US/GR BK/

INTERFEROMETRIC SOURCE MODELING IN THE PRESENCE OF NOISE

[Interferometer Group - Internal Report]

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February 1973

INTRODUCTION

Since the technique of aperture synthesis was first introduced into astronomy in 1960, it has gained wide acceptance as a powerful tool of the radio observer. The advantage an interferometer has over the single dish is its ability to resolve out individual sources from the total of the radiation arriving at each element. This is accomplished not only by the geometrical properties of the instrument itself, but also by the complex computer reduction processes that follow the observations.

As generally bright objects within the field of view have been observed, astronomers have shown a great deal of confidence in the system's ability to locate (i.e., assign a position to the beam center) and determine a brightness distribution for the source. However, when the incoming signal is low, i.e., of the same order of magnitude as the receiver noise, one has much less confidence in his interpretation of the data. The determination of the flux density and position of a component of the field becomes a function of many parameters. A few of the more important are: the baseline configuration of the interferometer, the tracking interval(s), the source declination, receiver noise, delay line switching, atmospheric effects, other sources in the field of view (interacting sidelobes), and so on.

Basic to the interpretation of faint (and multicomponent) sources is an understanding of the response of the interferometer and the reduction technique to uncorrelated noise. Does the system respond to a source and noise in a similar manner? How randomly distributed does noise appear on an interferometer map? Can noise have sidelobes? In other words, does noise mimic real sources?

The answers to the above questions have a wide range of ramifications. How accurate and reliable are the many deep surveys? What confidence can be given to the detection of weak transient sources, e.g. the radio stars? Are apparent motions within fields that are near the noise limit real, or are they just misinterpretetions of noise effects?

The following computer program has provided a foundation for analyzing these perplexing problems (see Gibson, Master's Thesis, available Spring 1973). Now, the program is available to NRAO users for application to their individual needs as part of the Interferometer Job Library. The program provides a platform from which the investigation of any or all of the previously mentioned variables may be made, namely a mock interferometer that incorporates the features of the NRAO three-element interferometer, so that all the procedures from data acquisition through computer reduction may be accurately mirrored. Provision is made for the user to insert sources and noise and sample them using any coverage (or combination of coverages for a more complete synthesis) he desires. Reductions are then made using the standard programs already available in the Interferometer Job Library. Several features not presently available in the Library are offered:

1) The created data can be stored on a nine-track tape so that combinations of scans can be reduced and analyzed. The tape is written in the same Fortran-accessible format as the nine-track telescope tapes. Thus, the tapes can be reduced by the standard interferometer programs. The source modeling aspect of this program can also act as a debugging tool for the reduction programs through comparisons of input and output models.

2) Modeling of sources can be done using the exact coverage that

was given to the real source when the data was taken. This is accomplished by accessing baseline and scan time information from the origional data and substituting an artificial source in its place.

3) Random Gaussian noise can be injected; this mimics the effect of receiver noise. A standard deviation can be selected in a way such that changes in receiver response can be simulated.

Other modifications could be introduced into the program to further enhance its utility. These might include:

a) Introduction of phase errors, as caused by improper delay-line switching, to be combined with the Gaussian noise.

b) Correlated phase noise, such as might be introduced by the atmosphere (differential atmospheric refraction and retardation).

c) Time variable sources, similar to the phenomena associated with the radio stars.

d) Operation of the mock interferometer at S-band (11.1 cm) or X-band (3.7 cm), thus simultaneously observing both left-hand and right-hand circular polarization; in Dual Mode, observing at S- and X-band simultaneously in one polarization mode for thirty seconds and then switching modes, in addition to the normal Mixed Mode operation of X-band with left-hand circular polarization and S-band with right-hand circular polarization.

The program flow chart now follows.

FIG. 1a.

SUBPROGRAM COVERAGE

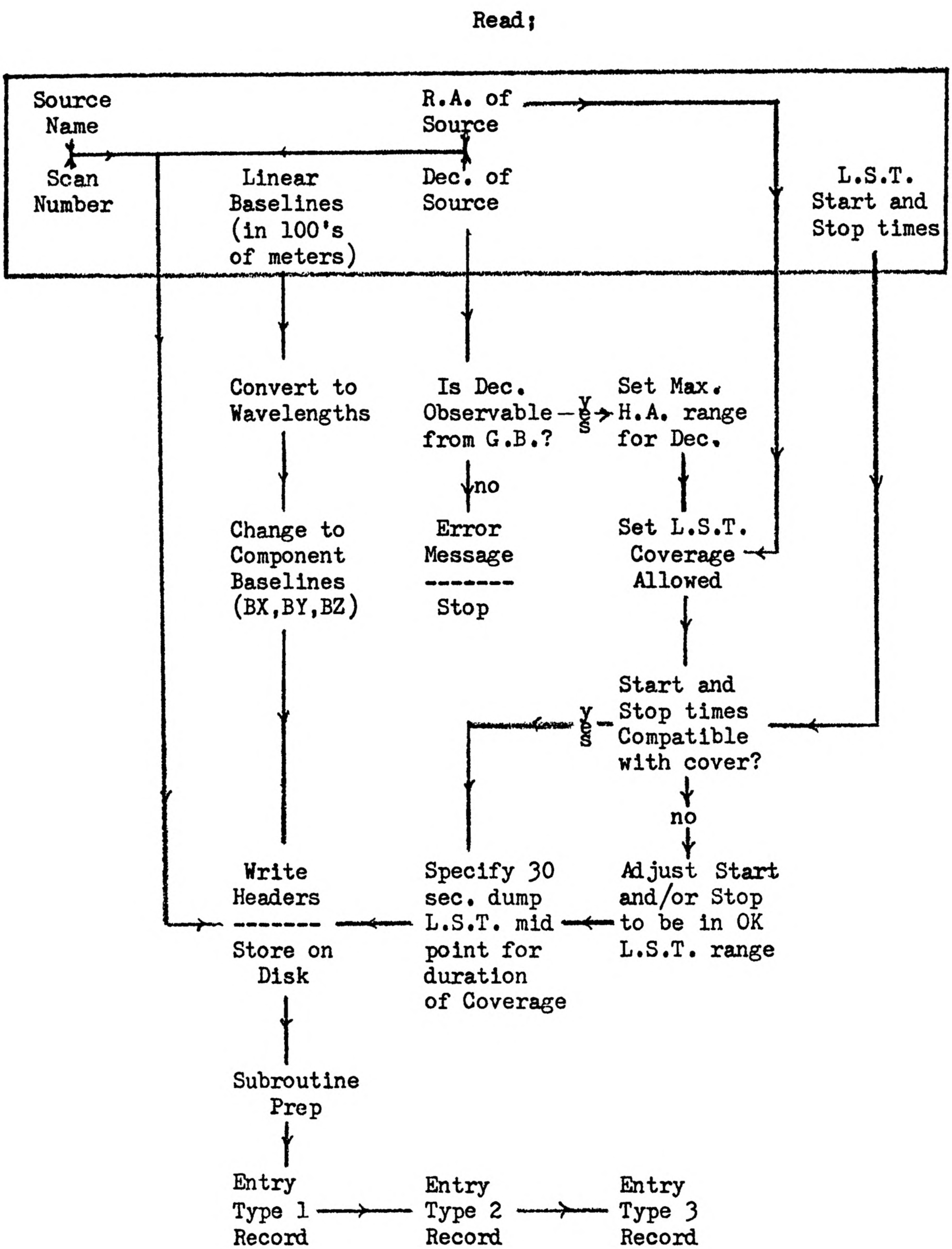


FIG. 1b.

SUBPROGRAM SOURCE NOISE

Read:

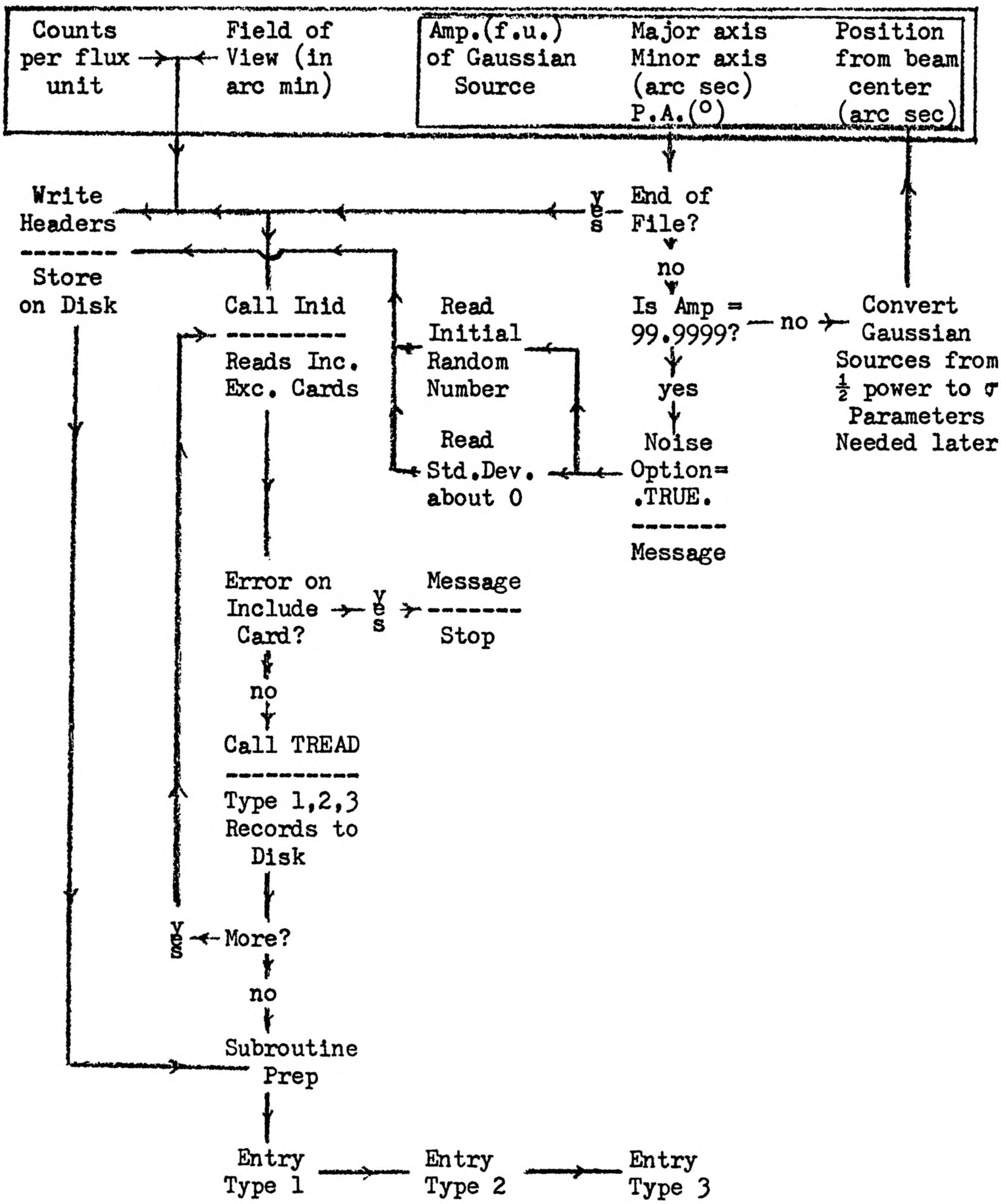


FIG. 1c.

TYPE 1. RECORDS

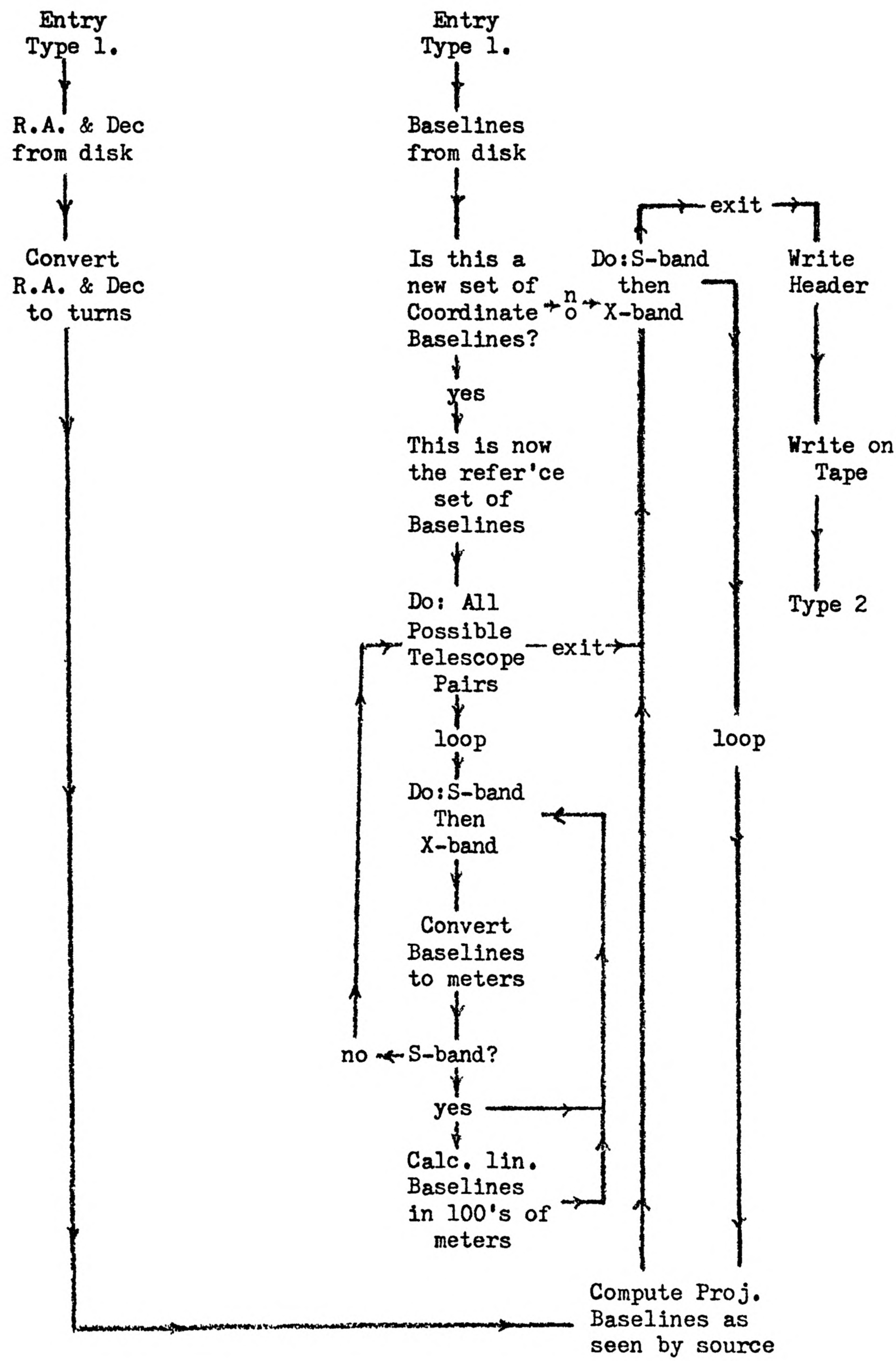


FIG. 1d.

TYPE 2. RECORDS

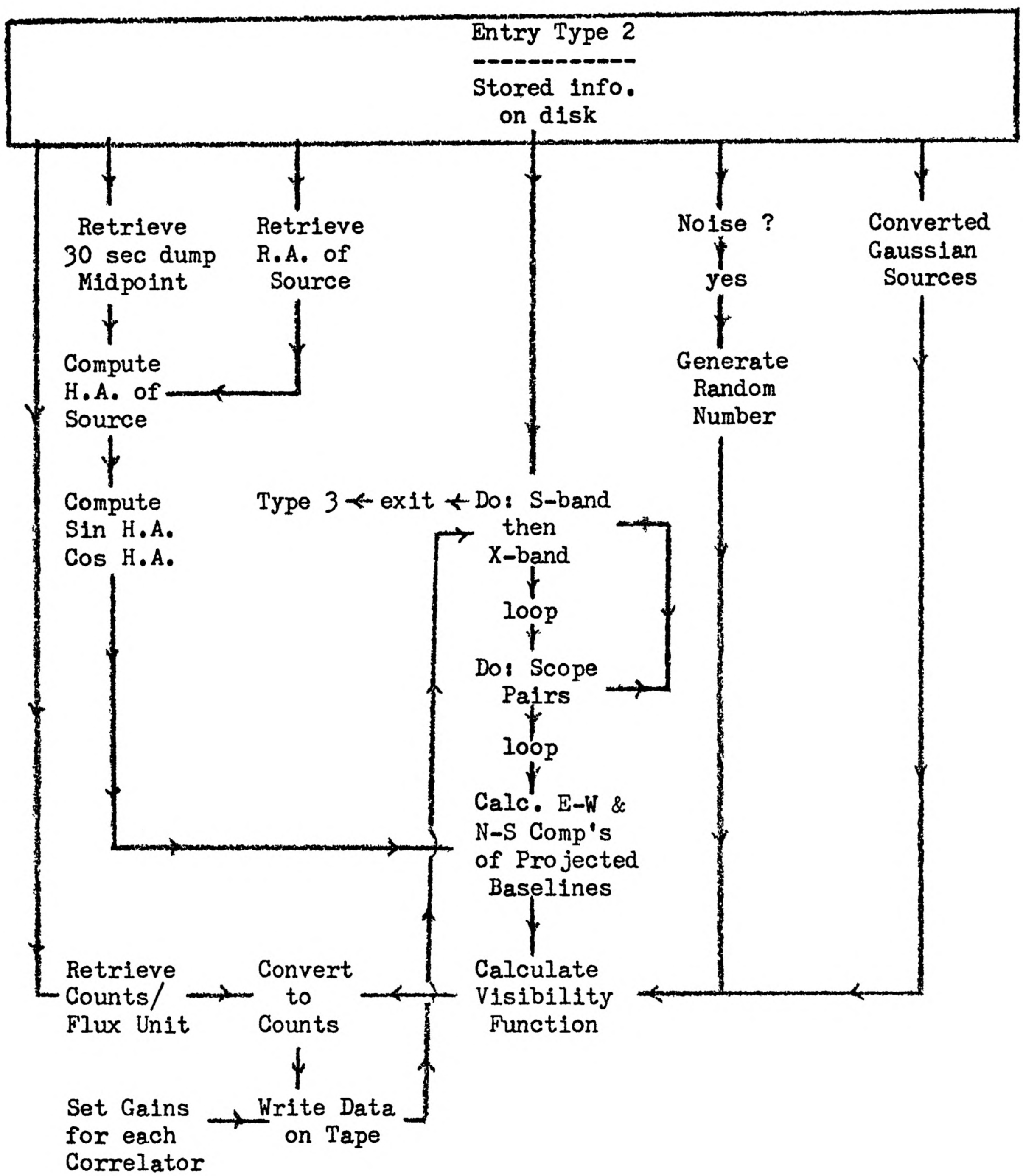


FIG. 1e.

TYPE 3. RECORDS

Entry
Type 3.

↓

Copy Type 3
Record onto
Simulated
Data Tape

↓

Tape now
Ready for
Reduction

SYNNOISE (an acronym for aperture synthesis noise simulation) is a Fortran level-G program that consists of two separate subprograms. The first, which is called COVERAGE, specifies the spatial configuration of the interferometer and the limiting hour angles of the observation. In particular, the vector baselines are those of the three element array located in Green Bank. The frequencies programmed are the same 2695 MHz and 8085 MHz used by the NRAO array.

The fringe phase of the source at any instant is a function of its distance and direction from the field center and its hour angle and declination. In the case of the NRAO interferometer, an average amplitude and phase are computed for each thirty-second interval that the observations are being made by an on-line computer. This feature is retained in the simulation program

The midpoints (in L.S.T. hours, minutes, and seconds) of these intervals are retained for the real as well as the simulated observations. Therefore, if one wished to model a source that has already been observed the coverage can be copied from the Archive Tape or the Today Data Set, which is stored on the disk. In this way the user can eliminate an important variable, the coverage, when comparing his modeled source to real observations. If the user chooses this option then he need only run the second subprogram, SOURCE-NOISE.

SOURCE-NOISE takes a model source of a known brightness distribution and allows it to be "observed" by the mock interferometer. The response is a function of the instantaneous apparent spatial distribution of the source and the direction cosine between the baseline and the source, i.e. a Fourier transform. These reals and imaginaries could be retransformed immediately to get the brightness distribution back again. This program, however, adds Gaussian distributed noise to the reals and the imaginaries before they are retransformed. (Remember these data are contained as thirty second integrations.) This procedure mimics the effects of random receiver noise and results in "dirty" interferometer maps that are representative of actual interferometer maps.

Each source is an elliptical Gaussian specified by a peak amplitude, the major and minor axes (measured between the half power points), the position angle of the minor axis of the ellipse, and a coordinate position of the source with respect to the center of the field (where $+x \rightarrow -$R.A., and $+y \rightarrow +$Dec.).

The number of counts per flux unit (CPF) can be specified to approximate the response of the receiver when the observations were made. The field of view (FLDVU) for the maps must also be specified.

Random Gaussian noise of a specified standard deviation can be included in the phase and amplitudes, resulting in realistic output. The present selection of 0.05 flux unit per thirty second record was made in the following manner. A map for which no apparent source was detectable, specifically an attempt to detect sources in the galactic center by Hjellming and Balick, was analyzed by both a program that lists the thirty second amplitude and phase and a program that lists the frequency of occurence of each map level. The standard deviation for the Gaussian noise was adjusted to various values while running a sequence of models with no source using SOURCE-NOISE. The coverage was copied from the actual observations. The output from these models was compared quantitatively and qualitatively with the null result until a suitable standard deviation could be found. Note that the noise is applied individually to each thirty second record and is not just added to the output model. This is more flexible and realistic way of putting in noise in that it need not be adjusted for different coverages.

The program listing is given on the next nine pages. It is well documented and should be easily understood by the user. It is compatible with the NRAO Interferometer Job Library, so many minor questions or problems with interfacing SYNNOISE with the rest of the Library can be answered by consulting the GUIDE TO USERS (Bosserman and Rhudy). Further questions can be directed to the author.

```
      REAL*4 SIND,COSD,SINH,COSH,RA,PI2/6.28318/,DEC,B(6),BX,BY,BZ,SEC30
     +     ,MAXHA,MINLST,MAXLST,START,STOP,TIME,TIMES,Z,CONFC
     +   ,SCANNO
      INTEGER*2 I,J,A(100),NAME(5),MODE/' M'/,IWRD(6)/37,39,41,69,71,73/
C
C
C---------------------------COVERAGE------------------------
C
C
C  COVERAGE IS A MIXED-MODE SIMULATION PROGRAM
C  THAT SPECIFIES THE INTERFEROMETER CONFIGURATION,
C  THE SAMPLING RATE, AND THE TRACKING TIME.
C  IT IS MEANINGLESS WHEN RUN ALONE, AND SHOULD
C  BE RUN BACK-TO-BACK WITH 'SOURCE-NOISE'.
C
C
C  ZERO THE HEADER RECORDS
      DO 10 I=1,100
   10 A(I)=0
C
C  INTERFEROMETER BASELINE AND POLE DATA
      SIND=0.376227
      COSD=0.926527
      SINH=-0.9530919
      COSH=-0.3026810
      CONFC= 900./1048576.
C  WHERE CONFC IS A CONVERSION FACTOR
C  FROM METERS TO WAVELENGTHS.
C
C  READ SOURCE AND BASELINE DATA
      READ (5,100) NAME,RA,DEC,SCANNO,B
  100 FORMAT(5A2,R12.2,8X,S12.1,5X,F3.0,6(F5.0))
C
C  SAFEGUARD AGAINST DIVISION BY ZERO
C  CHANGE RA AND DEC TO TURNS
      IF (ABS(RA).GT.1.0E-50) RA=RA/PI2
      IF (ABS(RA).LE.1.0E-50) RA=0.
      IF (ABS(DEC).GT.1.0E-50) DEC=DEC/PI2
      IF (ABS(DEC).LE.1.0E-50) DEC=0.
C  WE ARE NOW  CONSTRUCTING AN INTERFEROMETER TAPE
C  FILL IN EARLY PARTS OF THE HEADER
      A(1)=1
      A(2)=SCANNO
      DO 1 I=1,5
    1 A(6+I)=NAME(I)
      CALL INVDWD (RA ,A(12))
      CALL INVDWD (DEC,A(14))
      A(18)=MODE
C
C     COMPUTE AND STORE BASELINES.
      DO 2 I=1,6
      J=IWRD(I)
      B(I)=B(I)*CONFC
      IF (I.GT.3) B(I) = B(I)*3
      BZ=B(I)*SIND
      BX=B(I)*COSD*COSH
      BY=B(I)*COSD*SINH
      CALL INVDWD(BZ,A(J))
```

```
      CALL INVDWD(BX,A(J+8))
      CALL INVDWD(BY,A(J+16))
      A(J+24)=0
      A(J+25)=0
    2 CONTINUE
C
C     WRITE HEADER
      WRITE(9) A
C  ZERO THE DATA RECORDS
      DO 11 I=1,100
   11 A(I)=0
C  SET EARLY PARTS OF THE DATA RECORDS
      DO 14 I=43,91,2
   14 A(I)=1
      A(1)=2
      A(2)=SCANNO
      A(7)=4
C  SET MECHANICAL AND HORIZON LIMITS ON COVERAGE
C  AND THROW YOU OFF THE COMPUTER IF YOU PUT IN
C  IMPOSSIBLE COVERAGES
      IF (DEC.GE.0.0) MAXHA=87.5/360.
      Z=ARCOS(0.62166*SIN(DEC*PI2)+0.78328*COS(DEC*PI2))
      IF (DEC.LT.0.0.AND.Z.GT.PI2) WRITE (6,25)
   25 FORMAT (/,' THE DECLINATION IS TOO LOW')
      IF (DEC.LT.0.0.AND.Z.GT.PI2) STOP
      IF (DEC.LT.0.0.AND.Z.LE.PI2) MAXHA=AMIN1(ARCOS(-0.79367*TAN(DEC*PI
     .2))/PI2,72.5/360.)
C  SET MAXIMUM LST COVERAGE
      MINLST=RA-MAXHA
      MAXLST=RA+MAXHA
      IF (MINLST.GT.-0.5) GO TO 20
         MINLST=MINLST+1
         MAXLST=MAXLST+1
   20 IF (MAXLST.LT.0.5) GO TO 21
         MINLST=MINLST-1
         MAXLST=MAXLST-1
   21 START=-1.
C
C  READ IN LST START AND STOP TIMES
C  PROGRAM TAKES  CARE OF SIDERIAL DAY OVERLAP
C  AND  AUTOMATICALLY SETS YOU WITHIN THE LIMITS
C  IF YOU PUT IN IMPOSSIBLE COVERAGES
C  THE PROGRAM DEFAULTS TO FULL COVERAGE IF YOU DON'T
C  SPECIFY IT. THE DATA IS DUMPED EVERY 30 SEC
      SEC30=30./86400.
C     READ STOP AND START TIMES
C
   12 READ(5,101,END=1000) START,STOP
  101 FORMAT (R9.0,1X,R9.0)
      IF (ABS(START).GT.1.0E-50) START=START/PI2
      IF (ABS(START).LE.1.0E-50) START=0.
      IF (ABS(STOP ).GT.1.0E-50) STOP=STOP/PI2
      IF (ABS(STOP ).LE.1.0E-50) STOP=0.
      IF (START.GT.STOP) START=START-1
      IF (START.LE.MAXLST) GO TO 22
      START=START-1
      STOP=STOP-1
   22 IF (STOP.GE.MINLST) GO TO 23
```

```
      START=START+1
      STOP=STOP+1
   23 IF (START.LT.MINLST) START=MINLST
      IF (STOP.GT.MAXLST) STCP=MAXLST
      TIME=START
   13 CONTINUE
      TIMES=TIME
      IF (TIME.LT.0.0) TIMES=TIMES+1
      IF (TIME.GT.1.0) TIMES=TIMES-1
      CALL INVDWD (TIMES,A(5))
      TIME=TIME+SEC30
      IF (TIME.GT.STOP) GO TO 12
C  WRITE IT ON THE TAPE
      WRITE(9) A
      GO TO 13
 1000 IF (START.NE.-1.) STOP
      START=MINLST
      STOP=MAXLST
      TIME=START
      GO TO 13
 1001 CONTINUE
      END
```

```
C
C
      EXTERNAL TYPE1,TYPE2,TYPE3
      INTEGER  NRNDOM,  POL4/1/,FLDVU,CPF
      LOGICAL MORE,REWIND
      LOGICAL*1 POLAR(5,2)/'R','I','G','H','T',' ','L','E','F','T'/
      REAL*4  WA(10),WB(10),WC(10),AMP(10),X0(10),Y0(10),RAD2,W2
      REAL*4 CRUD,CRAP
      COMMON  CPF,WA,WB,WC,AMP,X0,Y0,NGAUSS,NRNDOM
      COMMON  CRUD,CRAP,FLDVU,NOISE
      LOGICAL*1 NOISE
C
C
C  --------------------  SOURCE-NOISE  -----------------
C
C          DUAL FREQUENCY PREP PROGRAM
C  INTERFEROMETER OBSERVATIONS ARE SORTED BY SOURCE AND THE SAMPLES
C  ARE WRITTEN ON SEQUENTIAL ACCESS FILES.
C  POL4=1 MEANS 42 FT RECEIVER IS ON LEFT CIRCULAR POLARIZATION.
C  POL4=0 MEANS 42 FT RECEIVER IS ON RIGHT CIRCULAR POLARIZATION.
C
C  READ IN FIELD OF VIEW IN MINUTES AND
C  NUMBER OF COUNTS PER FLUX UNIT
      READ (20,120,END=251) CPF,FLDVU
  120 FORMAT (2(I4,2X))
  251 CONTINUE
C
      PRINT 100, CPF,FLDVU
      PRINT 101,(POLAR(J,POL4+1),J=1,5)
  100 FORMAT(50X,'SYNNOISE' / 35X,'THE INSTRUMENTAL SENSITIVITY IS',
     +    I4,' COUNTS PER FLUX UNIT.' / 35X,'THE FIELD OF VIEW IS',
     +    I4,' MIN OF ARC IN RA, 5/6 AS LARGE IN DEC.')
  101 FORMAT(35X,'THE 42 FT. IS ON ',5A1,' CIRCULAR POLARIZATION.')
  105 FORMAT(////6X,'SCAN',8X,'BASELINES',6X,'SOURCE')
C
C
      NOISE=.FALSE.
C  SET THE INITIAL VALUE  FOR THE PSUEDO-RANDOM
C  NUMBER GENERATOR (ODD, LESS THAN 9 DIGITS)
C  READ IN THE STANDARD DEVIATIONS
C  FOR THE NOISE GENERATOR
      READ (20,123,END=250) NRNDOM,CRUD,CRAP
  123 FORMAT (I9,1X,2(F6.3,4X))
  250 CONTINUE
C   READ GAUSSIAN PARAMETERS, CALCULATE
C   CONSTANTS NEEDED LATER
      RAD2 = 6.2832/206265.
C  W2'S EQUAL TO SQRT(PI2/4LN2)/NO OF SECONDS PER RADIAN,ALL SQUARED
C  IT IS A HALF POWER TO SIGMA SCALING FACTOR
      W2 = -(1.8867186666/206265.)**2
      DO 201 I=1,10
C  READ IN THE GAUSSIAN SOURCES
C
  206 READ (10,200,        END=202) AMP(I),A,B,THETA,X0(I),Y0(I)
  200 FORMAT (F6.3,3F6.1,2F6.3)
C
C  SET THE NOISE OPTION
C  IF THE FIRST DATA CARD = 999999
```

```
C  THE NOISE WILL BE TURNED ON
      IF (AMP(I).NE.999.999) GO TO 205
      NOISE=.TRUE.
      WRITE (6,207)
  207 FORMAT (/,' NOISE IS TURNED ON')
      WRITE (6,124) NRNDCM,CRUD,CRAP
  124 FORMAT (//,' THE INITIAL RANDOM NUMBER IS ',I9,/,
     + ' THE PEAK GAUSSIANS FOR THE REALS AND THE IMAGINARIAES ARE ',
     +   F6.3,' AND ',F6.3)
      GO TO 206
  205 CONTINUE
      PRINT 204
  204 FORMAT (/////,' THESE ARE THE ARTIFICIAL GAUSSIAN SOURCES',//,
     +'   NO.      AMP        MAJ AX       MIN AX          P.A.         DX
     +DY')
      WRITE (6,203) I,AMP(I),A,B,THETA,XO(I),YO(I)
  203 FORMAT (3X,I2,4X,F6.3,4X,3(F6.1,6X),2(F6.3,5X))
C
C  SET UP  THE GAUSSIAN SOURCES FOR
C  LATER COMPUTATION
      NGAUSS=I
      THETA = THETA/57.2958
      CT = COS(THETA)
      ST = SIN(THETA)
      WA(NGAUSS) = W2 * ((A*ST)**2+(B*CT)**2)
      WB(NGAUSS)= W2*((B*ST)**2+(A*CT)**2)
      WC(NGAUSS)= W2 *    (A**2 - B**2) * ST
      XO(NGAUSS) = -RAD2*XO(NGAUSS)
      YO(NGAUSS) = +RAD2*YO(NGAUSS)
  201 CONTINUE
  202 CONTINUE
      PRINT 105
C
C  PLUG ALL THIS DATA INTO THE TAPE
C  WE ARE CREATING
    1 CALL INID(MORE,REWIND,&2,&3)
      CALL TREAD(MORE,REWIND,TYPE1,TYPE2,TYPE3,0,0)
      IF(MORE)   GO TO 1
C
    3 PRINT 103
  103 FORMAT(5X,'THAT''S ALL FOLKS.')
      STOP
C
    2 PRINT 102
  102 FORMAT(5X,'ERROR ON A DATA CARD IN INID')
      STOP 12
C
      END
```

```
      SUBROUTINE PREP
      LOGICAL*1 RECORD(24)
      REAL*8 RA,DEC,DWORD,BX(4,2),BY(4,2),BZ(4,2),SIND,COSD
      REAL*8 BXSIND(4,2),BYSIND(4,2),BZCOSD(4,2)
      REAL*8 PI2/6.2831853071795860D0/,T20/1048576.D0/
      REAL GAIN (2)/10.0,100.0/
      REAL  WA(10),WB(10), WC(10),AMP(10),X0(10),Y0(10)
      INTEGER LBASE(4),NRNDOM
C     THE CRAZY ORDER FOR THE 85FT CORRS IS NOT USED FOR THE 42FT
      INTEGER RELOC(4,4)/49,45,73,69,57,53,81,77,65,61,89,85,93,97,0,0/
      INTEGER IMLOC(4,4)/50,46,74,70,58,54,82,78,66,62,90,86,94,98,0,0/
      INTEGER WLOC (4,4)/51,47,75,71,59,55,83,79,67,63,91,87,95,99,0,0/
      INTEGER KOR(4,4)/2,1,8,7,4,3,10,9,6,5,12,11,13,14,15,16/
      INTEGER CPF
      INTEGER*2    NNOISE,   A(100),I,CORR(2)
      INTEGER*2 GN(16)
      LOGICAL*1 POLBYT(14),NOISE
      LOGICAL*1 BIT(16,2),NBYTE(4)
      COMMON  CPF,WA,WB,WC,AMP,X0,Y0,NGAUSS,NRNDUM
      COMMON  CRUD,CRAP,FLOVU,NOISE
      EQUIVALENCE (NBYTE,N)
      COMPLEX*8 CELL,CELNEW
      REAL*4 IMARG
      REAL*4 RE(2)
      EQUIVALENCE (CELL,RE(1))
C
C  WE NOW ENTER A SUBROUTINE IN WHICH
C  WE CAN SAMPLE OUR IMAGINARY SOURCES
C  IN EXACTLY THE SAME WAY AS THE INTERFEROMETER
C  WE ARE ALSO SAMPLING THE NOISE
C
C  MAKE A STRUCTURE TO CONSERVE WRITE TIME.
C  THE RECORD CONTAINS REAL, IMAGINARY, U, V,
C  FREQUENCY(0=S,1=X),  POLARIZATION(0=LL,1=LR,2=RL,3=RR)
C  REAL AND IMAGINARY PARTS ARE IN FLUX UNITS AND U AND V ARE IN WAVELENGTHS
      INTEGER*2 BAND,POLAR,BLEN,WT,IPOL(4)/0,3,1,2/
      EQUIVALENCE (RECORD(1),RE),(RECORD(5),IM),(RECORD(9),KU)
      EQUIVALENCE (RECORD(13),KV)
     .,  (RECORD(17),BAND),(RECORD(19),POLAR),(RECORD(21),BLEN)
     .,  (RECORD(23),WT)
C
C
C ..........................................................................
C
      ENTRY TYPE1(A,CORR)
      INTEGER A37,A39,A41,A43
C
C  ENTER WITH A TYPE 1 RECORD
C
C
C  BITS USES THE FIRST VARIABLE AS THE ARGUMENT (HALF WORD).
C  THE SECOND VARIABLE IS AN ARRAY OF 16 BYTES WHICH ARE SET TO
C  0 OR 1 IF THE CORRESPONDING BIT IN THE FIRST ARGUMENT IS RESET OR SET.
      CALL BITS(CORR(1),BIT(1,1))
      CALL BITS(CORR(2),BIT(1,2))
C
C  SAVE INFO FROM A HEADER RECORD OF A SCAN TO BE USED
C
```

```
C  DWORD TAKES A(I)/(2**15) AND A(I+1)/(2**30) AND MAKES A FULL WORD
C  RESULT, IN REVOLUTIONS OF A CIRCLE.
      RA=DWORD(A(12))*PI2
      DEC=DWORD(A(14))*PI2
      SIND=DSIN(DEC)
      COSD=DCOS(DEC)
C  RESET BASELINES WHEN BX CHANGES FOR ANY CORRELATOR
      IF(A(37).EQ.A37.AND.A(39).EQ.A39.AND.A(41).EQ.A41.AND.
     +   A(43).EQ.A43)    GO TO 3
      A37=A(37)
      A39=A(39)
      A41=A(41)
      A43=A(43)
      DO 2 K=1,4
      K2=2*K
      DO 1 N=35,67,32
      J=N/32
      BZ(K,J)=DWORD(A(N+K2))*T20
      BX(K,J)=DWORD(A(8+N+K2))*T20
      BY(K,J)=DWORD(A(16+N+K2))*T20
C
    1 CONTINUE
C  LBASE(K) IS THE BASELINE LENGTH IN HUNDREDS OF METERS.
      LBASE(K)=DSQRT(BX(K,1)*BX(K,1)+BY(K,1)*BY(K,1)+BZ(K,1)*BZ(K,1))*
     +  0.1115
    2 LBASE(K)=(LBASE(K)+50)/100
C
C  K IS THE TELESCOPE PAIR.
C
    3 DO 4 K=1,4
C  N IS THE FREQUENCY (S OR X BAND).
C
      DO 4 N=1,2
      BXSIND(K,N)=BX(K,N)*SIND
      BYSIND(K,N)=BY(K,N)*SIND
      BZCOSD(K,N)=BZ(K,N)*COSD
    4 CONTINUE
      WRITE(6,100)  A(2),LBASE,(A(J),J=7,11)
      WRITE(9) A
  100 FORMAT (4X,I6,1X,4I5,3X,5A2)
      RETURN
C
C ........................................................................................
C
      ENTRY TYPE2(A)
C
C
C  RETRIEVE THE SAMPLES FROM A DATA RECORD
C
C  THE H. A. IS THE MIDPOINT OF THE SAMPLE EXCEPT NEAR CROSSOVER
      HA=DWORD(A(5))*PI2-RA
      SINH=SIN(HA)
      COSH=COS(HA)
C  A(7) IS THE SYSTEM SWITCH FROM DDP-116 (00RL00RL00RL0MSX)
C  WHERE 0=>S, 1=>X, AND THE TELESCOPES ARE IN ORDER (1,2, THEN 3).
C  FOR THE LAST 3 BITS , (4=>M,0=>S,1=>X,2=>DS,3=>DX MODES).
      N=A(7)
      LBIT=MOD(N,2)+1
```

```
      MBIT=MOD(N,8)
      KBAN=LBIT
      IF(MBIT.EQ.4)   KBAN=2
      CALL CORGN (A(10),GN)
C
CYCLE FREQUENCIES (S THEN X )
      DO 20 NU=LBIT,KBAN
C
C  BAND IS THE FREQUENCY (0=>S,1=>X).
      BAND = NU -1
      M1 = 1
      MPOL = 4
      IF (MBIT.NE.4) GO TO 14
      M1 = NU
      MPOL = NU
   14 CONTINUE
C
CYCLE TELESCOPE PAIRS ( 1.2, 1.3, 2.3, 1.4 )
      DO 20 K = 1,4
C
C  BLEN IS THE BASELINE LENGTH IN HUNDREDS OF METERS.
      BLEN = LBASE(K)
C
C  E-W COMPONENT OF THE PROJECTED BASELINE
       U = BX(K,NU)*SINH-BY(K,NU)*COSH
C  N-S COMPONENT OF THE PROJECTED BASELINE
       V = BZCOSD(K,NU)-BXSIND(K,NU)*COSH-BYSIND(K,NU)*SINH
      UU=U*U
      UV=U*V
      VV=V*V
C
      MM = M1
      MMM = MPOL
C   NEXT 5 STMTS PATCHFOR 42 FT
      IF (K.LT.4) GO TO 13
      IF (NU.EQ.2) GO TO 20
      MM = 1
      MMM = 2
   13 CONTINUE
C
CYCLE POLARIZATIONS (LL, RR, LR, RL )
      DO 18 M = MM,MMM
C
C     IN MIXED MODE, 1R IS X BAND WHILE THE 42FT IS S BAND
      IF (K.EQ.4.AND.M.EQ.1.AND.MBIT.EQ.4) GO TO 18
C
C     CHECK WT AND CORR MASK
      IF (BIT(KOR(M,K),NU))  A(WLOC(M,K)) = 0
      WT = A(WLOC(M,K))
      IF (WT.LT.1) GO TO 18
C
C   COMPUTE VISIBILITY FUNCTION IF F.U.
      CELL = (0.,0.)
      IF (.NOT.NOISE) GO TO 22
C   FILL IN THE REAL AND IMAGINARIES
C   WITH RANDOM GAUSSIAN NOISE
C   OF STANDARD DEVIATIONS 'CRUD' AND 'CRAP'
C   RESPECTIVELY
```

```
      CALL GAUSS(NRNDCM,CRAP,0.,ANOISE)
      RE(1)=ANOISE
      CALL GAUSS(NRNDCM,CRUD,0.,ANOISE)
      RE(2)=ANOISE
   22 CONTINUE
      CALL EXPOFF
      DO 21 I=1,NGAUSS
      REARG   = WA(I)*UU+WB(I)*VV+WC(I)*UV
      IMARG   = XO(I)*U+YO(I)*V
C  CREATE THE SAMPLING CELLS AND FILL THEM IN
      CELNEW = AMP(I)*CEXP(CMPLX(REARG,IMARG))
      CELL = CELL + CELNEW
   21 CONTINUE
C
C   CONVERT TO COUNTS
      CELL = CELL*CPF
      CALL EXPON
C   ZERO THE GAINS
      A(10)=0
C   STUFF THE ANSWER INTO RE,IM,WT
C   FOR THIS CORR.
      A(RELOC(M,K)) = REAL(CELL)
      A(IMLOC(M,K)) = AIMAG(CELL)
      A(WLOC(M,K))=1
      A(WLOC(M,K)+1) = 0
C
C
   18 CONTINUE
C
   20 CONTINUE
C
C WRITE THE OUTPUT RECORD
C
      WRITE (9) A
C
      RETURN
C
C.....................................................
C
      ENTRY TYPE3(A)
C
C
      WRITE(9) A
      RETURN
      END
```

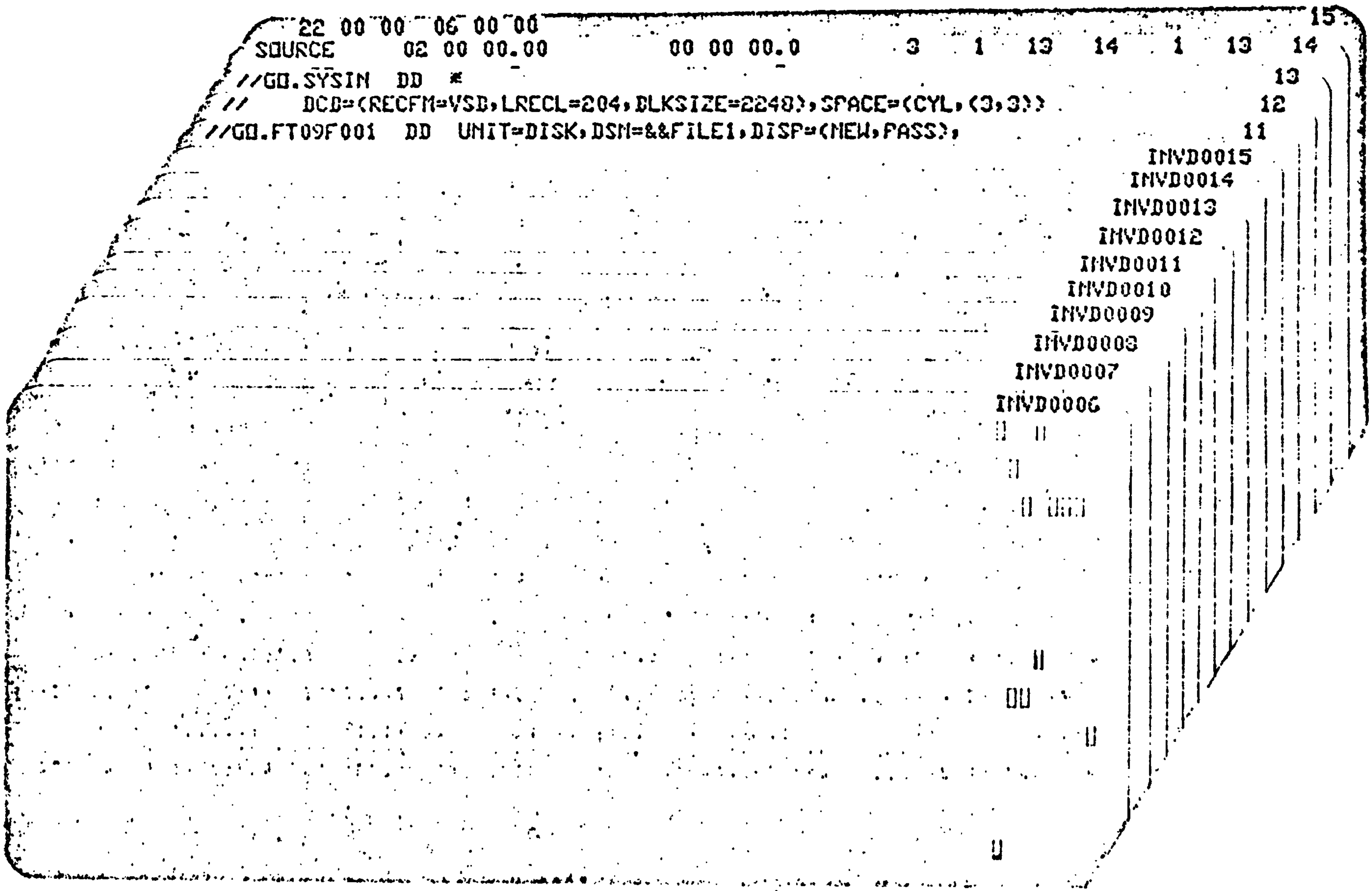
JCL? WHO NEEDS IT?

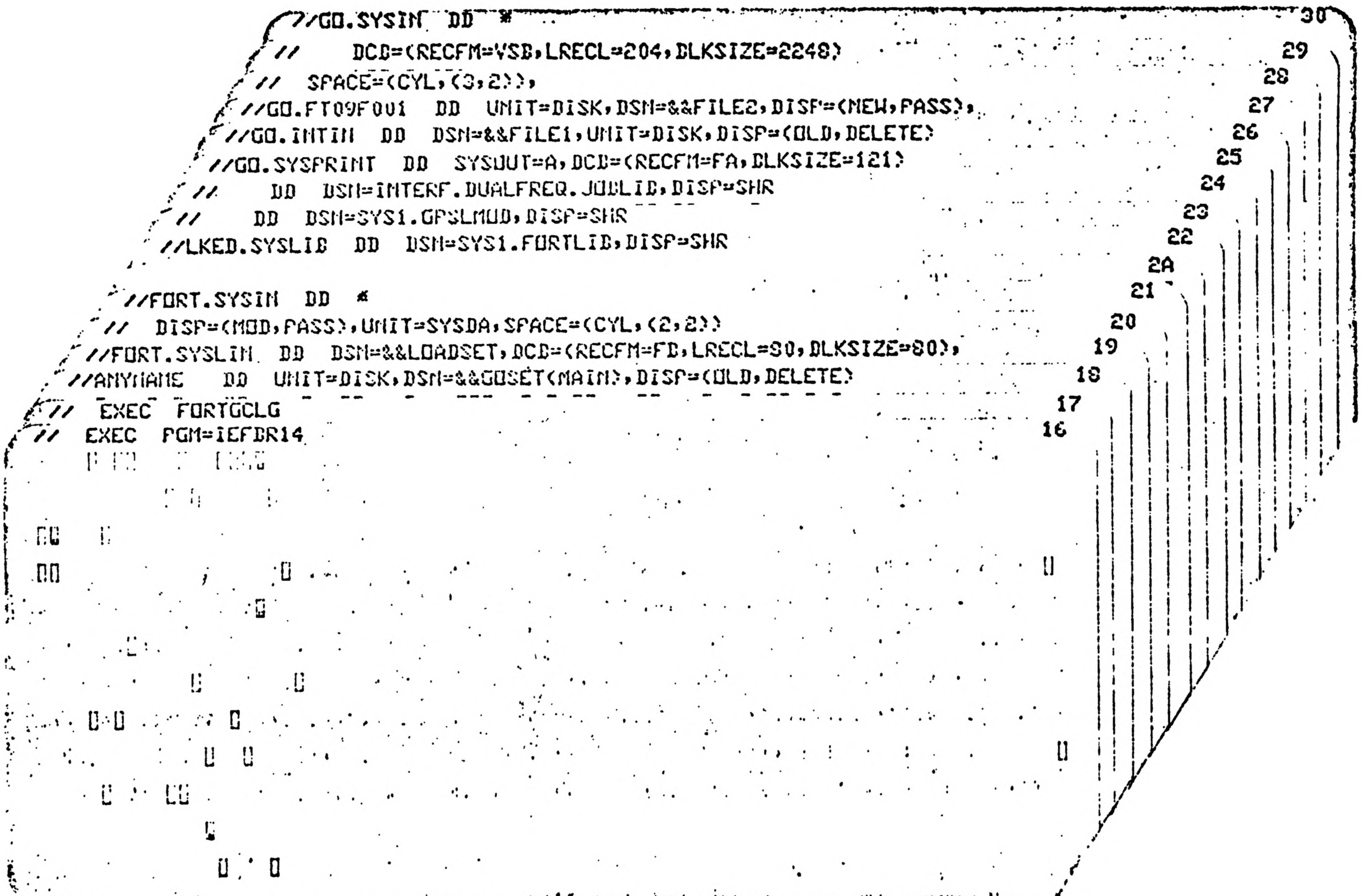
Experience has shown that the average visitor to NRAO can adjust his observing and reduction to all of the idiosyncracies of the observatory except the Job Control Language needed to get on and off the computer. For humanitarian reasons, the author now provides an explanation for the JCL and input data cards necessary to run the program in its four modes.

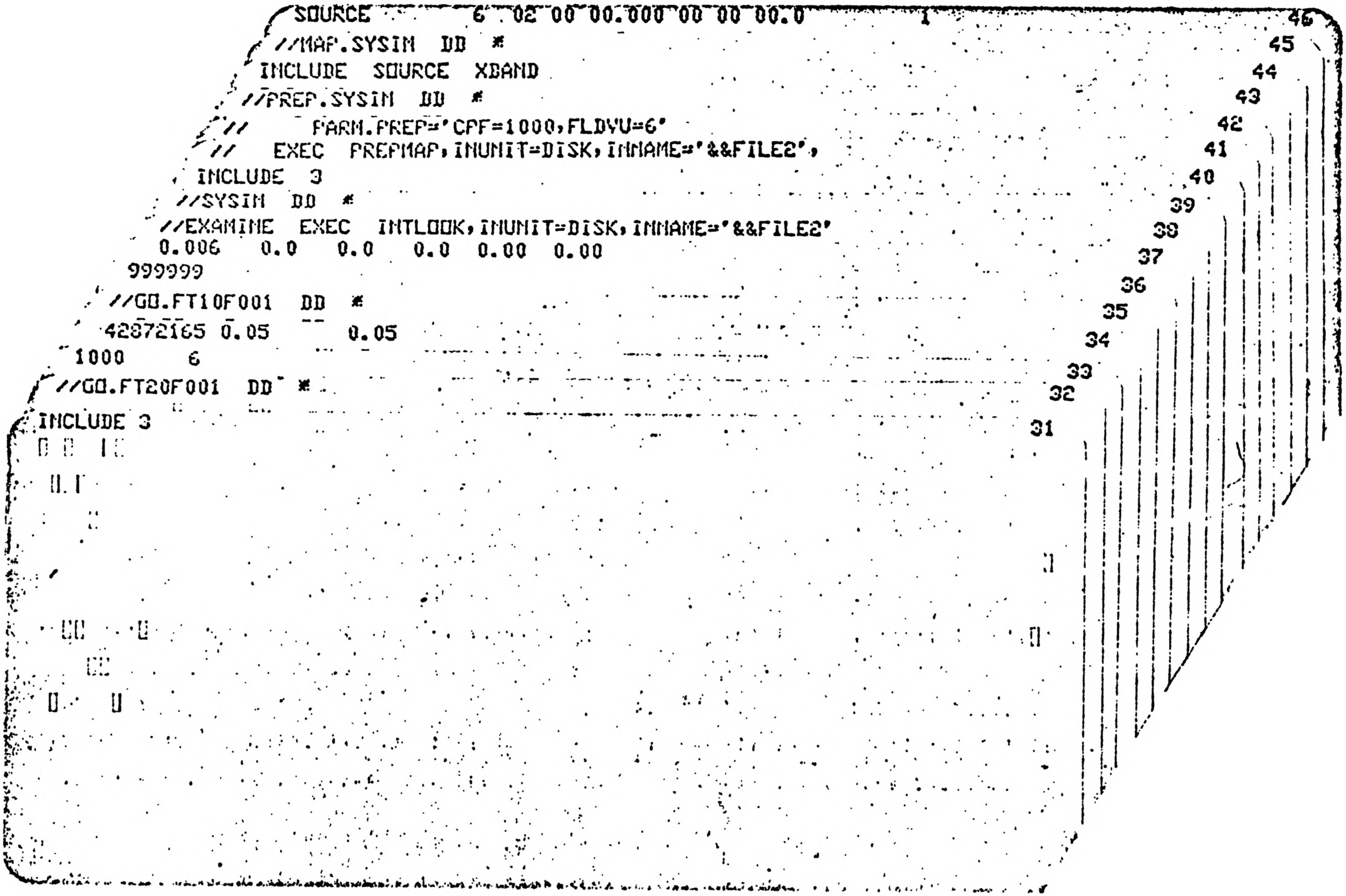
Mode 1. SYNNOISE

Synnoise is the complete modeling program. The user provides both the coverage and source data. Used in this mode the program has two main applications. First, the observer whose program includes several sources may wish to optimize his observing log prior to going on the telescope. Studies of beamshapes and sidelobe effects may reveal a better way to organize the observations, before they begin. Second, the user may just wish to model sources from a theoretical point of view under observation-like conditions. For instance, the response of the interferometer to an expanding source or a jet could be tested and compared with available observations.

The next four pages show the deck structure for SYNNOISE. The numbers in columns 79 and 80 are for ordering purposes only, and should not be included on the cards. A description of each card follows the deck structure. The JCL is designed along the lines of the Interferometer Job Library routines so that it can be immediately interfaced with other utility or reduction programs. Additional questions concerning the JCL can be answered by consulting the IBM - JCL Guide or the author.


22 00 00 06 00 00
15
SOURCE 02 00 00.00 00 00 00.0 3 1 13 14 1 13 14
//GO.SYSIN DD *
13
// DCB=(RECFM=VSB,LRECL=204,BLKSIZE=2248),SPACE=(CYL,(3,3))
12
//GO.FT09F001 DD UNIT=DISK,DSN=&&FILE1,DISP=(NEW,PASS),
11
INVD0015
INVD0014
INVD0013
INVD0012
INVD0011
INVD0010
INVD0009
INVD0008
INVD0007
INVD0006


//GO.SYSIN DD * 30
// DCB=(RECFM=VSB,LRECL=204,BLKSIZE=2248) 29
// SPACE=(CYL,(3,2)), 28
//GO.FT09F001 DD UNIT=DISK,DSN=&&FILE2,DISP=(NEW,PASS), 27
//GO.INTIN DD DSN=&&FILE1,UNIT=DISK,DISP=(OLD,DELETE) 26
//GO.SYSPRINT DD SYSOUT=A,DCB=(RECFM=FA,BLKSIZE=121) 25
// DD DSN=INTERF.DUALFREQ.JOBLIB,DISP=SHR 24
// DD DSN=SYS1.GPSLMOD,DISP=SHR 23
//LKED.SYSLIB DD DSN=SYS1.FORTLIB,DISP=SHR 22
2A
//FORT.SYSIN DD * 21
// DISP=(MOD,PASS),UNIT=SYSDA,SPACE=(CYL,(2,2)) 20
//FORT.SYSLIN DD DSN=&&LOADSET,DCB=(RECFM=FB,LRECL=80,BLKSIZE=80), 19
//ANYNAME DD UNIT=DISK,DSN=&&GOSET(MAIN),DISP=(OLD,DELETE) 18
// EXEC FORTGCLG 17
// EXEC PGM=IEFBR14 16


SOURCE 6 02 00 00.000 00 00 00.0 1
46
//MAP.SYSIN DD *
45
INCLUDE SOURCE XBAND
44
//PREP.SYSIN DD *
43
// PARM.PREP='CPF=1000,FLDVU=6'
42
// EXEC PREPMAP,INUNIT=DISK,INNAME='&&FILE2',
41
INCLUDE 3
40
//SYSIN DD *
39
//EXAMINE EXEC INTLOOK,INUNIT=DISK,INNAME='&&FILE2'
38
0.006 0.0 0.0 0.0 0.00 0.00
37
999999
36
//GO.FT10F001 DD *
35
42872165 0.05 0.05
34
1000 6
33
//GO.FT20F001 DD *
32
INCLUDE 3
31

Card	Description
1.	The job card -- where U is the user number, and S,T,R,D describe the type of program as specified by the NRAO Job Code (user's option). These are for accounting purposes. The job runs in a 90 K partition for 12 minutes of Central Processing Unit (CPU) time (Class E).
2.	The compile card -- compiles the Fortran program and links it to the object deck (INVDWD) and causes the program to execute.
3.-4.	The system-link card -- specifies how the data are handled. The data set name (DSN) is called Loadset. The &&'s indentify it as a temporary data set that will be killed when the program is terminated. The data have the following limiting values specified for the Data Control Block (DCB). The data are in record formats (RECFM) that are integral multiples of the logical record length (LRECL), i.e. they are fixed length and blocked (FB). The maximum logical record length is 80 bytes as are the data blocks (BLKSIZE). The disposition (DISP) of the data set is that it is to be created (MOD) and then passed (PASS) to a later job step. The data will be temporarily stored on a direct access device (SYSDA), namely a temporary disk (CYL) and will be allocated two tracks for storage with two more tracks held for overflow (2,2).
5.	The Fort. Sysin DD card -- always preceeds a Fortran program. It indicates that the source deck follows.
6.	Insert subprogram COVERAGE here.
7.-9.	Library cards -- these cards tell the computer to share (SHR) subroutines stored in the Fortran Library (SYS1. FORTLIB), the Scientific Subroutine Package (SYS1. GPSLMOD), and the Interferometer

Dualfrequency Job Library (INTERF.DUALFREQ.JOBLIB).

10. Link card -- links and edits the program to mesh with the assembly language subroutine Inverse D-Word (INVDWD) which comprise the next 15 cards. Inverse D-Word is a routine that allows one to make a hexadecimal word from a word that would normally occupy four times as many bits with the same information. It is a space saving routine.

11.-12. The Go.FT09 card -- assigns a unit, namely the disk, on which the data we are creating for the interferometer tape can be temporarily stored. We have equated the disk to UNIT 9. The A(100) pieces of data (see program listing) are lumped into a data set called FILE1. This is new data (NEW) that is passed (PASS) on to the SOURCE-NOISE program. However, these data are grouped into variable sized blocks (VSB) of no more than 2248 bytes. The logical records are no more than 204 bytes, and slightly more space (3,3) is allocated to the cylinder.

13. The Go card -- tells the computer to execute the program on the data cards that follow.

14. Data card -- this card specifies the source name, the right ascension and declination of the source, the scan number and the baselines. The card format is as follows: (5A2,R12.2,8X,S12.1,5X,F3.0,6F5.0). The source name cannot be over ten letters long. The R.A. and Dec. are read in the usual way; the R and S formats are NRAO formats that automatically are converted to radians. The scan number <u>must</u> be specified anytime the data will be stored on tape; it is one of the key words used on the include-exclude cards.

The baselines are read in hundreds of meters. The stations for the movable elements are at 12,15,18,19,21,24, and 27 hundred meters, so care must be taken to assure that the baselines of any single observation period are possible. For instance, 1,18,19 is a possible set of baselines, while 12,18,27 is not. If this set of baselines is desired then at least two scans of the source would have to be made. The first three baselines correspond to S-Band, and the second three correspond to X-Band. But, unless one has special reasons for making them different, it is suggested that they be made identical. (Note that the sample card has incorrect baselines needed to maintain continuity in the numerical ordering of the cards.)

15. Time card -- this card gives the Local Siderial start and stop times. The format is (R9.0,1X,R9.0).

16. The PGM card -- this card can link the programs COVERAGE and SOURCE-NOISE together. It effectively holds the partition so that the piggy-back program can be run immediately following the execution of COVERAGE. This card and all the previous cards (including the COVERAGE deck) are unnecessary if the coverage information is copied from other sources.

17. see 2.

18. Dummy Data card -- this card kills any extraneous data from the previous program (GOSET(MAIN)).

19.-20. see 3.-4.

21. see 5.

2A. Insert the SOURCE-NOISE program here.

22.-24. see 7.-9.

25. Print card -- this card indicates that data in the A(100) array (see program listing) will be printed. The records are fixed length and the printer control characters will be supplied (FA).

26. Intin. card -- here we indicate that input data from the previous program (OLD) under the name FILE1 will be supplied from the disk. After the data are accessed they are no longer useful and will be killed (DELETE).

27.-29. Go.FT09 card -- same as 11.-12. except that we are creating a new data set that we call FILE2.

30. see 13.

31. An Include card -- indicates that we only want data from FILE1 with a scan number of three (in this example). Include-Exclude cards may also contain the source name, the frequency band, polarization, and mode. See the <u>Guide to Users</u> for additional information. We only need to supply the scan number since it cannot be confused with any other data (in this case).

32. Go.FT20 card -- this card indicates that the data to be read by unit 20 follows. Recall that we have included several READ(20,..) statements in the program.

33. CPF card -- this card contains the counts per flux unit and the field of view for the map. The format is 2(I4,2X). Remember that all I-formats must be right justified. The field of view is in minutes of arc and is normally 18' for S-Band and 6' for X-Band.

34. Noise card -- this card contains the initial number for the noise generator (it must be an odd number of between three and nine digits), and the standard deviations of the noise for the real and imaginary parts of the visibility function. Note that the number

generator is not truly random, but that the numbers generated will always be the same, consecutively, for the same initial number. Therefore, the program is exactly repeatable for a given initial number. Bearing this in mind one would want to use a different initial random number when generating each scan. The standard deviation should only be changed from its value of 0.05 f.u. if the receiver characteristics change.

35. Go. FT10 card -- similar to 32.

36. Noise triggering card -- if this card is included, then a flag will be set in the program that will include noise in the model observations. Without this card, the models will be generated in a noise-free (ideal receiver) field. The format is F6.4.

37. Source card -- all model sources to be observed in the field are included here. Each source has the following attributes (in order):

a) flux density at maximum -- in f.u. ($10^{-26}W/m^2$).
b) major axis -- in seconds of arc to the half power points.
c) minor axis -- same as above (Note that point sources are represented by zero widths.)
d) the position angle of the minor axis -- in degrees.
e) the E-W cartesian position from the center of the field -- in seconds of arc.
f) the N-S cartesian position from the center of the field -- in seconds of arc.

Up to ten sources may be placed in the field at any one time. The program will accept negative sources, so proper combinations can result in ring structures if the observer desires.

The remaining cards are JCL and input cards for two programs that are standard (i.e. in the Interferometer Job Library) reduction procedures, and are helpful in examining the model source data.

38. Intlook card -- this card requests computer output concerning the header and data records. It gives the baseline coverage and the amplitude and phase for each thirty second record. See Fig. 4 for some sample output. The data are passed from the previous program on the disk under the temporary data set name FILE2.

39. Sysin card -- this card indicates that an Include-Exclude card will follow.

40. see 31.

41.-42. Prepmap card -- this card indicates that we want to prepare a map for output. The standard program constructs a 256x256 element map from the SOURCE-NOISE program on disk under the temporary data set name of FILE2. Two parameters must be specified before the program can be executed (PARM.PREP), the counts per flux unit and the field of view. These should be the same as the parameters given on card 33.

43. Prep.Sysin card -- this card gives the go ahead for the map preparation according to the specifications of the include card that follows.

44. see 31.

45. Map.Sysin card -- this card gives the go ahead to print the map.

46. Title card -- this card contains the source name, the field of view, and the source position for use in printing these as a header or title for the map. The formats are given in the <u>Guide to</u>

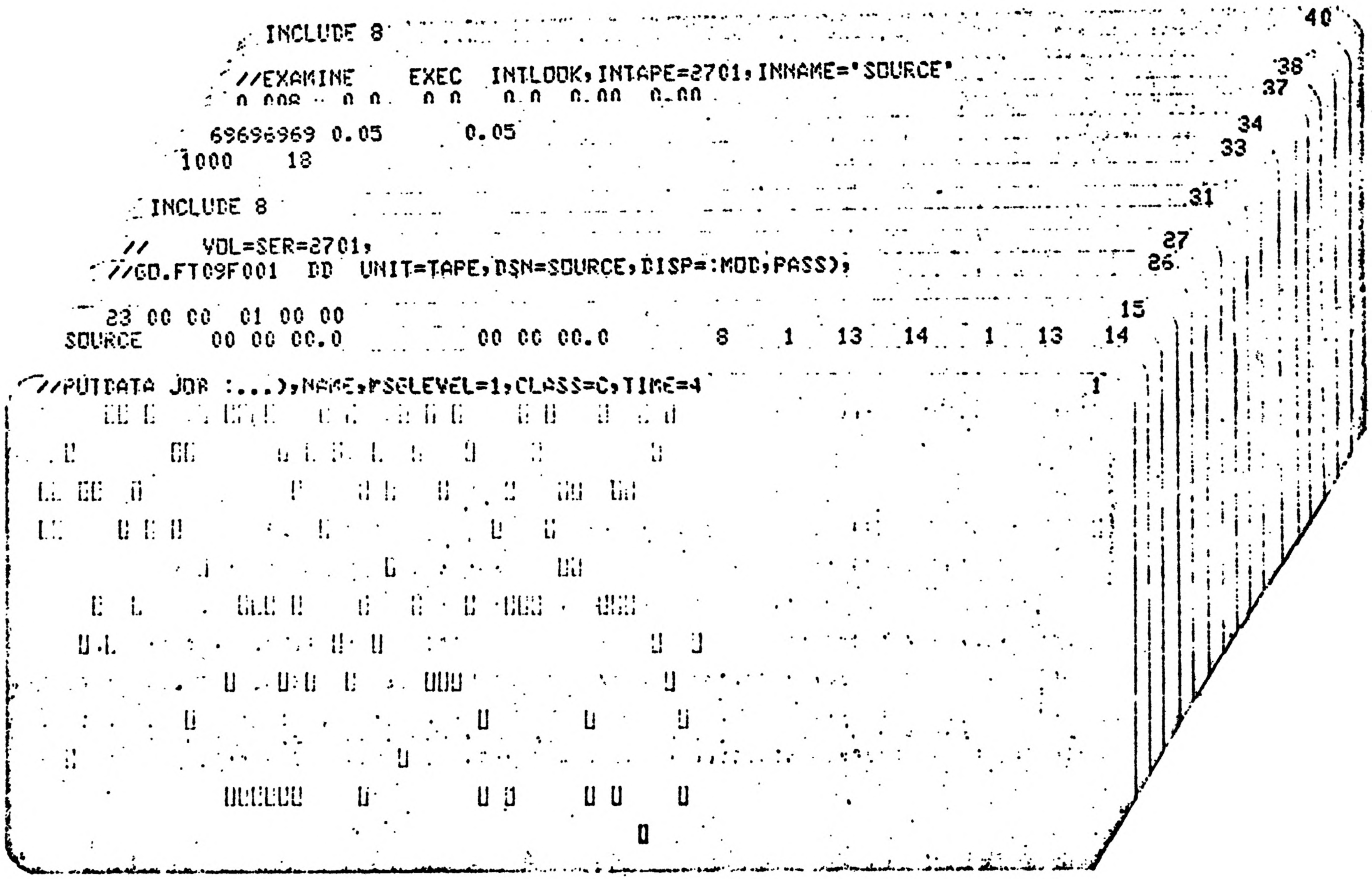
Users.

Several auxillary modes for operation of this program now follow. They demonstrate the versatility of the program, and also give the user additional flexibility in artificially creating his data to the specifications of his observing program.

Mode 2. PUTDATA

PUTDATA enables the user to store his scans on tape so that at a later time he may combine scans in much the same way as he would do during the reduction procedure. Cards 14,15,31,33,34,37, and 40 may be varied from scan to scan; certainly the initial random number should be changed since the noise is never the same for any two runs. The deck structure is shown on the following page. Only those cards that are different from those in SYNNOISE are shown; all other cards remain the same and are included in the PUTDATA deck, except the mapping cards 41-46.

Card	Description
1.	Note that the Job Class and Execution Time have now changed since we are no longer maping each individual scan.
26.-27.	Go.FT09 card -- note now that we are writing the data on tape, and since that data are permanent we have to assign it a permanent name, SOURCE. The particular tape has a volume (VOL), serial (SER) number assigned to it in this case 2701. These tapes may be borrowed by the user from the Computer Division. The disposition of the tape is that it is to be created, but the user should note with care the following. When the observer wants to create a new Archive Tape from scratch, DISP=NEW tells the computer to start writing from the beginning of the tape (i.e. it will erase any


INCLUDE 8
//EXAMINE EXEC INTLOOK,INTAPE=2701,INNAME='SOURCE'
69696969 0.05 0.05
1000 18
INCLUDE 8
// VOL=SER=2701,
//GO.FT09F001 DD UNIT=TAPE,DSN=SOURCE,DISP=(MOD,PASS),
23 00 00 01 00 00
SOURCE 00 00 00.0 00 00 00.0 8 1 13 14 1 13 14
40
38
37
34
33
31
27
26
15
1

data on the tape before it begins). To add further scans to the data tape, change DISP=NEW to DISP=MOD. The computer will search for an end of file and then begin to add new data to the tape.

38. The Intlook card -- the user should specify his archive tape number and the name of the source for which he wishes printed data. This job is inserted to allow the user to check the new data after it has been written on tape.

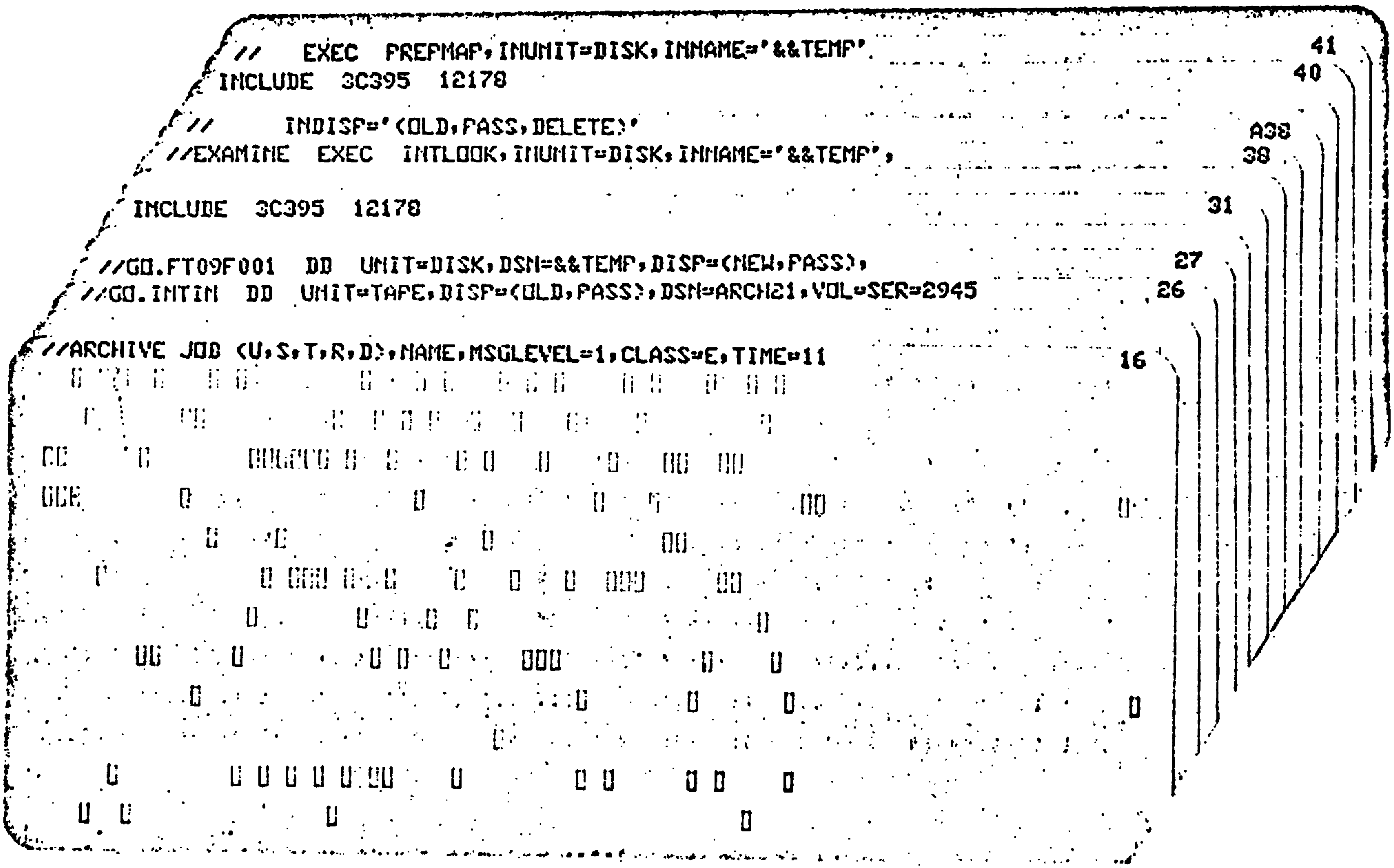
If the user would now want to map one or more of the scans he has created he can do it according to the procedure outlined in the Guide to Users.

The following two jobs allow the user the oppportunity to model sources using identical coverage th that of the real observations. This is done by copying the coverage data from the stored data of the real observations.

Mode 3. ARCHIVE

ARCHIVE allows the user to copy the coverage data from observations stored on Archive tapes. By comparing source data taken several months or years apart the user would be in a position to test evolutionary models. He can also gain a feel for apparent changes in source structure that are merely the result of different coverages or receiver characteristics. In short, ARCHIVE provides the user with the opportunity to model sources under actual observing conditions. Note that the first 15 cards of the original SYNNOISE deck are now omitted. Again, blank cards indicate that the original intervening cards are to be included.

Card	Description
16.	Job card -- Note that ARCHIVE is an 11 minute job.



// EXEC PREPMAP,INUNIT=DISK,INNAME='&&TEMP'. 41
INCLUDE 3C395 12178 40
// INDISP='(OLD,PASS,DELETE)' A38
//EXAMINE EXEC INTLOOK,INUNIT=DISK,INNAME='&&TEMP', 38
INCLUDE 3C395 12178 31
//GO.FT09F001 DD UNIT=DISK,DSN=&&TEMP,DISP=(NEW,PASS), 27
//GO.INTIN DD UNIT=TAPE,DISP=(OLD,PASS),DSN=ARCH21,VOL=SER=2945 26
//ARCHIVE JOB (U,S,T,R,D),NAME,MSGLEVEL=1,CLASS=E,TIME=11 16

26. Go.Intin card -- we are receiving our input data from the TAPE unit. Since it is already available, its disposition is OLD; we PASS it on to the program. The data set name and the tape number also have to be provided as part of the input data.

27. Go.FT09 card -- we are putting the new data we are creating on disk and passing it on to the INTLOOK step. We have assigned it the temporary data set name of TEMP.

31. Include card -- since the user will often have a number of scans of each source on his Archive tape it is imperative that he also include the scan number as part of the card data.

38.-A38 Intlook card -- the temporary data set is passed from the disk with the name TEMP. This old data will be passed to the next step if it is executed correctly or it will be deleted.

40. see 31.

41. Prepmap card -- the data set name passed is TEMP.

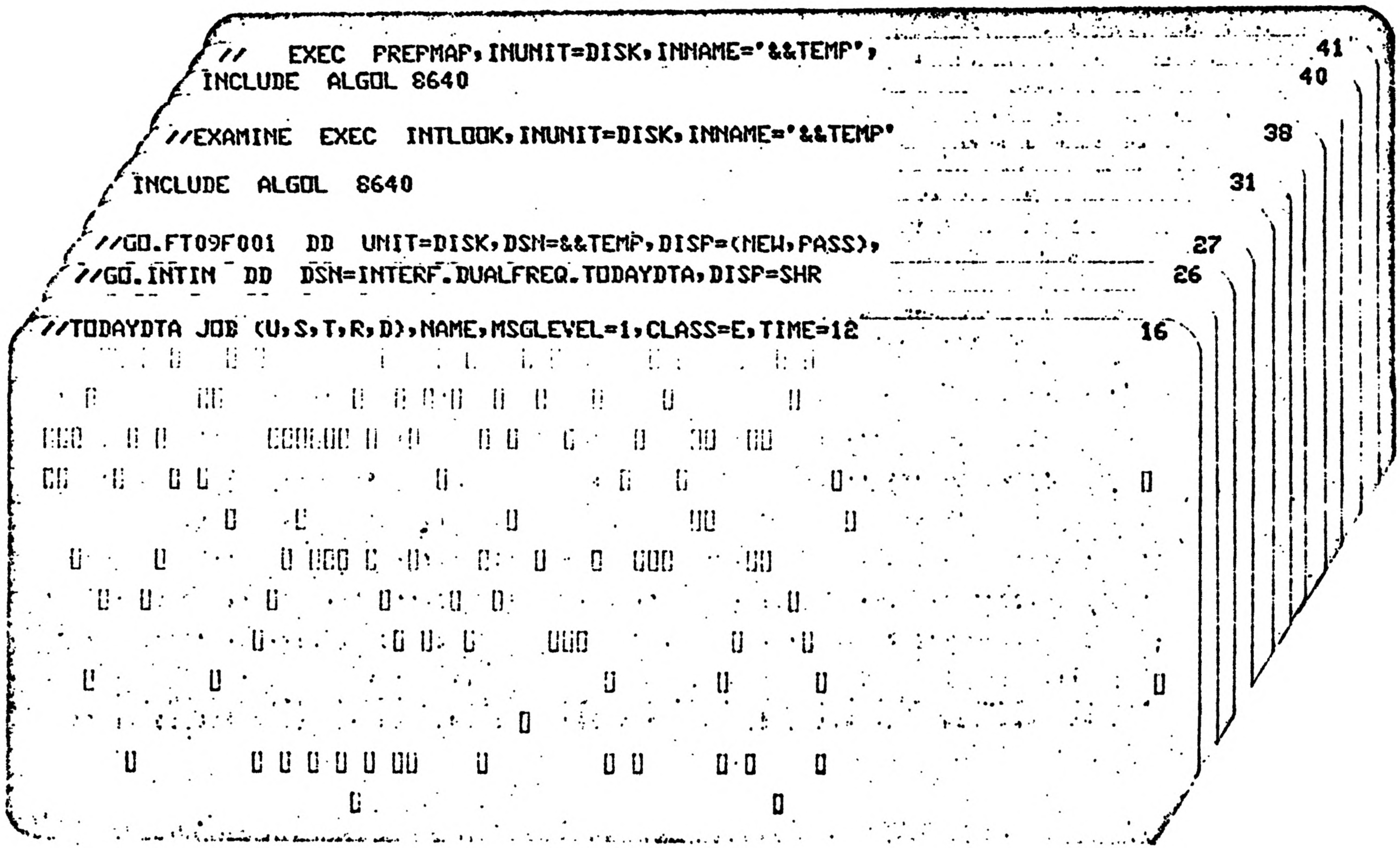
Mode 4. TODAYDTA

Sometimes there exists an anxious astronomer who cannot wait an extra day or two before he begins to reduce his data. Since the telescope tape is recorded on the disk and remains there for one day prior to filing it on an Archive tape, a slightly different approach must be made in order to access the coverage data. The deck on the following page shows the formula for modeling sources as per the coverage specified on the Today Data Set.

<u>Card</u> <u>Description</u>

16. The Job card -- TODAYDTA is a 12 minute job.

26. Go.Intin card -- the data set named INTERF.DUALFREQ.TODAYDTA is


// EXEC PREPMAP,INUNIT=DISK,INNAME='&&TEMP', 41
INCLUDE ALGOL 8640 40
//EXAMINE EXEC INTLOOK,INUNIT=DISK,INNAME='&&TEMP' 38
INCLUDE ALGOL 8640 31
//GO.FT09F001 DD UNIT=DISK,DSN=&&TEMP,DISP=(NEW,PASS), 27
//GO.INTIN DD DSN=INTERF.DUALFREQ.TODAYDTA,DISP=SHR 26
//TODAYDTA JOB (U,S,T,R,D),NAME,MSGLEVEL=1,CLASS=E,TIME=12 16

is shared with the disk.

27.- The remainder of the cards are similar to the ARCHIVE Job cards.

The following pages show sample output of the INTLOOK and Mapping routines. These are the most often used procedures in the Interferometer Job Library.

SOURCE (02 00 00.005, 045 00 00.08) GRWCH DAY NO. 2424832, LST 00 00 00. HA -02 00 00
IS OBSERVING WITH AS OPERATOR RETURN CODE WAS 0, CONSOLE SWITCHES 0000 0000 000

	85-1/85-2		85-1/85-3		85-2/85-3		
BX	-252.397	-252.397	-4543.163	-4543.163	-4795.562	-4795.562	0
BY	-794.759	-794.759	-14305.652	-14305.652	-15100.414	-15100.414	0
BZ	338.604	338.604	6094.878	6094.878	6433.483	6433.483	0
KTERM	0.0	0.0	0.0	0.0	0.0	0.0	0

****

22 00 00	000000	XS	78	-172	0.	22	92	0	56	-55	0	15	140	0	15	-26
22 00 30	000000	XS	98	13	0	42	31	0	47	-23	0	63	116	0	56	145
22 01 00	000000	XS	69	13	0	57	69	0	45	-100	0	80	86	0	55	132
22 01 30	000000	XS	39	-22	0	30	-29	0	19	30	0	84	45	0	36	-130
22 02 00	000000	XS	10	-5	0	86	68	0	40	128	0	75	-125	0	40	-34
22 02 30	000000	XS	48	-21	0	85	-155	0	86	123	0	125	-25	0	88	-71
22 03 00	000000	XS	130	-136	0	25	151	0	70	120	0	86	114	0	8	-20
22 03 30	000000	XS	36	-88	0	89	0	0	117	-56	0	48	41	0	41	60
22 04 00	000000	XS	88	-120	0	97	6	0	54	131	0	35	171	0	31	180
22 04 30	000000	XS	40	-32	0	56	-157	0	26	-34	0	61	-57	0	90	-86
22 05 00	000000	XS	20	43	0	52	45	0	40	-159	0	91	-67	0	59	-168
22 05 30	000000	XS	175	135	0	21	-52	0	6	116	0	62	11	0	111	175
22 06 00	000000	XS	77	136	0	94	-27	0	7	69	0	68	127	0	59	-130
22 06 30	000000	XS	106	-114	0	55	2	0	45	-89	0	26	173	0	48	-120
22 07 00	000000	XS	115	36	0	89	-16	0	99	42	0	28	67	0	112	-24
22 07 30	000000	XS	89	-89	0	87	-62	0	62	-31	0	24	-165	0	34	58
22 08 00	000000	XS	96	-44	0	101	-71	0	34	-138	0	36	47	0	69	-89
22 08 30	000000	XS	111	-66	0	69	156	0	80	108	0	90	37	0	23	180
22 09 00	000000	XS	70	108	0	46	-65	0	77	-137	0	31	10	0	34	-24
22 09 30	000000	XS	19	34	0	58	-133	0	38	-47	0	87	-155	0	10	-78
22 10 00	000000	XS	102	106	0	35	-4	0	28	-157	0	143	-106	0	32	29
22 10 30	000000	XS	67	-45	0	83	145	0	63	-105	0	22	-18	0	24	87
22 11 00	000000	XS	51	-82	0	30	-34	0	66	-31	0	82	-138	0	31	-52
22 11 30	000000	XS	35	-64	0	33	69	0	63	84	0	90	-22	0	80	104
22 12 00	000000	XS	12	-138	0	93	-13	0	84	96	0	70	47	0	84	139
22 12 30	000000	XS	112	150	0	54	61	0	36	60	0	61	5	0	26	107
22 13 00	000000	XS	104	103	0	58	39	0	61	80	0	73	-114	0	58	-137
22 13 30	000000	XS	65	163	0	50	40	0	38	-27	0	41	-164	0	13	-126
22 14 00	000000	XS	17	10	0	21	-62	0	56	-129	0	39	117	0	106	54
22 14 30	000000	XS	108	-62	0	28	53	0	52	65	0	70	-61	0	64	-172
22 15 00	000000	XS	76	-22	0	146	-35	0	65	154	0	89	42	0	21	-138
22 15 30	000000	XS	49	-124	0	29	9	0	51	19	0	26	116	0	48	-55
22 16 00	000000	XS	25	103	0	114	0	0	114	-175	0	45	-86	0	112	28
22 16 30	000000	XS	43	44	0	36	-99	0	30	119	0	78	-70	0	112	-131
22 17 00	000000	XS	36	-11	0	11	154	0	58	-48	0	41	-132	0	41	-14
22 17 30	000000	XS	27	-68	0	43	55	0	57	167	0	56	-140	0	74	156

CP ?? .0 45 00 00.0 MAP# 0 REAL (CF KAL 64 X 64)

```
 2 0-1 0-1 1 2 1-1 0 0 2 1 0 0 1-1-2 2 4 0-1 0-1 0 3 1-1 1 3-1-4 0 2 1-1 0 2 1-2-1 2 2-1-3 0 1-2-2 0 0 0
-1-1 0 0-1 2 3-1-2 1 2 0 0 0 0 1-2 0 (5) 2-5-2 4 1-1 1 2 0-1 0 0-1 1 3 0-1 0 1 0-1 0 1 0-2-2 1 2-1-1 2 1-1
-1 1 3 0 0 3 1-3 0 3 1-1 0 0 1 1 0 0 3-1-5 1 (7) 0-4 0 3-1-3 0 2 0 0 1 0-1 0 0-1 0 0-1 0 0 0 1 2-1-1 2 0-3
 1 3 1-1 0 1-1-2 3 2-2 0 1 0 0 2 0 0 1 0-1 + 4-3-4 2 3-2-1 + 4 0-2 0 0 0 0-2 0 3-1-3 2 3-2-1 1-2-1 1-1-3
 1 0 0-1 0 0 0 2 3-1-2 2 2-2 0 3-1-2 1 2 0 0 0-2 0 3 1 0 0 3 0-3-1 0 1 2 0-2 2 3-4-2 (6) 1-6-1 3-1-1 2-1-1
-2-1 0 0 0 1 1 2 0-3 0 (5) 0-3 1 3-1-1 3 3-1-3 0 3 1 0 0 0 0-1-1 0 1 1-1 2-1-2 3 1-5 0 (5)-2-6 2 4-2 0 2-1 0
-3 0 3 1 0 0 0 0-2-1 3 3-2-2 3 2-2 0 3 1-3-1 4 +-2-3 1 1-2-2 1 3 2-1 0 1-1-2 2 0-3 1 3-3-1 (6) 1-4 0 2-2-1
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-1-2-1 0 2 1 0 2 2-3-3 3 4-1-1 3 2-3 0 4 0-2 0 1 1 2 0-1 1 0-4-1 3 0 0 3 0-3 0 2-2-3 1 2-2-3 2 4 0-1 0 0
-3 0 1 2 2 0-1 1 0-3 0 (6) 2-4 0 4 0-4 1 4-1-2 3 3 0-1-2 0 3-1-4 4 (6)-2-2 3 0-4 0 2-2-2 3 1-2 1 5 0-5 0 2-2
 0 3 2 0 0-1-1 1 1 0 2 3-1-3 1 3 0-1 2 2-2 0 3 1-2-1 0 2 3-1 0 (6) 2-7-3 4 0-3 2 2-1 0 3 0-2 3 1-6-4 (5) 1-5
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 3-1-5 0 4 1 0 1 2 0-4-1 4 3-1 0 2 0-1 0 1 1-1 0 3 3-1 0 1 0-2 0 0 0 3 2-1 0 0 0-1 0 0-1 0 1 0 0 4 2-5-3
 1-3-1 4 4 0-2 0 1-1-2 3 (5) 0-4 1 3-1-1 2 2 0-1 1 3 0-4-1 3 0-3 1 (5) 2-1-1 0 0-1 0 0 0 0 1 0 0 1 0-1-2-2 0
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 3 0-3 0 4 3-2-3 1 1-2 0 (5) 3-2-3 0 2 0-1 2 4-1-3 3 3-3-3 2 1-1 0 3 3 0 0-2-2 1 1-4 0 (5) 0-4 4 3-5 0 3-5-4
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-2 0 4 0-3 0 0 0 3 1-1 0-1-3 1 (5) 2 0 0 0 0 0 0 0 1 0 0 1 2 1-2 0 1-2-4 2 4 0 0 2-1 0 2-3-3 2 0-3 2 2 0 1
-3 3 4-4-3 (5) 2-1 0 0-1 0 0 1 (6) 2-4-1 2-1-2 2 3 0 0 2 1-1 0 0-2-1 1-1 0 (6) 2-4 0 2-4-2 2-1-2 2 1 0 1 0-1-1-
-2 (5) 0-7 1 (7) 0-4 0 0 0 1 1 3 3-3-6 2 4-1 0 3 2-4-1 3 0-4 0 2-1 0 3 0 1 3-3-6 2 2-5 0 (5) 0-2 2 1-1 0-1-1 0
-1 4-2-3 (6) 3-5-1 3 1 1 2 0 0 0-4 0 (7) 3-2 0 3-1-4 1 4-1-3 3 3-1 0 3-1-2 0-4-2 (6) 2-4 2 (5)-2-3 1 0-2-1 0 0 1
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 0 (5) 0-4 0 3-2-4 0 2 2 1 0-1 0 0 0 1 0-3-2 2 3 1 0 0-1-2-2 0 2 1 0-1-1 0 0 1 2 0-4-1 1 0-1 0 1 1 0-2-1 2-
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 0 0 0 0 0 0 0 2 1 0-1-2-1 2 2-2-1 1 1 0 2 0-4-3 0 1 1 1 1 0-1-2-1 1 2 0-2-1 0 0 1 3 0-2 0 1-2-1 1 0 0 1
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