANALOG DISPLAY (UNIT 160)

1) With all recorder input cables disconnected, center the pens on all channels by using the POSITION controls. (The cables and connectors are located inside the rack behind the Sanborn recorder.)

2) Channel 1 Sanborn input cable connects to CORR OUT 1/2 connector.

3) Channel 2 Sanborn input cable connects to CORR OUT 1/3 connector.

4) Channel 3 Sanborn input cable connects to CORR OUT 2/3 connector.

5) Channel 4 Sanborn input cable connects to IF MON 3 connector.

6) Channel 1 console input cable connects to IF MON 1 connector.

7) Channel 2 console input cable connects to IF MON 2 connector.

8) Switch positions for channels 1, 2, and 3 on recorder follow:

POWER ON

RANGE 2.0 v/cm

9) Switch positions for channel 4 on recorder follow:

POWER ON

RANGE 1.0 v/cm

10) SPEED of recorder is normally set at 10 mm/min.

3.5 SYSTEM CONSOLE (UNIT 130)

Set the switches for both channels of the Sanborn recorder as follows:

SPEED 1 mm/min.

RANGE .2 v/mm

LST to SLOW position

EST switch to SLOW

POWER ON

4.0 BACKEND PREPARATION FOR SWITCHED RECEIVER MODE

The following checks and adjustments are required for the Switched Receiver Mode of operation.

4.1 POWER CONTROL (UNIT 300)

1) Press RECEIVER CONTROL to MANUAL position.

2) DELAYS and CORRELATORS are not used in this mode, but they can be placed in MANUAL control.

4.2 NRAO SYNCHRONOUS DETECTOR (UNIT 300)

1) Set GAIN MODULATOR RANGE switch to the 0-2.0 position.

2) Set SYNC DETECTOR FUNCTION switch to 10 .

3) The FULL SCALE TEMPERATURE switch will be set to 300 or to 100 as determined by the relative strength of the source to be observed. Normally, the observer will indicate which position to use for each source.

4) Set METER-MONITOR switch to ANALOG position.

5) Set ANALOG OUTPUT CONTROLS as follows:

SCALE EXPAND to X3

OFFSET RANGE to OFF

6) Set the TIME CONSTANT switch to .1.

7) Balance the receiver by setting the SYNCHRONOUS DETECTOR meter to zero using the GAIN RATIO potentiometer. (Make sure the telescope is off source while making this adjustment.)

4.3 IF MONITOR (UNIT 300)

Re-check the LEVEL METERS to assure they indicate between 17-22. If necessary, adjust the attenuators to attain this reading.

4.4 ANALOG DISPLAY (UNIT 160)

1) Channel 1 Sanborn input cable connects to SYNC DET 1 connector.

2) Channel 2 Sanborn input cable connects to SYNC DET 2 connector.

3) Channel 3 Sanborn input cable connects to SYNC DET 3 connector.

4) The channel 4 Sanborn and the channel 1 and 2 console input cables connect to the IF MON 1, 2, or 3 connectors, depending on where the observer or the operator wants that information displayed.

5) The switch positions for all channels are determined by the strength of the source, and they must be set by the operator after observations begin.

6) The speed of the Unit 160 Sanborn is normally set at 20 mm/min.

7) The speed of the Unit 130 Sanborn is normally set at 1 mm/min.

SECTION 2

COMPUTER OPERATION

Paragraphs 5.0-14.0

Pages 1-20

## 5.0 DDP-116 COMPUTER OPERATION FOR INTERFEROMETER MODE

If all backend functions are set properly and indicate within allowable limits, observations can begin. The DDP-116 computer controls the operation of the telescopes and receivers in the Interferometer Mode. All aspects of computer operation for this mode follow. Refer to DDP-116 CONTROL PANEL diagram, Fig. 1.

### 5.1 LOADING THE KEY-IN LOADER

1) Press POWER button in the lower left corner of the computer control panel. Wait 4 minutes.

2) Punch the MASTER CLEAR button.

3) Punch 016540 into the DATA REGISTER.

4) Punch the P button on the REGISTER SELECT section.

5) Punch the ENTER button. At this time the number 016540 will be displayed on the DISPLAY REGISTER.

6) Place the STORE/READ switch on the MEMORY section to the STORE position. (NOTE: The P ADDR/Y ADDR switch should always remain in the P ADDR position.)

7) Punch the red CLEAR button on the DATA REGISTER.

8) Punch 030105 into the DATA REGISTER.

9) Punch the ACCESS button in the MEMORY section. At this time the number in the DISPLAY REGISTER will increase to 016541.

10) Punch the red CLEAR button on the DATA REGISTER.

11) Punch 131005 into the DATA REGISTER.

12) Punch the ACCESS button in the MEMORY section. Again, the number in the DISPLAY REGISTER will increase by 1 to 016542.

13) Punch the red CLEAR button.

14) Punch 003541 into the DATA REGISTER.

15) Punch ACCESS.

16) Punch CLEAR.

17) Punch 041470 into the DATA REGISTER.

18) Punch ACCESS.

19) Punch CLEAR.

20) Punch 130005 into the DATA REGISTER.

21) Punch ACCESS.

22) Punch CLEAR.

23) Punch 003544 into the DATA REGISTER.

24) Punch ACCESS.

25) Punch CLEAR.

26) Punch 011472 into the DATA REGISTER.

27) Punch ACCESS.

28) Punch CLEAR.

29) Punch 025546 into the DATA REGISTER.

30) Punch ACCESS. At this time the DISPLAY REGISTER will advance to 016550.

31) Punch CLEAR.

32) Punch 003541 into the DATA REGISTER.

33) Punch ACCESS. The DISPLAY REGISTER will now read 016551.

34) Place the STORE/READ switch to the READ position.

35) Punch MASTER CLEAR.

36) Place SENSE SWITCH 4 in SET position (flip it up).

5.2 LOADING THE INPUT/OUTPUT CARD SYSTEM AND SYSTEM TAPE

1) Press POWER ON button on CARD READER. Wait 30 seconds.

2) Place the IOCS card deck (located in the card filing cabinet in the control room) in the input (right) side of the CARD READER. The card deck must be placed FACE DOWN, TOP EDGE OUT. Place the card weight on top of the deck.

3) Press RESET button, then START button on CARD READER. (NOTE: When preparing the card reader to read cards, always press RESET then START.)

4) Punch 016540 into the DATA REGISTER on the computer control panel.

5) Punch the P button on the REGISTER SELECT section.

6) Punch the ENTER button on the REGISTER SELECT section.

7) Place the MODE switch in the RUN position.

8) Press the START button on the computer control panel.

9) The CARD READER will read the IOCS card deck and stop. The computer will type out the coded date, sidereal time, sect number, and a return code on the teletype.

10) Place the TAPE-TO-DISK card deck in the card reader.

11) Press RESET and START on the card reader.

12) Place the MODE switch on the computer to the SINGL. INSTR. position.

13) Punch MASTER CLEAR.

14) Punch 016540 into the DATA REGISTER.

15) Punch P and ENTER buttons.

16) Place MODE switch to RUN position.

17) Load the CURRENT SYSTEM TAPE (located in the tape rack) onto the TAPE DECK. To do this, the tape must be placed on the top spindle with the indention around the center of the reel toward the tape deck. If there is a plastic ring in this indention, it must be removed. Turn the knob on the spindle clockwise until it locks the tape in place. Hold the START/BRAKES switch (located between the spindles) to the BRAKES position and manually unwind enough tape to traverse the reading heads and roll onto the empty reel on the lower spindle. Insert the tape through the slot and onto the heads and begin winding it onto the empty reel until it will hold itself. Hold the START/BRAKES switch to the START position until the tape is pulled into the vacuum chambers. At the top of the tape deck, depress the HIGH DENSITY button, then depress the LOAD POINT button and the AUTO button. The tape is now ready to be read.

18) Press the START button on the computer. The computer now reads the TAPE-TO-DISK card deck and stops.

19) Press START again. The computer will read the preparation date from the tape and print it on the TELETYPE. Ascertain that this is the correct tape (usually, the most recent) to be loaded.

20) Press START again. The contents of the tape will be read by the computer and stored in memory. When finished, the tape will rewind and can be removed from the tape deck and stored in its usual place. The TELETYPE will print DONE, indicating the computer has the system tape in memory. (NOTE: The system tape should be loaded after every maintenance day.)

21) Place SENSE SWITCH 4 in RESET position (down).

5.3 LOADING THE OBSERVING PROGRAM

1) Press START button on the computer. The TELETYPE will print out a coded date, sidereal time, sect number, and a return code. At this point in initializing the computer from a cold start, the sect number should be 00000. Make sure this is the sect number indicated. If it is not, see the troubleshooting procedure for loading the correct sect number (par. 15.10). The teletype then prints SCAN NNNNN?

2) Type NO, and punch the RETURN key on the teletype keyboard. (Any time anything is typed on the teletype, the RETURN key must be punched before the computer will continue.) The teletype now prints the following message: ENTER 4 CARDS WITH BASELINE CONSTANTS, 3 WITH POINTING CONSTANTS, 1 WITH DELAY CENTERS, 1 WITH SCAN NUMBER.

3) Place the BASELINE deck of IBM cards (refer to Fig. 2) for the present telescope configuration (deck normally located on top of the card reader) and a card with the correct scan number MINUS 1 in cols. 1-5 in the CARD READER. (If necessary, see the troubleshooting procedures entitled POINTING CONSTANTS and BASELINE CONSTANTS, pars. 13.0 and 14.0.)

4) Press RESET and START on the card reader. The computer will read the

4) Press RESET and START on the card reader. The computer will read the deck and type the following message: PRESS START PLEASE.

5) Press START on the computer. The computer now types: THANKS. READY PROGRAM IN CARD READER.

6) Place the card deck of sources to be observed (supplied by the observer) in the card reader.

7) Press RESET and START on the card reader. The computer now types: ENTER DAY NUMBERS.

8) Remove the program deck from the card reader, and place a handful of Besselian Day Number cards in the card reader. (These cards are located in the card filing cabinet in the control room, and they are color coded by month.)

9) Press RESET and START on the card reader.

10) MASTER CLEAR the computer.

11) Punch 016540 into the DATA REGISTER.

12) Punch P and ENTER buttons.

13) Press START on the computer. The computer will read part of the deck, will print the date, time, sect no, and return code on the teletype, then prints: SCAN NNNNN?

14) Remove the cards from the reader and store. Type YES and punch the RETURN key on the keyboard. (The scan number should be the correct one.) The computer now prints SOURCE LIST EMPTY READY PROGRAM IN CARD READER.

15) At this point, the operator has the option of leaving SENSE SWITCH 4 in the RESET (down) position or placing it in SET (up) position. The former allows the information in each source card to print out after each is read, but allows only 50 cards maximum to be read; the latter suppresses all printouts and allows a maximum of 100 cards to be read.

16) Place the observing deck in the card reader.

17) Press RESET and START on the card reader. The computer now reads the deck, typing out any unusual conditions and pertinent warnings. When all cards have been read and memorized (up to the maximum amount), the computer will type: RETURN TO OBSERVING, followed by the coded date, time, sect no, and return code. If SS4 is SET, the computer will now pause, and the operator should place SS4 in RESET; if SS4 was left RESET at step 15, no action is required at this point.

18) The computer now asks if it remembers the correct scan number.

19) Place the telescopes under computer control (Unit 100), then type YES and the RETURN key on the keyboard (assuming the scan number was the correct one). The computer now slews the telescopes to the correct source, prints out pertinent information about the source, and begins observing when the sidereal time and source identification prints out.

THE INTERFEROMETER SYSTEM IS NOW ON THE AIR.

20) To stop observing before the program is exhausted, perform the following steps on the computer control panel:

SENSE SWITCH 4 to SET (up)

MODE switch to SINGL. INSTR.

MASTER CLEAR

Punch 017000 into the DATA REGISTER

Punch P and ENTER buttons

MODE switch to RUN position

Punch START

The computer will print out through the return code and stop. If desired, the MODE switch can be placed to SINGL. INSTR. position, MASTER CLEAR button punched, and the computer can be used for other operations, such as the UTILITY PROGRAMS described in par. 16.0. To restart the computer observations on the program still in memory, follow the instructions in par. 15.1.

## 6.0 DDP-116 COMPUTER OPERATION FOR SWITCHED RECEIVER MODE

Several types of programs can be run using one telescope working independently of the others. Only one of these is used frequently at the Interferometer, and it is the only one for which the computer is programmed to run automatically (that is, the computer operates the telescopes and makes necessary calculations...the backend functions must be controlled by the operator). This is the Telescope Pointing program, and computer instructions for this program follow.

The Backend must be set up as instructed in par. 2.0 and par. 4.0, and the Interferometer Mode computer instructions must be followed through par. 5.3.18. At that point, perform the following operations.

1) Place the computer MODE switch to the SINGL. INSTR. position.

2) Press MASTER CLEAR.

3) Place SENSE SWITCH 4 to RESET position (down).

4) Place card deck MTL in card reader.

5) Press RESET and START on card reader.

6) Punch MASTER CLEAR.

7) Punch 016540 into the DATA REGISTER.

8) Punch P and ENTER.

9) Place MODE switch to RUN.

10) Press START on the computer. The card deck will be read, and the computer stops.

11) Mount the magnetic tape entitled POINTING PROGRAM (PT) onto the tape deck (see instructions par. 5.2.16).

12) Place MODE switch to SINGL. INSTR. position.

13) Press MASTER CLEAR.

14) Punch 016560 into the DATA REGISTER.

15) Punch P and ENTER.

16) Place MODE switch to the RUN position.

17) Press the START button on the computer until the tape reads 1 record, rewinds, and stops.

18) Place the MODE switch to the SINGL. INSTR. position.

19) Press MASTER CLEAR.

20) Punch 001000 into the DATA REGISTER.

21) Punch P and ENTER.

22) Place the MODE switch to the RUN position.

23) Press START on the computer. The teletype will print out pertinent information about the source to be observed. (NOTE: When using this program, the computer does not keep track of scan numbers. The scan number indicated will be 04792, which is meaningless.) The computer then prints a header as follows:

TELESCOPE COORD HA ERROR CHANGE AMPL

After the telescopes get to the source, the computer will begin taking data from the SYNC DETECTOR outputs, making calculations, and printing them on the teletype periodically. NOTE: No data goes on disk. The only output is the teletype output. If an analog record is desired, the ANALOG DISPLAY Unit 160 channels 1, 2, and 3 recorder input cables must be connected to SYNC DET OUT 1, 2, and 3 connectors respectively.

## 6.1 COMPUTER TROUBLESHOOTING IN SWITCHED RECEIVER MODE

There are certain operating and troubleshooting procedures peculiar to this mode of operation, and, for convenience, will be covered here.

### 6.1.1 LOADING MORE OR DIFFERENT SOURCE CARDS

1) SET SENSE SWITCH 4 (up).

2) Place MODE switch to SINGL. INSTR. position.

3) Press MASTER CLEAR.

4) Punch 017000 into the DATA REGISTER.

5) Punch P and ENTER.

6) Press START. The computer will print the time, return, etc., then it may or may not print DISK DATA AFU, WOULD YOU BELIEVE SECT NNNNN?.

7) Place MODE switch to SINGL. INSTR.

8) Press MASTER CLEAR.

9) Punch 016000 in DATA REGISTER.

10) Punch P and ENTER.

11) Place MODE switch to RUN.

12) Place source cards in card reader and punch START on reader.

13) Press START on computer. Computer will type: CARDS IN READER SHOULD: PRECEDE, REPLACE, OR FOLLOW EXISTING OBSERVING LIST?

14) Type REPLACE, and punch the RETURN key on teletype.

15) Computer should read the card deck, then print RETURN TO OBSERVING DISK DATA AFU, WOULD YOU BELIEVE SECT NNNNN? (If computer does not do this, see paragraph 6.1.1.26.)

16) Press MASTER CLEAR.

17) Punch 016560 in DATA REGISTER.

18) Punch P and ENTER.

19) Press START until computer reads 1 record and rewinds tape.

20) Place MODE switch to SINGL. INSTR. position.

21) Press MASTER CLEAR.

22) Punch 001000 in DATA REGISTER.

23) Punch P and ENTER.

24) Place MODE switch to RUN position.

25) Press START. The computer will begin observations.

26) If the computer did not read the deck at par. 6.1.1.15, do the following:

Press MASTER CLEAR

Punch 002000 in DATA REGISTER

Punch P and ENTER

Press START.

If the computer now reads deck, continue at par. 6.1.1.16.

If the computer does not read deck, continue at par. 6.1.1.27.

27) Press MASTER CLEAR.

28) Punch 017000 in DATA REGISTER.

29) Punch P and ENTER.

30) Press START on computer. The time, return, etc. will print out.

31) RESET SENSE SWITCH 4 (down). The computer is now reverted back to the Interferometer Mode. One of two things will occur.

32) The computer may print out SCAN NNNNN? or it may print out DISK DATA AFU, WOULD YOU BELIEVE SECT NNNNN? In either case, SET SENSE SWITCH 4 (up), type YES and punch the RETURN key on the keyboard. The computer now prints SOURCE LIST EMPTY, then it reads the deck, prints date, return, etc., and stops. At this point, punch MASTER CLEAR, put SS4 in RESET position, and continue at par. 6.0.11.

33) If program card data is retained in computer memory from a previous program, the computer may possibly print out the name of a source and begin moving the telescopes to it. If this happens, place telescopes in MANUAL control. The computer will print the LST and source name and will begin taking data. Type XLOAD WR and the RETURN key on the keyboard. The computer will print out the time, return, etc., then CARDS IN READER SHOULD: PRECEDE, REPLACE, OR FOLLOW EXISTING CARD LIST. Place SS4 in SET position, then type REPLACE and the RETURN key on the keyboard. Cards will be read and computer will stop. Place MODE switch to SINGL. INSTR. and continue at par. 6.0.11.

6.1.2 UNEXPLAINED COMPUTER STOPS WHILE POINTING

1) Try restarting at par. 6.0.18.

2) Try restarting at par. 6.0.11.

3) Try restarting at par. 6.0.1.

4) If none of these procedures work, do the following:

SET SS4 (up)

Press MASTER CLEAR

Punch 017000 into DATA REGISTER

Punch P and ENTER

Punch START on computer (make sure MODE switch is at RUN position)

After the computer prints out sect, return, etc. or after it prints out DISK DATA AFU, WOULD YOU BELIEVE SECT NNNNN?, put MODE switch in SINGL. INSTR. position and continue at par. 6.0.2.

6.1.3 SYNCHRONOUS DETECTOR BALANCE

If the sync det gets too far out of balance (i.e. if the pointer on the meter begins to go off scale while scanning across a source), wait until telescope scans off source, re-balance the detector to zero using the GAIN RATIO POT., mark out that scan on teletype output, and continue observing.

6.1.4 CRT OUTPUT

While using this program, the CRT telescope coordinate readouts (see par. 10.0, CRT DISPLAY SYSTEM) may not always be updated. This does not affect the telescope operation.

7.0 SWITCHED RECEIVER PROGRAMS WITH NO COMPUTER AID

In the Switched Receiver Mode of operation, several types of programs (e.g. ON-OFFS, DRIFTS) can be run by operating the telescopes manually and collecting the data from the Synchronous Detector outputs on some type of analog recorder. The computer is not used for these programs, and the receiver must be set up as instructed in paragraph 4.0. The recorder to be used is dependent on the observer's instructions. The observer will also dictate how he wants these programs run...in other words, the speed of the scans, direction of scans, etc. In addition, the observer may request any of the following:

1) ALC OFF. Turn the ALC off by punching the ALC ON/OFF switch on the

IF LEVEL CONTROL panel (Unit 300). An orange light will glow when it is off.

2) FEED CONTROL. This switch is on the FRONT END SWITCH CONTROL panel (Unit 300). The switch marked FEED POLAR. SWITCH CONTROL RIGHT POSITION controls the feed on the front end. If the green light is on, it is in RIGHT position; if the light is off, it is in LEFT position.

3) CALIBRATION. To fire a LO-CAL, press the switch on Unit 300 marked LOAD POSITION/NOISE POSITION. The NOISE POSITION half of the switch will glow if CAL is on. To fire a HI-CAL, do the above, then press CAL ON switch on the IF MONITOR panel (Unit 300). To turn the cal off, press same button again. Then, press the switch marked SWITCHED MODE & LOAD POSITION RELEASE. Now, press NOISE MOD MODE/SWITCHED MODE switch, and the bottom half should glow again indicating that the receiver is back in the SWITCHED MODE.

8.0 CHECKING AND SETTING FOCUS AND POLARIZATION

It is necessary to check the focus and polarization settings on all telescopes with the computer any time any maintenance has been performed on the telescopes. This includes after any normal maintenance day and when a telescope has been moved to another station on the baseline. This check should be performed before beginning observations and can be performed while the computer is taking data. In addition, a binary readout is provided in the SYSTEM CONSOLE UNIT 130 where the settings are visible continuously. These three methods of checking focus and polarization are described below.

1) To check before beginning observations, insert the following steps between paragraphs 5.2.19 and 5.2.20.

MODE switch to SINGL. INSTR.

MASTER CLEAR

Place FP card deck (located in card filing cabinet in control room) in card reader

Press RESET and START on card reader

Punch 016540 in DATA REGISTER

Punch P and ENTER

MODE switch to RUN

Press START. Computer will read card deck.

Press START. Computer will print out the polarization settings of each telescope, then will position the teletype type box under the first reading. If the reading is correct, space across the number and the type box will advance to the next reading. (NOTE: The focus and polarization control switch on System Console Unit 130 must be in COMPUTER position.) If a reading is incorrect, type the correct number beneath it (the correct readings are listed on the teletype cover). The computer will move the front end box to the correct setting, then advance to the next telescope reading. After all telescopes polarization settings are checked, focus settings are typed out. Go through the same steps as with polarization checks. (If all telescopes are set correctly when read, the entire line can be skipped by typing the RETURN key.)

After all readings have been processed, computer will type: SCAN NNNNN? Answer YES and punch the RETURN key. Computer then types: READY PROGRAM IN CARD READER.

Continue at par. 5.2.20.

NOTE: It is possible to program the computer so that the program on card deck will reenter itself after it is over. This can be useful when troubleshooting the focus and polarization settings or when a new front end box is installed on a telescope. To do this, immediately after reading the card deck, place the MODE switch to SINGL. INSTR. position, press MASTER CLEAR, punch 000046 into the DATA REGISTER, punch P and ENTER. CLEAR the DATA REGISTER, punch 014000 into the DATA REGISTER, place STORE/READ switch to

the STORE position, and punch ACCESS. Place STORE/READ switch back to the READ position. Press MASTER CLEAR, punch 014000 into the DATA REGISTER, punch P and ENTER, place MODE switch to the RUN position, and punch START. The computer will continuously read the focus and polarization settings, halting for the operator to check them each time, and will recycle itself and read them over and over until the MODE switch is placed in SINGL. INSTR. position.

2) To check while observing, make sure the focus and polarization motors are under computer control (Unit 130). Type XLOAD FP and the RETURN key on the teletype. The computer will cease observing, type out through the return code, then will type out the actual settings of the polarization on each telescope. The operator should go through the same steps as described in par. 8.0.1. After all settings have been checked, the computer will return to observing. NOTE: The computer will advance the scan number by 1 any time this program is used unless it is initiated during the last few seconds of a scan.

3) There is a binary focus and polarization readout in the System Console Unit 130 where the actual settings are visible in octal form at all times. This readout is read exactly as described in Fig. 1, DDP-116 CONTROL PANEL DIAGRAM, except that there are only 5 digits instead of 6. The correct settings are listed as octal numbers in the System Console Unit 130 Notebook.

## 9.0 TELETYPE DATA OUTPUT

The data being collected by the computer from the correlator outputs can be sampled at certain intervals and typed out on the teletype. The amount of information printed on the teletype output is determined by the positions of the DIGISWITCH on the Unit 130 above the Sanborn recorder and by the positions of SENSE SWITCHES 1 and 2 on the computer.

1) 100000 on the DIGISWITCH causes correlator 1 to print out.

2) 040000 on the DIGISWITCH causes correlator 2 to print out.

3) 020000 on the DIGISWITCH causes correlator 3 to print out.

4) 010000 on the DIGISWITCH causes correlator 4 (85-1 and 42') to print out.

5) Any combination of two or more of these numbers causes two or more correlator outputs to print out. (The units position of the DIGISWITCH is normally set on 1 to indicate that the 42' is <u>not</u> collecting good data.)

6) SENSE SWITCH 1 in the SET (up) position causes printouts to occur three times per minute; in the RESET (down) position, printouts occur once per minute.

7) SENSE SWITCH 2 in the SET position causes <u>calibrator sources only</u> to be printed out. Calibrators are identified by the size information in cols. 48-50 of the source card.

The settings to use, in any case, are at the discretion of the observer.

## 10.0 CRT DISPLAY SYSTEM

The Cathode Ray Tube in the Unit 130 will display various information concerning the data being collected and is updated every 15 seconds. The information that can be displayed is:

C the Cosine component

S the Sine component

R the root mean square value

A the Amplitude

P the Phase

Up to five quantities can be displayed at any one time. To change the quantities being displayed, type (while observing) XSHOW on the teletype keyboard, followed by one or more spaces, and the codes for the information desired in the format as follows:

XSHOW A2,P2,A4,P4,R4

The above example would cause the amplitude and phase of correlator 2, and the amplitude, phase, and rms of correlator 4 to be displayed. The format to use is exactly as shown above, including commas.

To keep information on the CRT (i.e. to stop the updating), type:

XSHOW *

To resume normal updating after having stopped it, type:

XSHOW "

## 11.0 DUMPING THE DISK TO TAPE

After an entire program has been observed (i.e. after all the sources in the program card deck have been observed), or, in any case, if the SECT NO has advanced to 2379, the DISK must be dumped onto magnetic tape for processing by the IBM 360 computer at Charlottesville. The procedure follows.

1) Load a data tape on the tape transport. (This is done exactly as described in par. 5.2.16, except that a plastic ring must be inserted in the indention on the back of the tape reel.)

2) A few seconds before the last source observation is to end, type XLOAD CP on the keyboard, followed by punching the RETURN key. The computer will cease observing and will load the CP program from disk memory. It will then search the tape to see whether or not any data information is already on it and halt.

NOTE: If the program ends before typing XLOAD CP, see par. 16.5.

3) Press START on the computer when ready. (NOTE: If, after pressing START, the computer prints INSERT FILE PROTECT RING, see par. 16.5.9.)

4) More than one disk load can be dumped onto the same tape. If a labeled (partially written) tape is mounted, the computer will type:

TAPE NOT CLEAR, OPTIONS FOLLOW

1 'CR' FOR 2ND TRANSFER

2 'ERASE OPID' FOR 1ST TRANSFER

3 'SKIP NNNN' TO SKIP NNNN RECORDS

The operator has the following options:

1) Type the RETURN key to add the existing disk contents onto the end

of the existing contents of the tape.

2) Type ERASE followed by operator initials to overwrite the data on tape with the data now on disk.

3) Type SKIP followed by a number to save the first NNNN records on tape. (This would be used if a dump problem arises during the dumping of a second disk load onto one tape.)

5) After one of the above commands has been given, or if no labeled tape was encountered, the computer will type:

ENTER TAPE NUMBER - NNNN.

6) Type the NRAO tape number (written on the front of the tape reel) and punch the RETURN key on the keyboard. NOTE: 4 digits must be typed...use leading zeroes if necessary.

7) The tape will be written, and the computer will write:

TRANSFER COMPLETE, PRESS CR TO CLEAR DISK.

3) After the tape rewinds, remove it from the tape deck, then punch the RETURN key.

9) After about 1 minute, the computer will print:

SECT 00000 RETURN 00002

A new program may be loaded and observations continued if desired.

10) The observer may request the teletype and analog outputs. These should be rolled and disposed of as instructed.

11) An IBM card, INTAPE, must be prepared on the Key Punch and sent with the tape to Charlottesville. These cards are normally located in the card file in the control room. Columns 24 through 27 must be punched with the tape number as written on the teletype.

## 12.0 OPERATOR COMMANDS TO THE COMPUTER

The following commands can be executed by the operator any time the computer is taking data. THEY WILL NOT WORK AT ANY OTHER TIME (for instance, while the computer

is positioning the telescopes, or when the pointing program is being run). In each case, the command is typed on the keyboard, followed by punching the RETURN key. If a mistake is made in typing, hold down the CTRL key and type the U key, then start over.

12.1 XOPID

This is the operator identification command. The teletype output is interrupted and the computer prints: ENTER OPERATOR ID, 2 CHARACTERS. The operator types his initials, and punches the RETURN key. The computer then prints: OPERATOR XX (or some such acknowledgement), then: ENTER OBSERVER INITIALS. The operator types the observer's initials and punches the RETURN key. The computer prints: OBSERVER XX. The interruption is complete and the computer reverts back to data output on the teletype.

12.2 XCURR

This command causes the computer to reprint the source header. This can be used to change the teletype paper. To change paper, type X. This prevents the teletype from typing on the roller until the paper is changed. When finished, type CURR. The computer reprints the source header and continues printing out data information.

12.3 XSKIP

This command causes the computer to stop observing and to go to the next source in memory without waiting for the stop time as previously memorized from the source card.

12.4 XCONT

This command causes the computer to continue observing a source beyond the memorized stop time. Then, the command XSKIP will end the scan when desired, and the computer will advance to the next source whose stop time has not expired.

12.5 XWAIT

This command causes the computer to cease taking data temporarily. After executing the command, the computer will print WAITING and will halt.

12.6 XBEGN

This command causes the computer to begin taking data again after having been halted by the XWAIT command provided the computer has not been stopped (MODE switch changed or MASTER CLEAR punched). If it has been stopped, it must be restarted as if it had stopped by itself (see TROUBLE SHOOTING).

12.7 XBASE

This command causes observing to stop temporarily, and the computer asks for the BASELINE card deck (see Fig. 2). This is used to change the baseline constants, scan number, delay centers, or pointing corrections. Place the card deck in the card reader and press RESET and START. The deck will be read, and the computer will begin taking data again, using this BASELINE information for making calculations and setting switches.

12.8 XLOAD WR

This command is used to change programs in memory (i.e. to load a new source deck). The new deck must be placed in the card reader and the RESET and START buttons punched. The computer will cease observing, type out the return code, etc., and ask if the program in the card reader should precede, replace, or follow existing observing list. The operator may SET SS4 (see par. 5.3.15), then answer on the teletype. The computer will read the deck. If SS4 was SET, the operator must RESET it. The computer will begin observing the new source deck.

12.9 XLOAD FP

This command causes the computer to stop observing and read out the focus and polarization settings of the front ends. (See par. 8.0.2.)

NOTE: Any XLOAD command causes the scan no to advance by 1.

12.10 XNOTE

To place a message on disk for the observer, type this command followed by the message.

## 13.0 POINTING CONSTANTS

After running a pointing program, the positioning errors are relayed to Charlottesville. The Charlottesville 360 computer determines the new pointing constants for the telescope which has been moved to a new station. This information is relayed from Charlottesville and is in the form of 16 numbers. The operator must punch a new IBM card containing this information. The number of the telescope (1, 2, or 3) must be punched in col. 1. The 16 numbers, regardless of the number of digits in each, must be punched so that the last digit of each falls in the following columns: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, and 80. If a number is negative, a minus sign must be punched in the column just preceding the first digit of the number. NEVER USE PLUS SIGNS OR LEADING ZEROES. The card is then inserted in the proper place in the BASELINE deck, replacing the old constants, and, after all new cards have been inserted, must be entered into computer memory. (See pars. 5.3.3, 12.7, and Fig. 2.)

## 14.0 BASELINE CONSTANTS

Any time a telescope is moved to a different station, the baseline constants for that configuration must be punched on IBM cards and entered into computer memory BEFORE BEGINNING AN INTERFEROMETER PROGRAM. These constants are periodically revised, and the proper ones to use will be on the latest dated sheet titled: REVISED BASELINE PARAMETERS FOR THE SYNTHESIS PROGRAM. Four sets of numbers must be punched in each card. One number, a single digit, is the correlator number (1, 2, 3, or 4) which is punched in col. 61. The three sets of numbers entitled BX, BY, and BZ are punched in the card so that the decimal point of the BZ, BX, and BY numbers fall in cols. 8, 28, and 48, respectively. If a number is negative, a minus sign must be punched in the column just preceding the first digit of the number. NEVER USE PLUS SIGNS OR LEADING ZEROES. The card is then inserted in the proper place in the BASELINE deck, replacing the old card, and, after all new cards have been inserted, must be entered into computer memory. (See pars. 5.3.3, 12.7, and Fig. 2.)

SECTION 3

TROUBLESHOOTING THE COMPUTER

Paragraphs 15.0-15.16

Pages 1-7

## 15.0 TROUBLESHOOTING THE COMPUTER

If any unexplained or unusual halts occur, try the following steps in order until something works.

### 15.1 RESTART AT MEMORY LOCATION 017000

1) Place MODE switch to SINGL. INSTR. position
2) Press MASTER CLEAR
3) Punch 017000 into DATA REGISTER
4) Punch P and ENTER
5) Place MODE switch to RUN position
6) Press START

### 15.2 RELOAD IOCS

1) Place IOCS card deck in card reader
2) Press RESET and START on card reader
3) Place MODE switch to SINGL. INSTR. position
4) Press MASTER CLEAR
5) Punch 016540 into DATA REGISTER
6) Punch P and ENTER
7) Place MODÉ switch to RUN position
8) Press START. The computer should read the deck, ask if it remembers the correct scan number, and begin observing after answering YES.

### 15.3 IOCS WILL NOT LOAD

If IOCS will not load, the KEY-IN LOADER has probably been wiped out. Reload the KEY-IN LOADER, as per instructions par. 5.1. Then load IOCS as instructed in par. 15.2.

### 15.4 RELOAD SYSTEM TAPE

If IOCS loads but trouble still persists, reload the System Tape as instructed in par. 5.2.16 and continue from there.

### 15.5 REMOVE POWER FROM COMPUTER

If trouble still persists, place the MODE switch to SINGL. INSTR. position and press the POWER button on the computer. Wait 1 minute and press the POWER button on computer again. Wait 4 minutes, press MASTER CLEAR, and re-load the KEY-IN LOADER, IOCS, etc.

15.6 CHECK POWER INPUT

If none of the previous troubleshooting procedures work, there is a good possibility that some unit of the computer system has lost power, either by a popped circuit breaker or inadvertent disconnection of a power cord. Check all units in the basement and make sure power is on. If power is off of some unit, proceed to find the fault and restore power to the unit.

15.7 INTERNAL EMERGENCY ROUTINE

There is an internal emergency routine programmed into the computer that is activated whenever a situation arises in which the computer feels it cannot continue operating without operator intervention. The operator is made aware of this situation if the computer prints out a six digit number then begins ringing the bell on the teletype. In this situation, the operator should stop the computer and examine the location printed on the teletype. The number typed has a meaning which is listed, along with the proper action to take, in B. Clark's PROGRAMS FOR THE INTERFEROMETER, Section IX, MESSAGE DICTIONARY.

NOTE: The ASR35 teletype sometimes prints out 888888888.....instead of ringing the bell.

15.8 CARD DECK TROUBLE

If, after loading a card deck, the computer prints out the number 1, 2, or 3, or, if the computer hangs up with a card deck partially read, there is something wrong with the card deck. Check the deck to make sure it is the correct one, the cards are in proper sequence, it contains the correct number of cards, and there is no read or feed error indicated on the reader.

15.9 ELECTRICAL INTERFERENCE

If severe electrical interference gets on the lines coming into the control building (e.g. lightning, static electricity), the computer will sometimes begin printing garbage on the teletype. Generally, if the operator stops the computer and tries to restart from 017000, the KEY-IN LOADER is found to be wiped out and must be reloaded. To avoid this when it is happening frequently, it will sometimes suffice to punch the RETURN key on the teletype while it is printing garbage.

15.10 INCORRECT DISK SECTOR

An occasion sometimes arises where the computer or the operator feels that the next disk sector (sect no) which the computer wants to write on is not a blank sector (in other words, there may already be data on that sector). If the computer questions the number, it will stop observing, print out the message DISK DATA AFU, then, after a short time, will print out a 5 digit sect no followed by a question mark. The operator should ascertain whether or not this is a blank sector by checking back in the teletype output. If it is correct, the answer YES followed by punching the RETURN key on the keyboard will permit the computer to go back to observing. If it is not the correct number, the operator should keep answering NO until the computer either gives the correct one, or else asks: WHAT, THEN? The operator can then type in a 5 digit number and the computer will begin writing on that sector. If the operator should ever feel that the number is incorrect but the computer does not question it, the following procedure should be used. Stop observing. Find the correct sector number in the DDP-24 CONVERSION TABLES manual, Table 1, OCTAL TO DECIMAL CONVERSION. Press MASTER CLEAR on the computer. Punch 000022 into the DATA REGISTER, then punch P and ENTER. Punch CLEAR on the DATA REGISTER. Place the READ/STORE switch to the STORE position. Punch the correct octal sect no into the DATA REGISTER.

Punch ACCESS. The correct sect no should now be in computer memory. Place the READ/STORE switch to the READ position. Press MASTER CLEAR. Punch 017000, P, and ENTER on the DATA REGISTER. Punch START. The computer will print out the time, date, sect no, and return code. Verify that the sect no just entered is indeed the one the computer printed out, and continue observing. IF THERE IS EVER ANY DOUBT ABOUT THE SECT NO, the safest thing to do is to dump the disk to tape and continue with the program. This assures that data already on disk will not be destroyed. If the operator should ever want to start at the beginning of the disk when some data is already on disk, use the procedure above, except punch nothing in the DATA REGISTER before punching ACCESS. This will start the sect no at zero.

15.11 ALARM BIT ASSIGNMENTS

The alarm system programmed into the computer indicates an abnormal condition in the system. The operator is made aware of the difficulty by an alarm printout on the teletype, and can identify the trouble by checking the code number of the alarm on the code sheet provided at the teletype and in B. Clark's PROGRAMS FOR THE INTERFEROMETER, Table III-3, ALARM BIT ASSIGNMENTS, then by checking the proper meter or other monitor in the system. In many instances, the proper technician, engineer, or operator will have to be consulted, but in the following cases, the operator can usually remedy the trouble.

1) IF LEVEL OUT OF RANGE

Add or subtract enough attenuation on the IF MONITOR panel to bring the level within range (see par. 2.4).

2) LO UNLOCKED

At the individual telescope control building involved, turn the micrometer-type pot all the way CCW. Then, holding the ALC LOOP CHECK switch in, turn it slowly CW until the pointer above it reads mid-scale. This should lock

the LO in (the red OUT-OF-LOCK light goes out). It may then be necessary to adjust the trombone-type tuner for the receiver in difficulty. This tuner is located at the Control Building in Unit 400. Pull the PHASE SHIFTER SERVO CONTROL drawer out, turn the switch for that trombone to the UP or DOWN position (depending on which limit the trombone travelled to) and hold the SERVO SLEW button down until the SIN and COS meters almost reach the proper settings (see par. 2.2). Release the SLEW button, and turn the UP/DOWN switch off. It will finish adjusting itself.

3) CORRELATOR OUT OF RANGE

Occasionally, the observer may not have the correct gain information in the program card, and the computer will set the correlator gain too high, causing it to saturate. Generally, any swing to left and right greater than 35 on the CORRELATOR OUT meter is in saturation. The operator should put the correlator in MANUAL control and set the gain to a lower position by pressing the 25/125 or the 1250 gain switch. IF THIS IS DONE, MAKE SURE THE ALC FOR THAT CHANNEL IS ON.

15.12 LOADING BESSELIAN DAY NUMBERS MANUALLY

If, when loading the Besselian Day Numbers, the computer will not take the card deck, the operator can load the numbers manually using the teletype. When the computer prints ENTER DAY NUMBERS, type the day numbers for the FOLLOWING DAY using the following format:

±DD.DDD,±DD.DDD,±DD.DDD,±DD.DDD

The day numbers are found in THE AMERICAN EPHEMERIS AND NAUTICAL ALMANAC under the heading Besselian and Independent Day Numbers for $0^h$ Ephemeris Time. The signs are written every 5th number, and apply to all below. Day numbers less than 10" must have an initial 0. The new day starting at $0^h$ Ephemeris Time is equal to $19^h$ Eastern Standard Time.

15.13 ENCODER MALFUNCTIONS

Each telescope is equipped with a polar and declination encoder which reads the actual position of the telescope and transmits the information to the computer so that correct positioning can be accomplished. This information, in the form of Hour Angle, Right Ascension, and Declination, is also visible to the operator on the CRT readout and the Nixie tube readout located in the Antenna Control Unit 100. Frequently, a malfunction occurs, and the encoder momentarily transmits incorrect information. This becomes apparent to the operator if the CRT and Nixie readouts jump from one reading to another, then back again. Sometimes these jumps are infrequent; sometimes they are practically continuous. Invariably, this will interfere with computer operation, inasmuch as the computer will try to position the telescope while two different coordinate positions are alternately being fed to it. The computer will move the telescope first one direction then the reverse (in the coordinate which is malfunctioning). In this situation, the digital engineer or technician responsible should be contacted. It may become necessary to remove the telescope involved from the system until the malfunction is repaired. As an aid in troubleshooting, the operator should try to record the readings between which the readout is jumping. It will also assist the engineer or technician if the operator observes whether or not both coordinates are malfunctioning and whether or not both the CRT and Nixie readouts indicate the jumps.

15.14 DISK MALFUNCTIONS

If the computer cannot be restarted, or if it continuously stops or goes into a loop after restarting, and if all previous troubleshooting procedures produce negative results, there is a possibility that some malfunction has occurred in the Disk Unit located in the basement of the Control Building. Access to the Disk Unit can be gained by opening the lower door on the front of the Unit. At the left are three lights labeled ACTUATION PRESSURE LOW, DRUM SPEED LOW, and DRUM TEMPERATURE HIGH. If any of these lights are lit,

the digital engineer or technician should be contacted and advised of the malfunction. (NOTE: A computer loop is a situation whereby the computer will not or can not go to the next programmed instruction...in other words, it simply "hangs up". The operator can usually identify this situation by the abnormal blinking of the lights in the buttons on the Data and F Registers.)

15.15 COMPUTER TEMPERATURE LIMITS

The computer and any of its associated digital equipment should not be operated if the room temperature should fall below +50 degrees F. or rise above +100 degrees F. The upper limit for the temperature inside the computer cabinet is +125 degrees F. If the temperature should reach any of these extremes (e.g. if the heating/air conditioning equipment malfunctions), contact the engineer or technician responsible for the digital equipment and follow his instructions.

15.16 THINGS TO AVOID

In addition to the preceding troubleshooting procedures, there are some things the operator should avoid doing.

1) NEVER punch a button on the computer while the computer is running.

2) DON'T turn the card reader on or off unless the computer is actually taking data or is completely stopped.

3) DON'T turn the CRT's on or off while the computer is running.

4) DON'T attempt to change a light bulb on the computer or any backend unit while observing.

5) DON'T stop the computer while it is slewing the telescopes UNLESS IT IS AN EMERGENCY.

SECTION 4

# COMPUTER UTILITY PROGRAMS

Paragraphs 16.0-16.5

Pages 1-4

## 16.0 COMPUTER UTILITY PROGRAMS

There are several utility programs which can be entered into the computer to aid the electronics or digital labs in troubleshooting some of their equipment in the system. These programs CANNOT be used while the computer is on-line (that is, while it is taking data or running a pointing program). To use any of these programs, the computer must be stopped, and the program deck entered into memory.

### 16.1 ADCT

To use this program, place the ADCT card deck in the card reader and press RESET and START. Press MASTER CLEAR on the computer, then transfer to 016540 (see Fig. 1), place MODE switch to RUN position, and press START. The deck will be read. Press MASTER CLEAR and transfer to 014000, RUN, START. Enter the A-to-D line number or Buffer Channel number of interest into the A REGISTER (in octal). Press START. The A-to-D value will be printed out. To read another or the same line, enter the number into the A REGISTER, and press START. The value the computer prints out is (in decimal) the voltage read by the Analog-to-Digital Converter (negative full-scale to positive full-scale).

### 16.2 A/D DISK TO PRINT

While the computer is taking data, it also, at 5 minute intervals after an observation starts, reads 64 system monitor channels and records the voltage there (in millivolts) on disk. The A/D Disk to Print program will read from 1 to 4 of these channels (at any one time) off of disk and print them on the teletype. Operator comments (SNOTE's) also appear when they occur. To use this program, place the A/D DISK TO PRINT deck in the card reader and press RESET and START. Press MASTER CLEAR on the computer, transfer to 016540 (see Fig. 1), place MODE switch to RUN, and press START. The deck will be read. Press MASTER CLEAR, and transfer to 014000, RUN, START. The computer types a line and the operator must then type the

earliest LST of interest on disk. (Type in the format HHMM.) The entire disk can be read by typing 3000. Punch the RETURN key on the keyboard. The computer types another line. The operator must type a number from 1 to 4 (the total number of lines to be read), a comma, and then the decimal line (channel) numbers with no separations. (In other words, to read lines 28, 29, 32, and 35, the operator must type 4,28293235.) Punch the RETURN key. (A-to-D line 10 is the lowest line number the computer will read.) The computer types a heading, the LST, the A-to-D channels, and operator's comments. When finished, it types END OF DATA ON DISK. If the computer was not asked to read the entire disk, it reads up to the LST 2400. To read past that time, SET SENSE SWITCH 1. The computer will ask for a new LST and, after the operator types it, will print out the data from the time given to the end of the disk. If the program hangs up (bad record on disk), SET SS2. NOTE: After using this program, be sure to check location 22 for the correct sect no (see par. 15.10).

16.3 OUTPUT SELECT LINE TESTS

Key the following program into computer memory. (For example, MASTER CLEAR, punch 001020 into the DATA REGISTER, punch P and ENTER. Clear the DATA REGISTER, punch 013027 into the DATA REGISTER, place READ/STORE switch to STORE, and punch ACCESS.)

| LOCATION | INSTRUCTION |
|---|---|
| 1020 | 013027 |
| 1021 | 011023 |
| 1022 | 000201 |
| 1023 | 000000 |
| 1024 | 003023 |
| 1025 | 000000 |
| 1026 | 003020 |

| | |
|---|---|
| 1027 | 170000 |

After entering the above program, transfer to 1020 (see Fig. 1). Enter the Output Select Line number into the A REGISTER. Enter the output command (see drawing No. B7894522-set or reset bits) into the B REGISTER. Press START. To test another line, set up the A and B registers in a similar manner and press START. The function being tested (e.g. correlator, delay) must be under computer control before giving the command.

INPUT SELECT LINE TESTS

Key the following program into computer memory. (For example, MASTER CLEAR, punch 001000 into the DATA REGISTER, punch P and ENTER. CLEAR the DATA REGISTER, punch 000000 into the DATA REGISTER, place READ/STORE switch to STORE, punch ACCESS.)

| LOCATION | INSTRUCTION |
|---|---|
| 1000 | 000000 |
| 1001 | 000201 |
| 1002 | 013014 |
| 1003 | 011005 |
| 1004 | 140040 |
| 1005 | 000000 |
| 1006 | 000000 |
| 1007 | 000201 |
| 1010 | 005005 |
| 1011 | 013014 |
| 1012 | 000201 |
| 1013 | 003000 |
| 1014 | 130000 |

After entering the above program, put line number of interest in the B REGISTER, then transfer to 1001 (put 1001 in P REGISTER). The answer

appears in the A REGISTER after pressing START.

16.5 CP

This program is used to dump the disk to magnetic tape, and it is stored in memory and used as described in par. 11.0 If, however, it cannot be called from memory for use (e.g. if observations end before XLOAD CP is typed), it is available on card deck and can be used as follows.

1) Load a blank or partially written tape on the tape transport.

2) Place the card deck entitled CP in the card reader.

3) Press RESET and START on the card reader.

4) Punch MASTER CLEAR on the computer.

5) Punch 016540 into the DATA REGISTER.

6) Punch P and ENTER.

7) Place the MODE switch in the RUN position (if it is not already).

8) Press START on the computer. The deck will be read.

9) Press START on the computer. At this point the teletype may print INSERT FILE PROTECT RING. If it does, make sure the plastic ring is on the tape reel. Then punch MASTER CLEAR, punch 003000 into the DATA REGISTER, punch P and ENTER, place the MODE switch to RUN position, and press START.

10) Continue at par. 11.4.

SECTION 5

DIAGRAMS

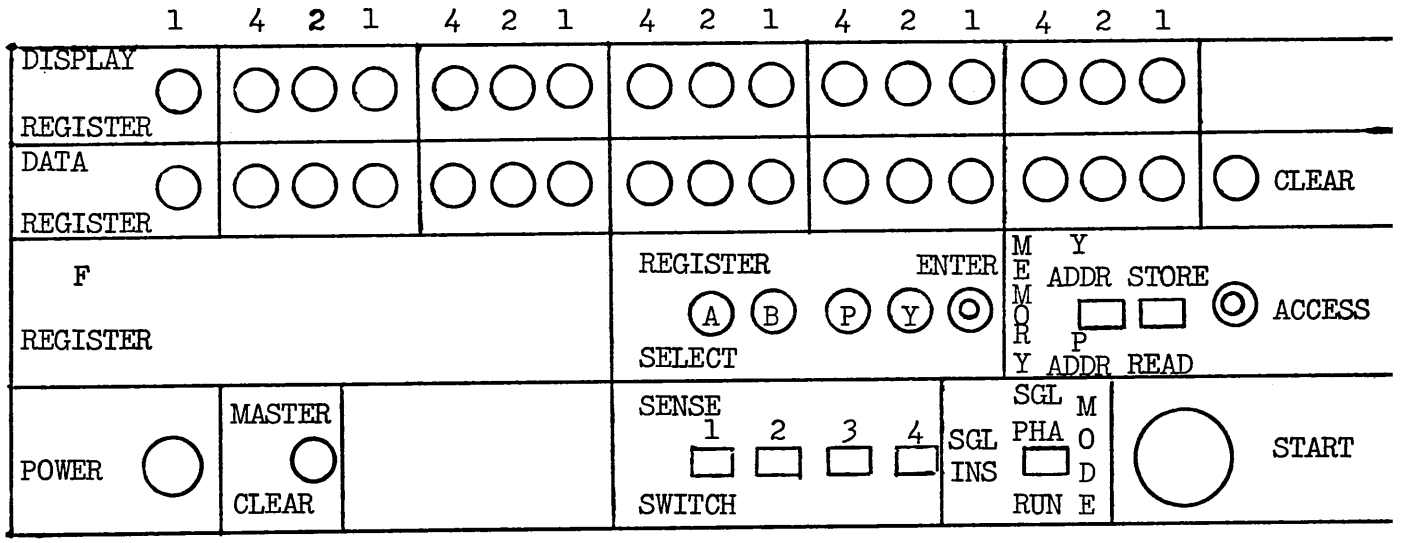
Figures 1-3

Pages 1-4

FIG. 1 DDP-116 CONTROL PANEL DIAGRAM

DIGIT 6 DIGIT 5 DIGIT 4 DIGIT 3 DIGIT 2 DIGIT 1

(MOST SIGNIFICANT) (LEAST SIGNIFICANT)




1) The computer instructions in this manual do not specify each individual button to punch on the DATA REGISTER, but simply state to punch a certain number into the register. All other buttons to punch or switches to set are specified.

2) The DISPLAY and DATA REGISTERS are divided into 5 sections of 3 buttons or lights per section plus 1 section of 1 button.

3) Up to a 6-digit octal number (see B. Clark's OPERATORS MANUAL dated 1/3/67) can be punched into the DATA REGISTER by pressing a combination of numbers in each section which adds up to the desired digit. The value of each button is written above it in the diagram above.

4) As an example, to punch the octal number 4073 into the DATA REGISTER:

Punch nothing in the digit 6 and 5 sections.

Punch the 4 button in digit 4 section.

Punch nothing in the digit 3 section.

Punch 4, 2, and 1 buttons in the digit 2 section.

Punch the 2 and the 1 buttons in the digit 1 section.

5) A light in each button punched will come on to indicate that the number punched can be loaded into a register (see B. Clark's manual THE DDP-116 -- CONSOLE PROCEDURES dated February 9, 1967). If a wrong button is punched, the DATA REGISTER CLEAR button on the far right of the control panel must be pressed and the entire number punched in again.

6) After a number is punched into the DATA REGISTER, it is usually "transferred" to the P REGISTER. This is done by punching the P and ENTER buttons. Rather than writing out each of these steps, the instruction "transfer to NNNNNN" in this manual means to punch the number NNNNNN into the DATA REGISTER, then to punch the P and ENTER buttons.

FIG. 2 BASELINE DECK

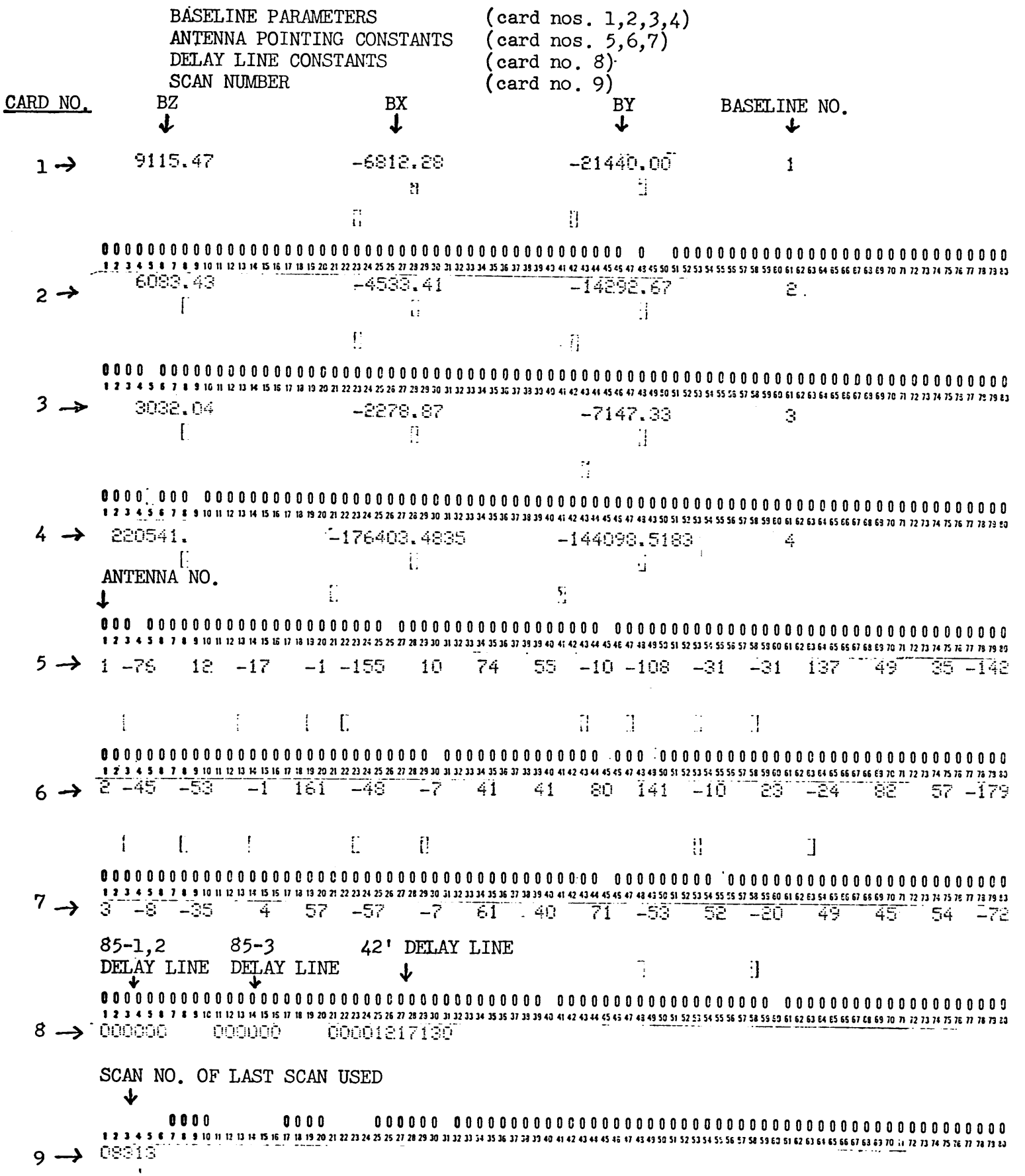
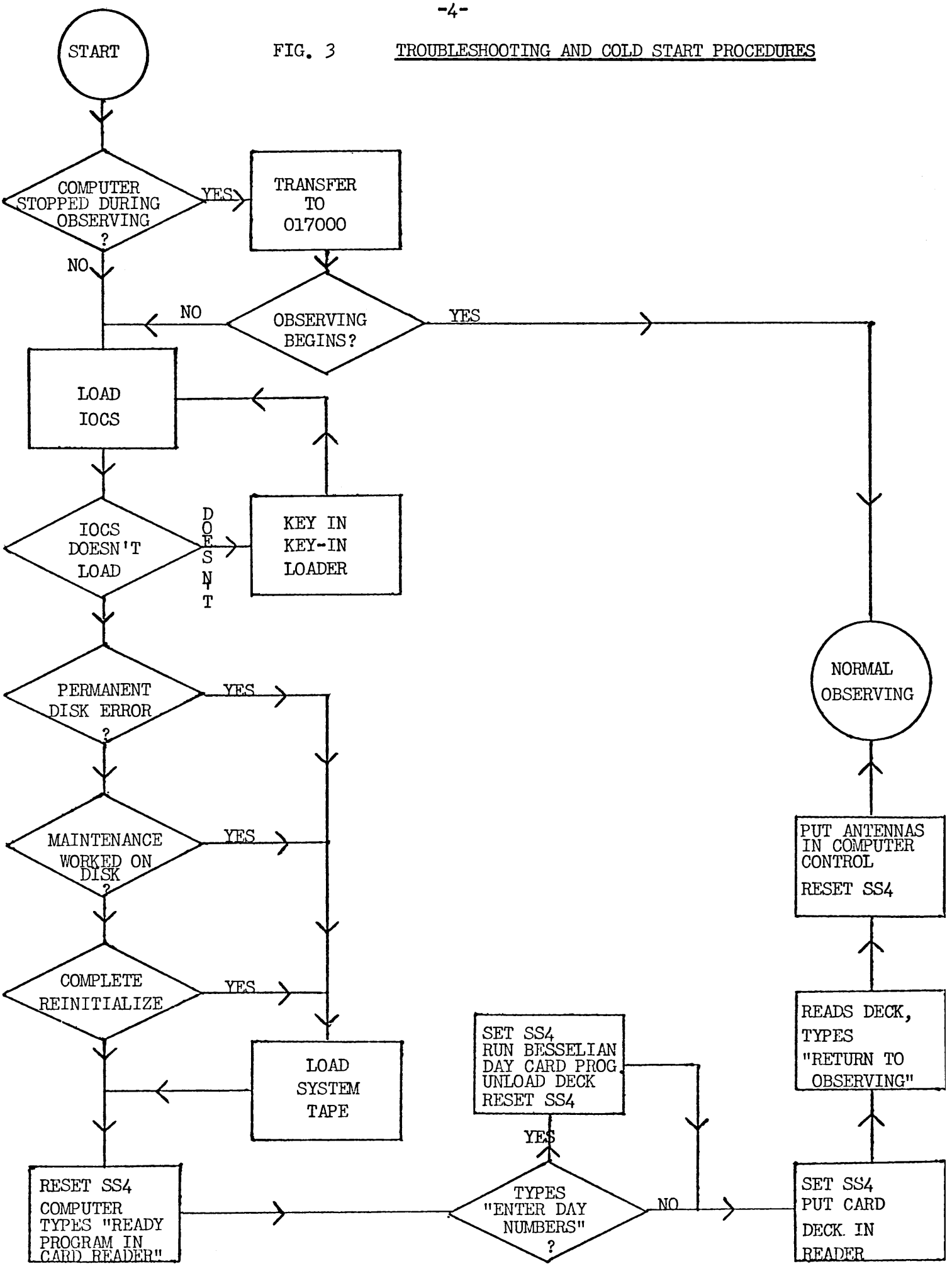


FIG. 3 TROUBLESHOOTING AND COLD START PROCEDURES



NATIONAL RADIO ASTRONOMY OBSERVATORY

Green Bank, West Virginia

TELESCOPE OPERATIONS DIVISION REPORT NO. 6

# BASIC INSTRUCTIONS FOR OPERATING THE INTERFEROMETER

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MARCH, 1970

(REVISED MARCH, 1971)

60 COPIES

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## INTRODUCTION

These instructions include all the basic steps in preparing the telescopes, backend units, and the computer for observing with the interferometer. Most of the technical aspects of the system are not included here, and they can be found in one of a number of publications kept at the control building (see Appendix). The purpose here is to provide instructions for operating the system, not to explain why. It is assumed that required power is being delivered to all equipment and that all equipment is functioning properly. Troubleshooting procedures follow these instructions.

SECTION 1

TELESCOPES AND BACKENDS

Paragraphs 1.0-4.3

Pages 1-4

## 1.0 TELESCOPES

Regardless of the mode of operation to be used, the procedure for preparing the telescope(s) to be operated is the same. The CONSOLE SYSTEM UNIT 130, ANALOG CONSOLE UNIT 160, and the ANTENNA CONTROL UNIT 100 are located in the control building control room.

### 1.1 CONSOLE SYSTEM UNIT 130

1) Place all OFF/MONITOR switches for the telescope(s) to be operated in the MONITOR position (relay shack, polar platform, declination platform, apex, and control room).

2) Make sure the monitor SYSTEM, LOCAL, and LEVEL controls are turned up sufficiently to be able to hear.

### 1.2 PERSONNEL WARNING

Make sure the telescope(s) to be used is clear of all personnel and is ready to be operated.

### 1.3 ANALOG CONSOLE UNIT 160

1) Check wind speed monitors to ascertain the wind is below a steady 30 mph and there are no frequent gusts above 35 mph.

2) Check outside temperature to assure it is above $-10^{\circ}$F.

3) Check relay shack temperatures. Safe operating limits are +40 to +100 degrees F.

### 1.4 ANTENNA CONTROL UNIT 100

1) Make sure the green emergency stop reset button at the top of the telescope control panel is IN.

2) Push ACCEPT COMMAND switch.

3) Push BRAKES ON/OFF switch. The light should come on and the hydraulic pump will be audible over the monitor.

4) When the brakes are released, POL BRAKES OFF, DEC BRAKES OFF, and MANUAL CONTROL switch will be lit.

5) Telescope(s) should be run manually to insure all scan and slew motors are functioning properly.

2.0 BACKEND PREPARATION FOR ALL MODES

Regardless of the mode of operation to be used, the following checks and adjustments are required on the L O DISTRIBUTION UNIT 400 and the BACKEND UNIT 300 (both units located in the control building equipment room) and the ANALOG DISPLAY UNIT 160 and the ANTENNA CONSOLE UNIT 100 (both units located in the control building control room).

2.1 MASTER OSCILLATOR (UNIT 400)

1) The frequency counter should indicate 47499.000 to 47501.000 kHz. (To obtain this frequency indication, the switches on the COUNTER SELECT panel below the frequency counter must be set so that only the green LO switch is glowing.)

2) The SAMPLE RATE switch should be in the HOLD position. NOTE: The computer cannot read the frequency if it is not in this position.

3) Press the ALC-LOOP CHECK switch located under the PLO LEVEL meter. It should be set to mid-range using the micrometer-type potentiometer. (If it is not possible to obtain this mid-range setting, check with the proper engineer or technician to insure there is no malfunction.)

2.2 PHASE SHIFTER SERVO CONTROL (UNIT 400)

1) The AUTO/MONITOR switch should be in AUTO position.

2) The SIN meter should read 0± 1 ua.

3) The COS meter should read +45 to +50 ua.

2.3 IF MONITOR (UNIT 300)

Set the R.H. and L.H. LEVEL meters for the telescopes to be used so that they indicate between 15-20 ua. Use the ATTENUATOR controls to get this reading.

2.4 IF LEVEL CONTROL & NOISE TEMPERATURE MONITOR (UNIT 300)

The correct IF LEVEL, CONTROL SIGNAL, and NOISE TEMPERATURE readings change from time to time, and the current readings are listed on a chart kept in the equipment room. If any deviations are noted, notify the proper engineer or technician.

2.5 BOX TEMPERATURE (UNIT 160)

The meters for each telescope should read between .3-.7 ma.

2.6 ANALOG DISPLAY (UNIT 160)

1) The pens on each channel of the recorder can be centered by disconnecting the input cable and moving the POSITION control.

2) Using the Analog Display Patch Panel, the operator can monitor any correlator output (0-23) by connecting it to the input of one of the four recorder channels.

3) The operator can set the gain desired for each channel. The speed is normally 10 mm/min.

2.7 SYSTEM STATUS (UNIT 100)

This monitor panel is provided to warn the operator if a malfunction develops in some unit of the system. An alarm will sound and a light will glow to indicate where in the system a malfunction exists. The proper engineer or technician should be informed of any trouble so that corrective action can be taken.

3.0 BACKEND PREPARATION FOR INTERFEROMETER MODE

The following checks and adjustments are required for the interferometer mode of operation.

3.1 CORRELATOR (UNIT 300)

The correlators should swing around zero when observing. If zero is not the center of the swing, the proper engineer or technician should be notified.

3.2 POWER CONTROL (UNIT 300)

1) Press RECEIVER CONTROL switch so that it indicates COMPUTER position.

2) Press DELAY CONTROL switch so that it indicates COMPUTER position.

3) Press CORRELATOR CONTROL switch so that it indicates COMPUTER position.

## 4.0 BACKEND PREPARATION FOR SINGLE ANTENNA MODE

The following checks and adjustments are required for the single antenna mode of operation.

### 4.1 POWER CONTROL (UNIT 300)

1) Press RECEIVER CONTROL to MANUAL position.

2) DELAYS and CORRELATORS are not used in this mode, but they can be placed in MANUAL control.

### 4.2 FRONT END SWITCH CONTROL (UNIT 300)

The front end switches will automatically drop to the XR-XL position (X-band left and right) when the receiver is switched to manual control. If S-band IF is desired, press the SR-SL switch. XR-SL may be used if desired.

### 4.3 X-BAND AND S-BAND CALIBRATION CONTROLS (UNIT 300)

The IF MONITOR DETECTOR GAIN X-3 switch and the NOISE MOD OFF switch for the band desired should be pressed ON (lights on). SWEEPER ON and CAL ON switches should be OFF (lights off).

SECTION 2

COMPUTER OPERATION

Paragraphs 5.0-14.0

Pages 1-21

## 5.0 DDP-116 COMPUTER OPERATION FOR INTERFEROMETER MODE

If all backend functions are set properly and indicate within allowable limits, observations can begin. The DDP-116 computer controls the operation of the telescopes and receivers in the Interferometer Mode. All aspects of computer operation for this mode follow. Refer to DDP-116 CONTROL PANEL diagram, Fig. 1.

### 5.1 LOADING THE KEY-IN LOADER

1) Press POWER button in the lower left corner of the computer control panel. Wait 4 minutes.

2) Punch the MASTER CLEAR button.

3) Punch 016540 into the DATA REGISTER.

4) Punch the P button on the REGISTER SELECT section.

5) Punch the ENTER button. At this time the number 016540 will be displayed on the DISPLAY REGISTER.

6) Place the STORE/READ switch on the MEMORY section to the STORE position. (NOTE: The P ADDR/Y ADDR switch should always remain in the P ADDR position.)

7) Punch the red CLEAR button on the DATA REGISTER.

8) Punch 030105 into the DATA REGISTER.

9) Punch the ACCESS button in the MEMORY section. At this time the number in the DISPLAY REGISTER will increase to 016541.

10) Punch the red CLEAR button on the DATA REGISTER.

11) Punch 131005 into the DATA REGISTER.

12) Punch the ACCESS button in the MEMORY section. Again, the number in the DISPLAY REGISTER will increase by 1 to 016542.

13) Punch the red CLEAR button.

14) Punch 003541 into the DATA REGISTER.

15) Punch ACCESS.

16) Punch CLEAR.

17) Punch 041470 into the DATA REGISTER.

18) Punch ACCESS.

19) Punch CLEAR.

20) Punch 130005 into the DATA REGISTER.

21) Punch ACCESS.

22) Punch CLEAR.

23) Punch 003544 into the DATA REGISTER.

24) Punch ACCESS.

25) Punch CLEAR.

26) Punch 011472 into the DATA REGISTER.

27) Punch ACCESS.

28) Punch CLEAR.

29) Punch 025546 into the DATA REGISTER.

30) Punch ACCESS. At this time the DISPLAY REGISTER will advance to 016550.

31) Punch CLEAR.

32) Punch 003541 into the DATA REGISTER.

33) Punch ACCESS. The DISPLAY REGISTER will now read 016551.

34) Place the STORE/READ switch to the READ position.

35) Punch MASTER CLEAR.

36) Place SENSE SWITCH 4 in SET position (flip it up).

## 5.2 LOADING THE INPUT/OUTPUT CARD SYSTEM AND SYSTEM TAPE

1) Press POWER ON button on CARD READER. Wait 30 seconds.

2) Place the IOCS card deck (located in the card filing cabinet in the control room) in the input (right) side of the CARD READER. The card deck must be placed FACE DOWN, TOP EDGE OUT. Place the card weight on top of the deck.

3) Press RESET button, then START button on CARD READER. (NOTE: When preparing the card reader to read cards, always press RESET then START.)

4) Punch 016540 into the DATA REGISTER on the computer control panel.

5) Punch the P button on the REGISTER SELECT section.

6) Punch the ENTER button on the REGISTER SELECT section.

7) Place the MODE switch in the RUN position.

8) Press the START button on the computer control panel.

9) The CARD READER will read the IOCS card.deck and stop. The computer will type out the coded date, sidereal time, sect number, and a return code on the teletype.

10) Place the TAPE-TO-DISK card deck in the card reader.

11) Press RESET and START on the card reader.

12) Place the MODE switch on the computer to the SINGL. INSTR. position.

13) Punch MASTER CLEAR.

14) Punch 016540 into the DATA REGISTER.

15) Punch P and ENTER buttons.

16) Place MODE switch to RUN position.

17) Load the CURRENT SYSTEM TAPE (located in the tape rack) onto the TAPE DECK. To do this, the tape must be placed on the top spindle with the indention around the center of the reel toward the tape deck. If there is a plastic ring in this indention, it must be removed. Turn the knob on the spindle clockwise until it locks the tape in place. Hold the START/BRAKES switch (located between the spindles) to the BRAKES position and manually unwind enough tape to traverse the reading heads and roll onto the empty reel on the lower spindle. Insert the tape through the slot and onto the heads and begin winding it onto the empty reel until it will hold itself. Hold the START/BRAKES switch to the START position until the tape is pulled into the vacuum chambers. At the top of the tape deck, depress the HIGH DENSITY button, then depress the LOAD POINT button and the AUTO button. The tape is now ready to be read.

18) Press the START button on the computer. The computer now reads the TAPE-TO-DISK card deck and stops.

19) Press START again. The computer will read the preparation date from the tape and print it on the TELETYPE. Ascertain that this is the correct tape (usually, the most recent) to be loaded.

20) Press START again. The contents of the tape will be read by the computer and stored in memory. When finished, the tape will rewind and can be removed from the tape deck and stored in its usual place. The TELETYPE will print DONE, indicating the computer has the system tape in memory. (NOTE: The system tape should be loaded after every maintenance day.)

21) Place SENSE SWITCH 4 in RESET position (down).

5.3 LOADING THE OBSERVING PROGRAM

1) Press START button on the computer. The TELETYPE will print out a coded date, sidereal time, sect number, and a return code. At this point in initializing the computer from a cold start, the sect number should be 00000. Make sure this is the sect number indicated. If it is not, see the troubleshooting procedure for loading the correct sect number (par. 15.10). The teletype then prints SCAN NNNNN?

2) Type NO, and punch the RETURN key on the teletype keyboard. (Any time anything is typed on the teletype, the RETURN key must be punched before the computer will continue.) The teletype now prints the following message: ENTER 4 CARDS WITH BASELINE CONSTANTS, 3 WITH POINTING CONSTANTS, 1 WITH DELAY CENTERS .

3) Place the BASELINE deck of IBM cards (refer to Fig. 2) for the present telescope configuration (deck normally located on top of the card reader) in the CARD READER. (If necessary, see the troubleshooting procedures entitled POINTING CONSTANTS and BASELINE CONSTANTS, pars. 13.0 and 14.0.)

4) Press RESET and START on the card reader. The computer will read the

deck and type the following message: ENTER SCAN NO. After the correct scan number is typed on the teletype, the computer prints PRESS START PLEASE.

5) Press START on the computer. The computer now types: THANKS. READY PROGRAM IN CARD READER.

6) Place the card deck of sources to be observed (supplied by the observer) in the card reader.

7) Press RESET and START on the card reader. The computer now types: ENTER DAY NUMBERS.

8) Remove the program deck from the card reader, and place a handful of Besselian Day Number cards in the card reader. (These cards are located in the card filing cabinet in the control room, and they are color coded by month.)

9) Press RESET and START on the card reader.

10) MASTER CLEAR the computer.

11) Punch 016540 into the DATA REGISTER.

12) Punch P and ENTER buttons.

13) Press START on the computer. The computer will read part of the deck, will print the date, time, sect no, and return code on the teletype, then prints: SCAN NNNNN?

14) Remove the cards from the reader and store. Type YES and punch the RETURN key on the keyboard. (The scan number should be the correct one.) The computer now prints SOURCE LIST EMPTY READY PROGRAM IN CARD READER.

15) At this point, the operator has the option of leaving SENSE SWITCH 4 in the RESET (down) position or placing it in SET (up) position. The former allows the information in each source card to print out after each is read, but allows only 50 cards maximum to be read; the latter suppresses all printouts and allows a maximum of 100 cards to be read.

16) Place the observing deck in the card reader.

17) Press RESET and START on the card reader. The computer now reads the deck, typing out any unusual conditions and pertinent warnings. When all cards have been read and memorized (up to the maximum amount), the computer will type: RETURN TO OBSERVING, followed by the coded date, time, sect no, and return code. If SS4 is SET, the computer will now pause, and the operator should place SS4 in RESET; if SS4 was left RESET at step 15, no action is required at this point.

18) The computer now asks if it remembers the correct scan number.

19) Place the telescopes under computer control (Unit 100), then type YES and the RETURN key on the keyboard (assuming the scan number was the correct one). The computer now slews the telescopes to the correct source, prints out pertinent information about the source, and begins observing when the sidereal time and source identification prints out.

THE INTERFEROMETER SYSTEM IS NOW ON THE AIR.

20) To stop observing before the program is exhausted, perform the following steps on the computer control panel:

SENSE SWITCH 4 to SET (up)

MODE switch to SINGL. INSTR.

MASTER CLEAR

Punch 017000 into the DATA REGISTER

Punch P and ENTER buttons

MODE switch to RUN position

Punch START

The computer will print out through the return code and stop. If desired, the MODE switch can be placed to SINGL. INSTR. position, MASTER CLEAR button punched, and the computer can be used for other operations, such as the UTILITY PROGRAMS described in par. 16.0. To restart the computer observations on the program still in memory, follow the instructions in par. 15.1.

## 6.0 DDP-116 COMPUTER OPERATION FOR SINGLE ANTENNA MODE

Several types of programs can be run using one telescope working independently of the others. Only one of these is used frequently at the Interferometer, and it is the only one for which the computer is programmed to run automatically (that is, the computer operates the telescopes and makes necessary calculations...the backend functions must be controlled by the operator.) This is the Telescope Pointing program, and computer instructions for this program follow.

The Backend must be set up as instructed in par. 2.0 and par. 4.0, and the Interferometer Mode computer instructions must be followed through par. 5.3.18. At that point, perform the following operations.

1) Place card deck PT in card reader.

2) Press RESET and START on card reader.

3) Place the computer MODE switch to the SINGL. INSTR. position.

4) Press MASTER CLEAR.

5) Place SENSE SWITCH 4 to RESET (down) position.

6) Punch 016540 into the DATA REGISTER.

7) Punch P and ENTER.

8) Place MODE switch to RUN.

9) Press START on the computer. The card deck will be read, and the computer halts.

10) Place the MODE switch to the SINGL. INSTR. position.

11) Press MASTER CLEAR.

12) Punch 001000 into the DATA REGISTER.

13) Punch P and ENTER.

14) Place the MODE switch to the RUN position.

15) Press START on the computer. The teletype will print out pertinent information about the source to be observed, then asks if the scan number is correct. After the operator answers, the following header is printed out:

TELESCOPE COORD HA ERROR CHANGE AMPL

At this point, the teletype may print SET RECEIVERS TO APPROPRIATE BAND. This depends on which IF is selected on the Backend Front End switches (see Section 1, par. 4.2). The IF to use is at the discretion of the observer, and the proper one can be selected according to the following list:

SL can be used by positioning SS1 and SS2 down.

SR can be used by positioning SS1 down and SS2 up.

XL can be used by positioning SS1 and SS2 up.

XR can be used by positioning SS1 up and SS2 down.

The same IF must be used on all telescopes being pointed. If the Front End switch or Sense Switch is changed during a scan, the computer will give erroneous results for that scan. Therefore, any such change should be noted on the teletype and in the observing log.

After the telescopes get to the source, the computer will begin taking data from the TOTAL POWER outputs, making calculations, and printing the results periodically on the teletype. The data also goes on disk. If an analog record of the scans is required, the recorder channels must be connected to the proper I.F. MON outputs on the Analog Display Patch Panel.

## 6.1 COMPUTER TROUBLESHOOTING IN SINGLE ANTENNA MODE

There are certain operating and troubleshooting procedures peculiar to this mode of operation, and, for convenience, will be covered here.

### 6.1.1 LOADING MORE OR DIFFERENT SOURCE CARDS

1) Place MODE switch to SINGL. INSTR. position.
2) Press MASTER CLEAR.
3) Punch 001002 into DATA REGISTER.
4) Punch P and ENTER.
5) Place MODE switch to RUN.
6) Press START.

7) After computer finishes type routine, type XLOAD WR on keyboard.

8) Place new source list in card reader, punch RESET and START.

9) Computer will ask if this deck should precede, replace, or follow existing card list.

10) After the operator answers appropriately, the deck will be read. The operator must stop the computer and transfer to 001000 to go back to the pointing program.

6.1.2 UNEXPLAINED COMPUTER STOPS WHILE POINTING

1) Try restarting at par. 6.0.10.

2) If this doesn't work, set SS4, transfer to 017000 and restart the computer. After the type-out is completed, stop the computer and begin again at par. 6.0.1.

NOTE: To skip a source, stop, transfer to 001001, and restart the computer.

## 7.0 CHECKING AND SETTING FOCUS AND POLARIZATION

It is necessary to check the focus and polarization settings on all telescopes with the computer any time any maintenance has been performed on the telescopes. This includes after any normal maintenance day and when a telescope has been moved to another station on the baseline. This check should be performed before beginning observations and can be performed while the computer is taking data. In addition, a binary readout is provided in the SYSTEM CONSOLE UNIT 130 where the settings are visible continuously. These three methods of checking focus and polarization are described below.

1) To check before beginning observations, insert the following steps between paragraphs 5.2.19 and 5.2.20.

MODE switch to SINGL. INSTR.

MASTER CLEAR

Place FP card deck (located in card filing cabinet in control room) in card reader

Press RESET and START on card reader

Punch 016540 in DATA REGISTER

Punch P and ENTER

MODE switch to RUN

Press START. Computer will read card deck.

Press START. Computer will print out the polarization settings of each telescope, then will position the teletype type box under the first reading. If the reading is correct, space across the number and the type box will advance to the next reading. (NOTE: The focus and polarization control switch on System Console Unit 130 must be in COMPUTER position.) If a reading is incorrect, type the correct number beneath it (the correct readings are listed on the teletype cover). The computer will move the front end box to the correct setting, then advance to the next telescope reading. After all telescopes polarization settings are checked, focus settings are typed out. Go through the same steps as with polarization checks. (If all telescopes are set correctly when read, the entire line can be skipped by typing the RETURN key.)

After all readings have been processed, computer will type: SCAN NNNNN? Answer YES and punch the RETURN key. Computer then types: READY PROGRAM IN CARD READER.

Continue at par. 5.2.20.

NOTE: It is possible to program the computer so that the program on card deck will reenter itself after it is over. This can be useful when troubleshooting the focus and polarization settings or when a new front end box is installed on a telescope. To do this, immediately after reading the card deck, place the MODE switch to SINGL. INSTR. position, press MASTER CLEAR, punch 000046 into the DATA REGISTER, punch P and ENTER. CLEAR the DATA REGISTER, punch 014000 into the DATA REGISTER, place STORE/READ switch to

the STORE position, and punch ACCESS. Place STORE/READ switch back to the READ position. Press MASTER CLEAR, punch 014000 into the DATA REGISTER, punch P and ENTER, place MODE switch to the RUN position, and punch START. The computer will continuously read the focus and polarization settings, halting for the operator to check them each time, and will recycle itself and read them over and over until the MODE switch is placed in SINGL. INSTR. position.

2) To check while observing, make sure the focus and polarization motors are under computer control (Unit 130). Type XLOAD FP and the RETURN key on the teletype. The computer will cease observing, type out through the return code, then will type out the actual settings of the polarization on each telescope. The operator should go through the same steps as described in par. 8.0.1. After all settings have been checked, the computer will return to observing. NOTE: The computer will advance the scan number by 1 any time this program is used unless it is initiated during the last few seconds of a scan.

3) There is a binary focus and polarization readout in the System Console Unit 130 where the actual settings are visible in octal form at all times. This readout is read exactly as described in Fig. 1, DDP-116 CONTROL PANEL DIAGRAM, except that there are only 5 digits instead of 6. The correct settings are listed as octal numbers in the System Console Unit 130 Notebook.

## 8.0 TELETYPE DATA OUTPUT

The teletype will print the vector average amplitude of each correlator at the end of each scan. This printing is overlapped with telescope slewing, but the next observation cannot start until this printout is complete. For this reason, several provisions are made to allow the operator or observer to eliminate this "busy" time.

First, setting SS1 terminates the printout at the end of the current line.

Second, the operator can specify the quantities to be printed by typing

a statement of the following form on the teletype at the beginning of an observer's program, or at any time the observer may wish to change it.

| | | | | |
|---|---|---|---|---|
| | ALL | | INCL | XBAND<br>SBAND |
| XPRNT | CALS | , | EXCL | , PPOL<br>XPOL |
| | NON CALS | | | 42FT<br>BUSY |

When typing the message, follow the initial XPRNT with one or more blanks. One entry may be typed from each of the first two columns, and as many as necessary from the last column. Separate all words with commas, but do not include any blanks. The following list gives the meanings of the words.

ALL means this specification refers to all sources.

CALS means it refers to calibrators only. (Calibrator sources are identified by a C in column 40 of the source card.)

NON CALS means it refers to all sources with no C in column 40.

(If no specification is made, ALL is assumed.)

INCL means that the quantities specified are to be printed.

EXCL means that all quantities are to be printed except those specified.

(If neither word appears, INCL is assumed.)

XBAND refers to the 4 cm observations.

SBAND refers to the 11 cm observations.

PPOL means parallel polarization.

XPOL means crossed hand polarization.

42FT refers to correlators 12 and 13.

BUSY refers to the time segment after the telescopes are pointed at the next source. That is, if BUSY is excluded, the observation will begin as soon as the antennas are pointed at the source, whether the printout is finished or not.

For example, the message XPRNT EXCLUDE causes everything to be printed; XPRNT 42FT, SBAND,PPOL will cause correlator 12 and no others to be printed; XPRNT PPOL is an

error, and will cause nothing to be printed because it specifies the inclusion of neither SBAND or XBAND.

Six columns are printed out at the end of each scan: Correlator number, Amplitude, Phase, Offset, RMS, and number of records averaged. The correlator numbers have significance given by the table in Section 5, Figure 4. The RMS column contains the averaged RMS over the scan. The operator should pay particular attention to the offset column. If the numbers go higher than about 500, the proper technician or engineer should be contacted so that the DC offset for that particular correlator can be adjusted. If the number reaches about 1000, the data is probably worthless.

## 9.0 CRT DISPLAY SYSTEM

The Cathode Ray Tube in the Unit 130 will display various information concerning the data being collected and is updated every 30 seconds. The LST and the MODE are always displayed. In addition, the operator or the observer can choose up to five quantities from the following list:

- C the Cosine component
- A the Amplitude
- S the Sine component
- P the Phase
- O the Correlator offset
- R the root mean square value

To change the quantities being displayed, type XSHOW on the teletype keyboard, followed by one or more spaces, and the codes for the information desired in the format as follows:

XSHOW A2,P2,A4,P4,R4

The above example would cause the amplitude and phase of correlator 1R3R, and the amplitude, phase, and rms of correlator 2R3R to be displayed. The format to use is exactly as shown above, including commas. The numbers 0-13 typed in the message denote correlators according to the following list:

| nn | Correlator |
|---|---|
| 0 | 1R2R |
| 1 | 1L2L |
| 2 | 1R3R |
| 3 | 1L3L |
| 4 | 2R3R |
| 5 | 2L3L |
| 6 | 1R2L |
| 7 | 1L2R |
| 8 | 1R3L |
| 9 | 1L3R |
| 10 | 2R3L |
| 11 | 2L3R |
| 12 | 1R42 |
| 13 | 1L42 |

To keep information on the CRT (i.e. to stop the updating), type:

XSHOW *

To resume normal updating after having stopped it, type:

XSHOW "

## 10.0 DUMPING THE DISK TO TAPE

After an entire program has been observed (i.e. after all the sources in the program card deck have been observed), or, in any case, if the SECT NO has advanced to 2379, the DISK must be dumped onto magnetic tape for processing by the IBM 360 computer at Charlottesville. The procedure follows.

1) Load a data tape on the tape transport. (This is done exactly as described in par. 5.2.16, except that a plastic ring must be inserted in the indention on the back of the tape reel.)

2) When source list is empty, the computer prints XLOAD and halts.

Type CP on the keyboard, followed by punching the RETURN key. The computer will load the CP program from memory. It will then search the tape to see whether or not any data information is already on it and halt. NOTE: If the computer does not print XLOAD, the operator may read the CP card deck into memory to initialize the tape dump. See par. 16.5.

3) Press START on the computer when ready. (NOTE: If, after pressing START, the computer prints INSERT FILE PROTECT RING, see par. 16.5.9.)

4) More than one disk load can be dumped onto the same tape. If a labeled (partially written) tape is mounted, the computer will type:

TAPE NOT CLEAR, OPTIONS FOLLOW

1 'CR' FOR 2ND TRANSFER

2 'ERASE OPID' FOR 1ST TRANSFER

3 'SKIP NNNN' TO SKIP NNNN RECORDS

The operator has the following options:

1) Type the RETURN key to add the disk contents onto the existing contents of the tape. NOTE: Several dumps can be made onto one tape.

2) Type ERASE followed by operator initials to overwrite the data on tape with the data now on disk.

3) Type SKIP followed by a number to save the first NNNN records on tape. (This would be used if a dump problem arises during the dumping of a second disk load onto one tape.)

5) If no labeled tape was encountered, the computer will type:

ENTER TAPE NUMBER - NNNN

6) Type the NRAO tape number (written on the front of the tape reel) and punch the RETURN key on the keyboard. NOTE: 4 digits must be typed...use leading zeroes if necessary.

7) In either case, the tape will be written, and the computer will type:

TRANSFER COMPLETE, PRESS CR TO CLEAR DISK

8) After the tape rewinds, remove it from the tape deck, then punch the RETURN key.

9) After about 1 minute, the computer will print:

SECT 00000 RETURN 00002

If there are additional source cards in memory and if SS4 is RESET, the computer will return to observing. If there are no source cards in memory, the computer will type:

SOURCE LIST EMPTY

XLOAD

The operator may type WR, and punch the RETURN key. A new program may be loaded and observations continued if desired.

10) The observer may request the teletype and analog outputs. These should be rolled and disposed of as instructed.

11) An IBM card, INTAPE, must be prepared on the Key Punch and sent with the tape to Charlottesville. These cards are normally located in the card file in the control room. Columns 24 through 27 must be punched with the tape number as written on the teletype.

## 11.0 PROGRAM CARD FORMAT

The following information may be useful to the operator if the observer makes a mistake in punching the program card deck, or if the operator is requested to punch the deck completely. Any IBM card can be used if the information is punched correctly.

1) Columns 1-10 contain the source name. This name must begin in col. 1.

2) Columns 12-23 contain the right ascension in the format HH MM SS.SSS. Leading zeroes must appear. Zeroes following the decimal point may be omitted, but the decimal point itself must appear.

3) Columns 25-36 contain the declination in the format SDD MM SS.SS. The sign (S) may be a blank (indicating a +), a plus (+), or a minus (-).

Leading zeroes must appear. Zeroes following the decimal point and the decimal point itself may be omitted.

4) Column 38 contains a code indicating the date of reference of the position. A blank or zero indicates a 1950 position; an M indicates a mean position for the nearest integer Besselian year. A D indicates that the position is the current one, and no precession is to be applied.

5) A C in column 40 identifies the source as a calibrator; a blank indicates a non-calibrator.

6) Columns 41-46 may be used to indicate the flux, in the format SSS.SS.

7) Columns 48-50 are used to set the gain of the receivers. If the source flux is less than 4 flux units, G=0; 4 to less than 40 flux units, G=1; 40 flux units and above, G=2. The flux is different for X-Band and S-Band; therefore, the code for the numbers to be punched in the card is determined by the formula: $G_S + 3G_X$.

8) Column 52 contains a mode character as follows (refer to Fig. 4):

| | |
|---|---|
| X | X-Band observations. |
| S | S-Band observations. |
| M | The RR correlators are X-Band, LL are S-Band. |
| D | Switches between S and X Bands at 30 second intervals. |
| Blank | Same as D. |
| C | Unpredictable. |
| Anything else | Same as S. |

9) A start time may be punched in columns 54-58 in the format HH MM. It is not necessary to indicate a start time, however.

10) Columns 60-64 contain the stop time in the format HH MM. At approximately 10 seconds after this time, the observation is terminated and the next observation is processed.

## 12.0 OPERATOR COMMANDS TO THE COMPUTER

The following commands can be executed by the operator by typing it on the keyboard and punching the RETURN key.

### 12.1 XOPID

This is the operator identification command. After the command has been typed out, the computer prints: ENTER OPERATOR ID, 2 CHARACTERS. The operator types his initials, and punches the RETURN key. The computer then prints: OPERATOR XX (or some such acknowledgement), then: ENTER OBSERVER INITIALS. The operator types the observer's initials and punches the RETURN key. The computer prints: OBSERVER XX. The interruption is complete and the computer continues taking data.

### 12.2 XCURR

This command causes the computer to reprint the source header. This can be used to change the teletype paper. To change paper, type X. This prevents the teletype from typing on the roller until the paper is changed. When finished, type CURR. The computer reprints the source header and continues observing.

### 12.3 XSKIP

This command causes the computer to stop observing and to go to the next source in memory without waiting for the stop time as previously memorized from the source card.

### 12.4 XCONT

This command causes the computer to continue observing a source beyond the memorized stop time. Then, the command XSKIP will end the scan when desired, and the computer will advance to the next source whose stop time has not expired

### 12.5 XWAIT

This command causes the computer to cease taking data temporarily. After executing the command, the computer will print WAITING and will halt.

12.6 XBEGN

This command causes the computer to begin taking data again after having been halted by the XWAIT command provided the computer has not been stopped (MODE switch changed or MASTER CLEAR punched). It will also start data taking for objects too near the east limit for computer pointing.

12.7 XBASE

This command causes the computer to ask for the BASELINE card deck (see Fig. 2). This is used to change the baseline constants, delay centers, or pointing corrections. Place the card deck in the card reader and press RESET and START. The deck will be read, then the computer will ask for the scan number. After the scan number is typed on the teletype, the computer will continue at the point where it was interrupted.

12.8 XLOAD WR

This command is used to change programs in memory (i.e. to load a new source deck). The new deck must be placed in the card reader and the RESET and START buttons punched. The computer will cease observing, type out the return code, etc., and ask if the program in the card reader should precede, replace, or follow existing observing list. The operator may SET SS4 (see par. 5.3.15), then answer on the teletype. The computer will read the deck. If SS4 was SET, the operator must RESET it. The computer will begin observing the new source deck.

12.9 XLOAD FP

This command causes the computer to stop observing and read out the focus and polarization settings of the front ends. (See par. 8.0.2.)

NOTE: Any XLOAD command causes the scan no to advance by 1.

12.10 XNOTE

To place a message on disk for the observer, type this command followed by the message.

12.11 XSTOW

This command causes the computer to stop whatever it is doing, move the telescopes under computer control to the stow position, and halt. This is useful when stowing the telescopes for normal maintenance, or when the wind speed requires the immediate stowing of them.

13.0 POINTING CONSTANTS

If the Pointing Analysis program (see par. 16.2) is not used to process pointing data, the data is relayed to Charlottesville. The Charlottesville 360 computer determines the new pointing constants for the telescope which has been moved to another station. This information is relayed from Charlottesville and is in the form of 16 numbers. The operator must punch a new IBM card containing this information. The number of the telescope must be punched in col. 1. The 16 numbers, regardless of the number of digits in each, must be punched so that the last digit of each falls in the following columns: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, and 80. If a number is negative, a minus sign must be punched in the column just preceding the first digit of the number. NEVER USE PLUS SIGNS OR LEADING ZEROES. The card is then inserted in the proper place in the BASELINE deck, replacing the old constants, and, after all new cards have been inserted, must be entered into computer memory. (See pars. 5.3.3, 12.7, and Fig. 2.)

14.0 BASELINE CONSTANTS

Any time a telescope is moved to a different station, the baseline constants for that configuration must be punched on IBM cards and entered into computer memory BEFORE BEGINNING AN INTERFEROMETER PROGRAM. These constants are periodically revised, and the proper ones to use will be on the latest dated sheet titled: REVISED BASELINE PARAMETERS FOR THE SYNTHESIS PROGRAM. Four sets of numbers must be punched in each card. One number, a single digit, is the baseline number (1, 2, 3, or 4) which is punched in col. 61. The three sets of numbers entitled BX, BY, and BZ are punched in the card so that the decimal point of the BZ, BX, and BY numbers fall in cols. 8, 28, and 48,

respectively. If a number is negative, a minus sign must be punched in the column just preceding the first digit of the number. NEVER USE PLUS SIGNS OR LEADING ZEROES. The card is then inserted in the proper place in the BASELINE deck, replacing the old card, and, after all new cards have been inserted, must be entered into computer memory. (See pars. 5.3.3, 12.7, and Fig. 2.)

SECTION 3

TROUBLESHOOTING THE COMPUTER

Paragraphs 15.0-15.16

Pages 1-6

## 15.0 TROUBLESHOOTING THE COMPUTER

If any unexplained or unusual halts occur, try the following steps in order until something works.

### 15.1 RESTART AT MEMORY LOCATION 017000

1) Place MODE switch to SINGL. INSTR. position
2) Press MASTER CLEAR
3) Punch 017000 into DATA REGISTER
4) Punch P and ENTER
5) Place MODE switch to RUN position
6) Press START

### 15.2 RELOAD IOCS

1) Place IOCS card deck in card reader
2) Press RESET and START on card reader
3) Place MODE switch to SINGL. INSTR. position
4) Press MASTER CLEAR
5) Punch 016540 into DATA REGISTER
6) Punch P and ENTER
7) Place MODE switch to RUN position
8) Press START. The computer should read the deck, ask if it remembers the correct scan number, and begin observing after answering YES.

### 15.3 IOCS WILL NOT LOAD

If IOCS will not load, the KEY-IN LOADER has probably been wiped out. Reload the KEY-IN LOADER, as per instructions par. 5.1. Then load IOCS as instructed in par. 15.2.

### 15.4 RELOAD SYSTEM TAPE

If IOCS loads but trouble still persists, reload the System Tape as instructed in par. 5.2.16 and continue from there.

### 15.5 REMOVE POWER FROM COMPUTER

If trouble still persists, place the MODE switch to SINGL. INSTR. position and press the POWER button on the computer. Wait 1 minute and press the POWER button on computer again. Wait 4 minutes, press MASTER CLEAR, and re-load the KEY-IN LOADER, IOCS, etc.

15.6 CHECK POWER INPUT

If none of the previous troubleshooting procedures work, there is a good possibility that some unit of the computer system has lost power, either by a popped circuit breaker or inadvertent disconnection of a power cord. Check all units in the basement and make sure power is on. If power is off of some unit, proceed to find the fault and restore power to the unit.

15.7 INTERNAL EMERGENCY ROUTINE

There is an internal emergency routine programmed into the computer that is activated whenever a situation arises in which the computer feels it cannot continue operating without operator intervention. The operator is made aware of this situation if the computer prints out a six digit number then begins ringing the bell on the teletype. In this situation, the operator should stop the computer and examine the location printed on the teletype. The number typed has a meaning which is listed, along with the proper action to take, in B. Clark's PROGRAMS FOR THE INTERFEROMETER, Section IX, MESSAGE DICTIONARY.

NOTE: The ASR35 teletype sometimes prints out 888888888.....instead of ringing the bell.

15.8 CARD DECK TROUBLE

If, after loading a card deck, the computer prints out the number 1, 2, or 3, or, if the computer hangs up with a card deck partially read, there is something wrong with the card deck. Check the deck to make sure it is the correct one, the cards are in proper sequence, it contains the correct number of cards, and there is no read or feed error indicated on the reader.

15.9 ELECTRICAL INTERFERENCE

If severe electrical interference gets on the lines coming into the control building (e.g. lightning, static electricity), the computer will sometimes begin printing garbage on the teletype. Generally, if the operator stops the computer and tries to restart from 017000, the KEY-IN LOADER is found to be wiped out and must be reloaded. To avoid this when it is happening frequently, it will sometimes suffice to punch the RETURN key on the teletype while it is printing garbage.

15.10 INCORRECT DISK SECTOR

An occasion sometimes arises where the computer or the operator feels that the next disk sector (sect no) which the computer wants to write on is not a blank sector (in other words, there may already be data on that sector). If the computer questions the number, it will stop observing, print out the message DISK DATA AFU, then, after a short time, will print out a 5 digit sect no followed by a question mark. The operator should ascertain whether or not this is a blank sector by checking back in the teletype output. If it is correct, the answer YES followed by punching the RETURN key on the keyboard will permit the computer to go back to observing. If it is not the correct number, the operator should keep answering NO until the computer either gives the correct one, or else asks: WHAT, THEN? The operator can then type in a 5 digit number and the computer will begin writing on that sector. If the operator should ever feel that the number is incorrect but the computer does not question it, the following procedure should be used. Stop observing. Find the correct sector number in the DDP-24 CONVERSION TABLES manual, Table 1, OCTAL TO DECIMAL CONVERSION. Press MASTER CLEAR on the computer. Punch 000022 into the DATA REGISTER, then punch P and ENTER. Punch CLEAR on the DATA REGISTER. Place the READ/STORE switch to the STORE position. Punch the correct octal sect no into the DATA REGISTER.

Punch ACCESS. The correct sect no should now be in computer memory. Place the READ/STORE switch to the READ position. Press MASTER CLEAR. Punch 017000, P, and ENTER on the DATA REGISTER. Punch START. The computer will print out the time, date, sect no, and return code. Verify that the sect no just entered is indeed the one the computer printed out, and continue observing. IF THERE IS EVER ANY DOUBT ABOUT THE SECT NO, the safest thing to do is to dump the disk to tape and continue with the program. This assures that data already on disk will not be destroyed. If the operator should ever want to start at the beginning of the disk when some data is already on disk, use the procedure above, except punch nothing in the DATA REGISTER before punching ACCESS. This will start the sect no at zero.

15.11 A-D CONVERTER CHANNELS

The Analog Display Patch Panel (located in the Analog Display Unit 160), in addition to providing outputs from the correlators, contains outputs from other A/D converter channels plus a digital voltmeter for reading them. This can be useful when a problem in the converter affects computer operation.

15.12 LOADING BESSELIAN DAY NUMBERS MANUALLY

If, when loading the Besselian Day Numbers, the computer will not take the card deck, the operator can load the numbers manually using the teletype. When the computer prints ENTER DAY NUMBERS, type the day numbers for the FOLLOWING DAY using the following format:

±DD.DDD,±DD.DDD,±DD.DDD,±DD.DDD

The day numbers are found in THE AMERICAN EPHEMERIS AND NAUTICAL ALMANAC under the heading Besselian and Independent Day Numbers for $0^h$ Ephemeris Time. The signs are written every 5th number, and apply to all below. Day numbers less than 10" must have an initial 0. The new day starting at $0^h$ Ephemeris Time is equal to $19^h$ Eastern Standard Time.

15.13 ENCODER MALFUNCTIONS

Each telescope is equipped with a polar and declination encoder which reads the actual position of the telescope and transmits the information to the computer so that correct positioning can be accomplished. This information, in the form of Hour Angle, Right Ascension, and Declination, is also visible to the operator on the CRT readout and the Nixie tube readout located in the Antenna Control Unit 100. Frequently, a malfunction occurs, and the encoder momentarily transmits incorrect information. This becomes apparent to the operator if the CRT and Nixie readouts jump from one reading to another, then back again. Sometimes these jumps are infrequent; sometimes they are practically continuous. Invariably, this will interfere with computer operation, inasmuch as the computer will try to position the telescope while two different coordinate positions are alternately being fed to it. The computer will move the telescope first one direction then the reverse (in the coordinate which is malfunctioning). In this situation, the digital engineer or technician responsible should be contacted. It may become necessary to remove the telescope involved from the system until the malfunction is repaired. As an aid in troubleshooting, the operator should try to record the readings between which the readout is jumping. It will also assist the engineer or technician if the operator observes whether or not both coordinates are malfunctioning and whether or not both the CRT and Nixie readouts indicate the jumps.

15.14 DISK MALFUNCTIONS

If the computer cannot be restarted, or if it continuously stops or goes into a loop after restarting, and if all previous troubleshooting procedures produce negative results, there is a possibility that some malfunction has occurred in the Disk Unit located in the basement of the Control Building. Access to the Disk Unit can be gained by opening the lower door on the front of the Unit. At the left are three lights labeled ACTUATION PRESSURE LOW, DRUM SPEED LOW, and DRUM TEMPERATURE HIGH. If any of these lights are lit,

the digital engineer or technician should be contacted and advised of the malfunction. (NOTE: A computer loop is a situation whereby the computer will not or can not go to the next programmed instruction...in other words, it simply "hangs up". The operator can usually identify this situation by the abnormal blinking of the lights in the buttons on the Data and F Registers.]

15.15 COMPUTER TEMPERATURE LIMITS

The computer and any of its associated digital equipment should not be operated if the room temperature should fall below +50 degrees F. or rise above +100 degrees F. The upper limit for the temperature inside the computer cabinet is +125 degrees F. If the temperature should reach any of these extremes (e.g. if the heating/air conditioning equipment malfunctions), contact the engineer or technician responsible for the digital equipment and follow his instructions.

15.16 THINGS TO AVOID

In addition to the preceding troubleshooting procedures, there are some things the operator should avoid doing.

1) NEVER punch a button on the computer while the computer is running.

2) DON'T turn the card reader on or off unless the computer is actually taking data or is completely stopped.

3) DON'T turn the CRT's on or off while the computer is running.

4) DON'T attempt to change a light bulb on the computer or any backend unit while observing.

5) DON'T stop the computer while it is slewing the telescopes UNLESS IT IS AN EMERGENCY.

SECTION 4

# COMPUTER UTILITY PROGRAMS

Paragraphs 16.0-16.5

Pages 1-5

## 16.0 COMPUTER UTILITY PROGRAMS

There are several utility programs which can be entered into the computer to aid the electronics or digital labs in troubleshooting some of their equipment in the system. These programs CANNOT be used while the computer is on-line (that is, while it is taking data or running a pointing program). To use any of these programs, the computer must be stopped, and the program deck entered into memory.

### 16.1 ADCT

To use this program, place the ADCT card deck in the card reader and press RESET and START. Press MASTER CLEAR on the computer, then transfer to 016540 (see Fig. 1), place MODE switch to RUN position, and press START. The deck will be read. Press MASTER CLEAR and transfer to 014000, RUN, START. Enter the A-to-D line number or Buffer Channel number of interest into the A REGISTER (in octal). Press START. The A-to-D value will be printed out. To read another or the same line, enter the number into the A REGISTER, and press START. The value the computer prints out is (in decimal) the voltage read by the Analog-to-Digital Converter (negative full-scale to positive full-scale).

### 16.2 POINTING ANALYSIS (PA)

1) Load the PA deck.

2) Set SS1 if a printout of the least squares matrix is desired. Otherwise, RESET SS1.

3) Transfer to 002000 and punch START twice.

4) The computer will type INPUT FROM DISK OR TAPE. If all required pointing data is on disk, reply DISK. If not, reply TAPE after mounting the appropriate data tape on the tape transport. The pointing data from the tape will be transferred to disk at the end of data already on disk.

CAUTION: It is now permanently on disk, and the operator should not reply TAPE again when reducing the other axes.

5) The computer will type POINTING REDUCTION FOR 85- . The operator should specify the antenna and coordinate (e.g. type in 2 RA so that the statement reads POINTING REDUCTION FOR 85-2 RA). After the RA reduction is entirely complete the operator may start again at step 3 and enter 2 DEC at this point.

6) The computer will then think for several tens of seconds. At the conclusion of this time it will investigate SS1, and if it is SET, will type the nine least squares equations (for declination, there are only 7 parameters, and the last two equations are meaningless).

7) The computer will type DO YOU WISH TO HOLD ANY PARAMETER FIXED? If a solution for all nine parameters (7 for declination) is desired, type a carriage return.

8) At this time the computer will type 9 pointing numbers (the last two will be zero for declination reductions) corresponding to H1-H9 or D1-D7, which may then be punched on cards and entered into the computer by means of the XBASE command (see par. 12.7).

9) After typing the numbers the computer will display the first 20 data points on the data CRT screen, showing record (sect) number, declination, hour angle, measured error, and residual from the fitted solution.

10) Points may be edited out (for a future solution) by using the CRT keyboard to delete (i.e. type blanks over) the measured error value. Do not erase the record number. Do not use the FORMAT INSERT or FORMAT DELETE functions.

11) After doing whatever editing you wish, send the output back to the computer by pressing SEND BLOCK. The computer will then display the next 20 data points.

12) After all data points have been displayed, the computer will halt.

To re-analyze the edited data, or to go to the next telescope or coordinate, press START.

13) If, at step 7, YES was typed, the computer will respond with a list of the physical significances of the pointing parameters. If the pointing data is restricted and it is not desirable to solve for all parameters, list, one at a time (i.e. one digit followed by a carriage return), the parameters to be held fixed, terminating the list with the word NO. The listed parameters will be taken from the appropriate pointing correction card which was read in at the last previous execution of the XBASE command, and will be held fixed. Program execution continues from step 8.

16.3 OUTPUT SELECT LINE TESTS

Key the following program into computer memory. (For example, MASTER CLEAR, punch 001020 into the DATA REGISTER, punch P and ENTER. Clear the DATA REGISTER, punch 013027 into the DATA REGISTER, place READ/STORE switch to STORE, and punch ACCESS.)

| LOCATION | INSTRUCTION |
|---|---|
| 1020 | 013027 |
| 1021 | 011023 |
| 1022 | 000201 |
| 1023 | 000000 |
| 1024 | 003023 |
| 1025 | 000000 |
| 1026 | 003020 |
| 1027 | 170000 |

After entering the above program, transfer to 1020 (see Fig. 1). Enter the Output Select Line number (e.g. 000260 for the second select line) into the A REGISTER. Enter the output command (see drawing No. B7894522-set or reset bits) into the B REGISTER. Press START. To test another

line, set up the A and B registers in a similar manner and press START. The function being tested (e.g. correlator, delay) must be under computer control before giving the command.

16.4 INPUT SELECT LINE TESTS

Key the following program into computer memory. (For example, MASTER CLEAR, punch 001000 into the DATA REGISTER, punch P and ENTER. CLEAR the DATA REGISTER, punch 000000 into the DATA REGISTER, place READ/STORE switch to STORE, punch ACCESS.)

| LOCATION | INSTRUCTION |
|---|---|
| 1000 | 000000 |
| 1001 | 000201 |
| 1002 | 013014 |
| 1003 | 011005 |
| 1004 | 140040 |
| 1005 | 000000 |
| 1006 | 000000 |
| 1007 | 000201 |
| 1010 | 005005 |
| 1011 | 013014 |
| 1012 | 000201 |
| 1013 | 003000 |
| 1014 | 130000 |

After entering the above program, put line number of interest in the B REGISTER, then transfer to 1001 (put 1001 in P REGISTER). The answer appears in the A REGISTER after pressing START.

16.5 CP

This program is used to dump the disk to magnetic tape, and it is stored in memory and used as described in par. 11.0 If, however, it cannot be

called from memory for use, it is available on card deck and can be used as follows:

1) Load a blank or partially written tape on the tape transport.

2) Place the card deck entitled CP in the card reader.

3) Press RESET and START on the card reader.

4) Punch MASTER CLEAR on the computer.

5) Punch 016540 into the DATA REGISTER.

6) Punch P and ENTER.

7) Place the MODE switch in the RUN position (if it is not already).

8) Press START on the computer. The deck will be read.

9) Press START on the computer. At this point the teletype may print INSERT FILE PROTECT RING. If it does, make sure the plastic ring is on the tape reel. Then punch MASTER CLEAR, punch 003000 into the DATA REGISTER, punch P and ENTER, place the MODE switch to RUN position, and press START.

10) Continue at par. 11.4.

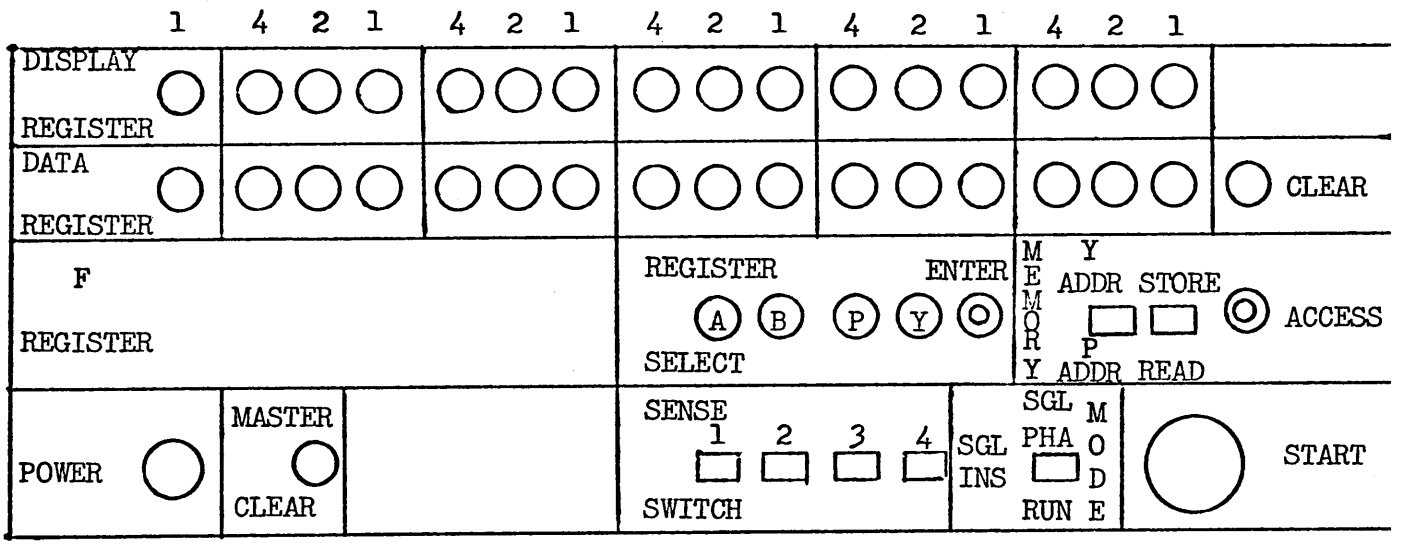
SECTION 5

DIAGRAMS

Figures 1-4

Pages 1-5

FIG. 1 DDP-116 CONTROL PANEL DIAGRAM




1) The computer instructions in this manual do not specify each individual button to punch on the DATA REGISTER, but simply state to punch a certain number into the register. All other buttons to punch or switches to set are specified.

2) The DISPLAY and DATA REGISTERS are divided into 5 sections of 3 buttons or lights per section plus 1 section of 1 button.

3) Up to a 6-digit octal number (see B. Clark's OPERATORS MANUAL dated 1/3/67) can be punched into the DATA REGISTER by pressing a combination of numbers in each section which adds up to the desired digit. The value of each button is written above it in the diagram above.

4) As an example, to punch the octal number 4073 into the DATA REGISTER:

Punch nothing in the digit 6 and 5 sections.

Punch the 4 button in digit 4 section.

Punch nothing in the digit 3 section.

Punch 4, 2, and 1 buttons in the digit 2 section.

Punch the 2 and the 1 buttons in the digit 1 section.

5) A light in each button punched will come on to indicate that the number punched can be loaded into a register (see B. Clark's manual THE DDP-116 -- CONSOLE PROCEDURES dated February 9, 1967). If a wrong button is punched, the DATA REGISTER CLEAR button on the far right of the control panel must be pressed and the entire number punched in again.

6) After a number is punched into the DATA REGISTER, it is usually "transferred" to the P REGISTER. This is done by punching the P and ENTER buttons. Rather than writing out each of these steps, the instruction "transfer to NNNNNN" in this manual means to punch the number NNNNNN into the DATA REGISTER, then to punch the P and ENTER buttons.

FIG. 2 BASELINE DECK

BASELINE PARAMETERS (card nos. 1,2,3,4)
ANTENNA POINTING CONSTANTS (card nos. 5,6,7)
DELAY LINE CONSTANTS (card no. 8)

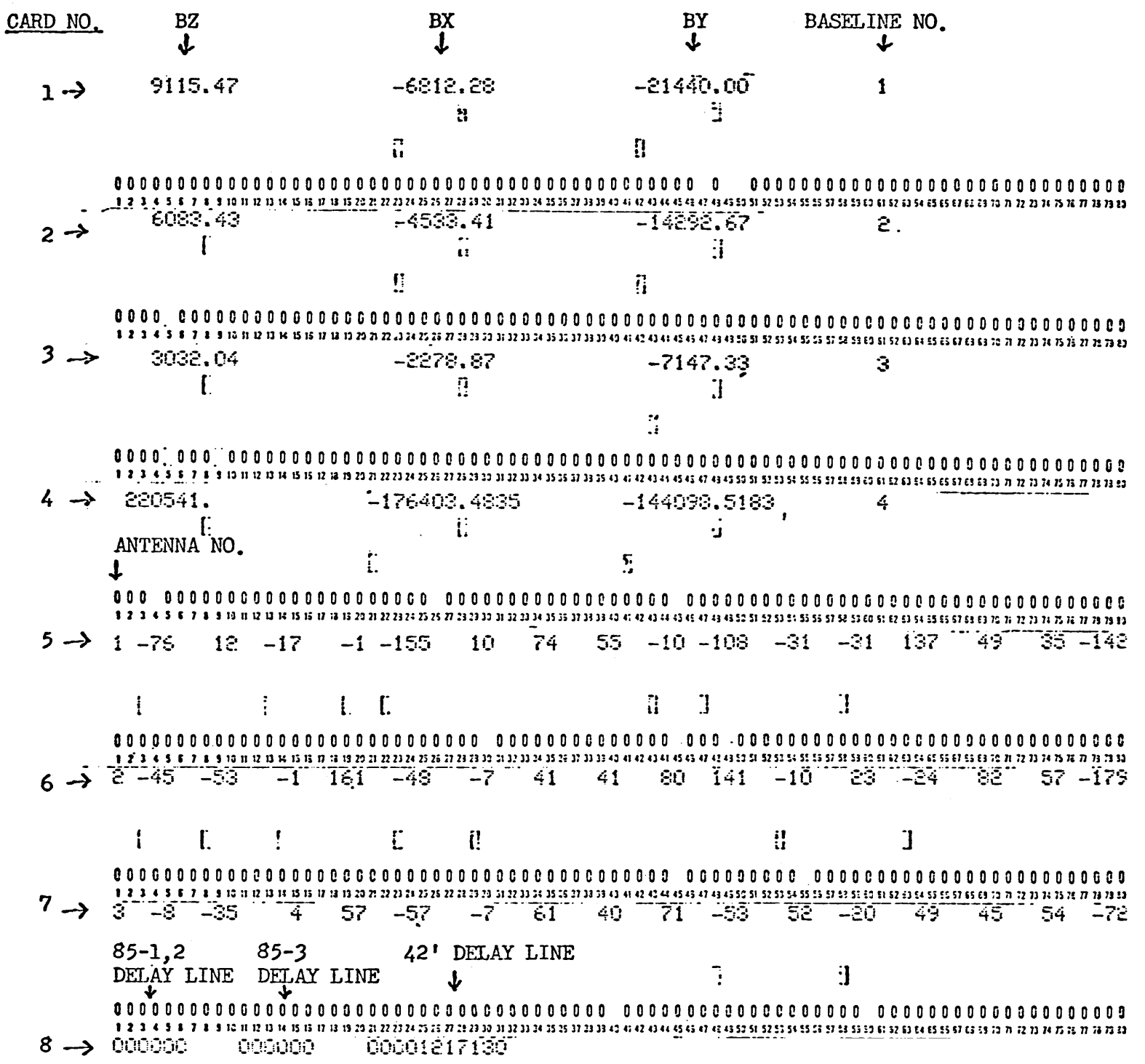


FIG. 3 TROUBLESHOOTING AND COLD START PROCEDURES

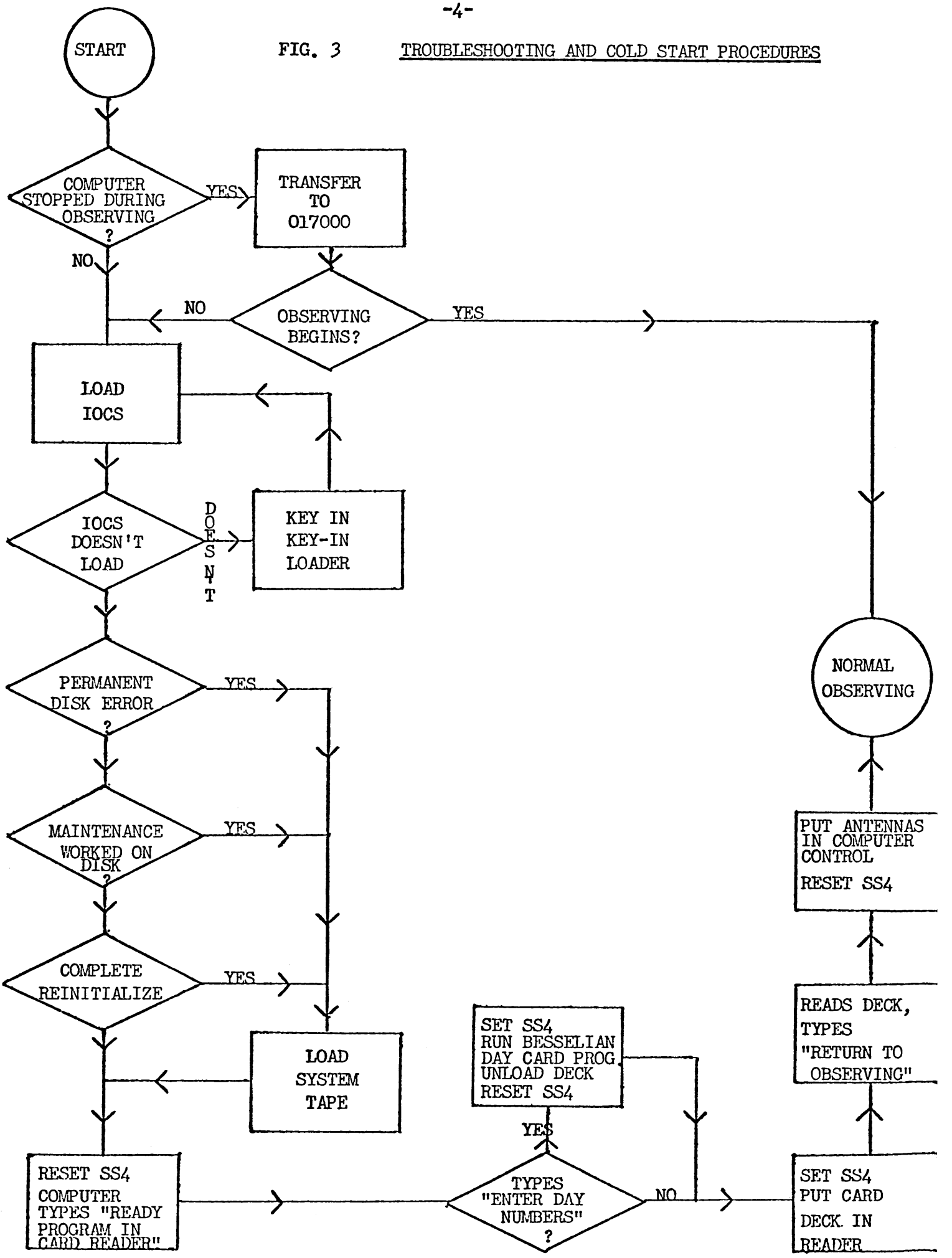


FIG. 4 CORRELATOR NUMBERS AND THEIR SIGNIFICANCE

| Corr Number \ Mode | S, X, D, or Blank | M. |
|---|---|---|
| 0 | 1R2RS | 1R2RX |
| 1 | 1L2LS | 1L2LS |
| 2 | 1R3RS | 1R3RX |
| 3 | 1L3LS | 1L3LS |
| 4 | 2R3RS | 2R3RX |
| 5 | 2L3LS | 2L3LS |
| 6 | 1R2LS | |
| 7 | 1L2RS | |
| 8 | 1R3LS | |
| 9 | 1L3RS | |
| 10 | 2R3LS | |
| 11 | 2L3RS | |
| 12 | 1R42S | |
| 13 | 1L42S | |
| 14 | 1R2RX | |
| 15 | 1L2LX | |
| 16 | 1R3RX | |
| 17 | 1L3LX | |
| 18 | 2R3RX | |
| 19 | 2L3LX | |
| 20 | 1R2LX | |
| 21 | 1L2RX | |
| 22 | 1R3LX | |
| 23 | 1L3RX | |
| 24 | 2R3LX | |
| 25 | 2L3RX | |

## APPENDIX

The following list of instruction manuals and memos contain more detailed and more technical aspects of the Interferometer System and the operation thereof than this report has attempted to describe. BASIC INSTRUCTIONS FOR OPERATING THE INTERFEROMETER has been taken almost entirely from these manuals and memos.

| | |
|---|---|
| PROGRAMS FOR THE INTERFEROMETER DDP-116 COMPUTER | B. CLARK |
| TELESCOPE OPERATORS MANUAL DDP-116 INTERFEROMETER COMPUTER | B. CLARK |
| THE DDP-116 -- MACHINE ORGANIZATION | B. CLARK |
| THE DDP-116 -- PROGRAMMING | B. CLARK |
| THE DDP-116 -- CONSOLE PROCEDURES | B. CLARK |
| THE DDP-116 -- INPUT-OUTPUT | B. CLARK |
| INSTRUCTIONS FOR USING THE INTERFEROMETER COMPUTER OPERATING SYSTEM | B. CLARK |
| PT OPERATING INSTRUCTIONS | B. CLARK |
| INSTRUCTIONS FOR CRT AND PRINTER | B. CLARK |
| INTERFEROMETER TELESCOPE OPERATORS COMPUTER MANUAL | R. L. SWENSSON |
| DDP-24 CONVERSION TABLES | COMPUTER CONTROL CO. |
| DDP-116 PROGRAMMERS REFERENCE MANUAL | COMPUTER CONTROL CO. |
| DDP-116 INSTALLATION MANUAL | COMPUTER CONTROL CO. |
| DDP-116 DAP MANUAL | COMPUTER CONTROL CO. |

In addition, observers may find useful information in Telescope Operations Division Report No. 5, INTERFEROMETER USERS' GUIDE, by Jonathan C. Spargo.

NATIONAL RADIO ASTRONOMY OBSERVATORY

Green Bank, West Virginia

TELESCOPE OPERATIONS DIVISION REPORT NO. 6

# BASIC INSTRUCTIONS FOR OPERATING THE INTERFEROMETER

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MARCH, 1970

(REVISED MARCH, 1971)

(REVISED JULY, 1975)

60 COPIES

This manual is divided into sections according to the following list of paragraphs. The TABLE OF CONTENTS lists the individual paragraphs in each section.

TABLE OF CONTENTS

## INTRODUCTION

The Interferometer is a complicated instrument consisting of three 85' telescopes and a 45' telescope capable of observing three separate frequencies in several different combinations as required. The basic interferometer mode of operation utilizes all four telescopes operating at 2695 MHz (SBAND, or 11.1cm) and 8085 MHz (XBAND, or 3.7cm), sensitive to both right and left circular polarizations. 85-1, 85-2, 85-3, and the 45' are referred to as channel 1, 2, 3, and 4, respectively, and together comprise a four-element system. The 45' antenna is peculiar to the 85' antennas in many ways and therefore will be handled separately in this report, unless otherwise indicated.

The 85' telescopes are operated independently when it is necessary to obtain antenna pointing corrections. This is called the single antenna mode of operation and will be described separately.

The Interferometer is also capable of receiving over the frequency range of 1347.5 MHz to 1430 MHz for the purpose of line interferometry, and this mode of operation will also be described separately.

These instructions include all the basic steps in preparing the telescopes, backend units, and the computer for observing in these various modes. A lot of information is also included to assist the operator in performing various operating and monitoring tasks. Most of the technical aspects of the system are not included here, and they can be found in one of a number of publications kept at the control building. It is assumed that required power is being delivered to all equipment and that all equipment is functioning properly. Troubleshooting procedures follow these instructions.

## 1.0 TELESCOPES

Regardless of the type of program to be run, the procedure for preparing the telescopes to be operated is the same. The 45' telescope is required for some observing programs. Contact between the 45' antenna and the control building is maintained via a phase locked microwave link. The equipment associated with this link is located in a single rack in the control building equipment room. The Console System Unit 130, Analog Console Unit 160, and the Antenna Control Unit 100 are located in the control building control room.

### 1.1 MICROWAVE LINK RACK

1) Make sure the link is locked and functioning properly. Locking instructions are attached to the rack.

2) Press the COMPUTER/MANUAL receiver control switch so that it indicates COMPUTER control.

### 1.2 CONSOLE SYSTEM UNIT 130

Place all OFF/MONITOR switches for the 85' telescopes to be operated in the MONITOR positions (relay shack, polar platform, declination platform, apex, and control room), and make sure the monitor SYSTEM, LOCAL, and LEVEL controls are turned up sufficiently to be able to hear.

### 1.3 PERSONNEL WARNING

Make sure the telescopes to be used are clear of all personnel and are ready to be operated.

### 1.4 ANALOG CONSOLE UNIT 160

1) Check the wind speed monitors to ascertain that the wind is below a steady 30 mph and that there are no frequent gusts above 35 mph.

2) Check the outside temperature to assure it is above -10 deg. F.

3) Check the 85' relay shack temperatures. Safe operating limits are +40 to +100 deg. F.

4) Ascertain that the inside temperature at the 45' is between +62

and +78 deg. F. If the temperature should ever go above 78 degrees, do not try to operate the telescope since serious malfunctions could develop. In such an event, contact the proper maintenance personnel so corrective action can be taken.

1.5 ANTENNA CONTROL UNIT 100

1) Make sure the green emergency stop reset buttons at the top of the telescope control panels are IN.

2) For the 85' antennas:

a) Push ACCEPT command switch.

b) Push BRAKES ON/OFF switch. The light should come on and the hydraulic pump should be audible over the monitor.

c) When the brakes are released, POL BRAKES OFF, DEC BRAKES OFF, and the MANUAL control lights will be lit.

d) Operate the telescope(s) manually to insure that all motors are functioning properly.

e) Press COMPUTER switch to place the telescope(s) in COMPUTER control.

3) For the 45' antenna:

a) If no lights are glowing on the 45' control panel, place the toggle switch on the control chassis behind the control panel to the ON position.

b) Press the POWER ON switch on the control panel. If the servo system is operating properly, the SERVO OK light will glow. (If the SERVO OK light does not glow, and the link is locked, some problem exists in the equipment, in which case the proper telescope operator should be notified.)

c) Press the ACCEPT command switch.

d) Ascertain that the stow pins are out. (If any stow pins are in,

lights will glow to indicate it.)

e) Ascertain that the ELEVATION and AZIMUTH motor control potentiometers are in the OFF positions.

f) Press the BRAKES OFF switch. The COMPUTER/MANUAL switch will indicate MANUAL position.

g) Operate the telescope manually to insure that the motors are functioning properly.

h) Press the COMPUTER/MANUAL switch to place the telescope in computer control.

1.6 TELESCOPE POSITION READOUTS

The Antenna Control Unit 100 is equipped with a CRT which gives the positions of the telescopes whenever the computer is on-line. In addition, a Nixie tube readout gives the positions of 85-1, 85-2, or 85-3, depending on which switch is pressed. The 45' telescope azimuth and elevation positions are visible in degrees on digital readouts located in the 45' control panel.

1.7 TELESCOPE LIMITS

The telescopes are equipped with limit switches to prevent them from being driven beyond safe operating limits.

1) The 85' limits are:

$\pm 5^h 50^m$ in the polar axis if the declination axis is +

$\pm 4^h 50^m$ in the polar axis if the declination axis is -

+85 degrees North

-46 degrees South

2) The 45' limits are:

| | | |
|---|---|---|
| Azimuth | cw 373.9 degrees | ccw 556.8 degrees |
| Elevation | up 114.1 degrees | down 02.6 degrees |

NOTE: Individual telescopes may vary somewhat from these ideals.

1.8 STOW POSITIONS

When the telescopes are not being operated, they are normally pointed at zenith, with the stow brakes set on the 85' telescopes and the POWER OFF of the 45' telescope.

The 85' stow position is: N38° 26' 08" and zero hour angle.

The 45' stow position is: Azimuth 719.9 (or 0) deg., Elevation 90.0 deg.

Always press the POWER OFF switch anytime the 45' is stowed or stopped any length of time.

NOTE: The telescopes should be driven to the stow position any time the wind becomes a steady 30 mph or if it starts gusting to 35 mph and above.

1.9 SERVICE POSITIONS

Any time maintenance must be performed on a front end box, the telescope can be run to the service position to make the front end accessible from a service elevator.

For the 85' telescopes, the service position is: $E4^h\ 15^m\ 00^s$, S45° 00' 00".

For the 45' telescope, the service position is: Az 719.9(or 0)°, El 05.0°.

NOTE: Any time an elevator has been used to work on a front end, the operator should make sure the elevator has been moved out of the way before moving the antenna.

1.10 SNOW AND ICE

The operator must pay particular attention to the telescopes whenever it is snowing or there is freezing rain. The surface of the telescope is usually colder than the air temperature and rain may begin freezing in the dish before it does on the ground, or snow may begin sticking to the surface when it is not accumulating on the ground. The added weight of ice or snow can damage the telescope or can cause a runaway condition because the motors may not be able to handle the excessive weight. In addition, the signal being received is affected and may even become

worthless. The operator can check the IF MONITOR meters (see par. 3.3) which will show an increase in signal strength and the NOISE TEMPERATURE readings which will show a decrease in strength. The operator should visually check the dishes frequently, and if it appears that snow or ice is accumulating, the telescopes should be placed in a position out of the wind and turned so that the snow or rain tends to run out of the dish. In no case should the operator allow more than two inches of snow or one fourth inch of ice to accumulate in the dish. Because the 45' telescope is usually located at a remote site, the operator can only check the meters which show the MOTOR CURRENT for azimuth and elevation on the 45' control panel. If either indicates an excessive amount of current, the telescope is probably accumulating a snow or an ice load and should be stowed.

NOTE: After having stowed the 45' telescope because of suspected snow or ice, someone must go to the telescope to check the actual conditions before it is operated again.

1.11 LOW TEMPERATURE LIMITS

If the temperature at the control building should go below -10 degrees F., the telescopes should be stowed until the temperature rises above that extreme because the steel may be too brittle for safe operation. In this situation, the operator should pump the brakes off occasionally in order to circulate the oil in the stow brake hydraulic system. This applies to the 85' telescopes only, since the low temperature limit for the 45' is -20 degrees F.; however, the 45' may be stowed also because it is useless to operate with one antenna.

1.12 PHASE LOCKED MICROWAVE LINK

In general, if, because of adverse weather conditions or some malfunction in the electronics controlling the link, the link becomes unstable, the 45'

control panel lights will begin flashing on and off. If this occurs, the operator should immediately press the POWER OFF switch on the control panel to prevent circuit breakers from tripping in the 45' control room. Resume 45' operation only after the link has stabilized. If the operator is unable to lock the link, the proper engineer or technician should be notified.

1.13 45' DATA LINK

The NRAO 45' TELESCOPE DIGITAL DATA LINK panel located on the System Console Unit 130 can be used to monitor many control and data signals being sent to and received from the 45'. This can help assure the operator or other technician that the 45' system is functioning properly. It can also aid in troubleshooting some malfunction in the system. There are two numerical and two binary readouts on this panel, plus two sets of digiswitches for dialing in the desired function. Complete instructions for using this panel are attached to it. Malfunctions in the monitor itself should be reported to the proper digital engineer or technician.

NOTE: Sometimes when the 45' telescope is not being used for a program, the link may be turned off to prevent interference at frequencies being received. This condition will cause the computer to operate improperly, and the operator will begin noticing a great amount of return codes 00007, whereby the computer stops and restarts each scan sometime during the scan. To prevent this, anytime the link is turned off, the operator should turn power off the NRAO 45 FOOT TELESCOPE DIGITAL DATA LINK panel by placing the POWER ON/OFF switch to the off position. This switch is located at the top right of the back of the panel. Then, put the computer in a waiting state, and unplug jacks J1 and J2 from OUTPUT 1 and INPUT 1 in the back of the south-most computer cabinet. The ON/OFF switch may be turned back on and the observing program restarted. When going back to a program requiring the 45' and after the link has been restored, reverse this procedure.

# NOTES

## 2.0 BACKEND PREPARATION FOR ALL MODES

Regardless of the mode of operation to be used, the following checks and adjustments are required on the L O DISTRIBUTION UNIT 400 and the BACKEND UNIT 300 (both units located in the control building equipment room) and the ANALOG DISPLAY UNIT 160 and the ANTENNA CONSOLE UNIT 100 (both units located in the control building control room).

### 2.1 MASTER OSCILLATOR (UNIT 400)

1) The frequency counter should indicate 47499.000 to 47501.000 KHz. (To obtain this frequency indication, the switches on the COUNTER SELECT panel below the frequency counter must be set so that only the green LO switch is glowing.)

2) The SAMPLE RATE switch should be in the HOLD position.

NOTE: The computer cannot read the frequency if it is not in this position.

### 2.2 PHASE SHIFTER SERVO CONTROL (UNIT 400)

1) The AUTO/MONITOR switch should be in AUTO position.

2) The SIN meter should read 0± 1 ua.

3) The COS meter should read +45 to +50 ua.

### 2.3 IF LEVEL CONTROL & NOISE TEMPERATURE MONITOR (UNIT 300)

The correct IF LEVEL, CONTROL SIGNAL, AND NOISE TEMPERATURE readings change from time to time, and the current readings are listed below the meters. If any large deviations are noted, notify the proper engineer or technician. (Includes 45', except NOISE TEMPERATURE.)

### 2.4 BOX TEMPERATURE (UNIT 160)

The meter for each telescope should read between .3-.7 ma.

### 2.5 ANALOG DISPLAY (UNIT 160)

1) The pens on each channel of the recorder can be centered by switching the channel to the OFF position and moving the position control.

2) Using the Analog Display Patch Panel, the operator can monitor any

A-D CONVERTER CHANNEL by connecting it to the input of one of the eight recorder channels. A list of these A-D CONVERTER CHANNELS and their functions is kept at the UNIT 160. (Includes 45'.)

3) The operator can set the gain desired for each channel. The speed is normally 5 mm/min.

2.6 CABLE PRESSURE (UNIT 160)

The meter should read between .3 and .7 ua. If it does not, contact the proper engineer or technician.

2.7 SYSTEM STATUS (UNIT 100)

This monitor panel is provided to warn the operator if a malfunction develops in some unit of the system. An alarm will sound and a light will glow to indicate where in the system a malfunction exists. The proper engineer or technician should be informed of any trouble so that corrective action can be taken. (Includes 45'.)

NOTE: If a warning light glows, the operator should check that particular function on the backend meter to ascertain if a malfuntion actually exists. Occasionally the warning is false because the warning light is set too close to the desired limits.

## 3.0 BACKEND PREPARATION FOR INTERFEROMETER MODE

The following checks and adjustments are required for the interferometer mode of operation.

### 3.1 CORRELATOR (UNIT 300)

The correlators should swing around zero when observing. If zero is not the center of the swing on any correlator, the potentiometer for that correlator should be adjusted before starting an observing program. (Includes 45'.)

NOTE: The Offset column on the line printer or teletype output is an accurate indication of this function. If the number goes above 500, it is out of range. (See paragraph 9.0.) However, the operator should check with the observer to see whether or not he wants it adjusted, particularly since this offset changes, sometimes drastically, from source to source.

### 3.2 POWER CONTROL (UNIT 300)

1) Press RECEIVER CONTROL switch so that it indicates COMPUTER position.

2) Press DELAY CONTROL switch so that it indicates COMPUTER position. (Includes 45'.)

3) Press CORRELATOR CONTROL switch so that it indicates COMPUTER position. (Includes 45'.)

### 3.3 IF MONITOR (UNIT 300)

Set the R.H. and L.H. LEVEL meters for the telescopes to be used so that they indicate between 15-20 ua. Use the ATTENUATOR controls to get this reading.

## 4.0 BACKEND PREPARATION FOR SINGLE ANTENNA MODE (PT)

The following checks and adjustments are required for the single antenna mode of operation.

### 4.1 POWER CONTROL (UNIT 300)

1) Press RECEIVER CONTROL to MANUAL position.

2) DELAYS and CORRELATORS are not used in this mode, but they can be placed in MANUAL control.

### 4.2 FRONT END SWITCH CONTROL (UNIT 300)

The front end switches will automatically drop to the XR-XL position (XBAND right and left) when the receiver is switched to manual control. If SBAND IF is desired, press the SR-SL switch. XR-SL may be used if desired.

### 4.3 XBAND AND SBAND CALIBRATION CONTROLS (UNIT 300)

The IF MONITOR DETECTOR GAIN X-3 switch should be pressed ON (lights on), and the NOISE MOD OFF switch should be pressed OFF (lights on) for the band desired unless the observer specifies otherwise.

### 4.4 IF MONITOR (UNIT 300)

Set the RH and LH LEVEL meters for the telescopes to be used so that they indicate approximately 25ua. Use the ATTENUATOR controls to get this reading.

NOTES

## 5.0 DDP-116 COMPUTER OPERATION FOR INTERFEROMETER MODE

If all backend functions are set properly and indicate within allowable limits, observations can begin. The DDP-116 computer controls the operation of the telescopes and receivers in the interferometer mode. All aspects of computer operation for this mode follow. Refer to DDP-116 CONTROL PANEL diagram, Fig. 1.

### 5.1 LOADING THE KEY-IN LOADER

1) Turn the POWER switch in the lower left corner of the computer control panel to the ON position. Wait 4 minutes (assuming power has been off).

2) Punch the MASTER CLEAR button.

3) Punch 016540 into the DATA REGISTER.

4) Punch the P button on the REGISTER SELECT section.

5) Punch the ENTER button. (At this point, the number 016540 will be displayed on the DISPLAY REGISTER.)

6) Place the STORE/READ switch on the MEMORY section to the STORE position. (NOTE: The P ADDR/Y ADDR switch should always remain in the P ADDR position.)

7) Punch the red CLEAR button on the DATA REGISTER.

8) Punch 030105 into the DATA REGISTER.

9) Punch the ACCESS button in the MEMORY section. (At this time the number in the DISPLAY REGISTER will increase to 016541.)

10) Punch the red CLEAR button on the DATA REGISTER.

11) Punch 131005 into the DATA REGISTER.

12) Punch the ACCESS button in the MEMORY section. (Again, the number in the DISPLAY REGISTER will increase by 1 to 016542.)

13) Punch the red CLEAR button.

14) Punch 003541 into the DATA REGISTER.

15) Punch ACCESS.

16) Punch CLEAR.

17) Punch 041470 into the DATA REGISTER.

18) Punch ACCESS.

19) Punch CLEAR.

20) Punch 130005 into the DATA REGISTER.

21) Punch ACCESS.

22) Punch CLEAR.

23) Punch 003544 into the DATA REGISTER.

24) Punch ACCESS.

25) Punch CLEAR.

26) Punch 011472 into the DATA REGISTER.

27) Punch ACCESS.

28) Punch CLEAR.

29) Punch 025546 into the DATA REGISTER.

30) Punch ACCESS. (At this time the DISPLAY REGISTER will advance to 016550.)

31) Punch CLEAR.

32) Punch 003541 into the DATA REGISTER.

33) Punch ACCESS. (The DISPLAY REGISTER will now read 016551.)

34) Place the STORE/READ switch to the READ position.

35) Punch MASTER CLEAR.

## 5.2 LOADING THE INPUT/OUTPUT CARD SYSTEM AND SYSTEM TAPE

1) Press POWER ON button on the CARD READER.

2) Place the IOCS & TAPE-TO-DISK card deck (located in the card filing cabinet in the control room) for the system tape to be loaded in the input (right) side of the CARD READER. The deck must be placed FACE DOWN, TOP EDGE OUT. Place the card weight on top of the deck.

Press the RESET button, then the START button on the CARD READER.

(NOTE: When preparing the card reader to read cards, always press RESET then START.)

4) Punch 016540 into the DATA REGISTER on the computer control panel.

5) Punch the P button on the REGISTER SELECT section.

6) Punch the ENTER button on the REGISTER SELECT section.

7) Place the MODE switch in the RUN position.

8) Press the START button on the computer control panel.

9) The card reader will read the IOCS & TAPE-TO-DISK card deck and stop.

10) Load the CURRENT 4-ELEMENT SYSTEM TAPE (located in the tape rack beside the computer) onto the TAPE DECK. To do this, the tape must be placed on the top spindle with the indention around the center of the reel toward the tape deck. If there is a plastic ring in this indention, it must be removed. Turn the knob on the spindle clockwise until it locks the tape in place. Hold the START/BRAKES switch (located between the spindles) to the BRAKES position and manually unwind enough tape to traverse the reading heads and roll onto the empty reel on the lower spindle. Insert the tape through the slot and onto the heads and begin winding it onto the empty reel until it will hold itself. Hold the START/BRAKES switch to the START position until the tape is pulled into the vacuum chambers. At the top of the tape deck, depress the HIGH DENSITY button, then depress the LOAD POINT button and the AUTO button. The tape is now ready to be read.

11) Press START on the computer control panel. The computer will read the preparation date from the tape and print it on the teletype. Ascertain that this is the correct tape (usually, the most recent) to be loaded.

12) Press START again. The contents of the tape will be read by the computer and stored in memory. When finished, the tape will rewind and can be removed from the tape deck and stored in its usual place. The teletype will print DONE, indicating the computer has the system tape in memory. (NOTE: The system tape should be loaded after every maintenance day.)

5.3 LOADING BESSELIAN DAY NUMBERS

1) At this point, place more than 24 Besselian Day Number cards for the 4-element system (located in the card file near the computer) with its program loader in front in the card reader. NOTE: Cards for two or three previous days must be included. The numbers in cols. 1-7 of the BESD cards is the G.S.D. for $0^h$ S.T. taken from the universal and sidereal times tables from the Ephemeris. (G.S.D. = GREENWICH SIDEREAL DAY.)

2) Punch RESET and START on the card reader.

3) Punch MASTER CLEAR on the computer.

4) Punch 016540 into the DATA REGISTER, punch P, ENTER, then START.

5) The computer now reads 24 of the day number cards, then the teletype will print out a coded date, sidereal time, sect number, and a return code. NOTE: At this point the sect number should be 00000. If it is not, see the troubleshooting procedure for loading the correct sect number (par. 18.9).

6) Place the Day Number cards, including those left in the feed hopper, back in their proper place in the card file.

5.4 LOADING BASELINE DECK

1) The teletype now prints SCAN NNNNN?

2) Type NO, and punch the RETURN key on the teletype keyboard. (Any time anything is typed on the teletype, the RETURN key must be punched before the computer will continue.)

3) The teletype now prints the following message:

NEED 8 CARDS--3BASEL.,4PTG., 1 DELAYS?

(OPTIONAL FSET CARD, PRECEDES OTHER 8)

4) Place the BASELINE deck of cards (see figure 2) for the present telescope configuration and system tape (deck normally located in the file under the card reader) in the card reader and press RESET and START.

5) The computer will read the deck and type: SCAN NR?

6) Type the correct scan number MINUS 1 on the teletype and RETURN.

7) The computer types: WANT TO READ SOURCE CARDS?

LOADING THE OBSERVING PROGRAM

1) Place the card deck of sources to be observed (supplied by the observer) in the card reader, press RESET and START.

2) Type YES and the RETURN key on the teletype.

3) The computer now reads the deck, typing out any unusual conditions and pertinent warnings. When all cards have been memorized (up to 100 cards), the computer will type: RETURN TO OBSERVING followed by the coded date, time, sect no, and return code. The computer then asks if it remembers the correct scan number.

4) If the scan number is correct and the telescopes are in computer control, type YES and the RETURN key. The computer begins slewing the telescopes to the source to be observed while printing out information about the source (called the source header). When it has set up on the source, it prints out the sidereal time and source identification, and begins taking data.

THE INTERFEROMETER SYSTEM IS NOW ON THE AIR.

NOTE: Some programs require only the 85' telescopes, while others require all four telescopes. In either case, the preceding instructions apply. However, if the 45' telescope is to be used and it will not move to the source or if it begins slewing to the elevation down limit, type XPT45RS on the teletype. This should release it from the stow position where it had previously been commanded to go and remain.

5) To stop observing before the program in memory is exhausted, the operator can type XWAIT or can perform the following on the computer.

a) SENSE SWITCH 4 to SET (up)

b) MODE switch to SINGL. INSTR.

c) MASTER CLEAR

d) Punch 017000 into the DATA REGISTER

e) Punch P and ENTER buttons

f) MODE switch to RUN position

g) Punch START

The computer will print out through the return code and halt. If desired, the computer can be used for other operations, such as the UTILITY PROGRAMS described in paragraphs 15.0, 16.0, and 17.0.

To restart the computer observations on the program still in memory, type XBEGN (if XWAIT was used), or begin at step c above (SS4 down).

NOTE: If a wrong key is struck while typing on the teletype, the incorrect message may be cancelled and not sent to computer by holding down the CTRL key and typing the U character.

6) If the observer should desire a printout of each source card while reading the observing deck into memory, this can be accomplished by placing Sense Switch 3 UP. If SS3 and SS4 are both up, slightly more of the source card will be printed out. Having SS3 UP also will cause the computer to notify the operator if an extra card has gone through the card reader but has not been committed to computer memory.

NOTE: SS3 up during observing will cause the computer to print out certain diagnostic messages, such as when disk-write had to be repeated because of disk data errors. Also, the summary of certain error-counts will be printed out every time there is a RETURN from observing (returned because the source was over, or there was an XSKIP, or an excessive pointing error, or CRT lost sync, etc.). The observer or programmer or an engineer may request that this function be used at certain times to help them find problems.

# NOTES

## 6.0 DDP-116 COMPUTER OPERATION FOR SINGLE ANTENNA MODE

Several types of programs can be run using one telescope working independently of the others. Only one of these is used frequently at the Interferometer, and it is the only one for which the computer is programmed to run automatically (that is, the computer operates the telescopes and makes necessary calculations...the backend functions must be controlled by the operator.) This is the 85' Telescope Pointing program, and computer instructions for this program follow.

The Backend must be set up as instructed in par. 2.0 and par. 4.0, and the Interferometer Mode computer instructions must be followed through par. 5.5.3. At that point, perform the following operations.

1) Place sense switch 4 UP.

2) Type YES and the RETURN key on the teletype. The computer will halt.

3) Type XLOAD PT.

4) The teletype will print out pertinent information about the source to be observed, then the following header is printed out:

TELESCOPE COORD HA ERROR CHANGE AMPL

5) At this point, the teletype may print SET RECEIVERS TO APPROPRIATE BAND?--PUSH START. This depends on which IF is selected on the FRONT END SWITCH CONTROL (Unit 300). (See par. 4.2.) The IF to use is at the discretion of the observer, and the proper one must be selected on the Unit 300 and on the computer Sense Switches according to the following list:

SL can be used by positioning SS1 and SS2 down.

SR can be used by positioning SS1 down and SS2 up.

XL can be used by positioning SS1 and SS2 up.

XR can be used by positioning SS1 up and SS2 down.

The same IF must be used on all telescopes being pointed. If the Front End switch or Sense Switch is changed during a scan, the computer will give erroneous results for that scan. Therefore, any such change should be noted

on the teletype and in the observing log.

6) After correctly setting receivers and pushing START on the computer if step 5 applied, or after the printout described in step 4, the telescopes will slew to the source. Then it will begin scanning the telescopes first in RA, then in DEC, taking data from the IF MONITOR outputs (sometimes called the TOTAL POWER outputs), making calculations, and printing the results on the teletype or line printer after each such scan. The data thus obtained also goes on disk. If an analog record of the scans is required, the recorder channels must be connected to the proper I.F. MONITOR outputs on the Analog Display Patch Panel (see par. 2.5).

6.1 LOADING MORE OR DIFFERENT SOURCE CARDS

1) Place Sense Switch 4 UP.

2) Place MODE switch to SINGL. INSTR. position.

3) Press MASTER CLEAR.

4) Punch 017000 into the DATA REGISTER.

5) Punch P and ENTER.

6) Place MODE switch to RUN.

7) Press START.

8) After computer finishes type routine, type XLOAD WR on keyboard.

9) Place new source list in card reader, punch RESET and START.

10) Computer will ask if this deck should precede, replace, or follow existing card list.

11) After the operator answers appropriately, the deck will be read. The operator must type XLOAD PT to begin pointing again.

6.2 UNEXPLAINED COMPUTER STOPS WHILE POINTING

1) Try restarting at location 001000.

2) If this doesn't work, set SS4, transfer to 017000 and restart. After the typeout is complete, type XLOAD PT.

## 6.3 SKIPPING A SOURCE

To skip a source while pointing, set SS3 (flip it up).

NOTE: Sometimes turning the power off the card reader while the PT program is running will cause the amplitudes of the scans to increase dramatically; this may look like good data, but it is in fact wrong. To avoid this, the card reader should be turned off immediately after loading the source card deck and before typing the XLOAD PT command.

NOTES

## 7.0 BASELINE DECK

The deck of cards referred to as the Baseline Deck contains three cards with baseline parameters, four cards with pointing corrections, and one card with delay centers. A ninth card, called an FSET card, is optional for normal observing and will be supplied by the observer if needed. (If an FSET card is used, it must precede, or be in front of, the regular baseline deck.)

Each time a telescope is moved from one station to another, this deck must be corrected for the new baseline and delay centers. Also, the pointing program (par. 6.0) must be run to determine the telescope pointing errors and the pointing analysis (par. 15.0) program must be run to analyze this pointing data. The information obtained is punched into the pointing correction cards. The delay centers for the new configuration are determined by tracking a strong source and changing the centers for the pairs of telescopes using the XDLYn function and the digiswitches on the System Console Unit 130 (see pars. 14.0.21-14.0.26).

This Baseline Deck is kept up to date by the Interferometer Scientific Adviser or someone designated by him, and it must be entered into the computer memory before beginning any observations. (Refer to Figure 2.)

## 8.0 PROGRAM CARD FORMAT

The following information describing the format used to punch essential information into a program card (source card) for entry into computer memory may be useful to the operator if the observer makes a mistake in punching the source card or if the operator is requested to punch the deck completely. Any IBM card may be used if the information is punched into the correct columns. This format is used only for the four element observing system tape.

1) Columns 1-8 contain the source name. This name must begin in col. 1, can contain no imbedded blanks, and must contain at least one non-numeric character.

2) Column 10 may contain a D denoting the up to the day positions for the source, an M denoting the mean year positions, or may be blank denoting 1950 positions. (For moving sources, the codes become E, N, or A.)

3) Columns 12-23 contain the right ascension in the format HH MM SS.SSS. Leading zeroes must appear. Zeroes following the decimal point may be omitted, but the decimal point itself must appear.

4) Columns 25-36 contain the declination in the format SDD MM SS.SS. The sign (S) may be a blank (indicating a +), a plus (+), or a minus (-). Leading zeroes must appear. Zeroes following the decimal point may be omitted.

5) Columns 48-53 are used to set the gain of the receivers. If the source flux is less than 4 Jy, G = 0; 4 to less than 40 Jy, G = 1; 40 Jy and above, G = 2. The flux is different for XBAND and SBAND; therefore, the code for the numbers to be punched in the card is determined by the formula: $G_S + 3G_X$.

6) Column 55 contains a mode character as follows (refer to Fig. 3):

| | |
|---|---|
| X | XBAND observations |
| S | SBAND observations |
| M | The RR correlators are XBAND, LL are SBAND |

D Switches between S and X Bands at 30 second intervals

Blank Same as D

7) A C in column 57 identifies the source as a calibrator; a blank indicates a non-calibrator. (This column is optional.)

8) Columns 60-64 contain the stop time in the format HH MM. The observation, however, will continue past this time until the computer finishes the last 30sec. integration. (The computer writes on the disk at the end of each 30sec. when observing.) It then stops the scan and goes to the next observation (or scan).

9) Columns 66-72 and 74-80 can be used to indicate the flux density of the system gain calibrator for S and X Band, respectively. (This is optional.)

10) If the computer encounters a format error while reading a program deck, it will stop reading cards and print the message: NNNNNN FMT. ERROR, READING TERMINATED. RETURN TO OBSERVING. The codes represented by NNNNNN indicate the type of error found, as follows:

003014 Blank found in first column of source name

003021 or 003032 Non-blank in one of the columns 9, 11, 14, 17, 24, 28, 31, 47, 54, 56, 59, 65, 73

003062 or 003064 R.A. decimal point missing

003077 R.A. 10-second digit greater than 5

003113 R.A. 10-minute digit greater than 5

003132 R.A. hours value computes out greater than 23

003144 R.A. conversion from hours to turns: division failed

003175 Dec. decimal point missing

003210 Dec. 10-second digit greater than 5

003224 Dec. 10-minute digit greater than 5

003243 Dec. value equal to or greater than 90.0 degrees

003255 Dec. conversion from degrees to turns: division failed

003270 or 003272 Dec. sign not plus, minus, or blank

003311 Some digit column not value 0 through 9

003317 Fmbedded blank in middle of a number (R.A. and Dec.)

003532 Some rate-field column not 0 through 9 (R.A. and Dec.)

004016 Illegal epoch code (col. 10): not A, D, E, M, N, BLANK or ZERO

004120 Some flux-field (integer part) col. not 0 through 9

004166 A flux value too big (greater than 32767?)

004213 Some flux-field (fraction part) col. not 0 through 9

004307 Some gain code digit not value 0 through 9

004356 Stoptime computes as greater than 86390 seconds (86400 = one day)

005257 Either an R.A. or a Dec. value missing from card

006472 Either WAIT EXCEEDS 1 HR , or STOP TIMES OUT OF ORDER

## 9.0 TELETYPE AND LINE PRINTER OUTPUT

The teletype or line printer (or both) will print the vector average amplitude of each correlator selected at the end of each scan. This printing is overlapped with telescope slewing, but the next observation cannot start until this printout is complete. For this reason, the line printer is usually used since it is much faster than the teletype. To use the line printer, make sure power is on and press the green ON LINE switch. On the teletype, type XLPRT,1. This causes output to be printed on the line printer. To prevent data from also printing out on the teletype, type XTYPE,0. Now only remarks followed by a question mark (from computer memory) will print out on the teletype.

The operator can specify the quantities to be printed by typing a statement of the following form on the teletype at the beginning of an observer's program, or at any time the observer may wish to change it.

| | | | | | | |
|---|---|---|---|---|---|---|
| XPRNT | ALL<br>CALS<br>NONCALS | , | INCL<br>EXCL | , | XBAND<br>SBAND<br>PPOL<br>XPOL<br>45FT<br>BUSY | |

When typing the message, follow the initial XPRNT with one or more blanks. One entry may be typed from each of the first two columns, and as many as necessary from the last column. Separate all words with commas, but do not include any blanks. The following list gives the meanings of the words.

ALL means this specification refers to all sources.

CALS means it refers to calibrators only.

NONCALS means it refers to all sources with no C in column 57.

(If no specification is made, ALL is assumed.)

INCL means that the quantities specified are to be printed.

EXCL means that all quantities are to be printed except those specified.

(If neither word appears, INCL is assumed.)

XBAND refers to the 3.7 cm observations.

SBAND refers to the 11.1 cm observations.

PPOL means parallel polarization.

XPOL means crossed hand polarization.

45FT refers to the 45' correlators.

BUSY refers to the time segment after the telescopes are pointed at the next source. That is, if BUSY is excluded, the observation will begin as soon as the antennas are pointed at the source, whether the printout is finished or not.

For example, the message XPRNT EXCL causes everything to be printed; XPRNT INCL will cause nothing to print; (Setting SS1 will also cause data printout to be suppressed.)

Ten columns are printed out at the end of each scan as follows: correlator code (0-47), antenna and receiver correlated, frequency band, gain, arithmetic average, vector average, phase (in degrees), offset average, rms average, and the number of records averaged for the scan. Probably the most important check to determine if the system is operating properly are the arithmetic averages for calibrator sources which have flux densities punched in columns 66-72 and 74-80 of the source card. This column gives the counts per flux unit (cpfu) for such calibrators, and the operator should compare them with a list of correct values which is attached to the line printer or teletype. Any deviation greater than 20% usually indicates trouble in the system, and the proper personnel should be notified. The operator should also pay attention to the offset column. If the numbers go higher than about 500, the operator should adjust that particular correlator so that it swings around zero, but only after checking with the observer. (See paragraph 3.1.)

The Return Codes and their meanings follow:

-1 Cold start....IOCS, Tape-to-Disk, or Besselian Day No. deck loaded.

1 Normal end of source. Clock passed stop time, or XSKIP was typed.

2 Return after completion of the CP or the WR program.
WR..either all cards read, or a format error forced a stop.
CP..data copied to tape, and disk erased (unless SAVE was typed).

3 After operator commanded XWAIT during observing, and before the program types WAITING. Also occurs after an unidentifiable XLOAD xx and after the program has answered xx?.

4 During observing, the operator typed either XLOAD or XBASE or XSTOW.

5 OBserving program found a distorted start time..value 32767 (octal 77777) ...whereas the greatest meaningful start time is 8639 in ten sec. units.

6 Operator manually restarted at octal location 17000.

7 The OB program forced an automatic restart, because it found that the CRT output time had jumped. When the latest CRT time (seconds) has units column different from the same column in the previous line, the assumption is that the 30-second interval was lost. In this case, the data on the CRT is discarded and not written on disk. The restarting causes a fresh setup of fringe amplitudes and phases and a new header record to be written on disk, with same scan number.

8 Disk full. This causes an automatic XLOAD CP.

9 Not presently used.

11 85-1 H.A. axis out of tolerance in pointing.

12 85-1 Dec. axis out of tolerance in pointing.

21 85-2 H.A. axis out of tolerance in pointing.

22 85-2 Dec. axis out of tolerance in pointing.

31 85-3 H.A. axis out of tolerance in pointing.

32 85-3 Dec. axis out of tolerance in pointing.

41 45' Az. axis out of tolerance in pointing.

42 45' El. axis out of tolerance in pointing.

300 Computed delay for 85-3 delay line negative; impossible condition.

## 10.0 CRT DISPLAY SYSTEM

The Cathode Ray Tube in the Unit 130 will display various information concerning the data being collected and is updated every 30 seconds. The LST and the MODE are always displayed. In addition, the operator or the observer can choose up to five quantities from the following list:

C the Cosine component

A the Amplitude

S the Sine component

P the Phase

O the Correlator Offset

R the root mean square value

To change the quantities being displayed, type XSHOW on the teletype keyboard, followed by one or more spaces, and the codes for the information desired in the format as follows: XSHOW A2,P2,A4,P4,R4. This example would cause the amplitude and phase of correlator 1R3R, and the amplitude, phase, and rms of correlator 2R3R to be displayed. The numbers 0-23 typed in the message denote correlators according to the following list:

| nn | CORR. | nn | CORR. | nn | CORR. |
|---|---|---|---|---|---|
| 0 | 1R2R | 8 | 1R3L | 16 | 3R4R |
| 1 | 1L2L | 9 | 1L3R | 17 | 3L4L |
| 2 | 1R3R | 10 | 2R3L | 18 | 1R4L |
| 3 | 1L3L | 11 | 2L3R | 19 | 1L4R |
| 4 | 2R3R | 12 | 1R4R | 20 | 2R4L |
| 5 | 2L3L | 13 | 1L4L | 21 | 2L4R |
| 6 | 1R2L | 14 | 2R4R | 22 | 3R4L |
| 7 | 1L2R | 15 | 2L4L | 23 | 3L4R |

To keep information on the CRT (i.e. to stop the updating), type: XSHOW *.

To resume normal updating after having stopped it, type: XSHOW ".

## 11.0 DUMPING THE DISK TO TAPE

After an entire program has been observed (i.e. after all the sources in the program card deck have been observed), or, in any case, if the SECT NO has advanced to 2379, the DISK must be dumped onto magnetic tape for processing by the IBM 360 computer at Charlottesville. The procedure follows.

1) Label the data tape to be used with date, program code, and inclusive scan numbers, then load it on the tape transport. (This is done exactly as described in par. 5.2.10, except that a plastic ring must be inserted in the indention on the back of the tape reel.)

2) When the source list is empty, the computer prints XLOAD and halts. Type CP on the keyboard, followed by the return key. The computer will load the CP program from memory. (If the computer doesn't print XLOAD, the operator may type the entire message to initiate the tape dump.)

3) The computer prints: IS THIS THE FIRST DUMP ON THIS TAPE? REPLY YES OR NO. Type either YES or NO on the keyboard.

4) If the answer was YES, the computer will search the tape to make sure no tape label 3 days previous or less is on the tape. If it encounters a too recent label, it will print: TAPE TOO RECENT TO DESTROY. MOUNT ANOTHER TAPE OR ADD TO EXISTING DATA. PUSH START WHEN READY TO CONTINUE. Obviously the operator was not aware that the tape was recently used. In this case, mount another tape and begin again by pushing start; have the first tape checked at Charlottesville to see if it in fact does contain good data.

5) When the computer is satisfied that a tape has no recent dated label, it will print ENTER TAPE NUMBER NNNN.

6) Type the NRAO tape number (written on the front of the tape reel) and punch the return key. Four digits must be typed...use leading zeroes if necessary.

7) The computer then prints TAPE NUMBER?NNNN?

8) Answer YES or NO. (This is to allow the operator to correct the tape number if the wrong one was entered at step 6.)

9) When the computer has the correct tape number, it will begin writing the data onto tape.

10) If, at step 3, the operator answered NO, the computer will skip over the data already on tape and begin writing.

11) In either case, after all disk data has been written onto tape, the computer backspaces and checks to make sure all data was written correctly, then the tape will rewind and the computer will print (if LPTR is on line):

DISK DATA TRANSFERRED TO TAPE. THERE WERE

n PARITY ERRORS

n CHECK SUM ERRORS

WANT TO ERASE OR SAVE DISK DATA?

12) If there were any errors, answer SAVE, then mount a fresh tape and start again. If there were no errors, type ERASE.

13) After about 45 seconds or so, the computer will print:

SECT 00000 RETURN 00002

14) If there are additional source cards in memory and if SS4 is reset, the computer will return to observing.

15) If there are no source cards in memory, the computer will print:

SOURCE LIST EMPTY?

XLOAD

The operator may type WR and the return key, load a new program deck, and continue observations if desired.

16) Normally at this time the analog records and line printer or teletype records are removed, labeled, and kept for the observer.

NOTE: Sometimes it is desirable to be able to erase tape headers when the operator is sure that there is no good data on a tape with a too recent date.

To accomplish this, load the tape at load point, set SS4, and type XLOAD CP. Place the MODE switch to SINGLE INSTRUCTION. Punch 005514 into the P register, LEAVE IN SINGLE INSTRUCTION, and press START. The computer will write a three inch blank at the beginning of the tape and stop. The operator may restart at 17000, reset SS4, and do an ordinary XLOAD CP and dump if so desired, after placing tape back to load point.

## 12.0 CHECKING AND SETTING 85' FOCUS AND POLARIZATION

It is necessary to check the focus and polarization settings on all telescopes any time any maintenance has been performed on the telescopes or the power has been off. This includes after any normal maintenance day and when a telescope has been moved to another station on the baseline. This check should be performed before beginning observations. A digital readout is provided in the System Console Unit 130 where the settings are visible continuously. In addition, the computer can be used to double check the readouts and to correct the positions if they are wrong. To check with the computer, insert the following steps after paragraph 5.4.

1) Type NO,

2) The computer now prints:

SOURCE LIST EMPTY

XLOAD

3) Place the focus and polarization control switch on the System Console Unit 130 to COMPUTER position, then type FP.

4) The computer will print out the polarization settings of each telescope, then will position the type box under the first reading. (The correct settings are listed on the teletype cover.) If the reading is correct, space across the number and the type box will advance to the next telescope reading. If a reading is incorrect, type the correct setting beneath it. The computer will move the front end box to the correct setting, then advance to the next reading. After all polarization readings are checked, the focus settings are typed out. Go through the same steps as with polarization checks. (If all telescope readings are correct, the entire line can be skipped by typing the return key.)

5) After all readings have been processed, the computer will type: SCAN NNNNN?

6) Type YES and the return key. The computer prints: SOURCE LIST EMPTY XLOAD

7) Continue at paragraph 5.5.

## 13.0 SPECIAL CONTROL OF THE 45'

There is a group of commands programmed into the system which controls several functions of the 45' telescope. These commands are initiated by typing them on the teletype followed by typing the return key. The format used is XPT45xx, where xx represents the codes described below. There is no space before the xx.

1) The FP command can be used to set the Focus or the Polarization of the 45' front end box. For example, to move the focus to a different position, the operator should first dial in 49.0 on one of the 3-digit data access control thumbwheels on the NRAO 45 FOOT TELESCOPE DIGITAL DATA LINK panel on the System Console Unit 130. The focus setting will then be displayed on the digital readout on the same side of the panel. On the 6-digit thumbwheel located on the panel to the right of the Data Link panel, dial a zero on the low order digit. (A 0 here means focus, while a 1 means polarization.) The high order digit should be 0 if the focus setting is to be increased, and should be 1 if the setting is to be decreased. The middle four digits represent the rate at which the focus is to be moved, and initially should be set to all zeroes. At this point, type XPT45FP and the return key on the teletype. Now, by watching the focus readout on the Data Link panel and changing the middle four digits to some octal value, the focus can be moved to the desired setting. By dialing a 1 on the low order digit, the polarization can similarly be set, after first having dialed 50.0 on the 3-digit thumbwheel to get the polarization readout.

2) The AC command can be used to move the Azimuth from the position presently commanded by the computer. This can be used only when the computer has control of the 45' telescope; the six digit thumbwheel switches set the offset of Azimuth position. The left most digit is the sign of the offset (0 = +, 1 = -) and the remaining five digits give the offset in arc-seconds. (Remember the switch is in octal.) This function is useful mainly as a quick check to see

if the Azimuth pointing corrections are good.

3) The EC command can be used to move the Elevation from the position presently commanded by the computer. This can be used only when the computer has control of the 45' telescope; the six digit thumbwheel switches set the offset of elevation in the same manner as the azimuth offset. This function is useful mainly as a quick check to see if the elevation pointing corrections are good.

4) The CC command clears or cancels the thumbwheel switch settings of the FP, AC, or EC commands.

5) The SS command causes the 45' antenna to go to the stow position.

6) The RS command causes the 45' antenna to be released from the stow position.

7) The PS command causes the 45' stow position to be printed on the teletype after having used the SS command. The numbers printed are in octal form.

# NOTES

## 14.0 OPERATOR COMMANDS TO THE COMPUTER

Several commands can be executed by the operator by typing it on the teletype followed by the return key. Some are recognized only when the computer is actually taking data (OBserving program), some are recognized only when the computer is in a waiting or slewing state (SUpervisor program), and some are recognized in either state. Each command requires an initial X, followed by a four-letter word which the computer looks up in a preprogrammed dictionary and takes appropriate action. (Some commands also have one or more parameters following the code word.) If the computer does not recognize the command, it will print WHAT??, in which case make sure the command is in fact a legitimate one, and, if so, enter it again. CAUTION: While the SUpervisor program is printing data summaries on the line printer at the end of scans, the teletype may appear to be free. However, typing in a command at this time will bomb out the computer. This is because the line printer, if on line, is required to log any typed-in command; trying to do this while it is already printing other material will cause the driving subroutines to lose track of where they are.

The following commands are recognized by both the SU and OB programs.

1) XDICT causes a list of all the commands the computer will recognize in the program presently being used to be printed out.

2) XOPID calls in a subroutine which asks for operator and observer identification (initials). Any two characters except carriage return are allowed.

3) XNOTE allows operator comments to be placed into the data on disk. Including the letters NOTE, a total of 100 characters may be stored.

4) XWAIT puts the program into a waiting state. The computer prints WAITING when this occurs. To escape from this state, type XBEGN, or manually restart the computer at location 017000.

5) XBASE calls in the subroutine for reading the BASELINE deck of cards. See paragraph 5.4.

6) XCURR calls in the subroutine for printing the current source or scan header, except that if Sense Switch 2 is up, it will not print.

7) XSTOW causes any telescopes under computer control to go to the stow position. (If the 45' antenna is stowed this way, it can later be released from this stow position by typing XPT45RS. See paragraph 13.0.)

8) XSKIP causes the source being observed to be erased from the source list as though it had reached its stop time. If initiated during the OB program, it causes immediate cancellation without waiting for the current 30 second integration to finish.

9) XCRTN forces the antenna position CRT to have its format reinitialized.

10) XPRNT has slightly different functions in OB and SU. In OB it requires extra parameters which describe the items to be included in a data summary to be printed out when the scan is over (see paragraph 9.0). In SU the command with no parameters will cause the data summary to be printed out immediately if the parameters have previously been commanded.

11) XLOAD xx loads some other program which has the code xx. One space must separate xx from XLOAD. The allowed program codes are WR (which allows source cards to be read), CP (which allows data to be dumped from the disk onto magnetic tape), FP (which allows 85' focus and polarization settings to be read and changed), PT (which loads the telescope pointing program), and PA (which loads the pointing analysis program).

12) XTYPE,n is used to turn the teletype on or off as a data summary printout device. The n represents either 0 or 1. 0 turns the teletype off; 1 turns it on. This command is used in conjunction with the XLPRT command.

13) XLPRT,n is used to turn the line printer on or off as a data summary printout device. The n represents either 0 or 1, which turns the line printer off or on, respectively.

14) XPT45xx is used for special control of the 45'. See paragraph 13.0.

15) XREVU,n in the OB program sets up the format for printing the results of the current source or scan when next under SU control. The printed results are a revue of the individual 30 second data integrations which have been written on disk and some of which may have been displayed on the Data CRT. The parameter n (or n,n,n...) may have the following values.

0 cancels the command XREVU which was previously entered;

1 causes the data from correlators 0-5 to be printed out;

2 causes the data from correlators 6-11 to be printed out;

3 causes the data from correlators 12-17 to be printed out;

4 causes the data from correlators 18-23 to be printed out.

16) XSHOW followed by up to five coded parameters causes the Data CRT to print out selected 30 second integrations. See paragraph 10.0.

17) XC1PR,n turns the Data CRT on or off as an output device. If n is 0 the CRT will not output; if n is 1 the CRT will output.

18) XCARD,n will at some future date allow the card reader to be used to command the computer or to store XNOTE's on the disk, if desired. If n is 0, the card reader cannot be used for this purpose; if n is 1, the card reader can be used for this purpose.

The following commands are recognized only by the OB program.

19) XCONT causes a scan to continue past the stop time punched in the source card. To cancel this command, XSKIP must be typed.

20) XLOBR,n can be used to turn the lobe rotator on or off. The lobe rotator is an internal computer device which causes the received signals to be correlated at an even rate. If n is 0, this device is turned off; if n is 1 it is turned on.

21) XDLYQ flags the data as questionable as delay centers are about to change.

22) XDLY2 has the effect of XDLYQ, then starts setting the delay centers of telescope pair 1 and 2 from the thumbwheel switches on the Unit 130.

23) XDLY3 works the same for telescope pair 1 and 3.

24) XDLY4 works the same for telescope pair 1 and 4. (The left most octal bit is not used. Set it to zero.)

25) XDLYP stops setting any delay center from the thumbwheels, then prints the octal values of all three delay centers on the teletype.

26) XDLYR cancels inputting of delay centers from the thumbwheels. (However, the last delay center is kept until the end of the scan.) If these thumbwheels are now set to zero, it also cancels the XDLYQ flag; if not, it asks that they be set to zero and retype the XDLYR command.

NOTE: These XDLY_ functions are used to determine the delay centers of the telescope pairs after one or more telescopes have been moved to another station on the baseline, or when an observer wants to check the values being used. These values are inputted into the computer via the BASELINE deck. (See par. 7.0.) These commands are cancelled at the scan end.

The following commands are recognized by the SU program only.

27) XBEGN forces escape from the waiting state which was caused by XWAIT.

28) XWIPE permits either the source list or the data area of the disk to be erased. The computer will ask which to erase; reply either DA or SO. When the erasure is completed, the computer will print DONE.

29) XREVU,n NNNNN,NNNNN,NNNNN will cause a printout of data from scans NNNNN, NNNNN, and NNNNN for the correlators specified by n. (More than one n can be specified, separated by commas.) The possible correlators are:

1 for correlators 0-5;

2 for correlators 6-11;

3 for correlators 12-17;

4 for correlators 18-23.

30) XCRT1 erases the data from the Data CRT and resets the format.

31) XDINT calls in the subroutine for disk interrogation. A printout

occurs only if there is disagreement with the sector number.

32) XDATE calls in a subroutine to read the hardware calendar device and store the resulting date in the system date location. No printout results. The SU program effects XDATE automatically in the course of normal initializing.

33) XDRAW,n will be used at some future date to draw various schemes on the CRT Storage Scope, located in the Analog Display Unit 160. The n will be used to turn this capability on or off, with a 1 or 0, respectively.

34) XZF resets the format on the Data CRT but doesn't erase. Note that there are two spaces after XZF.

35) XPRNT will in the future have a function in addition to that described in paragraph 14.0.10 above.when used in the SU program. If it is desired to change the parameters being printed out without returning to the OB program, it will allow them to be changed, by adding them before typing the return key. See paragraph 9.0 for the parameters allowed.

NOTE: The additional operator commands XADCT, XIOLT, plus a precise description of the XLOAD PA command, because of their complexity, are described in the following three paragraphs, 15.0, 16.0, and 17.0. All three commands can be used in the SU program only (i.e. when the computer is in a WAITING state).

## 15.0 POINTING ANALYSIS

After collecting pointing data with the PT program, the PA program must be run to analyze the data points collected.and determine the actual pointing corrections. A scientist or someone qualified to analyze the data will do the actual analysis, but the operator must know how to initiate the various functions of the program. The procedure follows.

1) If the line printer has previously been in use, turn it to STANDBY (press the yellow button), or else type XTYPE,1 then XLPTR,0 on the teletype.

2) If a printout of the least squares matrix is desired (by the person analyzing the data), set SS1; otherwise, reset SS1.

3) Type XLOAD PA on the teletype.

4) The computer will print: INPUT FROM DISK OR TAPE?

5) If all required pointing data is on disk, reply DISK. If not, reply TAPE after mounting the appropriate data tape on the tape transport. The pointing data from the tape will be transferred to disk at the end of data already on disk (if any).

6) The computer will print: POINTING REDUCTION FOR 85- The operator must specify the antenna and coordinate desired (e.g. type 2 RA so that the statement reads POINTING REDUCTION FOR 85-2 RA).

7) The computer will think for several tens of seconds. At the conclusion of this time it will investigate SS1, and if it is set, will type the nine least squares equations (for declination, there are only 7 parameters, and the last two equations are meaningless).

8) The computer will now print: DO YOU WISH TO HOLD ANY PARAMETER FIXED?

9) If a solution for all nine parameters (7 for declination) is desired, type a carriage return.

10) If the pointing data is restricted and it is not desirable to solve for all parameters, type YES. The computer will respond with a list of the

physical significances of the pointing parameters. The operator may list, one at a time,(i.e. one digit followed by a carriage return), the parameters to be held fixed, terminating the list with the word NO. The listed parameters will be taken from the appropriate pointing correction card which was read in at the last previous execution of the XBASE command and will be held fixed.

11) At this time the computer will type 9 pointing numbers (the last two will be zero for declination reductions).

12) On the Data CRT the computer will display the first 20 data points from the pointing data, including record (sect) number, declination, hour angle, measured error, and residual from the fitted solution.

13) Points may be edited out by using the CRT keyboard to delete (i.e.type blanks over) the measured error value.

CAUTION: Do not erase the record number; do not use the FORMAT INSERT or the FORMAT DELETE functions of the keyboard.

14) After doing whatever editing desired, send the output back to the computer by pressing SEND BLOCK. The computer will then display the next 20 data points.

15) After all data points for that telescope coordinatehave been displayed, the computer will halt.

16) Press START on the computer.

17) The computer will print: INPUT FROM DISK OR TAPE?

(Since the data has already been put on disk, always reply DISK at this point.)

18) The computer will print: POINTING REDUCTION FOR 85-

19) The operator may enter any telescope and coordinate desired, and continue at step 7.

20) If the program halts at any point, try restarting at location 002001.

21) Always XWIPE the disk when finished with the PA program.

## 16.0 ANALOG/DIGITAL CONVERTER TESTS

As an aid in troubleshooting, an electronics enginger or technician may need to read the voltages on certain lines in the Analog-Digital Converter. The procedure follows. The computer must be in a WAITING state before starting.

1) Type XADCT on the teletype, followed by the return key.

2) The teletype will print a header: CHANNEL VOLTAGE

3) Enter the A-toÐD line number or buffer channel of interest into the A REGISTER (in octal).

4) Press START.

5) The value found on that line will be printed out on the teletype. This value is in decimal the voltage read by the Converter,,and will be in the range -9.999 to +9.999 volts.

6) To read another or the same line, enter the number into the A Register and press start.

7) When finished with this program, the operator must transfer to 017000 in order to do anything else with the computer.

## 17.0 INPUT/OUTPUT LINE TESTS

As an aid in troubleshooting, it is sometimes desired to check the voltage on certain input lines to the computer or to check an output line from the computer to ascertain that the computer is setting receiver functions properly. The procedure for checking either input or output follows. The computer must be in a WAITING state before starting.

1) Type XIOLT on the teletype, and the return key.

2) The computer immediately prints the following messages:

```
INPUT/OUTPUT LINE TESTER--TYPE:
IN (CR)  TO SELECT INPUT-LINE TESTS,
OUT (CR)  FOR OUTPUT-LINE TESTS,
END (CR)  TO QUIT + RETURN TO SYSTEM.

  WITHIN INPUT-TESTS ONLY:
ALL (CR)  TO SAMPLE ALL IN-LINES,
L=NNNN (CR)  TO SAMPLE 1 LINE,
  WHERE NNNN IS ONE OF THE NUMBERS
  61,161,...,761, 62,162,...,1562.

  WITHIN OUTPUT-TESTS ONLY:
L=NNNN (CR)  TO SELECT 1 OUT-LINE, WHERE NNNN
  IS ONE OF 160,260,...,1760;
B=NNNNNN (CR)  TO OUTPUT A BIT PATTERN ON THE PREVIOUSLY
   CHOSEN (L=) LINE, REPRESENTED BY UP TO 6 OCTAL DIGITS  NNNNNN
```

3) By following these computer instructions, any of the input or output lines may be tested. Remember that the B=NNNNNN function of the output line test must be in octal.

4) When finished with this program, the operator may type END and the computer will print a return code and can be used for other programs.

## 18.0 COMPUTER TROUBLESHOOTING PROCEDURES

If any unexplained or unusual computer halts or loops occur, try the following steps, in order, until something works. (A computer loop is a condition whereby the computer will not continue to the next step in its observing sequence.)

### 18.1 RESTART AT MEMORY LOCATION 017000

1) Place MODE switch to SINGL. INSTR. position.

2) Press MASTER CLEAR.

3) Punch 017000 into DATA REGISTER.

4) Punch P and ENTER.

5) Place MODE switch to RUN position.

6) Press START.

### 18.2 RELOAD IOCS

1) Place the IOCS card deck for the system in the card reader.

2) Press RESET and START on card reader.

3) Place MODE switch to SINGL. INSTR. position.

4) Press MASTER CLEAR.

5) Punch 016540 into the DATA REGISTER.

6) Punch P and ENTER.

7) Place MODE switch to RUN position.

8) Press START. The computer should read the deck, ask if it remembers the correct scan number, and begin observing after YES is typed.

### 18.3 IOCS WILL NOT LOAD

If IOCS will not load, the KEY-IN LOADER has probably been wiped out. Reload the KEY-IN LOADER, as instructed in paragraph 5.1 and continue.

### 18.4 RELOAD SYSTEM TAPE

If the IOCS deck loads but trouble still persists, something in memory may have been wiped out. Reload the proper system tape as instructed in paragraph 5.2 and continue from there.

18.5 REMOVE POWER FROM COMPUTER

If trouble still persists, place the MODE switch to SINGL. INSTR. position and turn the POWER switch to the OFF position. Wait approximately one minute, turn the POWER switch back ON, press MASTER CLEAR then reload IOCS and try starting again.

18.6 CHECK POWER INPUT

If none of the previous troubleshooting procedures work, there is a good possibility that some unit of the computer system has lost power, either by a tripped circuit breaker, inadvertent disconnection of a power cord, or a bad power supply somewhere in the system. Check all units in the basement and make sure power is on. If some unit has lost power, proceed to find the fault and restore power to the unit.

18.7 CARD DECK TROUBLE

If, after loading a card deck, the computer prints out the number 1, 2, or 3, or, if the computer hangs up with a card deck partially read, there is something wrong with the card deck. Check the deck to make sure it is the correct one, the cards are in proper sequence, it contains the correct number of cards, and there is no read or feed error indicated on the reader.

18.8 ELECTRICAL INTERFERENCE

If severe electrical interference gets on the lines coming into the control building (e.g. lightning, static electricity), the computer will usually go into a loop or a halt condition or else begin printing garbage on the teletype or line printer. Generally, if the operator stops the computer and tries to restart from location 017000, the key-in loader is usually found to be wiped out and must be reloaded. Sometimes it is impossible to reload the key-in loader, or, if it will load, the program still will not start properly. If this happens, the only thing to do is wait until the storm subsides or the source of the interference is found and eliminated.

18.9 INCORRECT DISK SECTOR

Sometimes while observing the computer questions whether the next sect number to be written on is in fact a blank sector. It will stop observing, call in the XDINT subroutine (see par. 14.31), print out the message DISK DATA AFU, then, after a short time, will print out a 5 digit sect no followed by a question mark. The operator should ascertain whether or not this is a blank sector by checking back in the printed output. If it is correct, the answer YES will permit the computer to go back to observing. If it is not correct, the operator should keep answering NO until the computer either gives the correct one, or else asks: WHAT, THEN? The operator can then type in a 5 digit number and the computer will continue writing at that sector. If the operator should ever find that the sect number is incorrect,but the computer does not question it, he should immediately stop observing, look up the correct sect number in the DDP-24 CONVERSION TABLES manual, and enter the correct octal number into location 000022. However, the safest thing to do is to immediately dump the data onto tape, wipe the disk, and begin observing again at sector 00000. If the operator should ever want to start at the beginning of the disk when some unwanted data is already on disk, put computer into a waiting state, type XWIPE then DA and wait for printout. Another way is to type XLOAD CP, then transfer to 04234 (don't MASTER CLEAR).

18.10 DISK MALFUNCTIONS

If previous troubleshooting procedures produce negative results and the computer cannot be restarted or continues to loop, there is a possibility that some malfunction has occurred in the Disk Unit located in the basement. Access to this unit can be gained by opening the lower door on the front. At the left are three lights labeled ACTUATION PRESSURE LOW, DRUM SPEED LOW, and DRUM TEMPERATURE HIGH. If any of these are lit, the digital engineer or technician should be advised of the malfunction.

## 18.11 ENCODER MALFUNCTIONS

Each 85' telescope is equipped with a polar and declination encoder which reads the actual position of the telescope and transmits the information to the computer so that correct positioning can be accomplished. This information is visible to the operator on the CRT readout and the Nixie tube readout located in the Antenna Console Unit 100 in the form of Hour Angle, Right Ascension, and Declination. Sometimes a malfunction occurs in this readout system and the computer momentarily receives erroneous readings. This becomes apparent to the operator if the readout jumps from one reading to another and back again. Sometimes these jumps are infrequent; sometimes they are practically continuous. Invariably, this will interfere with computer operation, inasmuch as the computer will try to position the telescope while two different coordinate positions are alternately being fed to it. The computer will move the telescope first one direction then the reverse in the coordinate which is malfunctioning. In this situation, the digital engineer or technician responsible should be notified. It may become necessary to remove the telescope involved from the system until the malfunction is repaired. As an aid in troubleshooting, the operator should try to record the readings between which the readout is jumping. It will also assist the engineer or technician if the operator observes whether or not both coordinates are jumping and whether or not both the CRT and the Nixie readouts indicate the jumps.

## 18.12 A-D CONVERTER CHANNELS

The Analog Display Patch Panel (located in the Analog Display Unit 160), in addition to providing outputs from the correlators, contains outputs from other A/D converter channels plus a digital voltmeter for reading them. This can be useful when a problem in the converter affects computer operation. (Also see paragraphs 2.5.2 and 16.0.)

18.13 INTERNAL EMERGENCY ROUTINE

There is an internal emergency routine programmed into the computer that is activated whenever a situation arises in which the computer cannot continue operating without operator intervention. The operator is made aware of this situation if the computer prints out a six digit number then begins ringing the bell on the teletype or printing garbage. In this situation, the operator should stop the computer and examine the location printed on the teletype. The number printed is a numerical address which is listed in the Interferometer Program Assembly along with the probable trouble.

18.14 COMPUTER TEMPERATURE LIMITS

The computer and its associated digital equipment should not be operated if the room temperature should fall below +50° F. The upper limit for the temperature inside the computer cabinet is +100° F. If the temperature should reach any of these extremes (e.g. if the heating/air conditioning malfunctions), stop observations immediately and turn power off the computer. Notify the digital engineer or technician and follow his instructions.

18.15 THINGS TO AVOID

In addition to previous ones, here are some DON'Ts for the operator:

DON'T punch a button on the computer while it is running.

DON'T turn the CRT's on or off while the computer is running.

DON'T attempt to change a light bulb on the computer while running.

DON'T change bulbs on certain computer-oriented backend switches.

DON'T stop the computer while it is slewing the telescopes UNLESS IT IS AN EMERGENCY.

18.16 CALENDAR

Occasionally, particularly at 2400 EST, the calendar may fail to update. This is especially true on the last day of the month. If the computer refuses to run, check the date on the calendar in the basement. If it is wrong,

it can be set to the correct date by using the switches for day and month. After having set the correct date, the operator should check the G.S.D. date which is printed as the first number in the return code line before and after scans. The correct G.S.D. date can be found in the universal and sidereal time tables in the Ephemeris for $0^h$ S.T.

NOTE: This date does not update until 0000 L.S.T. on the date in question.

# NOTES

## 19.0 THE LINE INTERFEROMETER (H-LINE SYSTEM)

At various scheduled times, the interferometer is used to make line observations. At such times, the NRAO CORRELATION RECEIVER is installed in the equipment room, along with the LINE SYSTEM IF MONITOR. Signals are then routed from the IF MONITOR to the CORRELATION RECEIVER (referred to as the AUTOCORRELATOR), and thence to the computer, in addition to the continuum correlators. A complete description of the autocorrelator and its use, the source cards, and the FSET card (part of the BASELINE deck) can be found in Chapter I of THE NRAO LINE INTERFEROMETER: A MANUAL, by E. W. Greisen, and will not be included here. The switch and cable settings and any changes necessary in them during the program will be made according to the observer's instructions.

NOTE: In some of the following paragraphs, instructions included in previous paragraphs are referred to rather than to repeat them. These instructions are basically the same except that the computer language may vary somewhat. Card decks and Besselian day number cards are in drawers marked H-LINE.

### 19.1 KEY-IN LOADER

The KEY-IN LOADER is loaded the same as described in paragraph 5.1.

### 19.2 IOCS

The H-Line IOCS deck must be entered into the computer as described in par. 5.2. If the Dual Frequency system tape is in memory, remove the last card from the IOCS deck before loading. The teletype will print a 3 and the computer will halt. (If H-Line system is in memory and it is desired to go back to Dual Frequency, it is likewise necessary to remove the last card from the Dual Frequency IOCS deck.)

### 19.3 LOADING THE H-LINE SYSTEM TAPE

Load the H-Line tape-to-disk card deck and system tape as in par. 5.2.

### 19.4 BESSELIAN DAY NUMBERS

Load the H-Line Day Numbers as described in par. 5.3.

19.5 BASELINE DECK

Load the H-Line Baseline Deck as described in par. 5.4, except that an FSET card must be included. This card will be supplied by the observer.

19.6 OBSERVING PROGRAM DECK

Load the source list as described in par. 5.5, except place SS1 up.

19.7 DATA TAPE

For line work, the disk is not used to collect data, but the data is written directly on tape.

1) Load a blank data tape with a ring in the back on the tape transport, and punch LOAD POINT and AUTO.

2) Type XLOAD CP on the teletype.

3) The computer will print GOOD MORNING, WHAT CAN WE DO FOR YOU?

4) Type BOT.

5) The computer will write a file mark on the tape.

6) Place SS1 down. The computer and associated receiving equipment will begin taking data, and a record will be written on the tape at the end of each 80 or 160 seconds.

19.8 DATA STORAGE SCOPE

A visual check can be made on the output of the Autocorrelator by watching the storage scope in the Analog Display Unit 160. This scope is a HP 141S, and two Differential Amplifiers control the vertical and horizontal sweep of the two traces. The power on-off switch is in the lower left corner below the storage screen. In general, the observer will initially set this up and inform the operator how the pattern should look. Gain is controlled by the two lo-order digiswitches on the Unit 130. If the high order digit is 0, the cosine and sine functions are displayed; if it is 1, amplitude and phase are displayed. SS2 up gives the sum of 384 independent values for the write period. SS3 up gives 3 or 4 repeats on the scope.

19.9 RESTARTING THE COMPUTER

The manual restart of the computer is accomplished by punching MASTER CLEAR, 001000 into the Data Register, P, ENTER, and START. If this doesn't work, begin at par. 19.1 or 19.2 and re-enter everything.

19.10 SUPPRESSING DATA RECORDS

To keep data from being written on tape (as, for instance, when adjustments are being made on the receivers or autocorrelator), place SS1 up.

19.11 FREQUENCY SYNTHESIZER

The observing frequency can be changed somewhat according to the observer's wishes. This is accomplished by using the Frequency Synthesizer located in the equipment room. For any line work, the power must be turned on this unit, and the FREQUENCY SELECTION switch placed to REMOTE control. The computer then combines the line rest frequency from the FSET card with the velocity in the individual source or scan card to arrive at the desired observing frequency which is displayed on a frequency counter located in the Antenna Console Unit 100.

19.12 TOTAL POWER

The total power meters on the IF FILTER UNITS (Autocorrelator) should be checked whenever an observation is begun on a different source, and the I. F. ATTENUATORS used to center this meter, or at least to put it in the green portion.

19.13 XLOAD CP

In addition to labeling the data tape (par. 19.7), the following functions are accomplished by typing XLOAD CP and waiting until the computer prints GOOD MORNING, WHAT CAN WE DO FOR YOU?

1) To end a tape, type EOF. The computer writes a file mark and rewinds.

2) To reload and continue using a tape, type SKIP D. The computer will space to the EOF mark, will backspace and erase the mark, then will continue

writing more data. This will not work unless there were both a BOT and an EOF mark on the tape.

3) If you get into trouble when using the XLOAD CP function (e.g. by typing a wrong character on the teletype), type HELP and the computer will print a list of options to use.

19.14 EMERGENCY EOF

If for some reason the computer will not run and there is a tape mounted with data on it, an EOF mark can be written as follows:

1) MASTER CLEAR, punch 031000 in the Data Register, punch P and ENTER.

2) Punch the red CLEAR button, READ/STORE switch to STORE.

3) Punch 030610 in the Data Register, then punch ACCESS. This writes an EOF mark on the tape.

4) Similarly, store 000000 in location 031001. This HALTS the computer.

5) Place the READ/STORE switch to READ.

6) Remove the tape, if desired. (The REWIND switch can be used.)

19.15 POINTING AT 21 cm

If the system is operating at 21 cm and it is desired to run the pointing program, the special 21 cm Pointing System Tape must be entered into memory. This tape uses the Dual Frequency IOCS, TAPE-TO-DISK, DAY NUMBER, and BASELINE card decks. The receiver is set up as if pointing at SR (receiver switch to SBAND, SS2 up, X3 on). For very strong sources it may be necessary to switch the X3 off and readjust the attenuators to about 20ua. On the Autocorrelator Digital System Controls, place the N.T. switch to 1 (to turn the noise tubes off). Place SS4 up, transfer to 017000. Type XLOAD WR to read the source deck and XLOAD PT to begin pointing. When the PT program is completed, the XLOAD PA program can be used to analyze the data.

19.16 DATA CRT DISPLAY

The XSHOW command can be used (see par. 10.0) for correlators in Fig. 4.

## 19.17 21 cm CONTINUUM

The interferometer may be used for 21 cm continuum observations by loading the appropriate system tape into memory. The following things must be done in order for the program to work.

1) Disconnect the Autocorrelator from the online computer by disconnecting the large ELCO connector at the top rear of the A/C.

2) Discontinue A/C strobing of the noise tubes by setting the N.T. switch on the front panel of the A/C to position 1.

3) Disconnect the frequency synthesizer from the online computer by disconnecting connectors P7, P8, and P9 from their jacks J7, J8, and J9 at the rear of the synthesizer.

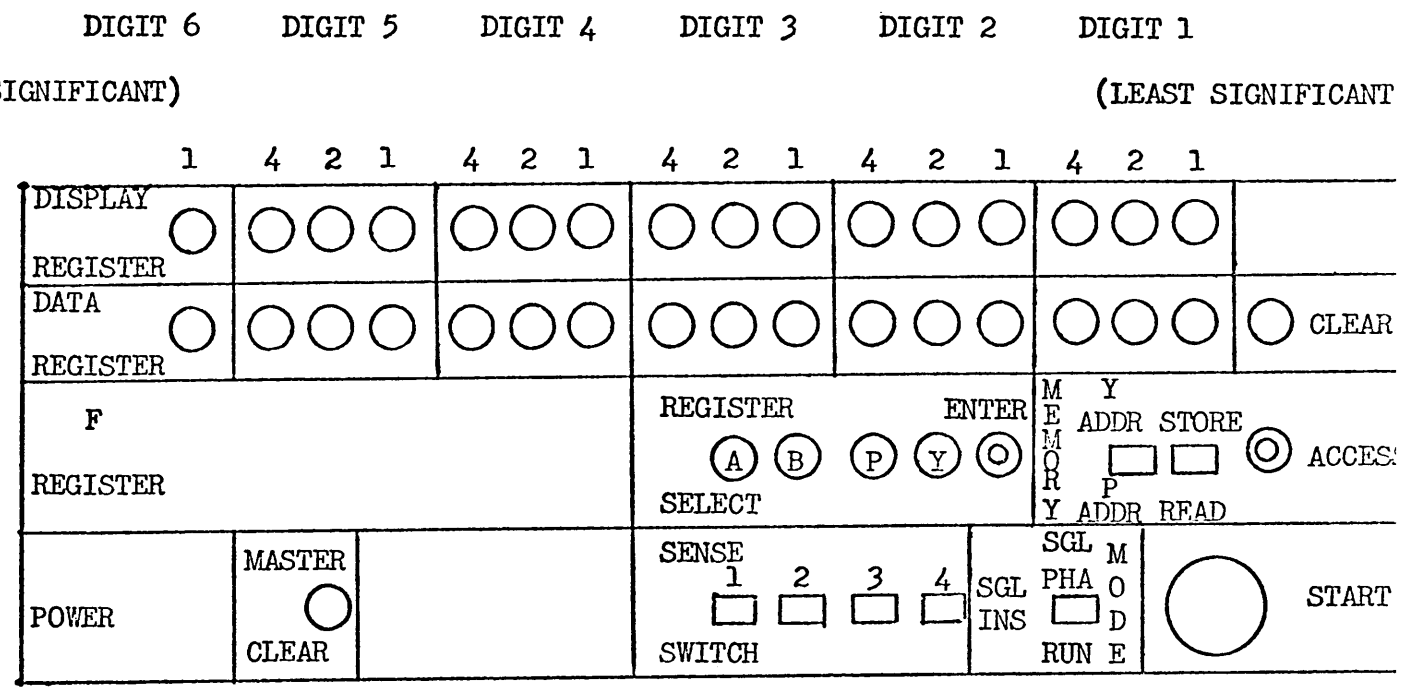
4) Change the frequency selection switch from REMOTE to LOCAL KEYBOARD on the front panel of the frequency synthesizer.

5) Enter the desired frequency (e.g. 172.500 000 0) into the local keyboard on the front panel of the frequency synthesizer.

NOTE: In calculating this frequency, be sure to use the subtraction constant 140.0 and not 130.0 MHz.

# NOTES

FIG. 1 DDP-116 CONTROL PANEL DIAGRAM




1) The computer instructions in this manual do not specify each individual button to punch on the DATA REGISTER, but simply state to punch a certain number into the register. All other buttons to punch or switches to set are specified.

2) The DISPLAY and DATA REGISTERS are divided into 5 sections of 3 buttons or lights per section plus 1 section of 1 button.

3) Up to a 6-digit octal number (see B. Clark's OPERATORS MANUAL dated 1/3/67) can be punched into the DATA REGISTER by pressing a combination of numbers in each section which adds up to the desired digit. The value of each button is written above it in the diagram above.

4) As an example, to punch the octal number 4073 into the DATA REGISTER:

Punch nothing in the digit 6 and 5 sections.

Punch the 4 button in digit 4 section.

Punch nothing in the digit 3 section.

Punch 4, 2, and 1 buttons in the digit 2 section.

Punch the 2 and the 1 buttons in the digit 1 section.

5) A light in each button punched will come on to indicate that the number punched can be loaded into a register (see B. Clark's manual THE DDP-116 -- CONSOLE PROCEDURES dated February 9, 1967). If a wrong button is punched, the DATA REGISTER CLEAR button on the far right of the control panel must be pressed and the entire number punched in again.

6) After a number is punched into the DATA REGISTER, it is usually "transferred" to the P REGISTER. This is done by punching the P and ENTER buttons. Rather than writing out each of these steps, the instruction "transfer to NNNNNN" in this manual means to punch the number NNNNNN into the DATA REGISTER, then to punch the P and ENTER buttons.

FIG. 2 BASELINE DECK

| | |
|---|---|
| FSET CARD (OPTIONAL) | (CARD # 0) |
| BASELINE PARAMETERS | (CARD # 1-3) |
| ANTENNA POINTING PARAMETERS | (CARD # 4-7) |
| DELAY CENTERS | (CARD # 8) |

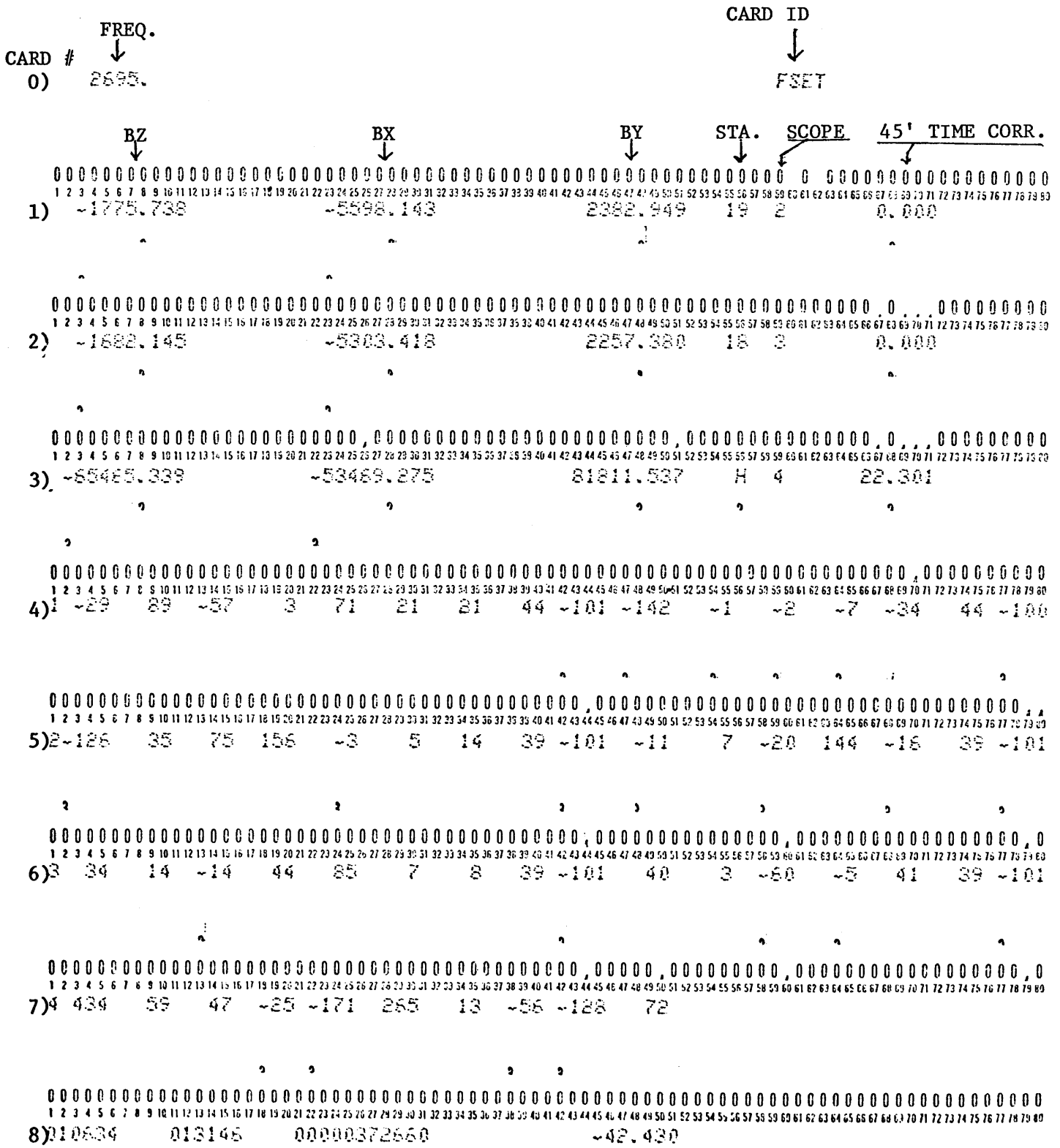


FIG. 3 CORRELATOR NUMBERS AND THEIR SIGNIFICANCE (4-ELEMENT SYSTEM)

| S, X, or DUAL S | DUAL X | CORR. DESIG. | MIXED MODE | CORR. DESIG. |
|---|---|---|---|---|
| 0 | 24 | 1R2R | 0 | 1R2R X |
| 1 | 25 | 1L2L | 1 | 1L2L S |
| 2 | 26 | 1R3R | 2 | 1R3R X |
| 3 | 27 | 1L3L | 3 | 1L3L S |
| 4 | 28 | 2R3R | 4 | 2R3R X |
| 5 | 29 | 2L3L | 5 | 2L3L S |
| 6 | 30 | 1R2L | 12 | 1R4R X |
| 7 | 31 | 1L2R | 13 | 1L4L S |
| 8 | 32 | 1R3L | 14 | 2R4R X |
| 9 | 33 | 1L3R | 15 | 2L4L S |
| 10 | 34 | 2R3L | 16 | 3R4R X |
| 11 | 35 | 2L3R | 17 | 3L4L S |
| 12 | 36 | 1R4R | | |
| 13 | 37 | 1L4L | | |
| 14 | 38 | 2R4R | | |
| 15 | 39 | 2L4L | | |
| 16 | 40 | 3R4R | | |
| 17 | 41 | 3L4L | | |
| 18 | 42 | 1R4L | | |
| 19 | 43 | 1L4R | | |
| 20 | 44 | 2R4L | | |
| 21 | 45 | 2L4R | | |
| 22 | 46 | 3R4L | | |
| 23 | 47 | 3L4R | | |

FIG. 4 H-LINE DATA CRT XSHOW CORRELATORS

| CORRELATOR | FUNCTION |
|---|---|
| 0 | CONTINUUM BASELINE 1-2 (SIGNAL BAND) |
| 1 | " " 1-3 " " |
| 2 | " " 2-3 " " |
| 3 | " " 1-4 " " |
| 4 | " " 1-2 (IMAGE BAND) |
| 5 | " " 1-3 " " |
| 6 | " " 2-3 " " |
| 7 | " " 1-4 " " |
| 8 | RX-SUM QUADRANT 1 (SIGNAL BAND) |
| 9 | " " 2 " " |
| 10 | " " 3 " " |
| 11 | " " 4 " " |
| 12 | " " 1 (IMAGE BAND) |
| 13 | " " 2 " " |
| 14 | " " 3 " " |
| 15 | " " 4 " " |

FIG. 5 TROUBLESHOOTING AND COLD START PROCEDURES

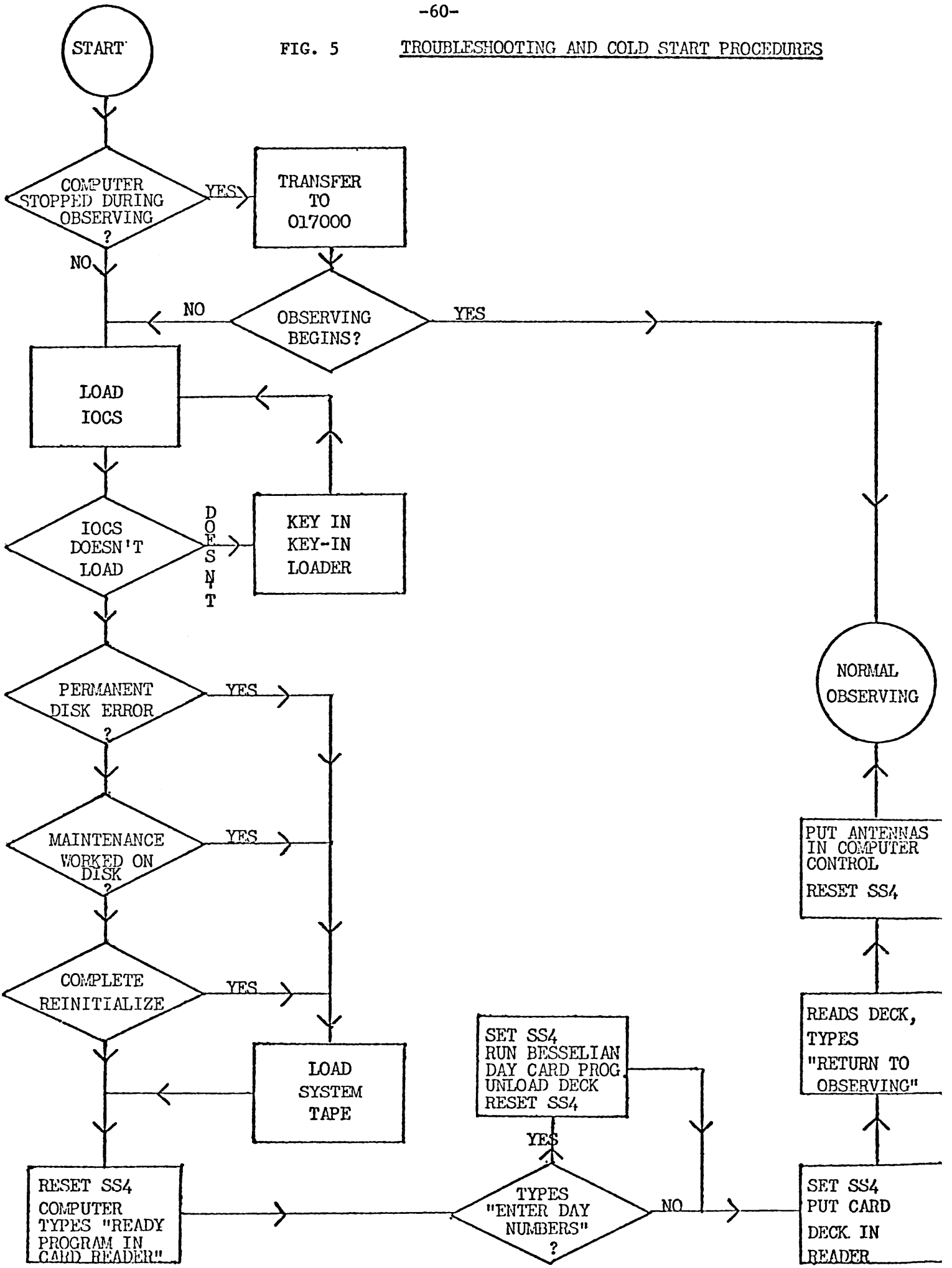


FIG. 6 85' SCAN AND SLEW RATES

A MOTOR = 5/5 SIDEREAL RATE = 15 DEGREES/HR.
B MOTOR = 7/5 SIDEREAL RATE = 21 DEGREES/HR.
C MOTOR = 8/5 SIDEREAL RATE = 24 DEGREES/HR.
SLEW MOTOR = 20 DEGREES/MIN.

| | SKY RATE OR R.A. HRS. INC. OR DEC. PER HR. OF SID. TIME | DEG./HR. TEL. SPEED AND DIR. | MOTOR DIR. A | B | C |
|---|---|---|---|---|---|
| EAST | 0.2 | 12°W | + | + | - |
| | 0.4 | 9°W | - | 0 | + |
| | 0.6 | 6°W | - | + | 0 |
| | 1.0 | 0° | 0 | 0 | 0 |
| | 2.0 | 15°E | - | 0 | 0 |
| | 3.0 | 30°E | + | - | - |
| | 4.0 | 45°E | 0 | - | - |
| | 5.0 | 60°E | - | - | - |
| WEST | 0.0 | 15°W | + | 0 | 0 |
| | 0.2 | 18°W | + | - | + |
| | 0.4 | 21°W | 0 | + | 0 |
| | 0.6 | 24°W | 0 | 0 | + |
| | 1.0 | 30°W | - | + | + |
| | 2.0 | 45°W | 0 | + | + |
| | 3.0 | 60°W | + | + | + |
| | SKY RATE | | | | |
| NORTH | 0.0 | 0° | 0 | 0 | 0 |
| | 0.2 | 3°N | 0 | - | + |
| | 0.4 | 6°N | - | + | 0 |
| | 0.6 | 9°N | - | 0 | + |
| | 1.0 | 15°N | + | 0 | 0 |
| | 2.0 | 30°N | - | + | + |
| | 3.0 | 45°N | 0 | + | + |
| | 4.0 | 60°N | + | + | + |
| SOUTH | 0.0 | 0° | 0 | 0 | 0 |
| | 0.2 | 3°S | 0 | + | - |
| | 0.4 | 6°S | + | - | 0 |
| | 0.6 | 9°S | + | 0 | - |
| | 1.0 | 15°S | - | 0 | 0 |
| | 2.0 | 30°S | + | - | - |
| | 3.0 | 45°S | 0 | - | - |
| | 4.0 | 60°S | - | - | - |

NOTE: The 45' telescope slews at 40°/MIN. when it is going wide open.

## APPENDIX

The following list of instruction manuals and memos contain more detailed and more technical aspects of the Interferometer System and the operation thereof than this report has attempted to describe. BASIC INSTRUCTIONS FOR OPERATING THE INTERFEROMETER has been taken almost entirely from these manuals and memos.

| | |
|---|---|
| PROGRAMS FOR THE INTERFEROMETER DDP-116 COMPUTER | B. CLARK |
| TELESCOPE OPERATORS MANUAL DDP-116 INTERFEROMETER COMPUTER | B. CLARK |
| THE DDP-116 -- MACHINE ORGANIZATION | B. CLARK |
| THE DDP-116 -- PROGRAMMING | B. CLARK |
| THE DDP-116 -- CONSOLE PROCEDURES | B. CLARK |
| THE DDP-116 -- INPUT-OUTPUT | B. CLARK |
| INSTRUCTIONS FOR USING THE INTERFEROMETER COMPUTER OPERATING SYSTEM | B. CLARK |
| PT OPERATING INSTRUCTIONS | B. CLARK |
| INSTRUCTIONS FOR CRT AND PRINTER | B. CLARK |
| OPERATING INSTRUCTIONS FOR THE 4-ELEMENT DUAL-FREQUENCY INTERFEROMETER WITH LOBE ROTATORS | G. CONANT |
| AN INTRODUCTION TO THE NRAO INTERFEROMETER | R. M. HJELLMING |
| THE FOUR-ELEMENT NRAO INTERFEROMETER | ED FOMALONT |
| THE NRAO LINE INTERFEROMETER: A MANUAL | E. W. GREISEN |
| 3-ELEMENT INTERFEROMETER 3.7, 11, AND 21cm RECEIVERS | JAMES R. COE |
| INTERFEROMETER TELESCOPE OPERATORS COMPUTER MANUAL | R. L. SWENSSON |
| DDP-24 CONVERSION TABLES | COMPUTER CONTROL CO. |
| DDP-116 PROGRAMMERS REFERENCE MANUAL | COMPUTER CONTROL CO. |
| DDP-116 INSTALLATION MANUAL | COMPUTER CONTROL CO. |
| DDP-116 DAP MANUAL | COMPUTER CONTROL CO. |
| MEMORANDUM: USE OF 45' DATA LINK DATA DISPLAYS | R. HALLMAN |

In addition, observers may find useful information in Telescope Operations Division Report No. 5, INTERFEROMETER USERS' GUIDE, by Jonathan C. Spargo.