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FINDING THE OPTIMUM DESIGNS OF ARBITRARY TEM-MODE QUADRATURE COUPLERS AND PHASE SHIFTERS, USING A DIGITAL COMPUTER

By

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ABSTRACT. This report discloses the full FORTRAN IV program (for an IBM 7094 digital computer) for the automatic design of arbitrary TEM quadrature couplers and differential phase shifters. The design is completely general in the sense that any number of coupled quarter wavelength sections, any nominal coupling value (or phase shift), and any design bandwidth of operation can be realized, although the user may specify any maximum coupling value in the design. This last degree of freedom in the specification to the machine, which is all-important in the physical realization of a theoretical design, is met by finding the proper number and types of tandem coupled junctions in the solution. This computer solution will be optimum. It will find the least ripple for the required bandwidth of operation for any (input) design complexity.

This report shows a complete flow chart of the total program. It also gives the special subroutines developed for automatic plotting of the coupler (or phase shifter) frequency-response functions. Various sample input data and machine outputs are also included.

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FOREWORD

This report discloses the full FORTRAN IV program, as used on an IBM 7094 digital computer at NOTS, for the automatic design of some 1000 arbitrary TEM quadrature couplers and differential phase shifters. The following listing of the program, complete with comment cards for explanations, was made on the machine in order that no typographical errors should be made. For the benefit of the readers who do not have a similar computing facility and thereby must modify this program, a complete flow chart is included; to the rest of the readers, the author apologizes for the excessive length of this report.

Work was accomplished on BuWeps Task RMGA-61-158/216-1/W1132 and RM-3781-001/216-1/WW115-00-001.

This report has been reviewed for technical accuracy by Robert G. Corzine and William Hughey.

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Section 1. INTRODUCTION

During the last decade, before the directional couplers attained their present peak of popularity, there has truely been a host of papers on this subject. (Ref. 1-10.) However, aside from the question of which published designs could, in fact, be built in practice, there still existed the need for high-quality (i.e., low ripple) extremely broad band couplers. Furthermore, because of the recently developed antenna feed matrices and receiver techniques, the quadrature relationship in some couplers and differential phase shifters are now applied in a multitude of microwave system designs.

This paper is primarily directed to the system design engineers who require arbitrary bandwidth, arbitrary ripple (or quality) performance, arbitrary but specifically controllable construction constraints on devices and still have an optimum solution. The paper is prepared for the engineer who does not care about the details of coupler synthesis, but only in what the solution and performance is for some given requirement and some physical constraint. It is beyond the scope of this report to delve into the synthesis of such arbitrary couplers and phase shifters.[1]

The explanation given on the comment cards in the beginning of the program were judged to be sufficiently complete so that any reader may be able to apply the program. This explanation became necessary when, in order to make the program more flexible, it was modified to accept several types of input data. With the enclosed examples, there should be no difficulty in using the program.

---

[1]Such is the purpose of a future paper: Shelton, J.P. and J.A. Mosko. "Synthesis and Design of Wide-Band Equal-Ripple TEM Direction Couplers and Fixed Phase Shifters," IEEE TRANS, Vol. MTT-14, No. 10 (October 1966).

Section 2. PROGRAM LISTING

The following text is a listing of the FORTRAN IV program (main program and subroutines) to design TEM couplers and phase shifters.

A casual glance at the text will reveal that not all subroutines are disclosed in detail. Those missing are non-essential in the sense that they are used to plot and label responses and write comments using the SC4020 plotting equipment. If this plotting system is not available, SCOUT V, TABL IV, AICRT 3, etc., and SUB ROUTINE PLOT would not be reproduced.

Note that tapes 5, 6, and 7 are for input data, written output, and punched card output. Also, tapes 16 and 18 are for written output (comments, labels, etc.) using the SC4020 plotted output.

Finally, the first five data cards, which are shown to be read in, are for comments and labeling of plots: these are non-essential and therefore can be blank cards or the read and write instructions can be removed altogether.

```
      20210   DECK
C
C     TITLE  DESIGN OF SYMMETRICAL TEM COUPLERS AND DIFFERENTIAL
C                               PHASE SHIFTERS
C
C           THIS PROGRAM IS TO DESIGN TEM QUADRATURE COUPLERS AND
C     DIFFERENTIAL PHASE SHIFTERS OPERATING OVER ARBITRARY BANDWIDTHS,
C     ANY NOMINAL COUPLING OR PHASE SHIFT, TO ANY DEGREE OF DESIGN
C     TOLERANCE, AND FOR ANY SPECIFIED MAXIMUM VOLTAGE COUPLING
C     COEFFICIENT (SPECIFIED BY THE DESIRED METHOD OF CONSTRUCTION
C     OF THE COUPLERS OR PHASE SHIFTERS).
C           THE PROGRAM, BY MEANS OF AN ITERATIVE SOLUTION, WILL GIVE
C     THE NORMALIZED EVEN MODE IMPEDANCES (ALSO THE NORMALIZED VOLTAGE
C     COUPLING COEFFICIENTS) OF THE INDIVIDUAL QUARTER-WAVELENGTH
C     COUPLED SECTIONS.  BECAUSE OF COUPLER SYMMETRY, ONLY HALF OF THE
C     COUPLING VALUES ARE GIVEN (OBVIOUSL, ALL THE ESSENTIAL ONES).
C     THIS PROGRAM BY USING THE SC4020 PLOTTER, WILL PLOT THE SOLUTION
C     AND DISPLAY THE COUPLING VALUES ON THE SAME FRAME AUTOMATICALLY.
C
C
C
C           DEFINITION OF SYMBOLS
C
C     K       IS THE SPECIFIC DESIGN PROBLEM CODE, I.E.
C             K = 0 FOR PHASE SHIFTERS
C             K = 1 FOR COUPLERS.
C     NMOST   IS THE MAXIMUM NUMBER OF CASCADED SECTIONS IN THE LARGEST
C             (OR,SOMETIMES,ONLY) TANDEM COUPLER/PHASE SHIFTER DESIGN.
C     N       EQUALS NMOST FOR PHASE SHIFTERS, AND
C             EQUALS ((1/2)*(NMOST+1) ) FOR COUPLERS.
C             (NOTE THAT N SIMPLY EQUALS THE LARGEST NUMBER OF DIFFERENT
C             IMPEDANCES OF THE LARGEST DEVICE).
C     NEND    IS THE END DATA CARD (I.E. IF NEND IS NON-ZERO, GO TO
C             END).
C     ITEMAX  IS THE NUMBER OF MAXIMUM ALLOWABLE ITERATIONS.
C     THETA   IS THE NORMALIZED FREQUENCY IN DEGREES (CENTER FREQUENCY =
C             90.0 DEGREES).
C     DELTA   IS THE INCREMENTAL THETA FOR COMPUTATIONS OF RESPONSE, AND
C             EQUALS 90 DEGREES DIVIDED BY ANY INTEGER.
C     UO      IS THE NOMINAL COUPLING FOR COUPLERS (IN DEGREES) OR THE
C             NOMINAL PHASE SHIFT FOR PHASE SHIFTERS (ALSO IN DEGREES).
C     TOL     IS THE REQUIRED TOLERANCE, OR HOW CLOSE THE EQUAL RIPPLE
C             PERFORMANCE MUST BE - - - READ IT IN PERCENT OF THE AVERAGE
C             RIPPLE.
C     ZMAX    IS THE MAXIMUM ALLOWABLE NORMALIZED EVEN MODE IMPEDANCE
C             OF ANY SECTION.
C     BW      IS THE DESIGN BANDWIDTH RATIO.
C     CONT    IS A CONTINUE CODE IN THE SENSE THAT THE STARTING
C             SOLUTION OF A NEW DESIGN PROBLEM SHOULD BE THE LAST
C             SOLUTION OF THE PRESENTLY COMPLETED PROBLEM.
C
C     IZCASE  IS A STARTING DATA CODE.  IF NON-ZERO, THIS MEANS THAT
C             THE INPUT DATA FOR THE STARTING SOLUTION IS IN TERMS OF
C             EVEN MODE IMPEDANCES AND NOT IN REFLECTION COEFFICIENTS.
C             IF ZERO (OR BLANK), THE STARTING DATA IS     IN TERMS OF
C             REFLECTION COEFFICIENTS, OR ANTENNA ELEMENT DISTRIBUTIONS.
C     N       IS THE NUMBER OF TANDEM COUPLERS OR IMPEDANCE PLANES
C             (CAN BE LEFT BLANK IF IZCASE = 0).
C     IDEV    IS A CODE FOR ADDITONAL PLOTTED DATA FOR THE DEVELOPMENT
C             OF COUPLERS.  IF IDEV IS NON-ZERO, IT WILL PLOT THE
C             INDIVIDUAL RESPONSE OF ALL TANDEM COUPLERS OF THE SOLUTION
C             ON SEPARATE GRAPHS. IF IDEV=0, NO DATA  IS GIVEN FOR THE
C             INDIVIDUAL COUPLERS OF THE TANDEM COUPLER SOLUTION.
C     ITABLE  IS A STARTING DATA CODE.  IF NON-ZERO IT SIGNIFIES THAT
C             THE DATA FOR STARTING THE SOLUTION IS TAKEN FROM
C             CHEBYSHEV ANTENNA TABLES.  LIST THE CENTER ELEMENT FIRST,
C             ETC., AND NORMALIZE FIRST (CENTER) VALUE TO 1.0. IF
C             ITABLE=0, THE STARTING DATA IS NOT TAKEN FROM ANTENNA
C             TABLES.
C     ZMIN    IS THE MINIMUM DESIRED EVEN MODE IMPEDANCE OF ANY COUPLED
C             SECTION IN A TANDEM COUPLER (OTHER THAN THE FIRST ONE).
C             IF ZMIN = 0 ON THE DATA CARD, THE PROGRAM FIXES ZMIN=1.001.
C     TRIMZ   IS A CODE FOR ARRANGING THE TANDEM COUPLERS. IF TRIMZ= 0,
C             THEN ALL INPUT TANDEM COUPLERS, PROVIDING THEY ARE SINGLE
C             SECTION COUPLERS, ARE MADE EQUAL. IF TRIMZ IS NONZERO,
C             NO ATTEMPT IS MADE TO TRY TO FIND EQUAL SINGLE SECTION
C             COUPLERS IN THE SOLUTION.
C     XPRINT  IS A CODE FOR OBTAINING THE PERFORMANCE DATA OF THE
C             DEVICE IN PRINTED FORM. IF NON-ZERO, THE PERFOR-
C             MANCE PER ITERATION WILL BE PRINTED.
C     SPEED   IS A CODE THAT CONTROLS  THE INTENSITY OF ERROR
C             CORRECTION. IF LEFT BLANK (I.E. ZERO) , THE ERROR
C             CORRCTION WILL BE WHAT THE THEORY DICTATES. BY
C             THIS CODE, RANGING BETWEEN LIMITS OF 0.1 TO 1.5,
C             THE NORMAL ERROR CORRECTION CAN BE ATTENUATED (BY
C             SETTING  SPEED  LESS THAN 1.0) OR AMPLIFIED (BY
C             SETTING  SPEED  GREATER THAN 1.0).
C
C     INUM    IS THE NUMBER OF IMPEDANCE VALUES IN THE SUCCEEDING TANDEM
C             COUPLER (ALSO EQUALS NU(IPLANE) WHERE IPLANE IS THE I(TH)
C             PLANE OF IMPEDANCES).
C     GAMMA   (I,J) IS THE J(TH) REFLECTON COEFFICIENT VALUE.
C
C
C     SAMPLE DATA CARDS
C
C     TYPE 1
C     IF THE DATA IS FROM CHEBYCHEV ANTENNA TABLES, THEN-
C
C     1ST DATA CARD - K, N, 0, ITEMAX, DELTA, UO, TOL, ZMAX, BW, 0
C          ACCORDING (ABBREVIATED ACC.) TO FORMAT (2I2, 2I3, 6F10.5)
C     2ND DATA CARD - 0, 0, IDEV, 1, ZMIN, TRIMZ, XPRINT,SPEED
C          ACC. TO FORMAT (2I2, 2I3, 6F10.5)
C     3RD DATA CARD - CHEBY(1)...CHEBY(N) ACC. TO FORMAT (7F10.5)
C        WHERE CHEBY(1) IS THE CENTER ELEMENT OF THE ANTENNA, AND
C        CHEBY(N) IS THE END ELEMENT OF THE ARRAY.
C
```

```
C      TYPE 2
C      IF THE DATA IS IN TERMS OF REFLECTION COEFFICIENTS, THEN-
C
C      1ST DATA CARD - K, N, O, ITEMAX, DELTA, UO, TOL, ZMAX, BW, D
C             ACC. TO FORMAT (2I2, 2I3, 6F10.5)
C      2ND DATA CARD - O, O, IDEV, O, ZMIN, TRIMZ, ,XPRINT,SPEED
C             ACC. TO FORMAT (2I2, 2I3, 6F10.5)
C      3RD DATA CARD - GAMMA(1)...GAMMA(N) ACC. TO FORMAT (7F10.5)
C           WHERE GAMMA(1)  IS THE REFLECTION COEFFICIENT FOR THE
C           CENTER SECTION.  GAMMA(N) FOR THE END SECTION.
C
C
C
C      TYPE 3
C      IF THE DATA IS IN TERMS OF EVEN MODE IMPEDANCES, THEN-
C
C      1ST DATA CARD - K, N, O, ITEMAX, DELTA, UO, TOL, ZMAX, BW, O
C             ACC. TO FORMAT (2I2, 2I3, 6F10.5)
C      2ND DATA CARD - 1, M, IDEV, O, ZMIN, TRIMZ, ,XPRINT,SPEED
C             ACC. TO FORMAT (2I2, 2I3, 6F10.5)
C      3RD DATA CARD - NU(1) ACC. TO FORMAT (I2)
C      4(TH) DATA CARD - Z, (1,1)...Z(1,NU(1)) ACC. TO FORMAT
C             (7F10.5)
C      5(TH) DATA CARD - NU(2) ACC. TO FORMAT (I2)
C      6(TH) DATA CARD - Z(2,1)...Z(2,NU(2)) ACC. TO FORMAT (7F10.5)
C      .
C      .
C      .
C      (2M+2)(TH) DATA CARD - NU(M) ACC. TO FORMAT (2I2)
C      (2M+3)(TH) DATA CARD - Z(M,1)...Z(M,NU(M)) ACC. TO FORMAT (7F10.5)
C
C
C
C      TYPE 4
C      IF A PRECEEDING FINAL SOLUTION BECOMES THE STARTING DATA OF A
C             NEW PROBLEM. (AS IF ZMAX IS THE ONLY CHANGE), THEN-
C
C      1ST DATA CARD - K, N, O, ITEMAX, DELTA, UO, TOL, ZMAX, BW, 1.
C             ACC. TO FORMAT (2I2, 2I3, 6F10.5)
C      2ND DATA CARD - O, O, IDEV, O, ZMIN, TRIMZ, ,XPRINT,SPEED
C             ACC. TO FORMAT (2I2, 2I3, 6F10.5)
C
C
C
C      THE LAST DATA CARD (REQUIRED) - O, O, 1 ACC. TO FORMAT (2I2, 2I3)
C
C
      CALL SCOUTV(1,15)
       EXTERNAL TABLIV
      CALL RITSTV(10,26,TABLIV)
      CALL MAXFRM(300)
      DIMENSION  UPPR(8),BOTT(9),SIDE(9),DAY   (2),FLUNK(2),TOUGH(2)
      DIMENSION ALFA(2000),ALPHA( 500),TD( 500),VAL(50),PEAK(50)
     C,Z(30),  C(10,30),A(4,4),B(4,4),GAM(10,30),NMAX(30),TT(99 )
     C,UB(30), BI(50),UQ(200)  ,DGAM(30),  THET(30), DU(30), XUQ(30)
      DIMENSION NU(30)  , ANGL(30),ANG(30), DUQ(30),DQ(30),GAMMA(3,30)
     C,RIBI(50), AGAM(3,30), BETA(300), CHEBY(25), SSI(25) ,YTOX(4)
        EQUIVALENCE( GAMMA,AGAM)
    1 FORMAT ( 2F10.5, 1F10.3, 6F10.5)
    2 FORMAT(7F10.5)
    5 FORMAT(2I2,2I3, 6F10.5)
    6 FORMAT(9A8)
    7 FORMAT(8A8)
    9 FORMAT(2A6)
   71 FORMAT(6X2HN=,I2,6X9HCOUPLING=,
     2 F8.4,4H DB , 6X10HBANDWIDTH=,F6.3, 3XF6.3)
   72 FORMAT (1H/)
   73 FORMAT(6X2HN=,I2,6X12HPHASE SHIFT=,
     C F8.2, 9H DEGREES ,8X10HBANDWIDTH=, F6.3, 3XF6.3)
   74 FORMAT(10X8HRIPPLE= ,F9.4,5H   DB,8X10HTOLERANCE=,F6.4)
   75 FORMAT( 1H )
   76 FORMAT( 5X3HRL=,F6.3,7X,
     2             9HRIPPLE=  ,F6.2,9H  DEGREES,6X10HTOLERANCE=,F8.4)
   78 FORMAT (3H N(,I2,3H )=,I3         )
   80 FORMAT (1H1)
   81 FORMAT(5H UO =,F8.4, 4X4HBW =,F6.3,4X6HZMAX =,F8.5,
     2 4X,1HTOLERANCE= ,F8.5,
     C5X,38HTHE MAX. ALLOWABLE ITERATION(S) ARE = , I2 )
   83 FORMAT(5X,8HGAMMA(1,,I2, 5H ) = ,F8.5)
   85 FORMAT(3H Z(,I2,1H,,I2,3H )=,F8.5,10X7HGAMMA (,I2,1H,,I2,3H )=,
     CF8.5, 10X 11H COUPLING =,F8.5)
   86 FORMAT(48H THE DESIGN DOES MEET THE SPECIFICATIONS, AFTER , I2
     1, 13H  ITERATIONS )
   89 FORMAT(5H VAL(,I2,3H)= ,F10.5)
   90 FORMAT(6H PEAK(,I2, 4H) = , F10.5)
   91 FORMAT( 4X5HDIFF.,4X7HRIPPLE.,2X,8HABSOLUTE,4X6HTHETA,
     C2X10HBANDWIDTH    )
   92 FORMAT(1X10HPHASE, DEG,4X3HDEG,4X10HPHASE, DEG,3X3HDEG,6X5HRATIO)
   93  FORMAT(1X/4X5HALPHA, 4X6HRIPPLE, 5X5HTHETA, 3X8HCOUPLING,
     C 3X6HRIPPLE, 3X9HBANDWIDTH   )
   95 FORMAT(/1X9H(DEGREES),2X9H(DEGREES), 2X9H(DEGREES), 3X4H(DB),
     C6X 4H(DB), 4X6HRATIO ,//  )
   96 FORMAT (45X8H EXIT BY , I2 )
   97 FORMAT(3H Z(,I2,4H) = ,F8.5,10XI2)
   98 FORMAT (23H THE ERROR COEFFICIENT ,I2, 16H IS OSCILLATING, ,
     C 10H APPLY FIX ,I2)
   99 FORMAT ( 5X51HTHE DESIGN DOES NOT MEET THE SPECIFICATIONS -- FAIL)
  101 FORMAT ( 5X, 28HCAUTIOUS ERROR CORRECTION ( , F5.3 , 2HX))
  102 FORMAT ( 5X, 27H  NORMAL ERROR CORRECTION   )
  103 FORMAT ( 5X,28HEXCESSIVE ERROR CORRECTION ( , F5.3 , 2HX))
  105 FORMAT (/5X, 38HEXIT 1  IMPEDANCES ARE LESS THAN 1.0      ,
     C/5X49HEXIT 2  TOO MANY PEAKS/VALLEYS IN RESPONSE CURVE  ,
     C/5X49HEXIT 3  TOO FEW PEAKS/VALLEYS FOR ERROR ANALYSIS  ,
     C/5X46HEXIT 4  DESIGN OF PHASE SHIFTER NOW COMPLETED   ,
     C/5X40HEXIT 5  DESIGN OF COUPLER NOW COMPLETED    ,
     C/5X58HEXIT 6  DESIGN OF COUPLER USED MAX. ALLOWABLE ITERATIONS   ,
     C/5X59HEXIT 7  DESIGN OF PHASE SHIFTER USED MAX. ALLOW. ITERATIONS,
     C/5X53HEXIT 8  A PEAK AND VALLEY ARE BEYOND BANDWIDTH EDGE  )
       WRITE(16,80 )
       WRITE (6,105)
       RAD = 57.2957795
       READ ( 5,9) TOUGH
       READ (5,9) FLUNK
```

```
      READ (5,7) UPPR
      READ (5,6) BOTT
      READ (5,6) SIDE
      KRUN = 0
      NPAGE=0
      IZERO = 0
      IONE = 1
      ITWO = 2
      ITHREE = 3
      IFOUR = 4
      IFIVE = 5
      ISIX = 6
      ISEVEN = 7
      IEIGHT = 8
      ININE = 9
      ITEN = 10
      CALL DATE(DAY)
      WRITE (7,9) DAY
   20 READ (5,5)  K,N, NEND, ITEMAX, DELTA,UD,TOL,ZMAX,BW,CONT
      THBW = 180./(BW+1.)
      CALL TABLC(C,NU,NMAX,K,N,UD,BW, PERF  ,TOLER,RL,DAY   ,KRUN,NEND)
      KRUN = KRUN + 1
      IF (NEND.GT.0) GO TO 595
      JRUN=0
      IRUN = 0
      ISCORE=0
      INSTBL = 0
      SCRI=0.
      KAK=K
      WRITE(6,80)
      WRITE(6,81) UD,BW, ZMAX, TOL, ITEMAX
      READ (5,5) IZCASE, M, IDEV ,ITABLE ,ZMIN,TRIMZ, XPRINT
     C , SPEED
      IF (SPEED. LE. .1) SPEED = 1.
      IF (SPEED. GT.1.5) SPEED = 1.
      IF(ZMIN.LE.0.) ZMIN=1.001
      IF(ITABLE) 35,35,27
C     DATA IN TERMS OF CHEBYCHEV ANTENNA DISTRIBUTIONS, ENDS AT 32
   27 READ (5,2)  ( CHEBY(I),I=1,N)
      IF(K.GT.0) GO TO 30
      SNUM=SIN(UD/RAD)*.5
      SSUM=0
      DO 28 I=1,N
      SSI(I)=(-1.)**(I-1)* CHEBY(I)/FLOAT(2*I-1)
   28 SSUM=SSUM+SSI(I)
      SNUM=SNUM/SSUM
      DO 29 I=1,N
   29 AGAM(1,I)=ABS(SSI(I))*SNUM
      GO TO 60
   30 CONTINUE
      SNUM = 0.
      DO 31 I=1,N
      SSI(I) = CHEBY (I)/FLOAT(I)
      SUMPRO = SIN(THBW/RAD * FLOAT(I)) *SSI(I)
      SNUM= SNUM+ SUMPRO
   31 CONTINUE
      DO 32 I=1,N
   32 GAMMA(1,I) = SSI(I)*(UD/RAD*0.5/SNUM)
      GO TO 60
   35 CONTINUE
C     DATA IN TERMS OF    EVEN MODE IMPEDANCES, ENDS AT 53
   40 IF (IZCASE) 53,53,43
   43 IPLANE = 0
      DO 45 ITIMES = 1,M
      READ (5,5) INUX
      IPLANE = IPLANE + 1
       NU(IPLANE) = INUX
      READ (5,2) ( C(IPLANE,I) , I=1,INUX )
       WRITE (6,2) (C(IPLANE, I) , I=1,INUX)
   45 CONTINUE
      I=0
      DO 49 IPL =1,IPLANE
      KNUU =  NU(IPL) +1
      C(IPL, KNUU) = 1.
      DO 47 INIT = 1,N
      GAM (IPL,INIT) = 0.
   47 CONTINUE
      KNU = NU(IPL)
      DO 49 NNU =1,KNU
      JNU = KNU+1-NNU
      JJNU = JNU +1
      GAM(IPL, JNU) = (C(IPL,JNU) - C(IPL,JJNU))/(C(IPL,JNU)+C(IPL,JJNU)
     C)
C     WRITE (6,2) GAM(IPL, JNU)
   49 CONTINUE
      N = NU(1)
      DO 50 IKS=1,N
      AGAM(1,IKS) = 0.
      DO 50 IPL=1,IPLANE
      AGAM(1,IKS) = GAM(IPL,IKS) + AGAM(1,IKS)
   50 CONTINUE
      GO TO 60
   53 IF (CONT) 55,55,60
C     PRESENT INPUT DATA FROM PRECEEDING SOLUTION
   55 READ(5,2) (GAMMA(1,I) , I=1,N)
   60 DO 61 I=1,N
      WRITE (6,83)I,AGAM(1,I)
      GAM(1,I) = AGAM(1,I)
      TT(I) = GAM(1,I)
   61 CONTINUE
   62 CONTINUE
      JL = N
      L=1
      M = 0
      JSTOP=0
      NTOT=0
      ANGLE=(UD/90.0)
      M=1
      I=1
      NU(1)=N
C     WRITE (6,78) I,NU(1)
      C(1,N+1)=1.
```

```
122 C(I,N  )=(1.+GAM(I,N  ))/(1.-GAM(I,N  ))*C(I,N+1)
    IF(C(I,N)-ZMAX) 123,123,124
123 N=N-1
    IF(N  ) 140,140,122
124 NMAX(I)=N
    J=N
125 C(M,J)=ZMAX
    IF(J-1)130,130,127
127 GAM(M,J-1)=0.
    J=J-1
    IF(J) 130,130,125
130 N=NMAX(I)
    J=N
    M=M+1
    GAMG=(ZMAX-C(M-1,J+1))/(ZMAX+C(M-1,J+1))
    GAM(M,J)=GAM(M-1,J)-GAMG
131 J=J-1
    IF(J) 135,135,133
133 CONTINUE
    GAM(M,J)=TT(J)
    IF(J-1) 135,135,131
135 CONTINUE
    JG=M-1
    I=I+1
    NU(I)=N
C   WRITE (6,78) I,NU(I)
    C(I,N+1)=1.
    DO 139 L=1,JL
    VOL=(C(JG,L)**2-1.)/(C(JG,L)**2+1.)
    IF(L-N) 139,137,139
137 GAM(JG,L) = GAMG
139 WRITE (6,85) JG,L, C(JG,L),JG,L,GAM(JG,L) ,VOL
    JL=N
    GO TO 122
140 DO 141 K=1,JL
    VOL=(C( I,K)**2-1.)/(C( I,K)**2+1.)
141 WRITE (6,85) I,K,C(I,K) , I,K,GAM(I,K),VOL
    M=I
    MMAX = I
    N = NU(1)
    IF( TRIMZ.NE.0.) GO TO 185
    IF (M-2) 150,145,145
145 CONTINUE
    CALL ZTRIM(C,NU, MMAX, ZMIN )
    M = MMAX
    DO 147 ILMX = 2,M
    ILMYX = NU(ILMX) + 1
    DO 147 ILMY = ILMYX, N
    C(ILMX, ILMY) = 0.
147 CONTINUE
150 CONTINUE
    IF (C(M,1) - 1.01) 185,185,160
160 IF ( C(M,2)) 163,163,185
163 GAMX = 0.
    L = 2
    IF ( C(M-1,2)) 165,165,185
165 IF (C(M-2,2)) 170,170,175
170 L=3
175 DO 177 IL = 1,L
    IGAM = M-IL+1
    GAMX = GAMX+GAM(IGAM,1)
177 CONTINUE
    GAMX = GAMX/ FLOAT(L)
    CIX = (1.+GAMX)/(1.-GAMX)
    DO 180 IL=1,L
    IGAM = M-IL+1
    GAM ( IGAM ,1) = GAMX
    IKONST = 1
    C( IGAM ,1) = CIX
    VOL=(CIX**2-1.)/(CIX**2+1.)
    WRITE (6,85) IGAM, IKONST,C(IGAM, 1) , IGAM, IKONST,GAM(IGAM,1),
   Z    VOL
180 CONTINUE
185 CONTINUE
    CALL ZTRIM(C,NU, MMAX, ZMIN )
    L=1
    I=0
    IPLANE = 0
    , = 0
    M = MMAX
C   WRITE (6,80)
200 CONTINUE
    K=KAX
    IPLANE = IPLANE + 1
    N = NU(IPLANE)
    NTOT=NTOT+N
    FAI. = 0.
    DO 203 I=1, N
    Z(I) = C(IPLANE,I )
    IF(Z(I).LE.1.) FAIL = 10.
C   WRITE (6,97) I, Z(I) ,IPLANE
203 CONTINUE
    IF(FAIL.LE.0.) GO TO 204
C   THIS IS EXIT 1
    WRITE ( 6,96 ) IONE
    GO TO 20
204 ADX=0.
    RZX=0.
    LKO = 1
    THETA = THBW
205 CONTINUE
213 THETAR=THETA/57.2957795
    TRZX=RZX
    CO  =COS (THETAR)
    SO  =SIN (THETAR)
C   START CALCULAT'ON OF COUPLER (OR PHASE SHIFTER) RESPONSE
    IF (K) 215,215,216
215 A(1,1)=CO
    A(2,2)=CO
    A(1,2)=SO *Z(1)
    A(2,1)=SO *(1./Z(1))
    J=2
```

```
      GO TO 217
  216 HTH=THETAR/2.
      A(1,1)=COS (HTH)
      A(2,1)=(1./Z(1))*SIN (HTH)
      A(2,2)=A(1,1)
      A(1,2)=Z(1)*SIN (HTH)
      J=2
  217 IF(M-J) 223,220,220
  220 B(1,1)=A(1,1)*CO +(-1.)*Z(J)*SO *A(2,1)
      B(1,2)=CO *A(1,2)+Z(J)*SO *A(2,2)
      B(2,1)=(1./Z(J))*SO *A(1,1)+CO *A(2,1)
      B(2,2)=((-1.)/Z(J))*SO *A(1,2)+A(2,2)*CO
      A(1,1)=B(1,1)
      A(1,2)=B(1,2)
      A(2,1)=B(2,1)
      A(2,2)=B(2,2)
      J=J+1
      GO TO 217
  223 IF(K)225,225,224
  224 ALFA(L)=ATAN (A(1,1)*A(1,2)-A(2,1)*A(2,2))
      IF ( LKO - 1 ) 2242,2242,2244
 2242 THETA = DELTA
 2244 L=L+1
      LKO = LKO + 1
      THETA = THETA + DELTA
      IF(THETA-90.) 213,213,2246
 2246 IF(JSTOP) 2248,2248,267
 2248 JSTOP=L-1
      GO TO 267
  225 RZX=A(2,1)/A(1,1)
      IF(RZX-TRZX )227,230,230
  227 ADX = ADX+360.
  230 ALFA(L)=2.*RAD*ATAN(RZX)+ADX
      IF ( LKO -1 ) 233,233,235
  233 THETA = DELTA
      RZX = 0.
  235 L=L+1
      LKO = LKO + 1
      THETA = THETA + DELTA
      IF(THETA-90.) 213,213,236
  236 IF(JSTOP) 237,237,240
  237 JSTOP=L-1
  240 CONTINUE
      M=M-1
      IF(M) 243,243,200
  243 CONTINUE
      THETA = THBW
      L=L-1
      JK=JSTOP
       IF ( L-JSTOP )250,250,248
  248 DO 247 NN = 1,JSTOP
      JK=JK+1
      DO 247 NN1=JK,L,JSTOP
  247 ALFA(NN)=ALFA(NN)+ALFA(NN1)
  250 CONTINUE
      IF(XPRINT. LE .0.) GO TO 251
      WRITE (6,91)
      WRITE (6,92)
  251 WRITE (6,72)
      DO 255  LK=1,JSTOP
      UX= (FLOAT(2*NTOT)+ANGLE)*THETA
      RL=UX/360.
      U=UX-ALFA(LK)
      ALPHA(LK) = U
      IF (U.LT. 0.) ALPHA(LK) = ALPHA(LK) + 360.
       TD(LK) = THETA
      RIPO = UO -ALPHA(LK)
      ABW= (180. - THETA) /THETA
      IF(XPRINT. LE .0.) GO TO 252
      WRITE (6,1) ALPHA(LK),RIPO, ALFA(LK), THETA, ABW,DOTS, U
  252 IF (LK - 1 ) 253,253,255
  253 THBW = THETA
      UBW=ALPHA(LK)
      THETA = DELTA
  255 THETA=THETA+DELTA
C     END OF PHASE SHIFTER
      GO TO 295
C     CONTINUE OF COUPLER RESPONSE CALCULATION - END AT 335
  267 CONTINUE
      M=M-1
      IF(M) 270,270,200
  270 CONTINUE
      L=L-1
  273 THETA = THBW
      JK=JSTOP
      IF ( L-JSTOP) 285,285,275
  275 CONTINUE
      IF (IDEV) 283,283,277
  277 IF (IRUN- ITEMAX ) 283,280,280
  280 CONTINUE
      LBI = 0
      DO 282 JLKX= 1, NMAX
      TD(1) = 0.
      JKX = 1
      DO 281 JLK = JKX, JSTOP
      LBI = LBI+1
      BETA( JLK) = 20. *ALOG10(ABS(SIN(ALFA(LBI))))
      TD(JLK)=DELTA*FLOAT(JLK)
  281 CONTINUE
      JSTOPX=JSTOP-1
      CALL AICRT 3(0,0,TD(2), BETA (2), JSTOPX,1,2, 1,44,
     CUPPR, BOTT, SIDE, 1,1, 16., 16., 1, XL,XU, 1, YL,YU)
  282 CONTINUE
      IDEV = 0
  283 CONTINUE
      DO 284 NN=1, JSTOP
      JK=JK+1
      DO 284 NN1 =JK,L,JSTOP
  284 ALFA(NN)=ALFA(NN)+ALFA(NN1)
  285 CONTINUE
      IF(XPRINT. LE .0.) GO TO 286
      WRITE(6,93)
```

```
      WRITE(6,95)
  286 RIPX = 20.* ALOG10(SIN(UO/57.2957795))
      DO 294   LK=1,JSTOP
      ALPHA(LK)=ALFA(LK)*RAD
      TD(LK) = THETA
      RIP1      = UO -ALPHA(LK)
      ABW=(180. - THETA) /THETA
      IF(ALFA(LK))      289,289,290
  289 TENLOG=-0.
      GO TO 291
  290 TENLOG = 20.*ALOG10(SIN(ALFA(LK)))
      RIPDB = RIPX - TENLOG
  291 IF(XPRINT. LE .0.) GO TO 292
      WRITE(6,1)ALPHA(LK),RIP1     ,THETA,TENLOG,RIPDB,ABW
  292 IF  (LK-1 ) 293,293,294
  293 THBW = THETA
      UBW =ALPHA(LK)
      THETA = DELTA
  294 THETA=THETA+DELTA
C     START PHASE SHIFTER AND CONTINUE COUPLER
  295 MGO = 1
      NPAGE=NPAGE+1
      ZPG = NPAGE
C     IF(XPRINT. LE .0.) GO TO 296
C     WRITE (6,80)
  296 N=NU(1)
      KGO = 2
      VAL(1) = ALPHA(1)
      JGO = JSTOP - 2
      KOUNT = 1
      DO 313 I=2,JGO
      IF  ((ALPHA(I) - ALPHA(I+1)) * (ALPHA(I+1)-ALPHA (I+2)))  300,300,
     1 310
  300 UB(KOUNT) = ALPHA(I+1)
      THET(KOUNT) = TD(I+1)
      KOUNT = KOUNT + 1
      IF(ALPHA(I) - ALPHA(I+1)) 307,303,305
  303 IF(ALPHA(I+1) - ALPHA(I+2)) 305,305,307
  305 VAL(KGO) = ALPHA(I+1)
      KGO = KGO +1
      GO TO 310
  307 PEAK(MGO) = ALPHA(I+1)
      MGO = MGO+1
  310 CONTINUE
  313 CONTINUE
      IF(KAX.LE.0) GO TO 320
      UB(KOUNT) = ALPHA(JSTOP)
      THET(KOUNT) = 90.
      IF  (ALPHA(JSTOP-1) - ALPHA(JSTOP)) 317,317,315
  315 VAL(KGO) = ALPHA(JSTOP)
      KGO = KGO+1
      GO TO 320
  317 PEAK(MGO) = ALPHA(JSTOP)
      MGO = MGO+1
  320 IF(KAX.LE.0) KOUNT = KOUNT - 1
      K1X = KGO -1
      DO 330 IKX = 1,K1X
      WRITE (6,89) IKX,VAL(IKX)
  330 CONTINUE
      M1X = MGO-1
      DO 331 INX =1,M1X
      WRITE(6,90) INX,PEAK(INX)
  331 CONTINUE
      CAUTN = 0.
      IF(NU(1) .EQ. 2 )    GO TO 333
      IF((K1X-1 + M1X) - NU(1)) 332,333,3310
 3310 WRITE ( 6,96 ) ITWO
C     THIS IS EXIT 2
      GO TO 20
  332 CAUTN = 10.
  333 CONTINUE
      IF(IRUN) 334,334,3340
  334 CAUTN=5.
C     WRITE (6,5) IZERO,IRUN
 3340 IRUN=IRUN+1
      JRUN=JRUN+1
      JSTOPX=JSTOP-1
      K = KAX
  335 IF(K) 337,337,417
  337 IF(K1X.GE.1) GO TO 338
      IF(M1X.GE.1) GO TO 338
      WRITE ( 6,96 ) ITHREE
C     THIS IS EXIT 3
      GO TO 20
  338 VMIN = XMN(K1X,VAL)
      VMAX = XMX(K1X,VAL)
      PMIN = XMN(M1X,PEAK)
      PMAX = XMX(M1X,PEAK)
      NPOFF=2*N-1
      PERF = (PMAX - VMIN + PMIN - VMAX )/4.
      YTOX(1) = ABS( VMIN + PERF - UO )
      YTOX(2) = ABS( VMAX + PERF - UO )
      YTOX(3) = ABS( PMAX - PERF - UO )
      YTOX(4) = ABS( PMIN - PERF - UO )
      YTOL = XMX(4,YTOX)
      TOLER = YTOL
  350 IF  (ABS(VMAX- VMIN) - TOL*PERF ) 353,353,365
  353 IF(ABS (PMAX - PMIN) - TOL*PERF ) 355,355,365
  355 IF  ( ABS((PMAX-UO)-(UO- VMIN)) - (2.*TOL*PERF )) 357,357,365
  357 WRITE(6,88) IRUN
      CALLPLOT(TD,ALPHA,JSTOP,VAL,K1X,PEAK,M1X,C,NU,MMAX,K,BW,UO,
     Z      ZPG,DAY  )
      I1000 = IPLANE
      IPLANE = 0
      WRITE(7,75)
      WRITE(7,73) N     ,UO,BW ,C(1,1)
      WRITE(7,76) RL,PERF,YTOL
      WRITE  (7,5) K,N,NEND , ITEMAX, DELTA,UO,TOL,ZMAX,BW
      WRITE(7,2)  (AGAM(1,I) ,I=1,N)
      WRITE(7,5) MMAX
      DO 360 ITIMES =1,MMAX
      IPLANE = IPLANE +1
```

```
      INUK5  = NU(IPLANE)
      WRITE(7,5) INUK5
      WRITE(7,2)  (C(IPLANE,I) , I=1,INUK5)
  360 CONTINUE
      IPLANE = I1000
      WRITE ( 6,96 ) IFOUR
C     THIS IS EXIT 4
      GO TO 20
  365 CONTINUE
C     START OF ERROR CORRECTION FOR PHASE SHIFTERS
      DU(1) = UO - UBW
      DQ(1)=DU(1)
  400 DU(1)=SQRT(DU(1)**2)
      ANG(1) = THBW
      DO 403 I=1,KOUNT
      DU(I+1) = UO - UB(I)
       DQ(I+1)=DU(I+1)
      DU(I+1)=SQRT(DU(I+1)**2)
      ANG(I+1) = THET(I)
  403 CONTINUE
      DUA=0.
      IKO = KOUNT + 1
      DO 405  I=1,IKO
  405 DUA = DUA    + DU(I)
      DUAVE = DUA/ FLOAT(N+1)
      DUAVEX = DUAVE
      DO 407 I=1,IKO
  407 WRITE(6,2) DQ(I),DUAVE
      I=1
  410 DUQ(I)=DQ(I)-DUAVE
      IF(I-IKO) 413,457,457
  413 I=I+1
      DUQ(I)=  (DQ(I)+DUAVE  )
      IF  (I-IKO) 415,457,457
  415 I=I+1
      GO TO 410
  417 CONTINUE
      DU(1) = UO - UBW
      DQ(1)=DU(1)
      DU(1) = ABS(RIPX - 20.*ALOG10(SIN(UBW/RAD)))
      ANG(1) = THBW
      DO420 I=1,KOUNT
      DU(I+1) = UO - UB(I)
       DQ(I+1)=DU(I+1)
      DU(I+1) = ABS(RIPX -20.*ALOG10 (SIN(UB(I)/RAD)))
      ANG(I+1) = THET(I)
  420 CONTINUE
      DUA=0.
      IKO = KOUNT + 1
      DO 423 I=1,IKO
  423 DUA = DUA    + DU(I)
      DUAVE = DUA/ FLOAT(N+1)
      DUAVEX = 10.**((RIPX+DUAVE)/20.)
      DUAVEX =ABS(ATAN(DUAVEX/(SQRT(1.-DUAVEX**2)))-UO)
      DO425 I=1,IKO
  425 WRITE(6,2) DU(I),DUAVE
```

```
      RIPP = XMX(IKO,DU)
      RIPN = XMN(IKO,DU)
      PERF=(RIPP+RIPN)*.5
      YTOL=(RIPP-RIPN)*.5
      TOLER = YTOL
      NPOFF=2*N-1
      IF ((RIPP-RIPN) - TOL*DUAVE)427,427,435
  427 IF(IDEV . LE . 0) GO TO 428
      ITEMAX = IRUN
C   THIS WILL YIELD THE DEVELOPMENT DATA
      GO TO 60
  428 WRITE(6,88) IRUN
      WRITE (7,75)
      WRITE (7,75)
      U3 = UO
      CALLPLOT(TD,ALPHA,JSTOP,VAL,K1X,PEAK,M1X,C,NU,MMAX,K,BW,UO,
     Z    ZPG,DAY  )
      I1000 = IPLANE
      IPLANE = 0
      WRITE(7,71) NPOFF,RIPX,BW ,C(1,1)
      WRITE(7,74) PERF,YTOL
      WRITE(7,5) MMAX
      DO 433 ITIMES =1,MMAX
      IPLANE = IPLANE +1
      INUK5  = NU(IPLANE)
      WRITE(7,5) INUK5
      WRITE(7,2)  (C(IPLANE,I) , I=1,INUK5)
  433 CONTINUE
      WRITE (7,5) K,N,NEND , ITEMAX, DELTA,UO,TOL,ZMAX,BW
      WRITE(7,2) (AGAM(1,I) ,I=1,N)
      IPLANE = I1000
      WRITE ( 6,96 ) IFIVE
C     THIS IS EXIT 5
      GO TO 20
  435 I=1
      IF( IRUN- ITEMAX) 440,440,437
  437 CONTINUE
      WRITE (7,5) K,N,NEND , ITEMAX, DELTA,UO,TOL,ZMAX,BW
      WRITE (7,75)
      WRITE(7,2) (AGAM(1,I) ,I=1,N)
      CALLPLOT(TD,ALPHA,JSTOP,VAL,K1X,PEAK,M1X,C,NU,MMAX,K,BW,UO,
     Z    ZPG,DAY  )
      CALL PRINTV(12,FLUNK, 918,15)
      WRITE ( 6,99)
      WRITE ( 6,96 ) ISIX
C     THIS IS EXIT 6
      GO TO 20
  440 CONTINUE
  442 DUVV = 10. **((RIPX - DUAVE)/20.)
      DUAVEV = ABS(UO- ATAN(DUVV/SQRT(1.-(DUVV)  **2))*RAD )
  443 DUQ(I)=DQ(I)-DUAVEV
C     WRITE (6,2) DUVV, DUAVEV, DUQ(I)
      IF(I-IKO)445,460,460
  445 I=I+1
      DUPV = 10. **((RIPX + DUAVE)/20.)
      DUAVEP = ABS(UO- ATAN(DUPV/SQRT(1.-(DUPV)  **2))*RAD )
```

```
      DUQ(I)= (DQ(I)+DUAVEP )
C     WRITE (6,2) DUPV, DUAVEP, DUQ(I)
  447 IF (I-IKO)450,460,460
  450 I= I+1
      GO TO 443
  457 CONTINUE
      IF(IRUN-ITEMAX) 459,458,458
  458 WRITE(7,75)
      WRITE (7,75)
      WRITE(7,99)
      WRITE (7,5) K,N,NEND , ITEMAX, DELTA,UO,TOL,ZMAX,BW
      WRITE (7,75)
      WRITE(7,2) (AGAM(1,I) ,I=1,N)
      CALLPLOT(TD,ALPHA,JSTOP,VAL,K1X,PEAK,M1X,C,NU,MMAX,K,BW,UO,
     Z    ZPG,DAY  )
      CALL PRINTV(12,FLUNK, 910,15)
      WRITE ( 6,99)
      WRITE ( 6,96 ) ISEVEN
C     THIS IS EXIT 7
      GO TO 4601
  459 CONTINUE
  460 IF(ANG(3).LE.O.) GO TO 461
      IF(ANG(1).LE.ANG(3)) GO TO 461
      WRITE ( 6,96 ) IEIGHT
C     THIS IS EXIT 8
 4601 GO TO 20
  461 IF(ANG(1)- ANG(2)) 463,463,462
  462 ANGL(2) = (ANG(1) + ANG(3))/2.
      XUQ(2) = DUQ(2)
      ANGL(1) = ANG(1)
      ANG(1)=0.
      XUQ(1) = DUQ(1)
      DUQ(1)=0.
      GO TO 464
  463 ANGL(1) = ANG(1)
      ANG(1)=0.
      ANGL(2) = ANG(2)
      ANG(2)= 0.
      XUQ(1)=DUQ(1)
      DUQ(1) = 0.
      XUQ(2)=DUQ(2)
      DUQ(2)=0.
  464 IF(2-IKO) 465,469,469
  465 DO 466 J=3,IKO
      ANGL(J)=ANG(J)
      ANG(J) = 0.
      XUQ(J)=DUQ(J)
      DUQ(J) = 0.
  466 CONTINUE
  469 IF(KAX.GT.0) GO TO 470
      IKO = IKO + 1
      XUQ (IKO) =  0.
      ANGL(IKO) = 90.
  470 IT=2
C     DO 471 I=1,IKO
C 471 WRITE(6,2) XUQ(I) ,ANGL(I)
      I=1
      UQ(1) = 0.
      THETA = 0.
      DSLO = (XUQ(1) / ANGL(1) )*DELTA
      UQ(1) = DSLO
      THETA = DELTA
  472 I= I+1
      UQ(I) = UQ(I-1) + DSLO
      THETA = THETA + DELTA
C     WRITE (6,2) UQ(I), THETA
      IF(THETA+DELTA-ANGL(1)) 472,472,473
  473 DSLO = (XUQ(IT) - XUQ(IT-1))/(ANGL(IT)-ANGL(IT-1))* DELTA
  474 I=I+1
      UJ(I)=UQ(I-1)+DSLO
      THETA = THETA + DELTA
C     WRITE (6,2) UQ(I), THETA
      IF (THETA - ANGL(IT)) 474,475,475
  475 CONTINUE
       IT=IT+1
      IF(IT-IKO) 473,473,495
  495 CONTINUE
      DTH=DELTA
      K = KAX
      N = NU(1)
      CALL COEF(UQ,   DTH,K,N,BI)
C     RESPONSE ERROR ANALYSIS COMPLETE
C     START IMPROVEMENT OF PREVIOUS SOLUTION
  502 KSET = 0
      I7=0
      ZEE=1.
      ZAW=1.
      KSET2 = 0
      IDX = 2-KAX
      NI = 2*N -K
      IBK=IDX
      DO 515 IB= IDX,NI,2
      BIBI(IB) = ABS(BI(IB))
      NI1 = 2*(N+1) -K
  515 CONTINUE
  520 BIMAX= BIBI( IDX)
      IBKD=IDX
      DO 525 JIPS=1,NI
      IPS=2*JIPS-KAX
      IF(BIMAX-BIBI(IPS)) 523,525,525
  523 BIMAX=BIBI(IPS)
      IBKD=IPS
  525 CONTINUE
      WRITE (6,5) IZERO,IBK
      IF (BIMAX- 0.8 * DUAVEX) 530,530,527
  527 CONTINUE
      CAUTN = 5.
  530 CONTINUE
  533 IF (K) 535,535,537
  535 I7=IBK/2
      IF(CAUTN. GT. 0.) GO TO 536
      ZAW = 1.
```

```
      CALL SCORE(IBK,BI(IBK), SCR1,ZAW,ZEE, ISCORE )
      GO TO 540
  536 ZAW = 0.5
      GO TO 540
  537 I?=(IBK+1)/2
      IF(CAUTN. GT. 0.) GO TO 539
      ZAW = 1.
      CALL SCORE(IBK,BI(IBK), SCR1,ZAW,ZEE, ISCORE )
      GO TO 540
  539 ZAW = 0.5
      GO TO 540
  540 NUB = NU(1)
      JTEST=0
      SPD = 1.
      CALL OSCIL(JRUN,AGAM,BI(IBK),IBK,NUB,JTEST,IRUN,ITEMAX)
      WRITE (6,5) IZERO, JTEST
      SPD =ZAW*ZEE*SPEED
      IF(JTEST) 542,542,578
  542 IF ((ZAW* ZEE) -1.) 5420,5421,5422
 5420 WRITE (6,101)  SPD
      GO TO 5423
 5421 WRITE (6,102)
      GO TO 5423
 5422 WRITE (6,103)  SPD
 5423 IF(XPRINT. LE .0.) GO TO 5424
      WRITE (6,80)
 5424 DO 575 I=1,NUB
       IF(K) 550,550,543
  543 KIK = 2*(I-1) + K
  545 DGAM(I)=BI(KIK)/RAD*ZAW*.5 *ZEE  *SPEED
      GO TO 570
  550 KIK=2*I
  565 DGAM(I)=BI(KIK)*ZAW/RAD *ZEE*SPEED
  570 AGAM(1,I) = + DGAM(I)+AGAM(1,I)
  575 CONTINUE
  578 CONTINUE
      IF(JTEST.LE.0) GO TO 580
      ITYP = 1
      JTINS = JTEST + INSTBL
      IF ( JTINS .GT.20 ) ITYP = 2
      IF ( INSTBL . GT .15 )  TRIMZ = 10.
C     IF ( INSTBL . EQ. 15) TOL = TOL*2.
      WRITE(7,75)
      WRITE (7,75)
      WRITE(7,99)
      WRITE ( 6,98 ) IBK, ITYP
      WRITE ( 7,98 ) IBK, ITYP
      WRITE (7,5) K,N,NEND , ITEMAX, DELTA,UO,TOL,ZMAX,BW
      WRITE (7,75)
      WRITE(7,2) (AGAM(1,I) ,I=1,N)
      CALLPLOT(TD,ALPHA,JSTOP,VAL,KIX,PEAK,MIX,C,NU,MMAX,K,BW,UO,
     Z    ZPG,DAY  )
      CALL PRINTV(12,TOUGH, 918, 15)
      INSTBL = 5+ INSTBL
  580 CONTINUE
      N= NU(1)

  590 GO TO 80
C
C
  595 WRITE ( 6,105)
      RETURN
C
C
      END
```

```
      SUBROUTINE ZTRIM(C,NU,MMAX,ZMIN)
C
C     THE PURPOSE OF THE ZTRIM SUBROUTINE IS TO LIMIT THE IMPEDANCE
C        VALUES TO SOME ZMIN OR HIGHER FOR THE INPUT END OF COUPLERS.
C
      DIMENSION C(10,30),NU(10),NUT(10)
      DO 10 IPL=2,MMAX
      NUX=NU(IPL)
      NUT(IPL)=0
      DO 10 I=1,NUX
      IF(C(IPL,I)-ZMIN) 5,10,10
    5 NU(IPL)=NU(IPL)-1
   10 CONTINUE
      IF(NU(MMAX)) 15,15,25
   15 MMAX=MMAX-1
   25 RETURN
      END


      FUNCTION XMX(N,XN )
C
C     FUNCTION XMX WILL FIND THE MAXIMUM VALUE IN THE XN ARRAY OF SIZE N
C
      DIMENSION XN(500)
  101 FORMAT ( 42H THE DIMENSION IN FUNCTION XMX IS EXCEEDED     )
      IF(N-500) 10,10,100
   10 XMX=XN(1)
      DO 1 I=1,N
      IF(XMX-XN(I)) 2,1,1
    2 XMX=XN(I)
    1 CONTINUE
      GO TO 200
  100 WRITE(6,101)
  200 RETURN
      END


      FUNCTION XMN(N,XN )
C
C     FUNCTION XMN WILL FIND THE MINIMUM VALUE IN THE XN ARRAY OF SIZE N
C
      DIMENSION XN(500)
  101 FORMAT ( 42H THE DIMENSION IN FUNCTION XMN IS EXCEEDED     )
      IF(N-500) 10,10,100
   10 XMN=XN(1)
      DO 1 I=1,N
      IF(XN(I)-XMN)2,1,1
    2 XMN=XN(I)
    1 CONTINUE
      GO TO 200
  100 WRITE(6,101)
  200 RETURN
      END
```

```
      SUBROUTINE COEF(UB,   DTH,K,N,BI)
C
C     THE PURPOSE OF THE COEF SUBROUTINE IS TO FIND THE FOURIER (SINE)
C        COEFFICIENTS OF THE ERROR CURVE (UB VERSUS THETA). THE THETA
C        ARRAY IS IMPLICIT --- FROM  0 TO 90 DEGREES IN EQUAL DTH
C        INCREMENTS.
C     BY SPECIAL CONSIDERATION OF SYMMETRY, THE NUMERICAL INTEGRATION,
C        USING SIMPSONS RULE, IS OVER  THETA OF 0 TO 90 DEGREES.
C
      DIMENSION BI(50),UB(200),YIK(200)
    1 FORMAT(3H B(, I2, 3H )=, F8.5)
      PI=3.14159265
      RAD = 180./PI
      IX = 0
      MM=0
      NI = 2*(N+1) -K
    2 KIK=2*IX+K
      TH=DTH
      RTH=TH/RAD
      IF ( KIK) 25,25,4
    4 XKIK=KIK
    6 MM=MM+1
      YIK(MM)=UB(MM)*SIN(XKIK*RTH)
      TH=TH+DTH
      RTH=TH/RAD
      IF(TH-90.000001) 6,6,8
    8 YO=0.
      DO 10 IM=1,MM,2
   10 YO=YO+YIK(IM)
      IF (-1. **MM)  12,12,13
   12 YO = YO - YIK(MM)/2.
      GO TO 14
   13 YIK(MM) = YIK(MM)/2.
   14 YE = 0.
      DO 16 IM=2,MM,2
   16 YE=YE+YIK(IM)
      BI(KIK) = 2./PI *(8.*YO +4.*YE)*DTH/(3.*RAD)
      WRITE (6,1 ) KIK,BI(KIK)
      MM = 0
   25 IX=IX+1
      IF(KIK-NI) 2,27,27
   27 RETURN
      END
```

```
      SUBROUTINEPLOT(TD,ALPHA,JSTOP,VAL,KIX,PEAK,MIX,C,NU,MMAX,K,BW,UD,
     2   ZPG,DATE )
C
C     THE PURPOSE OF THE  PLOT SUBROUTINE IS TO ---
C        1 PLOT THE RESPONSE FUNCTION ,LABELLING MAX AND MIN VALUES,
C        2 TITLE THE PLOT IN LARGE AND CENTERED LETTERS,
C        3 DISPLAY CLEARLY THE COUPLER/PHASE SHIFTER IMPEDANCE (AND
C            VOLTAGE COUPLING ) VALUES ,   AND
C        4 DATE THE DATA
C
C     TD    = THETA,NORMALIZED FREQUENCY (IN DEGREES).
C     ALPHA = RESPONCE FUNCTION (AN ARRAY) TO BE PLOTTED, WHICH
C             CONTAINS THE PEAKS(VALLEYS .
C     JSTOP = SUBCRIPT OF THE LARGEST TD.
C     VAL   = RELATIVE MINIMUM VALUES (I.E. VALLEYS) OF ALPHA.
C     KIX   = SIZE OF VAL (ARRAY).
C     PEAK  = RELATIVE MAXIMUM VALUES (I.E. PEAKS) OF ALPHA.
C     MIX   = SIZE OF PEAK (ARRAY).
C     C     = THE TWO-DIMENSIONAL IMPEDANCE ARRAY.
C     NU    = NUMBER OF COLUMNS OF C ARRAY (I.E. THE NUMBER
C             OF COUPLED SECTIONS IN ANY ONE TANDEM COUPLER).
C     MMAX  = SIZE OF NU ARRAY.
C     K     = CODE OF THE DEVICE, I.E.
C           = 1, FOR THE COUPLER
C           = 0, FOR THE PHASE SHIFTER
C     BW    = BANDWIDTH
C     UD    = NOMINAL VALUE OF THE RESPONSE FUNCTION.
C     ZPG= PAGE NUMBER
C
      DIMENSION C(10,30),NU(30),TD(360),ALPHA(360),VAL(50),PEAK(50),
     2    CA(360),JP(50),JV(50)
   41 FORMAT(40X,I5,2F15.5)
      U2=UD
      XR=90.
      XL = TD(1) -5.
      RD=3.14159/180.
      YT=XMX(MIX,PEAK)
      YB=XMN(KIX,VAL)
      IST=2
      DO 1 I=2,JSTOP
      IF(TD(1)-TD(I)) 9,9,1
    9 IST=I-1
      GO TO 2
    1 CONTINUE
    2 MM=0
      NN=0
C     THIS SECTION PREPARES ALPHA TO BE PLOTTED ACC. TO K=0 OR K=1.
C     ALSO FINDS SUBSCRIPTS OF ALPHA (PEAKS,VALLEYS) TO ENABLE LABELING
C     OF PEAK,VALLEY VALUES ON PLOT
      IF (K) 101,101,100
  100 CA(1)=20.*ALOG10(SIN(ALPHA(1)*RD))
      U2 = 20.*ALOG10(SIN(U2*RD))
      GO TO 103
  101 CA(1) = ALPHA(1)
  103 DO 8 I=IST,JSTOP
      IF(K)  105,105,107
  107 CA(I)=20.*ALOG10(SIN(ALPHA(I)*RD))
      GO TO 109
  105 CA(I) = ALPHA(I)
  109 DO 7 J=1,KIX
C     WRITE (6,41) J,ALPHA(I),VAL(J)
      IF(ALPHA(I)-VAL(J)) 7,6,7
    6 MK=MM+1
      JV(MM)=I
C     WRITE (6,41) I
      GO TO 8
    7 CONTINUE
    5 DO 4 J=1,MIX
C     WRITE (6,41) J,ALPHA(I),PEAK(J)
      IF(ALPHA(I)-PEAK(J)) 4,3,4
    3 NN=NN+1
      JP(NN)=I
C     WRITE (6,41) I
      GO TO 8
    4 CONTINUE
    8 CONTINUE
      IF(K) 200,200,201
  201 YT=20.*ALOG10(SIN(YT*RD))
      YB=20.*ALOG10(SIN(YB*RD))
      GO TO 203
  200 CONTINUE
  203 YB=AMIN1(YB,CA(IST))
       EXTERNAL TABL1V
      CALL CAMRAV(2)
      CALL RITSTV(18,26,TABL1V)
C     ESTABLISH GRID MARGINS,SPACING OF GRID LINES
      CALL SETMIV(60,30,340,50)
      CALL DXDYV(1,XL,XR,DX,N,I,NX,8.0,IR)
      CALL DXDYV(2,YB,YT,DY,M,J,NY,8.0,IR)
      YB=YB-DY
      YT=YT+DY
      CALL GRID1V(1,XL,XR,YB,YT,DX,DY,N,M,I,J,NX,NY)
C     PLOTS  TD VS COUPLING...TWICE FOR BRIGHTNESS
      DO 69 IO=1,2
      NXO=NXV(TD(IST))
       NYO=NYV(CA(IST))
      IS=IST+1
      DO 11 I=IS,JSTOP
      NX=NXV(TD(I))
      NY=NYV(CA(I))
      CALL LINEV(NXO,NYO,NX,NY)
      NXO=NX
      NYO=NY
   11 CONTINUE
   69 CONTINUE
C     PLOTS AVERAGE UD   (OVERLAY)
      WW=180./(BW+1.)
      NXO=NXV(WW)
      NYO = NYV(U2)
      NX = NXV(TD(JSTOP))
      NY  = NYV(U2)
```

```
      CALLLINEV( NXO,NYO,NX,NY)
      CALLLINEV( NXO,NYO,NX,NY)
      NN=NN+1
      JV(NN)=1
C     PLOTS VALLEY VALUES
      DO 25 I=1,NN
      N=JV(I)
      NX=NXV(TD(N))-24
      NY=NYV(CA(N))-12
   25 CALL LABLV(CA(N),NX,NY,7,2,3)
C      PLOTS PEAK VALUES
      DO 26 I=1,NN
      N=JP(I)
      NX=NXV(TD(N))-24
      NY=NYV(CA(N))+12
   26 CALL LABLV(CA(N),NX,NY,7,2,3)
      EXTERNAL RITE2V
C     LABELS PLOTS IN SMALL LETTERS,AND TITLE OF GRAPH,"-TO 1.0 BW) IN
C              LARGE LETTERS USING WRITE 18, ACCORDING TO K=0 OR K=1
      CALL VOUTV(24,RITE2V)
      IF(K) 30,30,31
   30 CALL APRNTV(0,-14,34,34HDIFFERENTIAL PHASE SHIFT  DEGREES ,30,860)
      CALL VLCSTV(240,280)
      WRITE(18,48) BW
   48 FORMAT(1H ,F6.3,1X,30HTO 1.0 BANDWIDTH PHASE SHIFTER)
      GO TO 32
   31 CALL VLCSTV(287,280)
      WRITE(18,49) BW
   49 FORMAT(1H ,F6.3,1X,24HTO 1.0 BANDWIDTH COUPLER)
      CALL APRNTV(G,-14,13,13HCOUPLING  DB ,30,730)
   32 CALL PRINTV(15,15HTHETA (DEGREES),482,320)
      NQY=270
C     PLOTS IMPEDENCE (C) VALUES , DATE AND PAGE NUMBER
      DO 35 IMPX=1,MMAX
      NQX=25
      NQY=NQY-45
      NUU=NU(IMPX)
      DO 35 IMPY=1,NUU
      NQX=NQX+75
      CALL LABLV(C(IMPX,IMPY),NQX,NQY,7,2,1)
      NQYC=NQY-15
      COUP=(C(IMPX,IMPY)**2 -1.)/(C(IMPX,IMPY)**2+1.)
   35 CALL LABLV(COUP,NQX,NQYC,7,2,1)
      CALL PRINTV(12,DATE ,918,35)
      CALL LABLV(ZPG,950,25,3,2,3)
      RETURN
      END
```

```
      SUBROUTINE SCORE(IBKD, BMAX,    SCR1,ZAW,ZEE,ISCORE)
C
C     THE PURPOSE OF THE  SCORE SUBROUTINE IS TO EITHER AMPLIFY OF
C        DIMINISH THE ERROR CORECTION VALUE . AMPLIFY,WHEN IN TWO
C        CONSECUTIVE  ITERATION THE  ERROR COEFFICIENTS ARE STATIONARY,
C        AND DIMINISH, ON  THE FIRST ITERATION AND ANY OTHER IF THE
C        CORRECTION  IS EXTREMELY  GREAT.
C
      SCR2= BMAX
      IF(IBKD-ISCORE) 10,5,10
    5 CONTINUE
      IF(SCR2-SCR1) 1,4,3
    3 IF(SCR1-.8*SCR2)10,4,4
    4 ZAW=1.
      ZEE=1.5
      GO TO 10
    1 IF(SCR2-.8*SCR1) 10,4,4
   10 SCR1=SCR2
      ISCORE=IBKD
      RETURN
      END
```

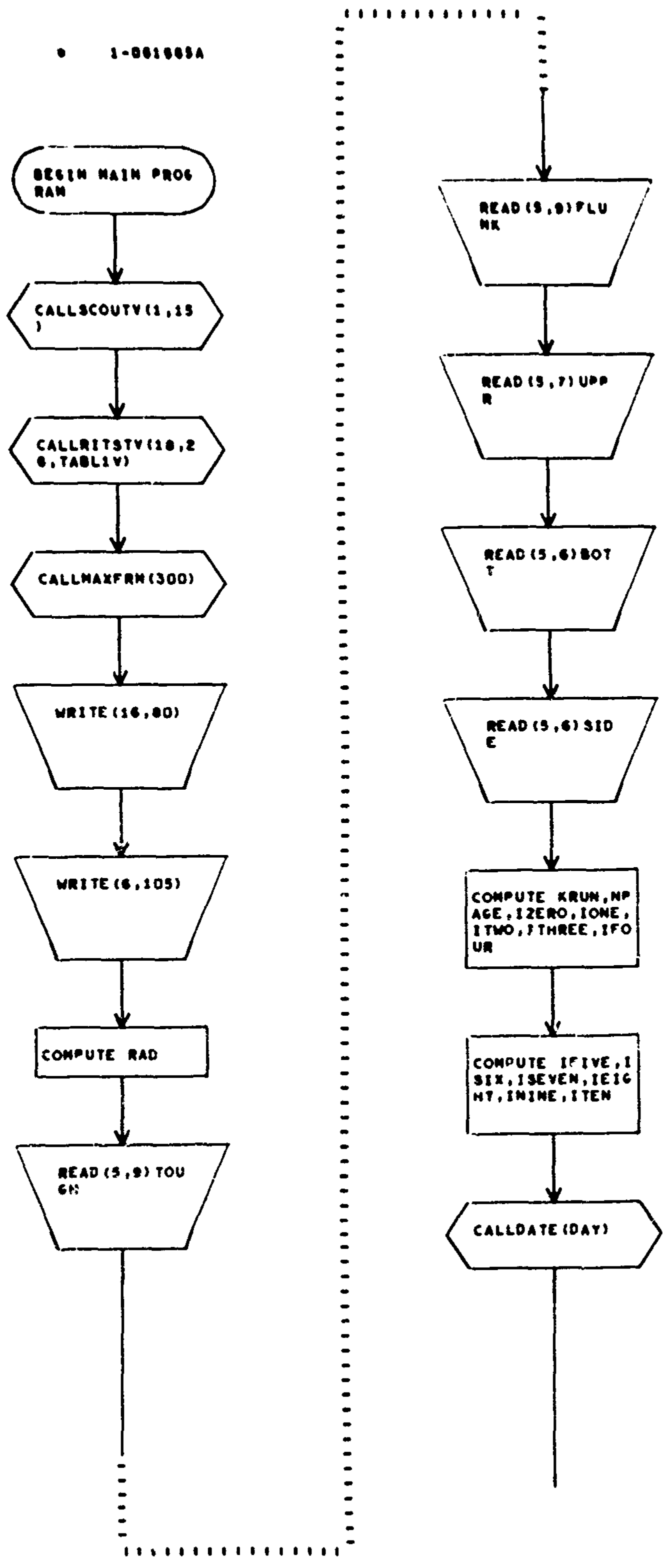
```
      SUBROUTINE OSCIL(JRUN,ATAU,BIMAX,IBK,NUB,JTEST,IRUN,ITEMAX)
C
C     THE PURPOSE OF THIS SUBROUTINE IS TO DETERMINE AND CORRECT
C           AN OSCILLATING ERROR CORRECTION PROCESS.
C
      DIMENSION ATAU(3,30),OLDTAU(2,30),BMX(2),IK(2),XTAU(1,30)
  100 FORMAT ( 5X,I15,3F10.5)
      IF(JRUN-2)  4,4,5
    4 GOTO (1,2), JRUN
    1 DO 3 I=1,NUB
    3 OLDTAU(1,I)=ATAU(1,I)
      BMX(1)=BIMAX
      IK(1)=IBK
      MID = 0
      LOW = 0
      RETURN
    2 DO 11 I=1,NUB
   11 OLDTAU(2,I)=ATAU(1,I)
      BMX(2)=BIMAX
      IK(2)=IBK
      RETURN
    5 IF(LOW.GT.0) GO TO 17
      IF(IBK-IK(1)) 6,8,6
    6 IK(1)=IK(2)
      IK(2)=IBK
      BMX(1)=BMX(2)
      BMX(2)=BIMAX
      DO 7 I=1,NUB
      OLDTAU(1,I)=OLDTAU(2,I)
    7 OLDTAU(2,I)=  ATAU(1,I)
      RETURN
    8 IF(ABS(BIMAX)-ABS(BMX(1))*.9) 6,13,13
   13 IF(ABS(BIMAX)-ABS(BMX(1))*1.1) 12,12,6
   12 IF(BIMAX*BMX(1)) 6,6,14
   14 JTEST = 2
      LOW = 1
      DO 16 I=1,NUB
      XTAU(1,I)=ATAU(1,I)
C     WRITE (6,100) NUB,   ATAU(1,I), OLDTAU(2,I), OLDTAU(1,I)
   16 ATAU(1,I)=.4 * ATAU(1,I) + .6*OLDTAU(2,I)
      RETURN
   17 IF(MID.GT.0) GO TO 19
      DO 18 I = 1, NUB
   18 ATAU(1,I) = .6000 * XTAU(1,I) + .4000 *OLDTAU(2,I)
      JTEST = 2
      MID = 1
      LOW = 1
      RETURN
   19 DO 20 I = 1, NUB
   20 ATAU(1,I)=.500*XTAU(1,I)+.500*OLDTAU(2,I)
      JTEST = 2
      MID = 0
      LOW = 0
      JRUN = 0
C     IRUN = ITEMAX + 10
      RETURN
      END
```

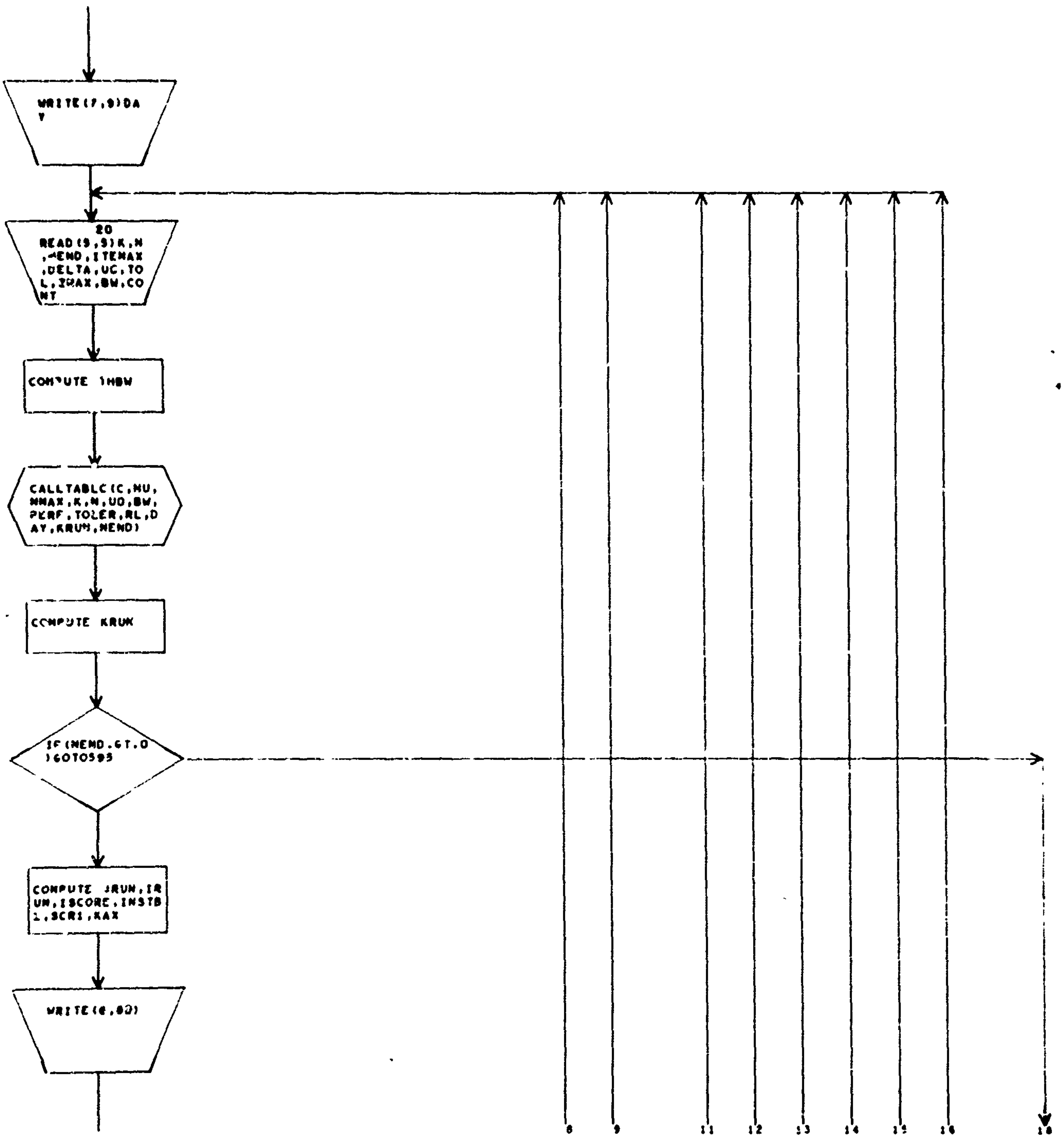
```
      SUBROUTINE TABLC(CT,NUT,MMAXT,KT,NT,UOT,BWT,RIPT,TOLT,RLT,DATE ,
     C  KRUN,NEND)
C
C
C     THIS PROGRAM PREPARES TABLES OF DESIGN DATA GROUPED BY KT,NT,BWT.
C
C     THIS PROGRAM REQUIRES THE INX SUBROUTINE
C
      DIMENSION TOL(10),RIP(10),C(10,30,10),NL  (30),RL(10),CT(10,30),
     2      NU(10,10),NUM(30),NUU(30) ,DATE(2) ,BAND(20)
   10 FORMAT( 3X2HZ(,I1,1H,I2,1H),2X10F 9.5)
C  10 FORMAT( 3X2HZ(,I1,1H,I2,1H),2X10F10.5)
  806 FORMAT (1X2HN= ,I2,78X10HCOUPLING= , F6.2, 3H DB)
  906 FORMAT (1X2HN=,I2,75X12HPHASE SHIFT=,F6.1,4H DEG)
C  91 FORMAT (2X10HBANDWIDTH , 10F10.3 )
   91 FORMAT (1X11HBANDWIDTH  ,10F 9.3 )
   92 FORMAT(1X11HRIPPLE, DEG,10F 9.5)
   94 FORMAT(1X11HTOLERANCE *,10F 9.5)
   95 FORMAT(1X19H*  READS IN DEGREES)
   96 FORMAT(1X11HREF. LENGTH,10F 9.5)
   97 FORMAT(1X14H*  READS IN DB)
   98 FORMAT(1X10HRIPPLE, DB,1X10F 9.5)
  100 FORMAT(1H )
  101 FORMAT (1H1)
  102 FORMAT(3X7HDATE  ' ,2X2A6)
      RAD=57.2957795
      CALL FRBUTV(5)
      IF(NEND.GT.0) GO TO 24
      IF(KRUN) 350,350,24
   24 CONTINUE
      BAND(KRUN + 1) = BWT
      TOL(KRUN)=TOLT
      RIP(KRUN)=RIPT
      RL(KRUN)=RLT
      DO 45 I=1,MMAXT
      IT=NUT(I)
      NU(I,KRUN)=IT
      DO 45 IA=1,IT
      C(I,IA,KRUN)=CT(I,IA)
   45 CONTINUE
      IF(NEND.GT.0) GO TO 200
      IF(MMAX-MMAXT) 47,47,48
   47 MMAX=MMAXT
   48 IF(KRUN-10)50,200,200
   50 IF(KT.NE.KCASE) GO TO 200
      IF(NT.NE.NTEST) GO TO 200
      T1=FLOAT(NT)*UOT
      IF(T1-TEST*.98) 200,60,55
   55 IF(T1-TEST*1.02) 60,60,200
   60 RETURN
  200 CONTINUE
       WRITE(16,101)
      IF(KCASE) 210,210,250
  210 CONTINUE
      WRITE(16,100)
```

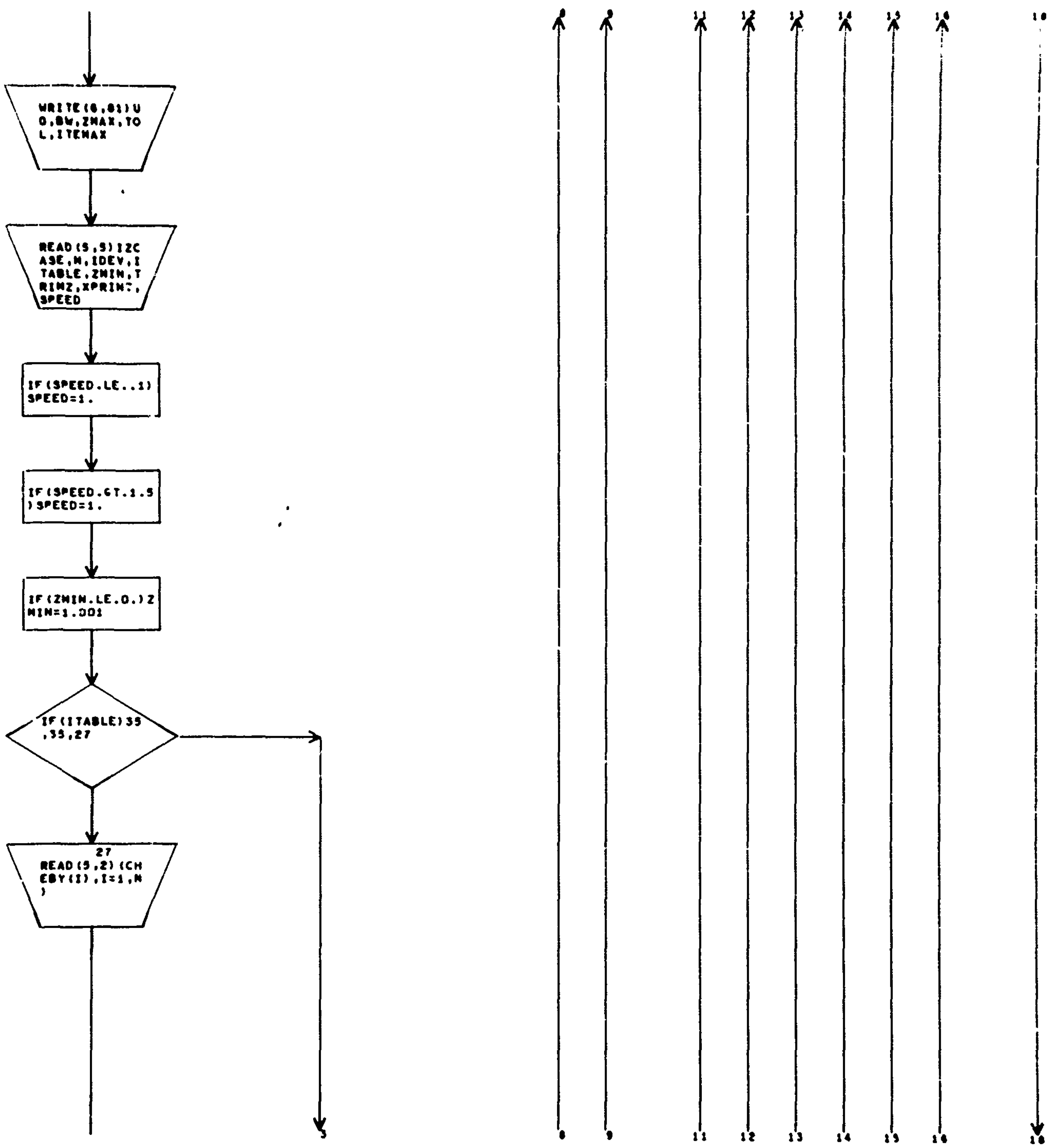
```
      WRITE(16,100)
      WRITE(16,906)NTEST,U1
      WRITE(16,100)
      WRITE (16,100)
      NUM(1)= NTEST
      IF(MMAX-1) 216,216 212
  212 CONTINUE
      DO 214 I2=2,MMAX
      DO 213 NO1= 1,KRUN
  213 NUU(NO1) = NU(I2, NO1)
      NUM(I2)=INX(KRUN,NUU)
  214 CONTINUE
  216 CONTINUE
      LINE = 15
      WRITE (16,91) ( BAND(J11), J11=1,KRUN)
      WRITE(16,92) (RIP(J11),J11=1,KRUN )
      WRITE(16,94) (TOL(J11),J11=1,KRUN )
      WRITE(16,96) ( RL(J11),J11=1,KRUN )
      DO 220 J1=1,MMAX
      WRITE (16,100)
      WRITE (16,100)
      ITA=NUM(J1)
      DO 220 J2=1,ITA
      WRITE(16,10) J1,J2,(C(J1,J2,J3) ,J3=1,KRUN )
C     LINE=LINE+1
      DO 220 J3=1,KRUN
      C(J1,J2,J3)=DOTS
  220 CONTINUE
  230 KRUN=0
      GO TO 350
  250 CONTINUE
      WRITE (16,100)
      WRITE (16,100)
      U2=20.*ALOG10(SIN(U1/RAD))
      NTX=2*NTEST-1
      WRITE(16,886) NTX,U2
      WRITE (16,100)
      WRITE (16,100)
      NUM(1)= NTEST
      IF(MMAX-1) 266,266,262
  262 CONTINUE
      DO 264 I2=2,MMAX
      DO 263 NO1= 1,KRUN
  263 NUU(NO1) = NU(I2, NO1)
      NUM(I2)=INX(KRUN,NUU)
  264 CONTINUE
  266 CONTINUE
      LINE = 14
      WRITE (16,91) ( BAND(J11), J11=1,KRUN)
      WRITE(16,98) (RIP(J11),J11=1,KRUN )
      WRITE(16,94) (TOL(J11),J11=1,KRUN )
      DO 270 J1=1,MMAX
      WRITE (16,100)
      WRITE (16,100)
      ITA=NUM(J1)
      DO 270 J2=1,ITA
      WRITE(16,10) J1,J2,(C(J1,J2,J3) ,J3=1,KRUN )
      LINE=LINE+1
      WRITE( 6,10) J1,J2,(C(J1,J2,J3) ,J3=1,KRUN )
      DO 270 J3=1,KRUN
      C(J1,J2,J3)=DOTS
  270 CONTINUE
      KRUN=0
  350 TEST=FLOAT(NT)*UDT
      MMAX=0
      BAND(1 ) = BWT
      U1=UDT
      KCASE=KT
      NTEST=NT
      RETURN
      END


      FUNCTION INX( ,,N )
C
C     FUNCTION INX WILL FIND THE MAXIMUM VALUE IN THE IN ARRAY OF SIZE N
C
      DIMENSION IN(500)
  101 FORMAT ( 42H THE DIMENSION IN FUNCTION INX IS EXCEEDED    )
      IF(N-500) 10,10,100
   10 INX=IN(1)
      DO 1 I=1,N
      IF(INX-IN(I)) 2,1,1
    2 INX=IN(I)
    1 CONTINUE
      GO TO 200
  100 WRITE(6,101)
  200 RETURN
      END
```

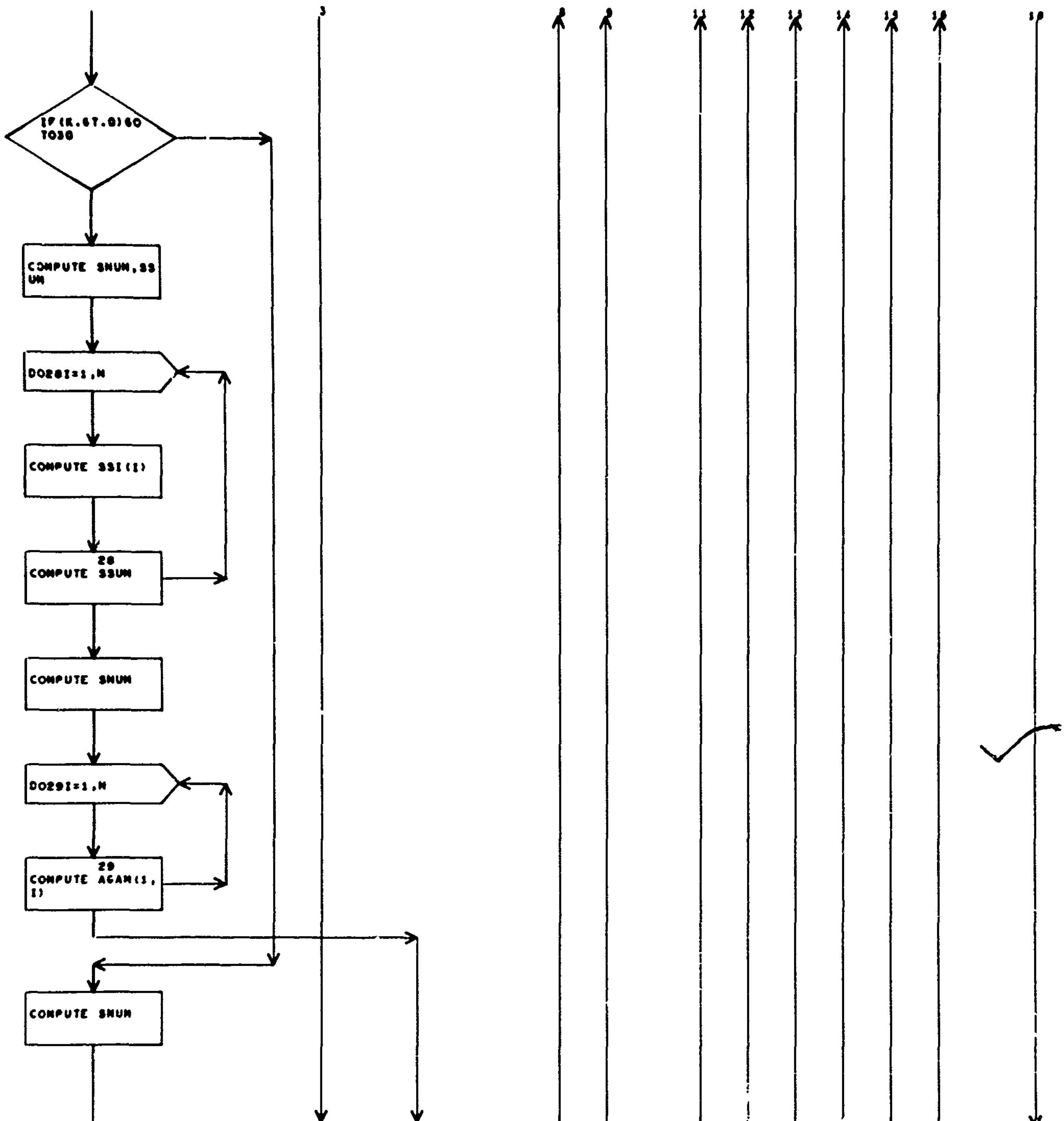
Section 3. FLOW CHART OF THE PROGRAM

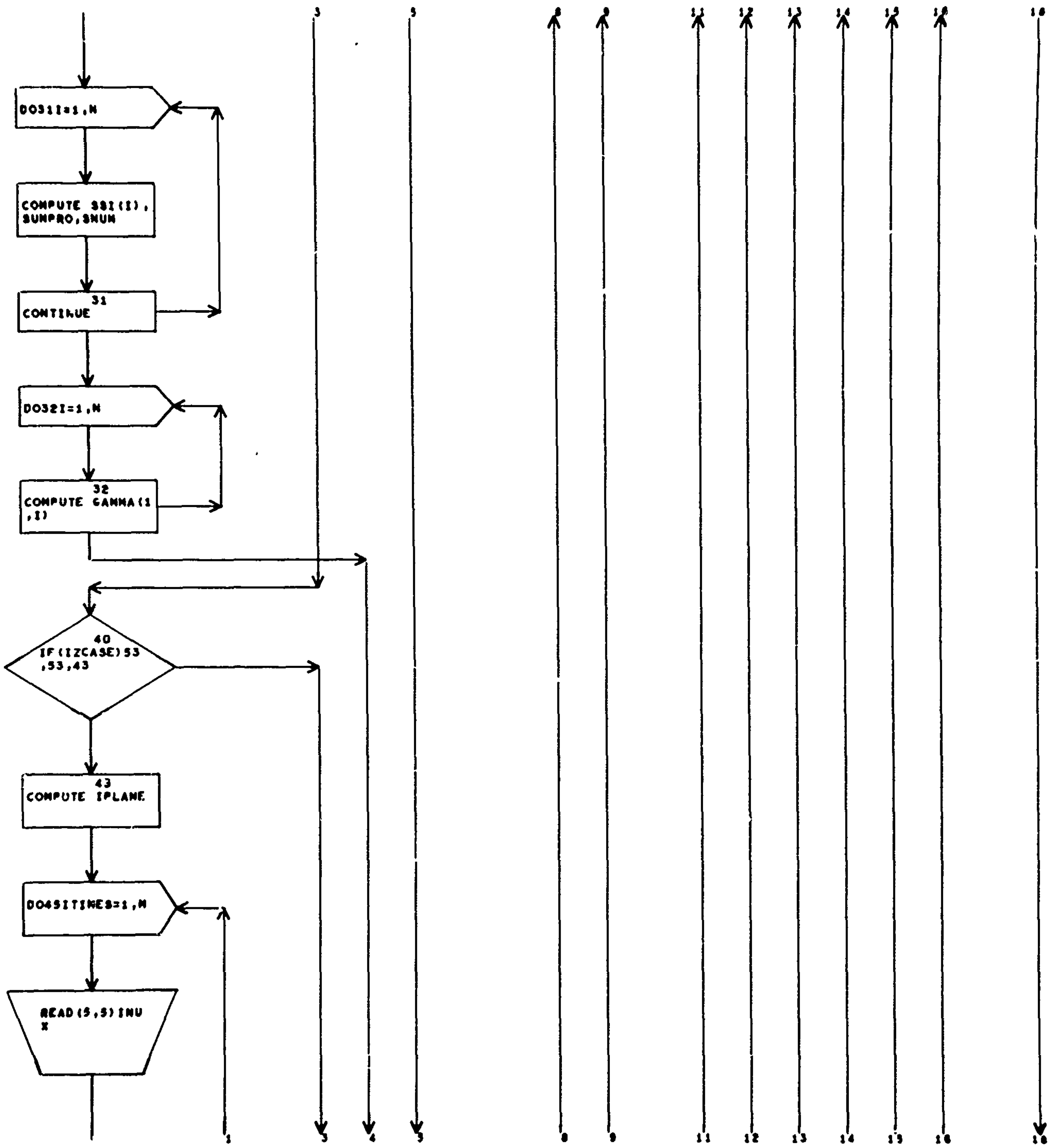
Using an automatic program with the SC4020, a lineal flow chart was prepared of the previous program. Because of the lineal display and the number of pages that are required, wherever possible, two "frames" were placed on a single page in the report. Thus, on page 19, for instance, the heavy broken line represents the proper sequence of events. In the absence of this broken line, it will be understood that flow lines at the top on one page directly connect to lines at the bottom of the immediately preceding page.

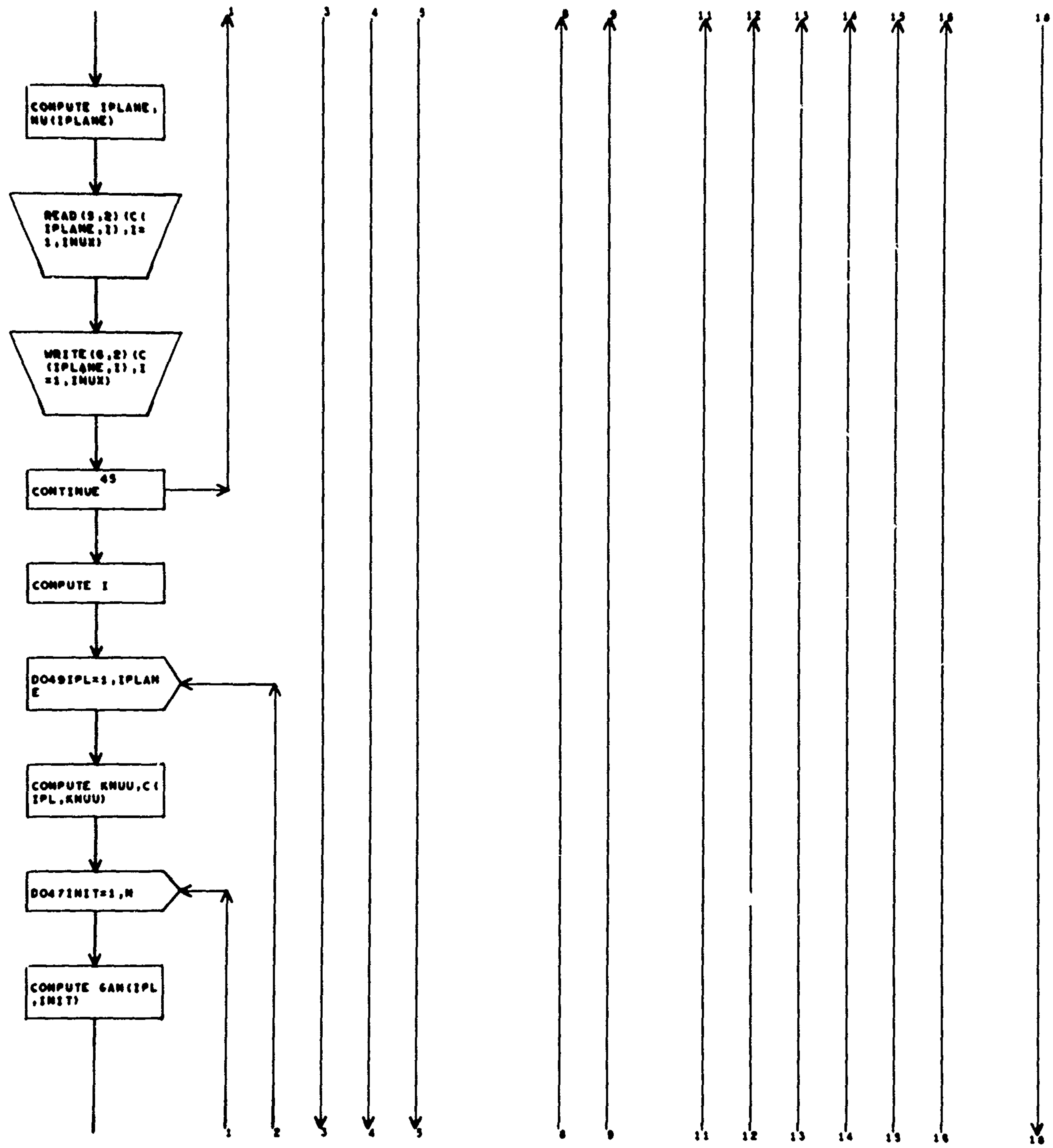

1-061665A
BEGIN MAIN PROG
RAM
CALLSCOUTV(1,15
)
CALLRITSTV(18,2
6,TABL1V)
CALLMAXFRM(300)
WRITE(16,80)
WRITE(6,105)
COMPUTE RAD
READ(5,9)TOU
GH
READ(5,9)FLU
NK
READ(5,7)UPP
R
READ(5,6)BOT
T
READ(5,6)SID
E
COMPUTE KRUN,NP
AGE,IZERO,IONE,
ITWO,JTHREE,IFO
UR
COMPUTE IFIVE,I
SIX,ISEVEN,IEIG
HT,ININE,ITEN
CALLDATE(DAY)

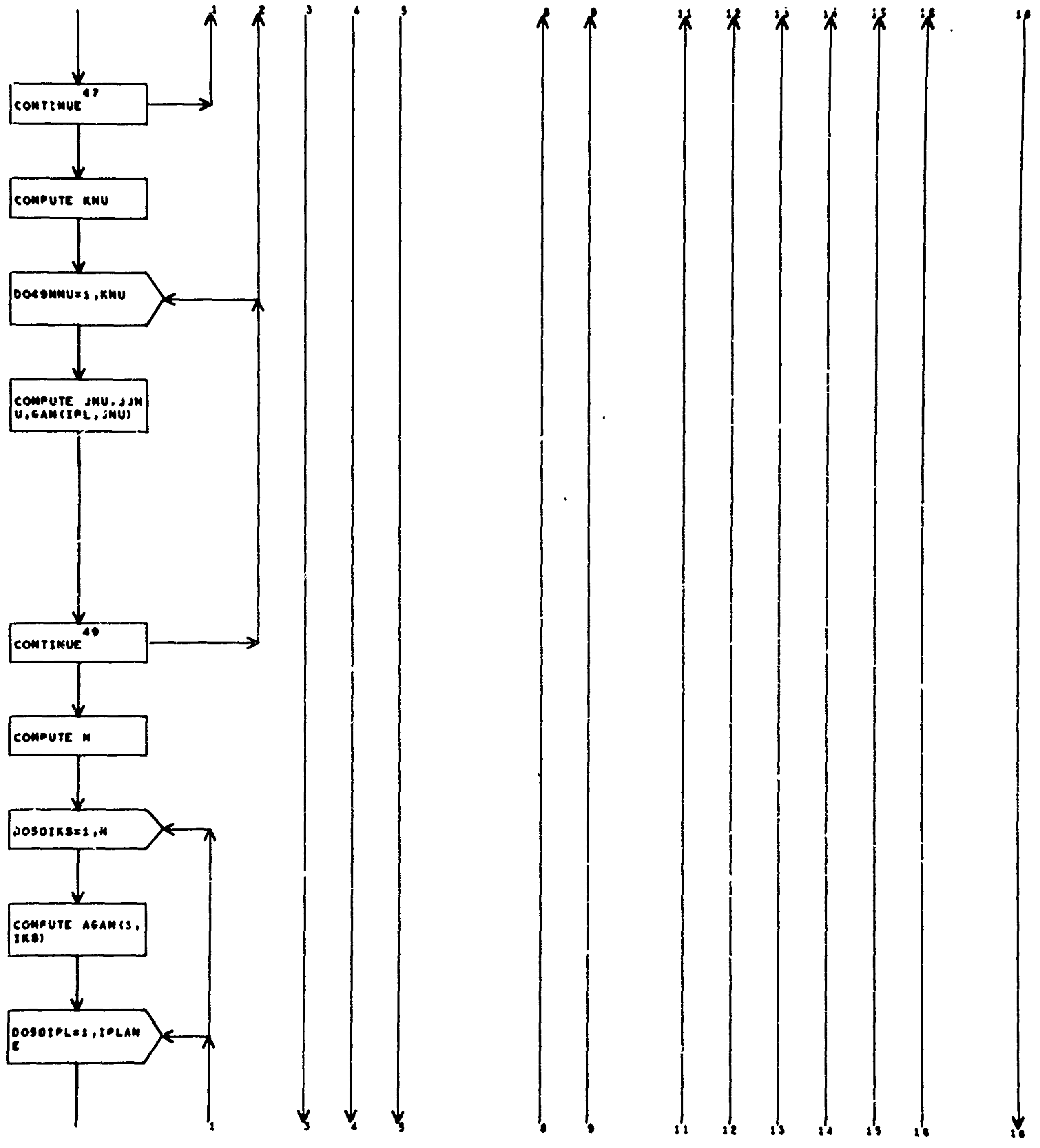

WRITE(7,9)DA
Y
20
READ(5,5)K,N
,NEND,ITEMAX
,DELTA,UC,TO
L,IMAX,BW,CO
NT
COMPUTE IHBW
CALLTABLC(C,NU,
NMAX,K,N,UO,BW,
PERF,TOLER,RL,D
AY,KRUN,NEND)
COMPUTE KRUN
IF(NEND.GT.0
)GOTO595
COMPUTE JRUN,IR
UN,ISCORE,INSTB
1,SCR1,KAX
WRITE(6,82)
8
9
11
12
13
14
16

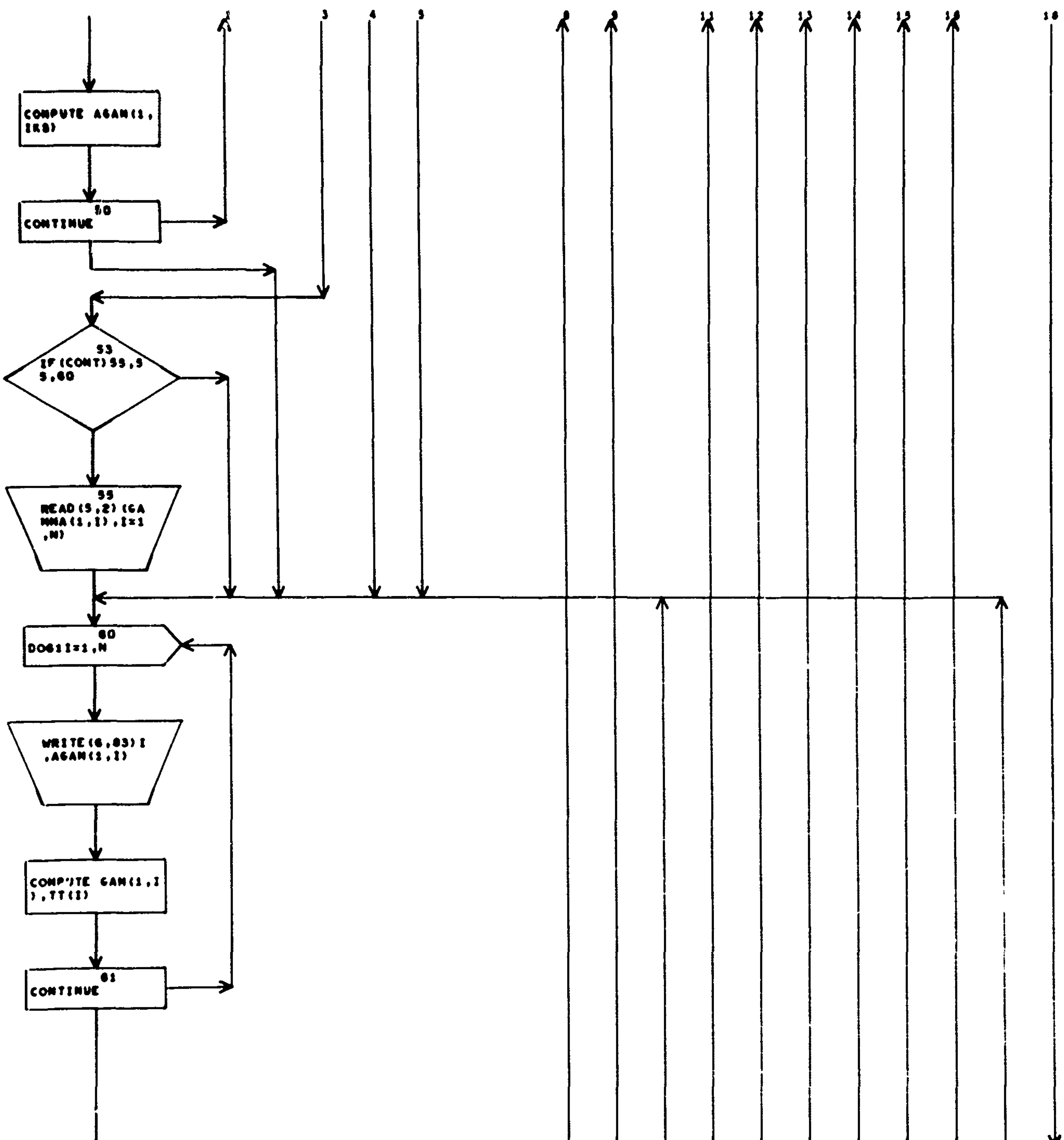

WRITE(6,81)U
O,BW,ZMAX,TO
L,ITEMAX
READ(5,5)IZC
ASE,N,IDEV,I
TABLE,ZMIN,T
RINZ,XPRINT,
SPEED
IF(SPEED.LE..1)
SPEED=1.
IF(SPEED.GT.1.5
)SPEED=1.
IF(ZMIN.LE.0.)Z
MIN=1.001
IF(ITABLE)35
,35,27
27
READ(5,2)(CH
EBY(I),I=1,N
)
8
9
11
12
13
14
15
16
18


IF(K.GT.0)GO TO30
COMPUTE SNUM,SSUM
DO28I=1,N
COMPUTE SSI(I)
28 COMPUTE SSUM
COMPUTE SNUM
DO29I=1,N
29 COMPUTE AGAM(1,I)
COMPUTE SNUM


DO31I=1,N
COMPUTE SSI(I), SUMPRO,SNUM
31
CONTINUE
DO32I=1,N
32
COMPUTE GAMMA(1,I)
40
IF(IZCASE)53,53,43
43
COMPUTE IPLANE
DO45ITIMES=1,N
READ(5,5)INUX


COMPUTE IPLANE, NU(IPLANE)
READ(5,2)(C(IPLANE,I),I=1,INUX)
WRITE(6,2)(C(IPLANE,I),I=1,INUX)
45 CONTINUE
COMPUTE I
DO49IPL=1,IPLANE
COMPUTE KNUU,C(IPL,KNUU)
DO47INIT=1,N
COMPUTE GAN(IPL,INIT)


CONTINUE 47
COMPUTE KNU
DO49NNU=1,KNU
COMPUTE JNU,JJN U,GAM(IPL,JNU)
CONTINUE 49
COMPUTE M
DO50IKS=1,M
COMPUTE AGAM(1, IKS)
DO50IPL=1,IPLAN E


COMPUTE AGAN(1,
IKB)
50
CONTINUE
53
IF(CONT)55,5
5,60
55
READ(5,2)(GA
MMA(1,I),I=1
,N)
60
DO61I=1,N
WRITE(6,83)I
,AGAN(1,I)
COMPUTE GAN(1,I
),TT(I)
61
CONTINUE
1
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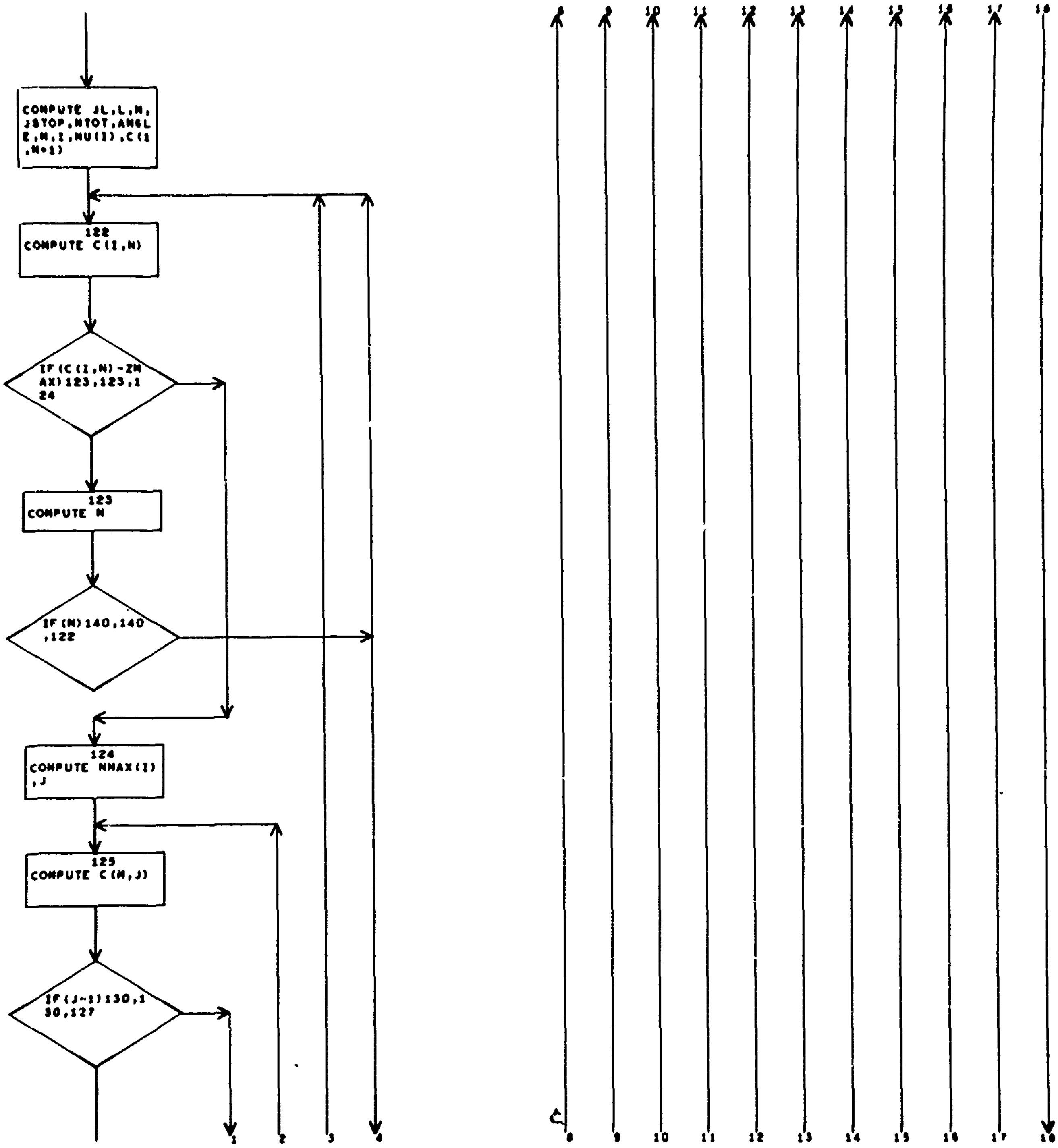
COMPUTE JL,L,N, JSTOP,NTOT,ANGL E,M,I,NU(I),C(1 ,N+1)
122
COMPUTE C(I,N)
IF(C(I,N)-ZM AX)123,123,1 24
123
COMPUTE N
IF(N)140,140 ,122
124
COMPUTE NMAX(I) ,J
125
COMPUTE C(M,J)
IF(J-1)130,1 30,127
1
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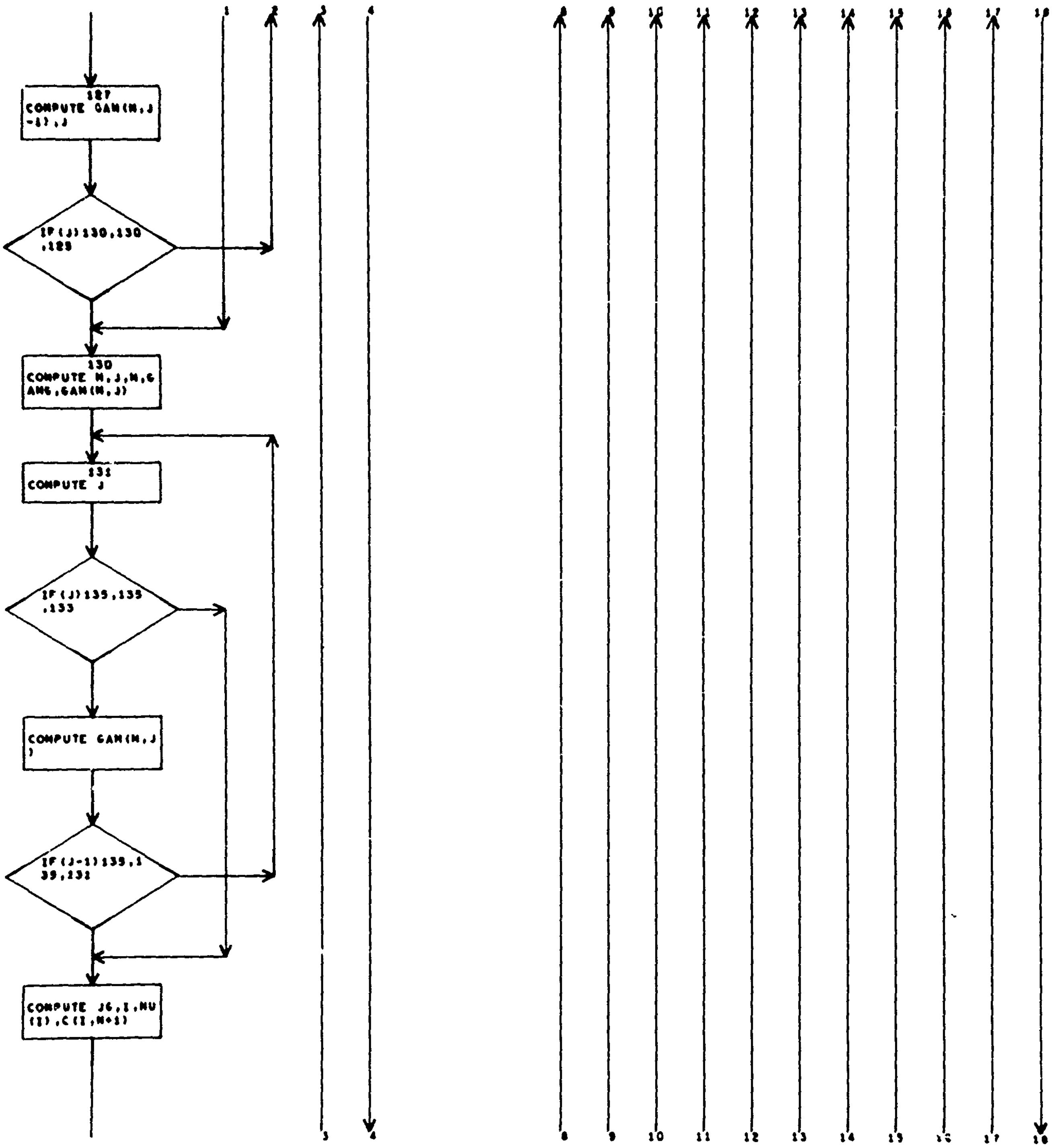
127
COMPUTE GAM(N,J-1),J
IF(J)130,130,128
130
COMPUTE N,J,M,GAMG,GAM(N,J)
131
COMPUTE J
IF(J)135,135,133
COMPUTE GAM(N,J)
IF(J-1)135,135,131
COMPUTE J6,I,NU(I),C(I,N+1)
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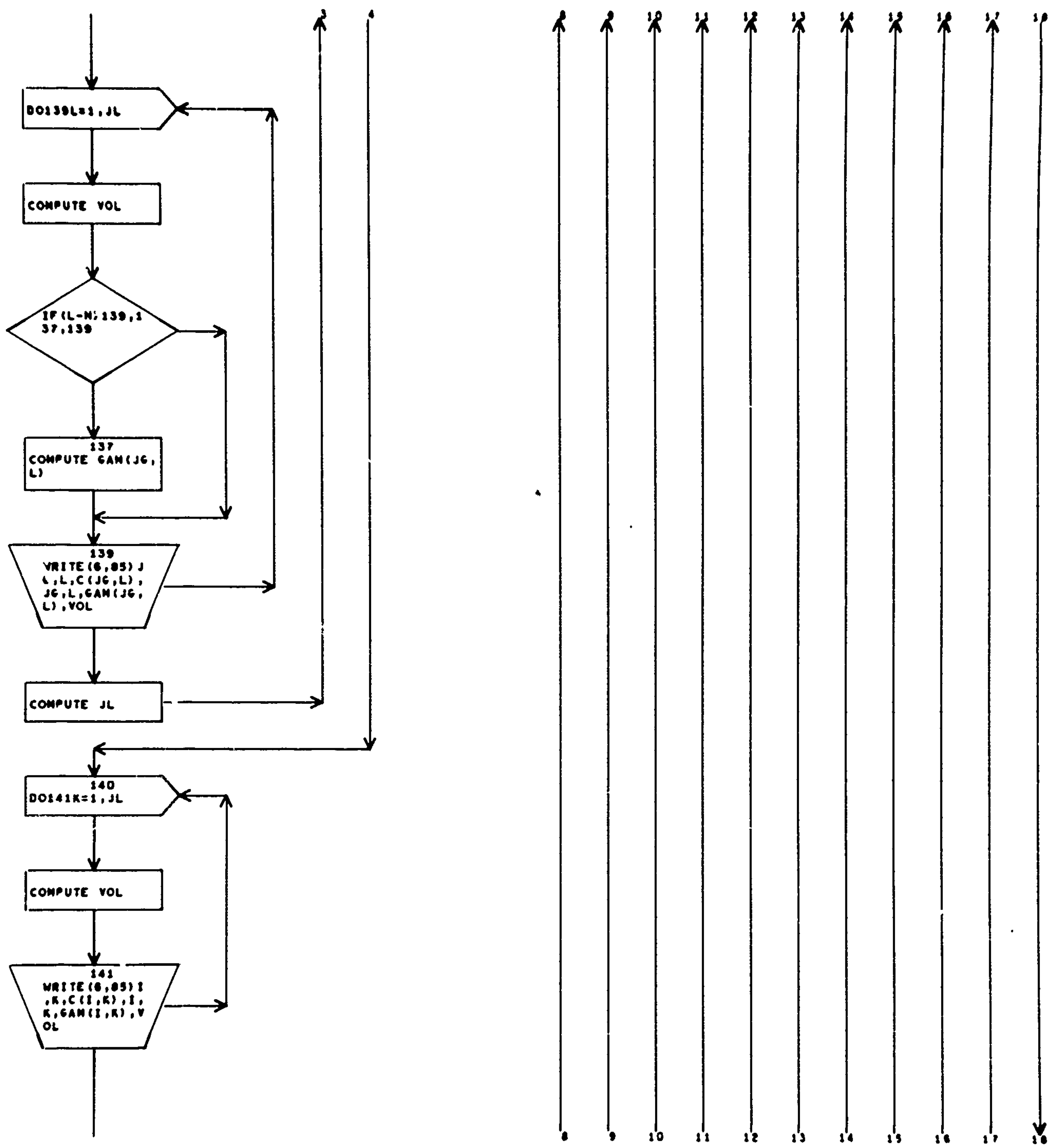

DO139L=1,JL
COMPUTE VOL
IF(L-N)139,1
37,139
137
COMPUTE GAM(JG,
L)
139
WRITE(6,85)J
L,L,C(JG,L),
JG,L,GAM(JG,
L),VOL
COMPUTE JL
140
DO141K=1,JL
COMPUTE VOL
141
WRITE(6,85)I
,K,C(I,K),I,
K,GAM(I,K),V
OL
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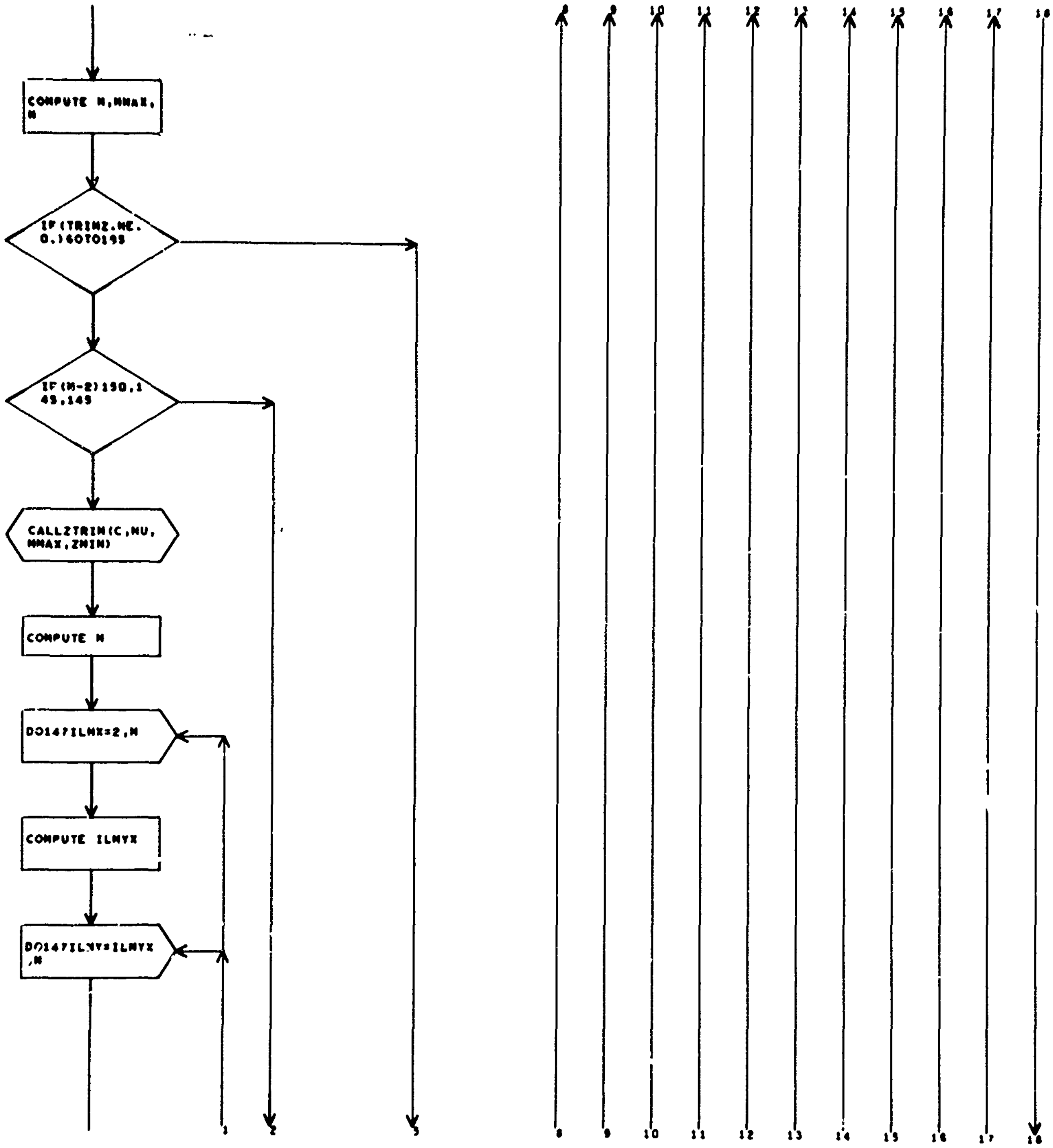
COMPUTE N,NMAX,M
IF(TRINZ.NE.0.)GOTO195
IF(M-2)150,145,145
CALLZTRIM(C,NU,NMAX,ZMIN)
COMPUTE M
DO147ILNX=2,M
COMPUTE ILNYX
DO147ILNY=ILNYX,M
1
2
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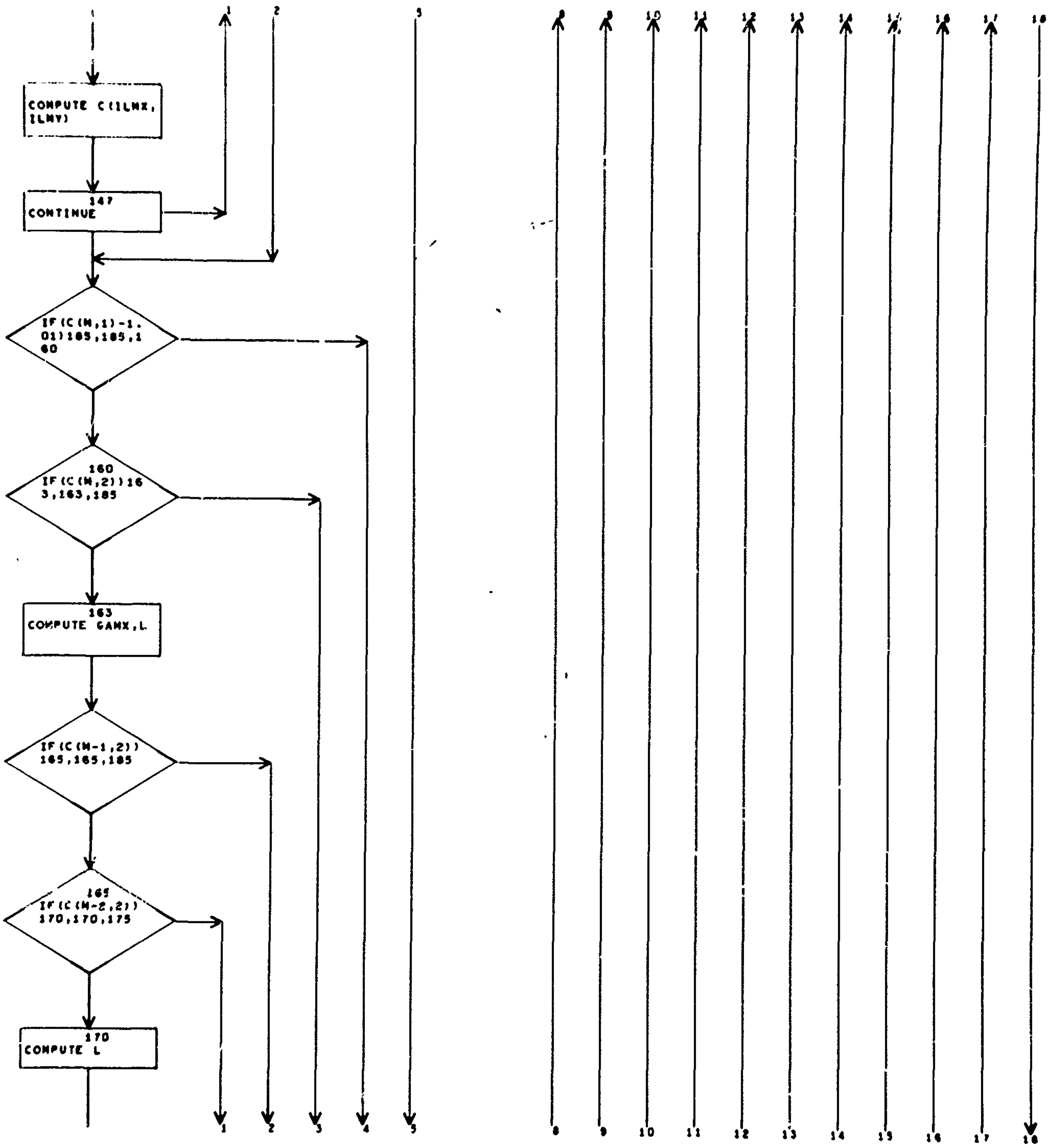
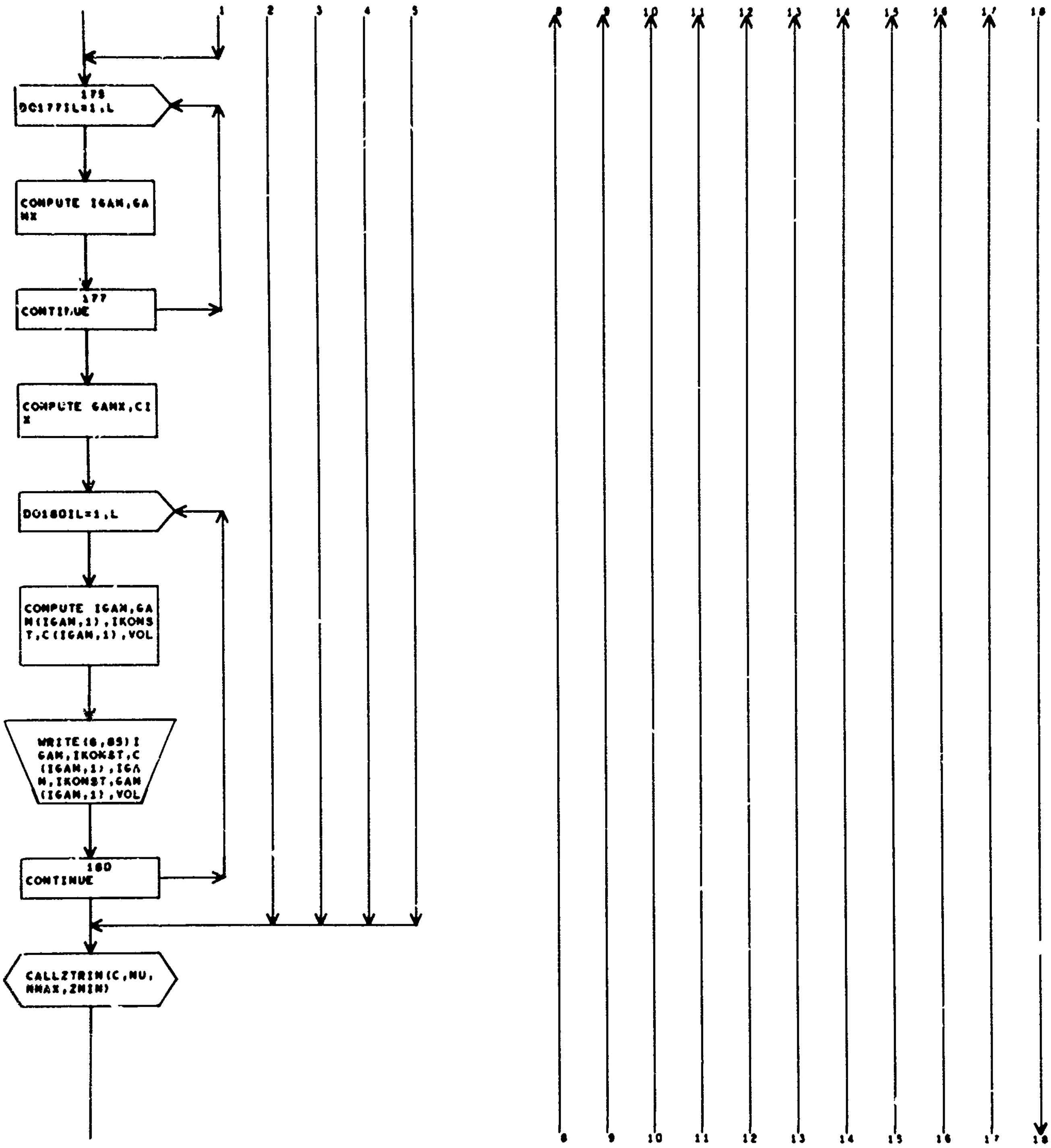
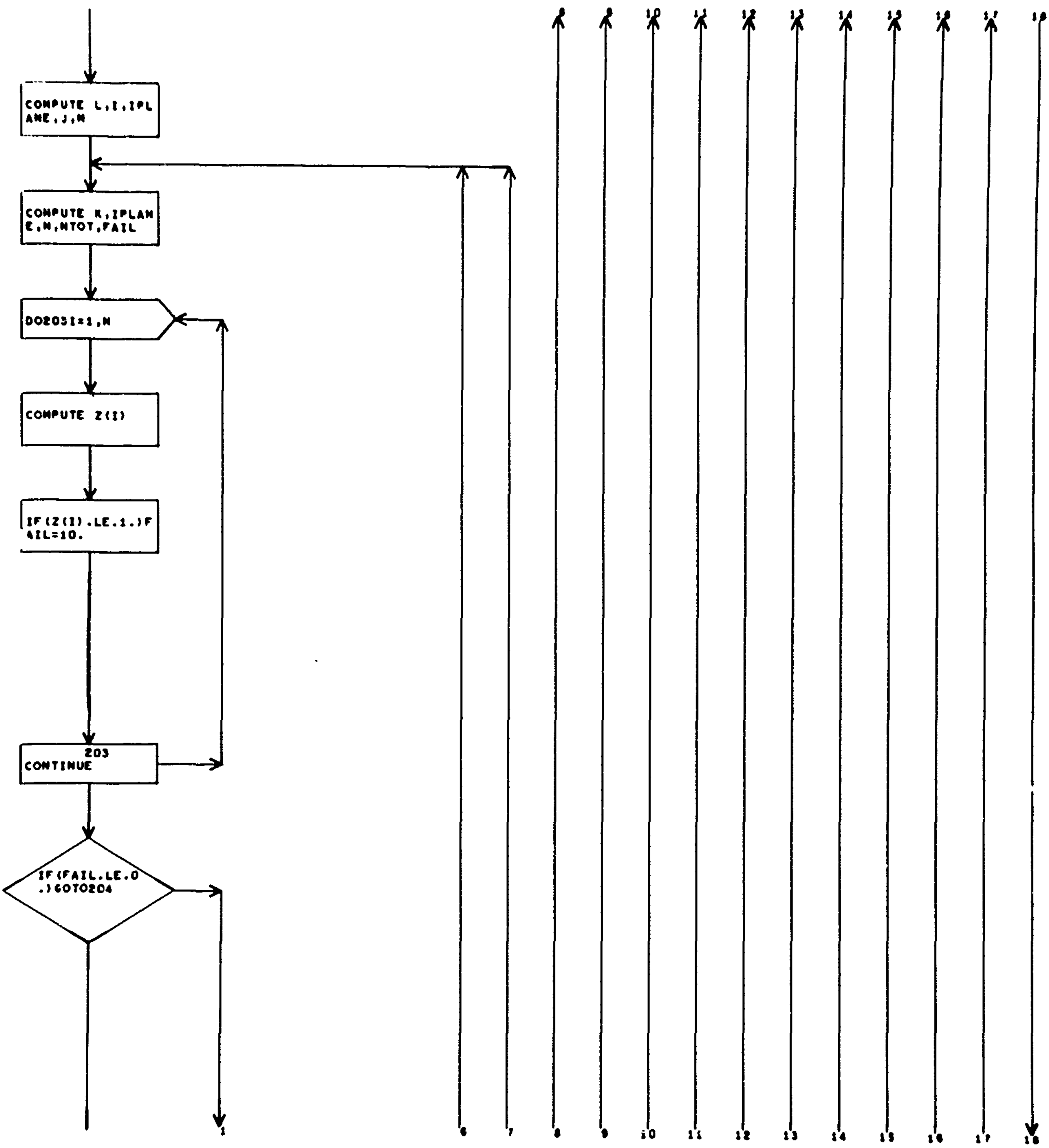
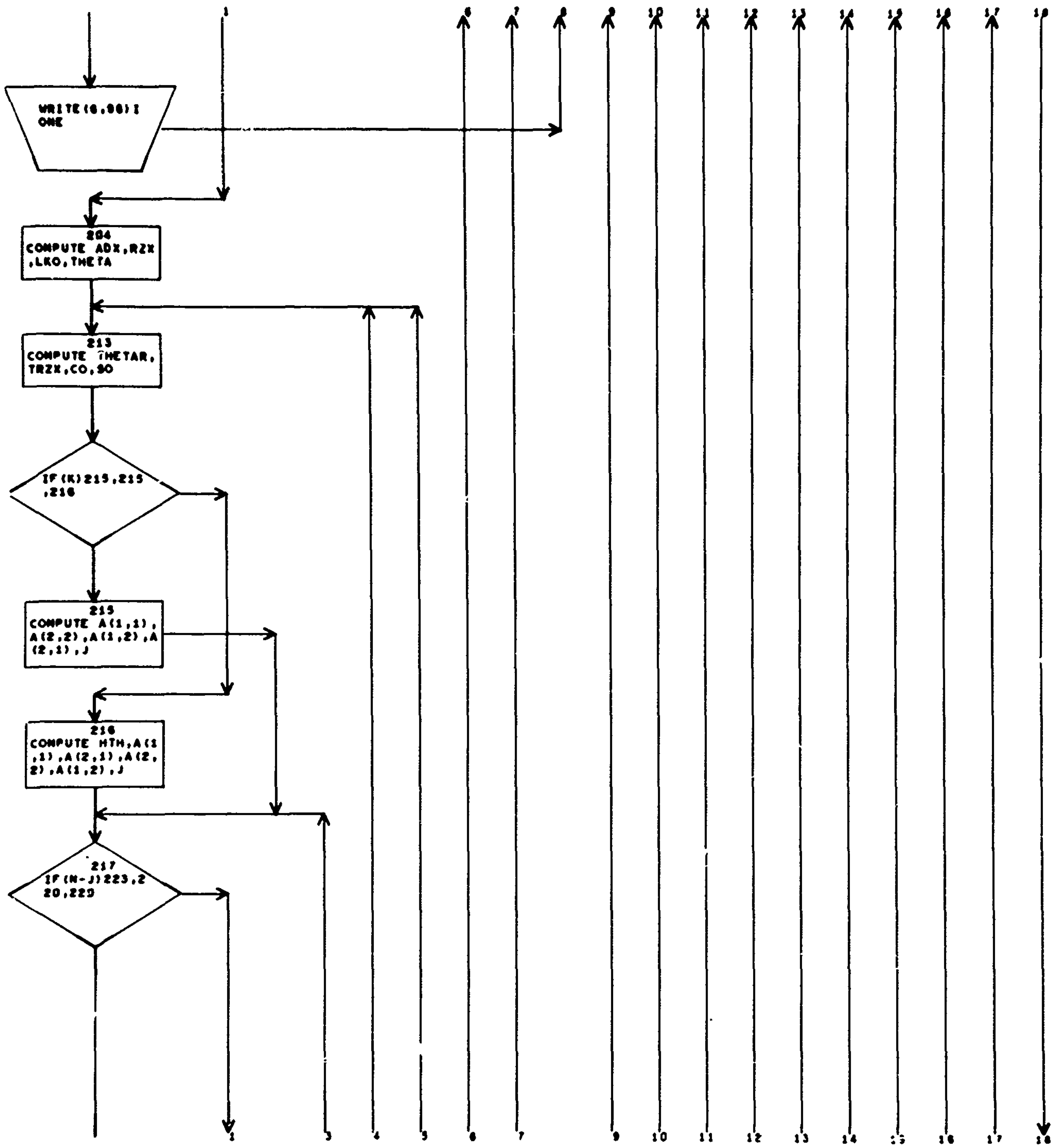
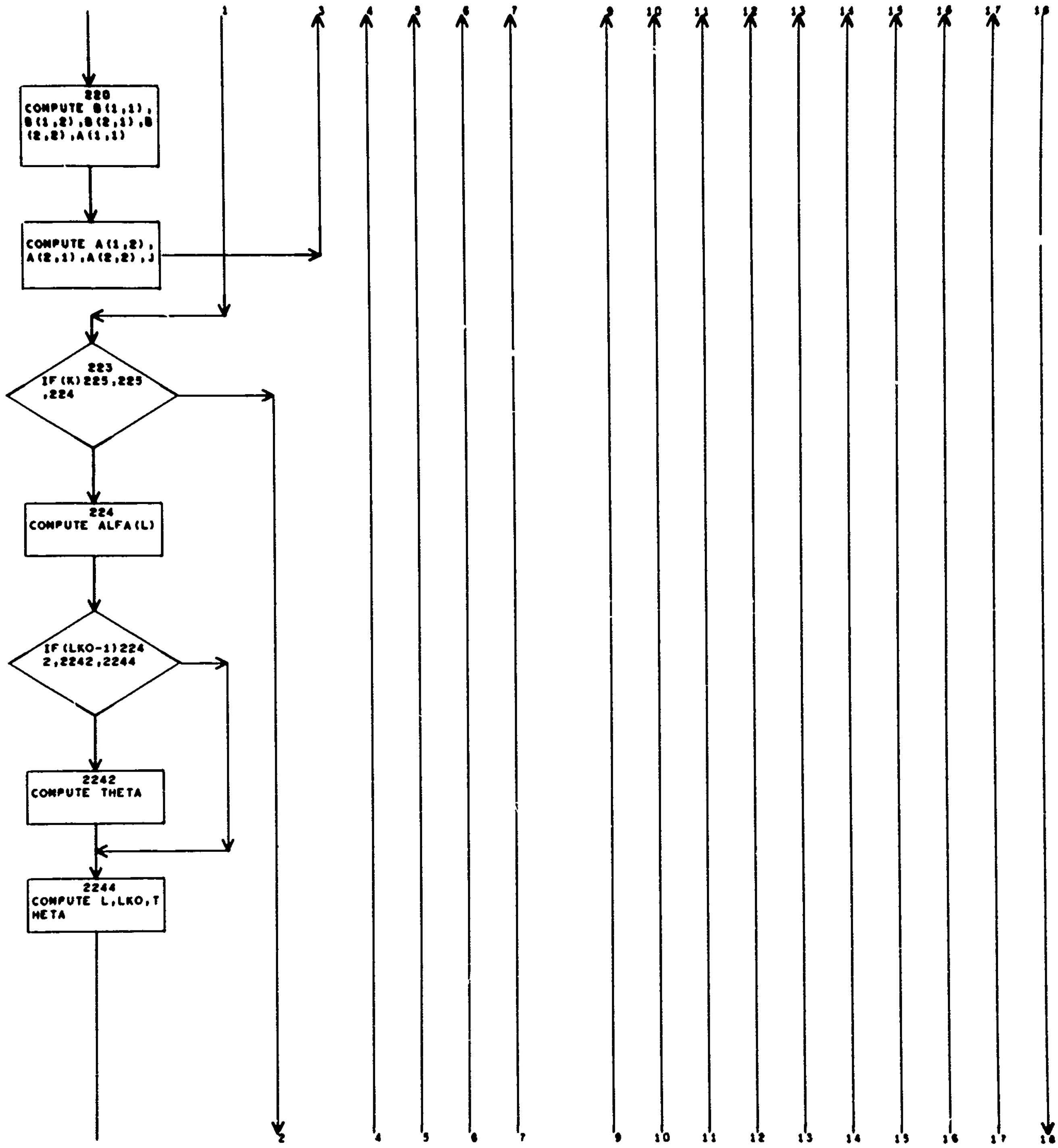

COMPUTE C(ILNX, ILNY)
147
CONTINUE
IF(C(M,1)-1.01)185,185,160
160
IF(C(M,2))163,163,185
163
COMPUTE GAMX,L
IF(C(M-1,2))165,165,185
165
IF(C(M-2,2))170,170,175
170
COMPUTE L


175
DO177IL=1,L
COMPUTE IGAM,GAMX
177
CONTINUE
COMPUTE GAMX,CIX
DO180IL=1,L
COMPUTE IGAM,GAN(IGAM,1),IKONST,C(IGAM,1),VOL
WRITE(6,85)IGAM,IKONST,C(IGAM,1),IGAN,IKONST,GAN(IGAM,1),VOL
180
CONTINUE
CALLZTRIN(C,NU,NMAX,ZMIN)


COMPUTE L,I,IPL ANE,J,M
COMPUTE K,IPLAN E,N,NTOT,FAIL
DO203I=1,N
COMPUTE Z(I)
IF(Z(I).LE.1.)F AIL=10.
203 CONTINUE
IF(FAIL.LE.0 .)GOTO204


WRITE(6,96)I
ONE
204
COMPUTE ADX,RZX
,LKO,THETA
213
COMPUTE THETAR,
TRZX,CO,SO
IF(K)215,215
,216
215
COMPUTE A(1,1),
A(2,2),A(1,2),A
(2,1),J
216
COMPUTE HTH,A(1
,1),A(2,1),A(2,
2),A(1,2),J
217
IF(N-J)223,2
20,223



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220
COMPUTE B(1,1), B(1,2),B(2,1),B (2,2),A(1,1)
COMPUTE A(1,2), A(2,1),A(2,2),J
223
IF(K)225,225 ,224
224
COMPUTE ALFA(L)
IF(LKO-1)224 2,2242,2244
2242
COMPUTE THETA
2244
COMPUTE L,LKO,T HETA
2
4
5
6
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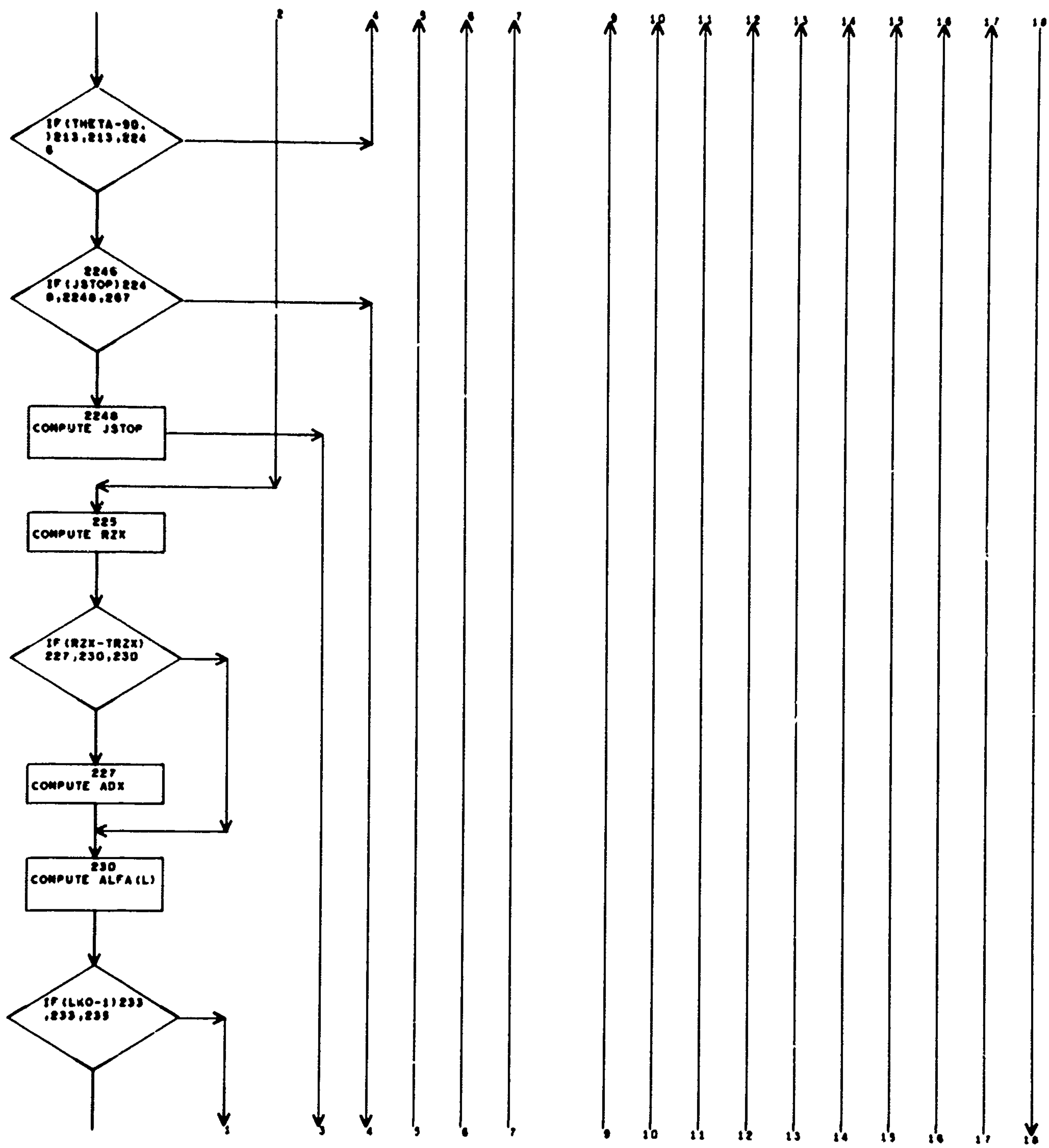
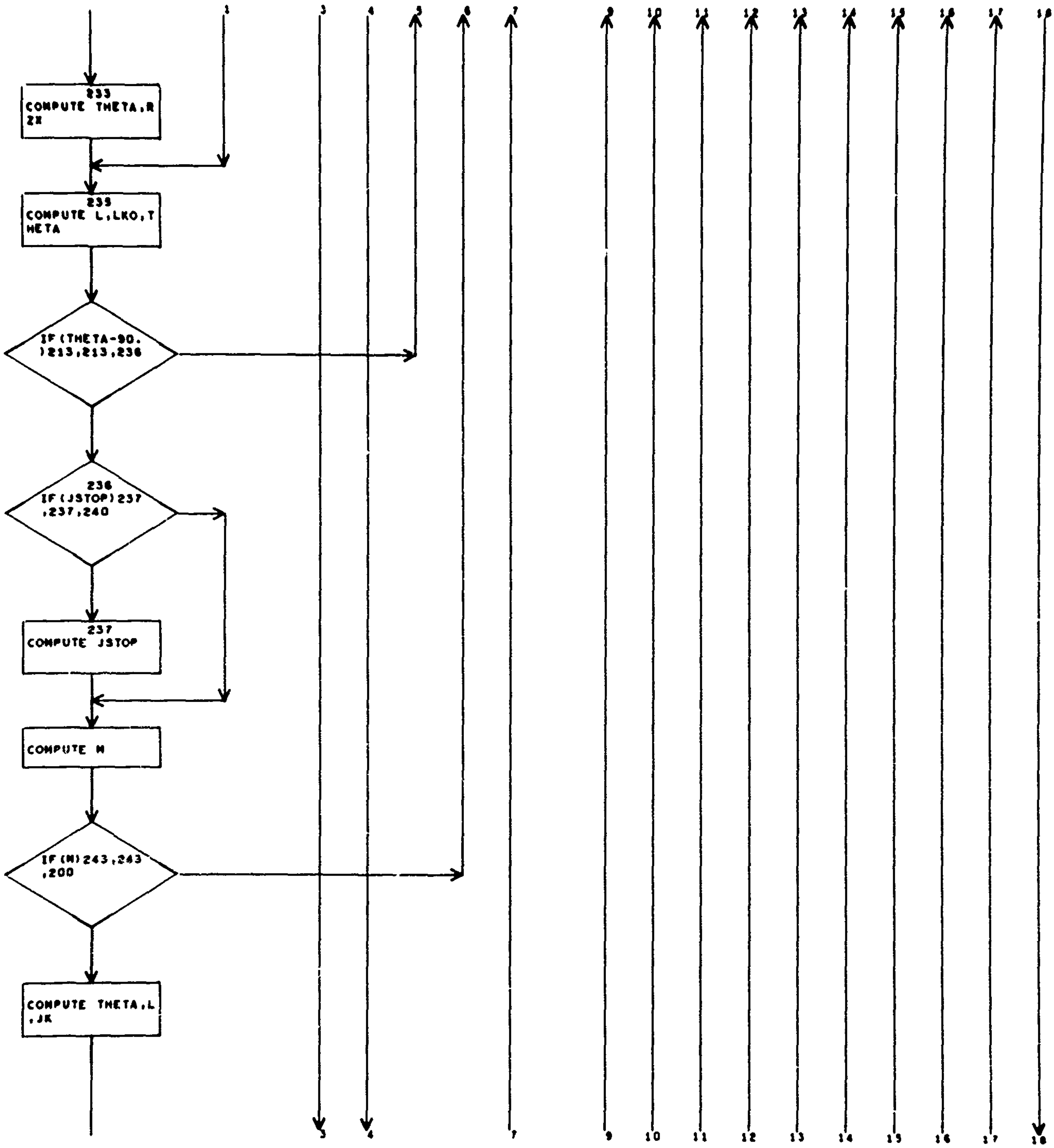

IF(THETA-90.)213,213,2246
2246
IF(JSTOP)2248,2248,267
2248
COMPUTE JSTOP
225
COMPUTE RZX
IF(RZX-TRZX)227,230,230
227
COMPUTE ADX
230
COMPUTE ALFA(L)
IF(LKO-1)233,233,235



233
COMPUTE THETA,R
2X
235
COMPUTE L,LKO,T
HETA
IF(THETA-90.
)213,213,236
236
IF(JSTOP)237
,237,240
237
COMPUTE JSTOP
COMPUTE M
IF(M)243,243
,200
COMPUTE THETA,L
,JK
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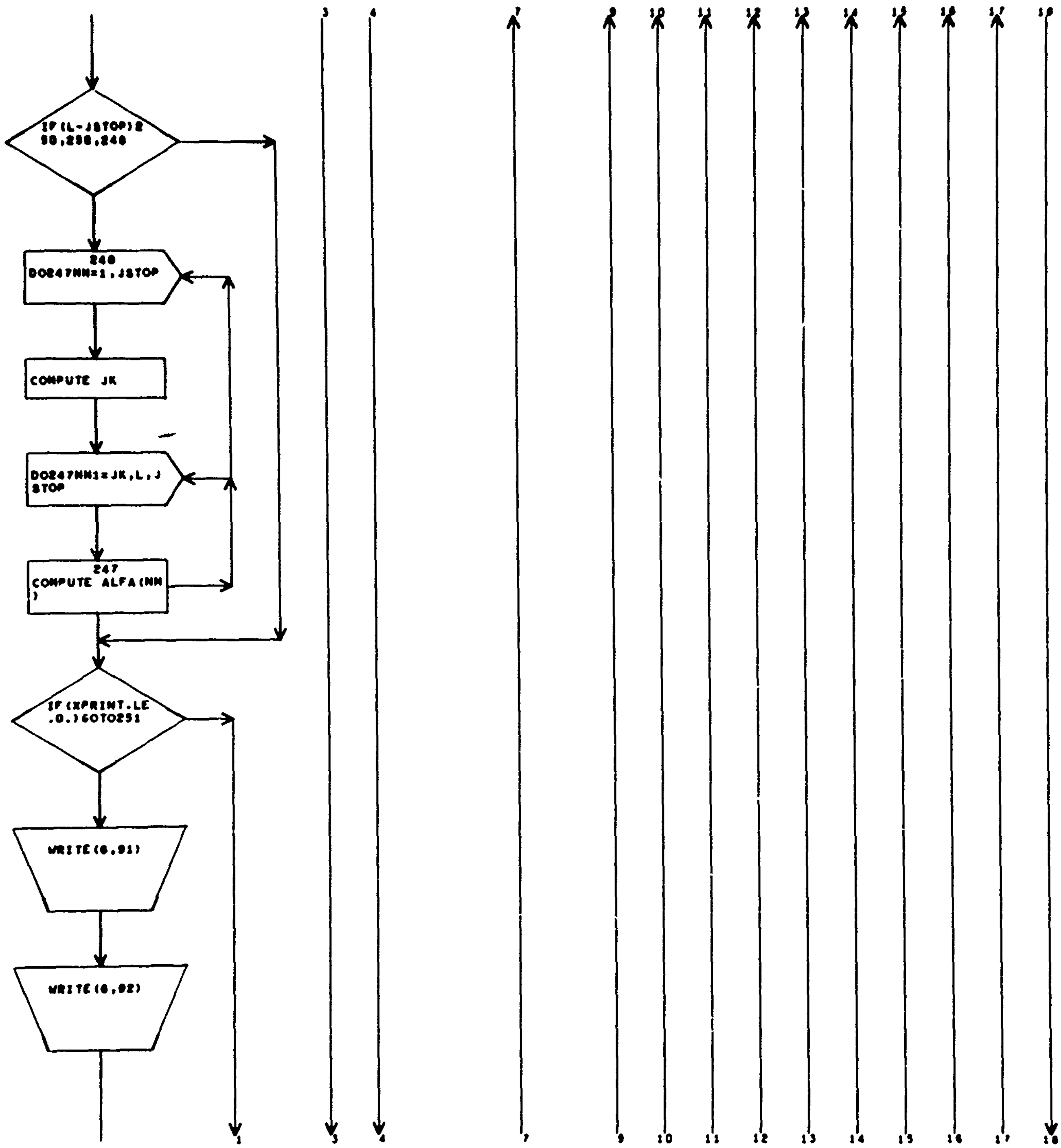

IF(L-JSTOP)2
58,258,248
248
DO247NN=1,JSTOP
COMPUTE JK
DO247NN1=JK,L,J
STOP
247
COMPUTE ALFA(NN
)
IF(XPRINT.LE
.0.)GOTO251
WRITE(6,91)
WRITE(6,92)
3
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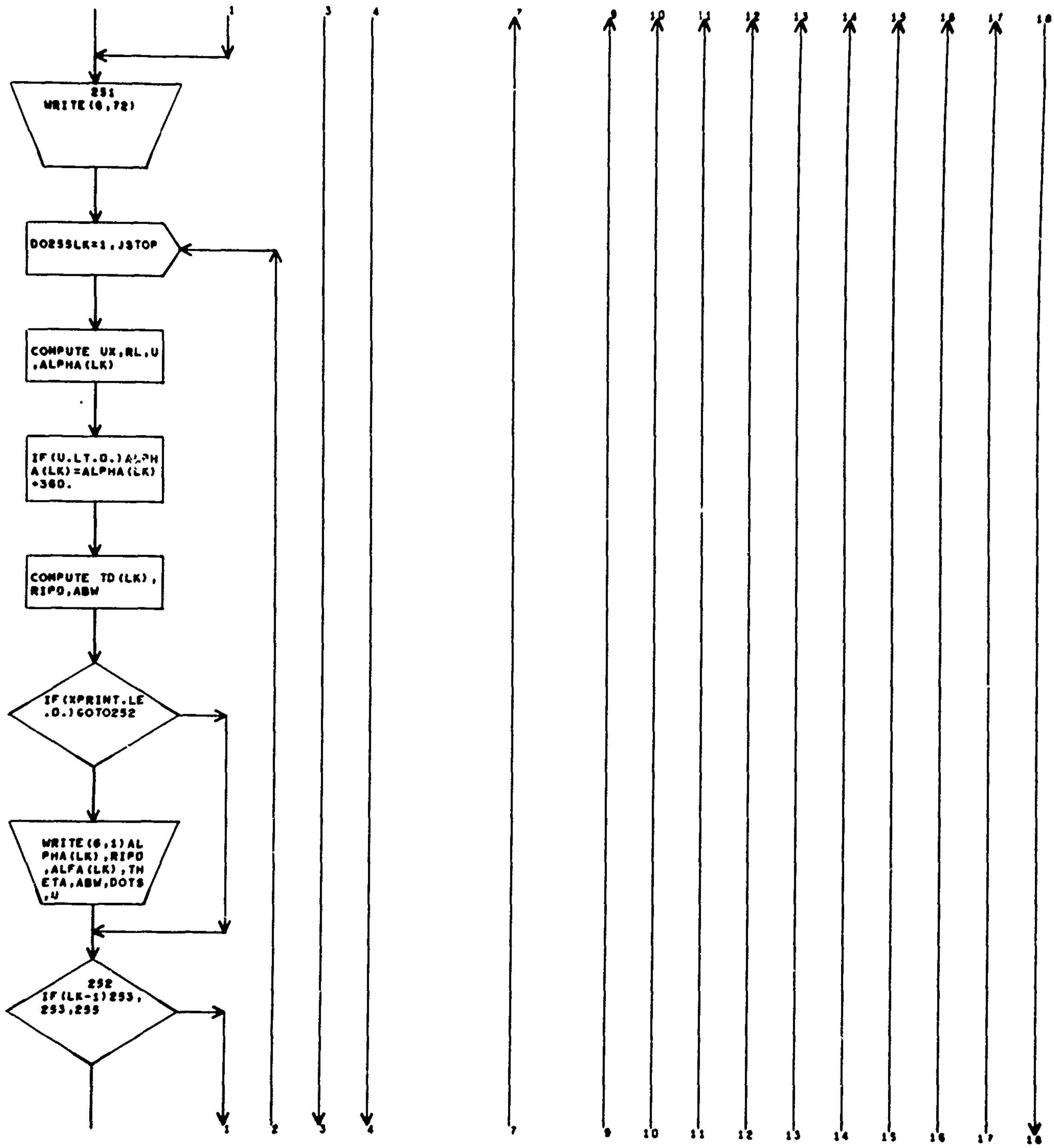
251
WRITE(6,72)
DO255LK=1,JSTOP
COMPUTE UX,RL,U
,ALPHA(LK)
IF(U.LT.0.)ALPH
A(LK)=ALPHA(LK)
+360.
COMPUTE TD(LK),
RIPO,ABW
IF(XPRINT.LE
.0.)GOTO252
WRITE(6,1)AL
PHA(LK),RIPO
,ALFA(LK),TH
ETA,ABW,DOTS
,U
252
IF(LK-1)253,
253,255
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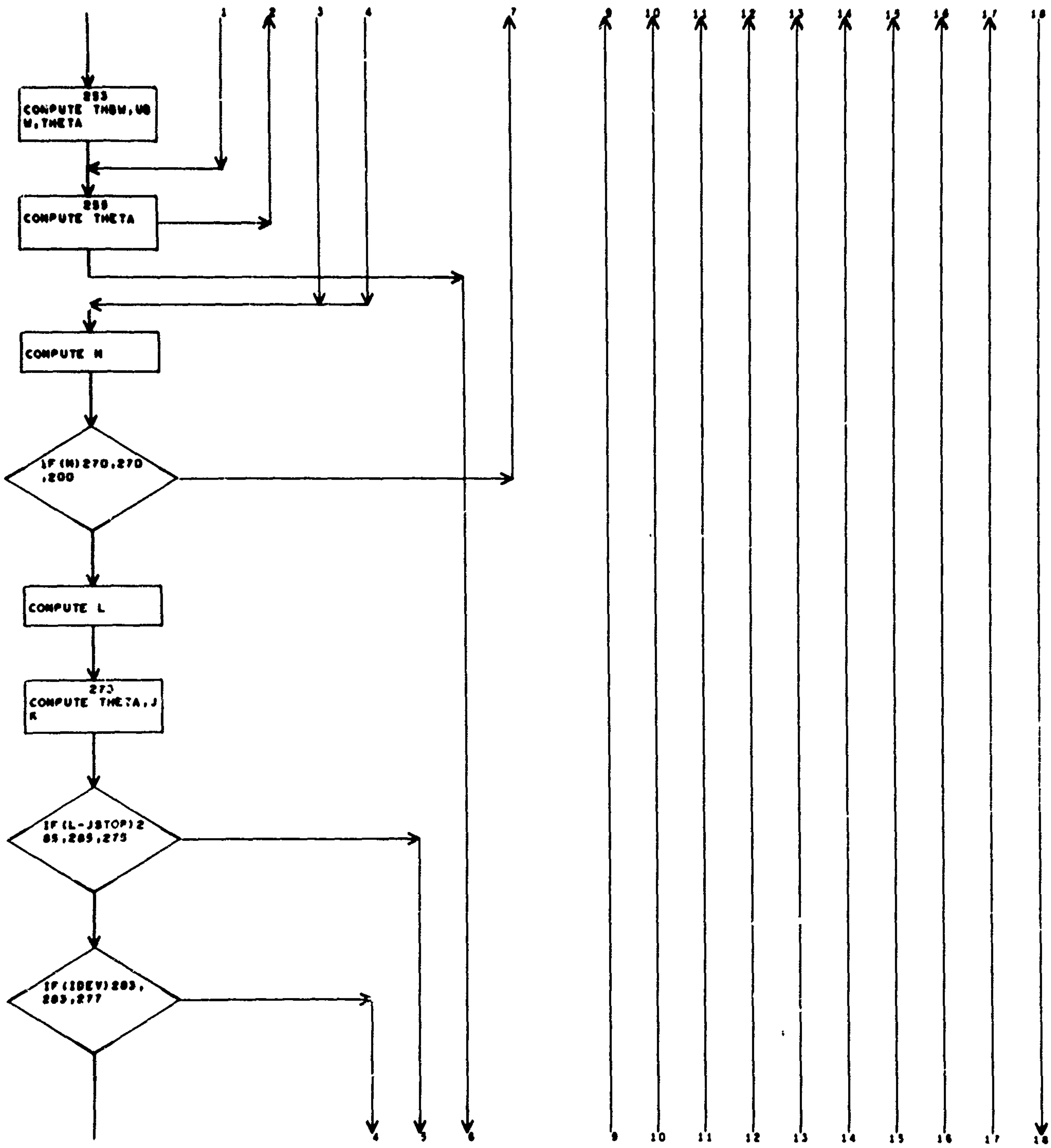
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253
COMPUTE THBW,UB
W,THETA
255
COMPUTE THETA
COMPUTE N
IF(N)270,270
,200
COMPUTE L
273
COMPUTE THETA,J
K
IF(L-JSTOP)2
85,285,275
IF(IDEV)283,
283,277
4
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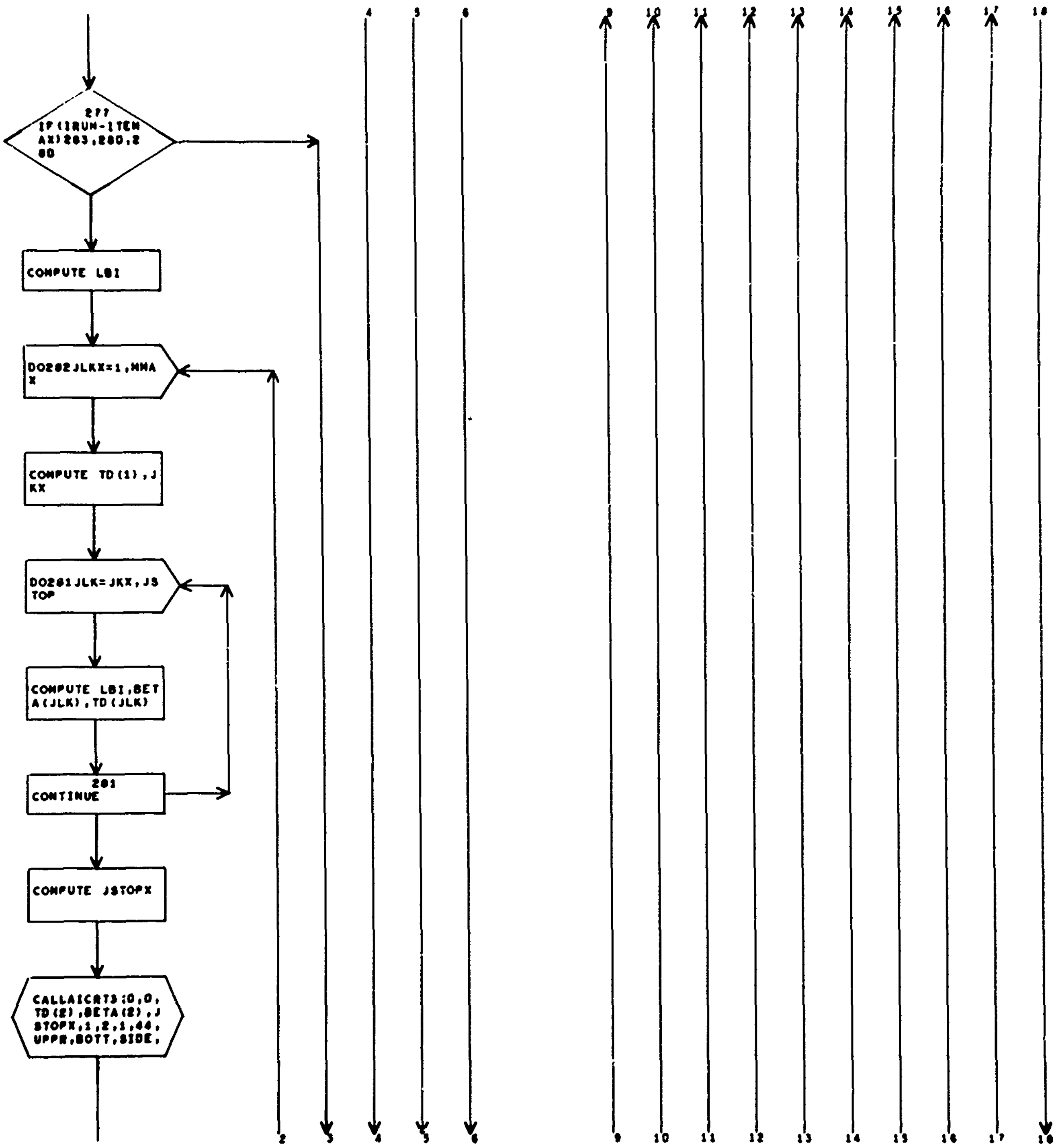
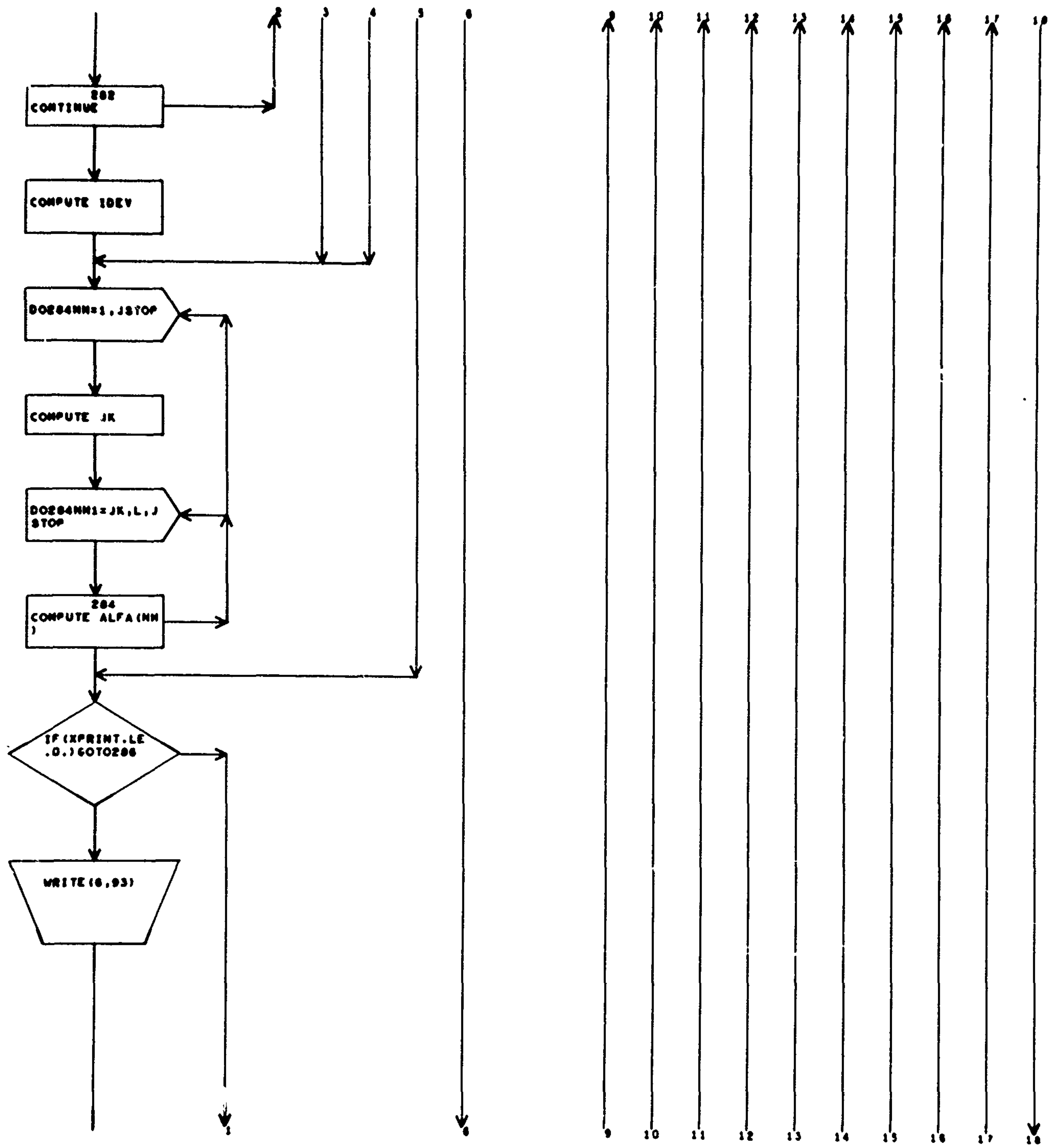
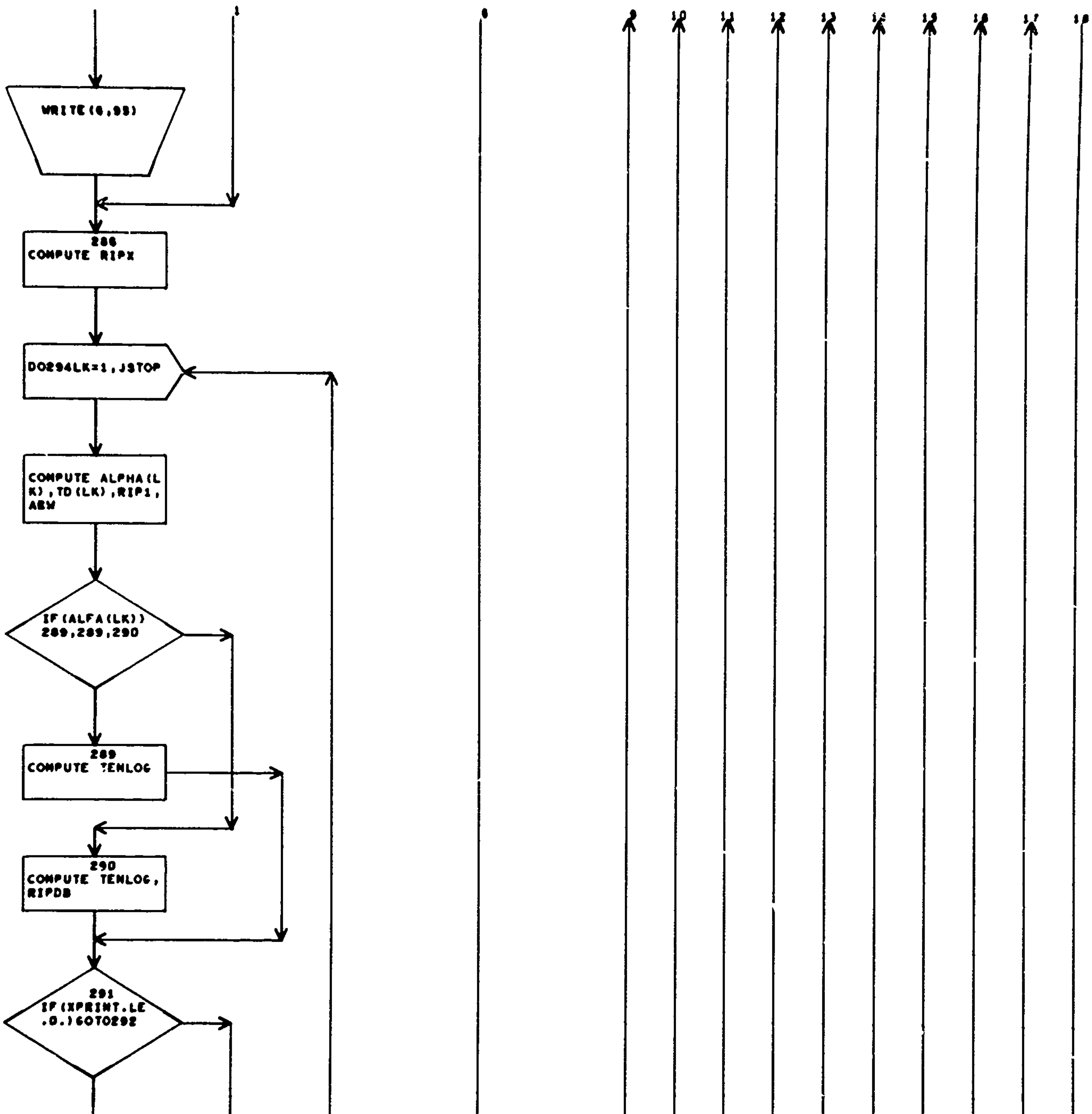

277
IF(IRUN-ITEN
AX)283,280,2
80
COMPUTE LBI
DO282JLKX=1,NMA
X
COMPUTE TD(1),J
KX
DO281JLK=JKX,JS
TOP
COMPUTE LBI,BET
A(JLK),TD(JLK)
281
CONTINUE
COMPUTE JSTOPX
CALLAICRT3(0,0,
TD(2),BETA(2),J
STOPX,1,2,1,44,
UPPR,BOTT,SIDE,


282
CONTINUE
COMPUTE IDEV
DO284NN=1,JSTOP
COMPUTE JK
DO284NN1=JK,L,J
STOP
284
COMPUTE ALFA(NN
)
IF(XPRINT.LE
.0.)GOTO286
WRITE(6,93)


WRITE(6,95)
286
COMPUTE RIPX
DO294LK=1,JSTOP
COMPUTE ALPHA(L
K),TD(LK),RIP1,
ABW
IF(ALFA(LK))
289,289,290
289
COMPUTE TENLOG
290
COMPUTE TENLOG,
RIPDB
291
IF(XPRINT.LE
.0.)GOTO292
10
11
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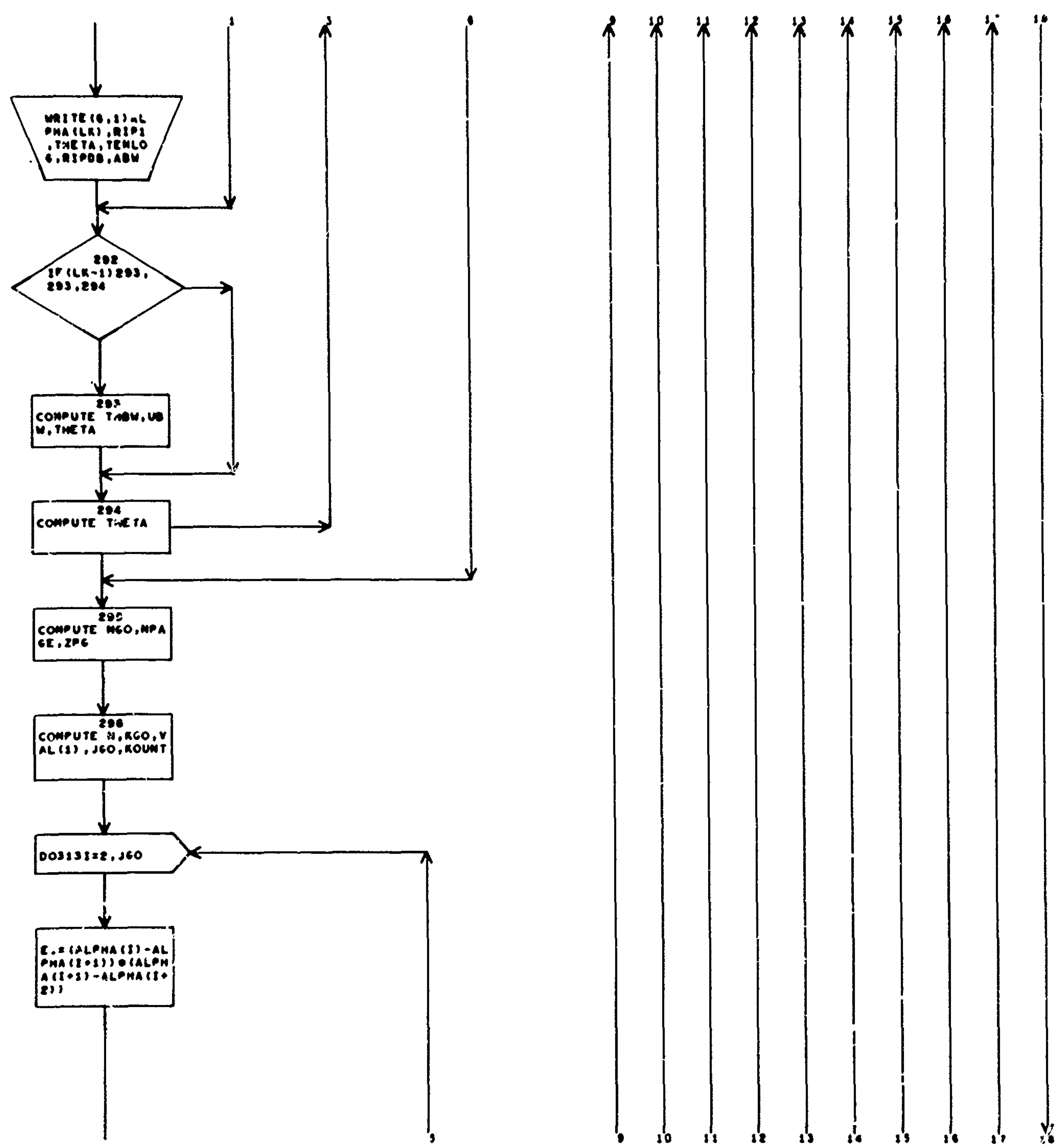
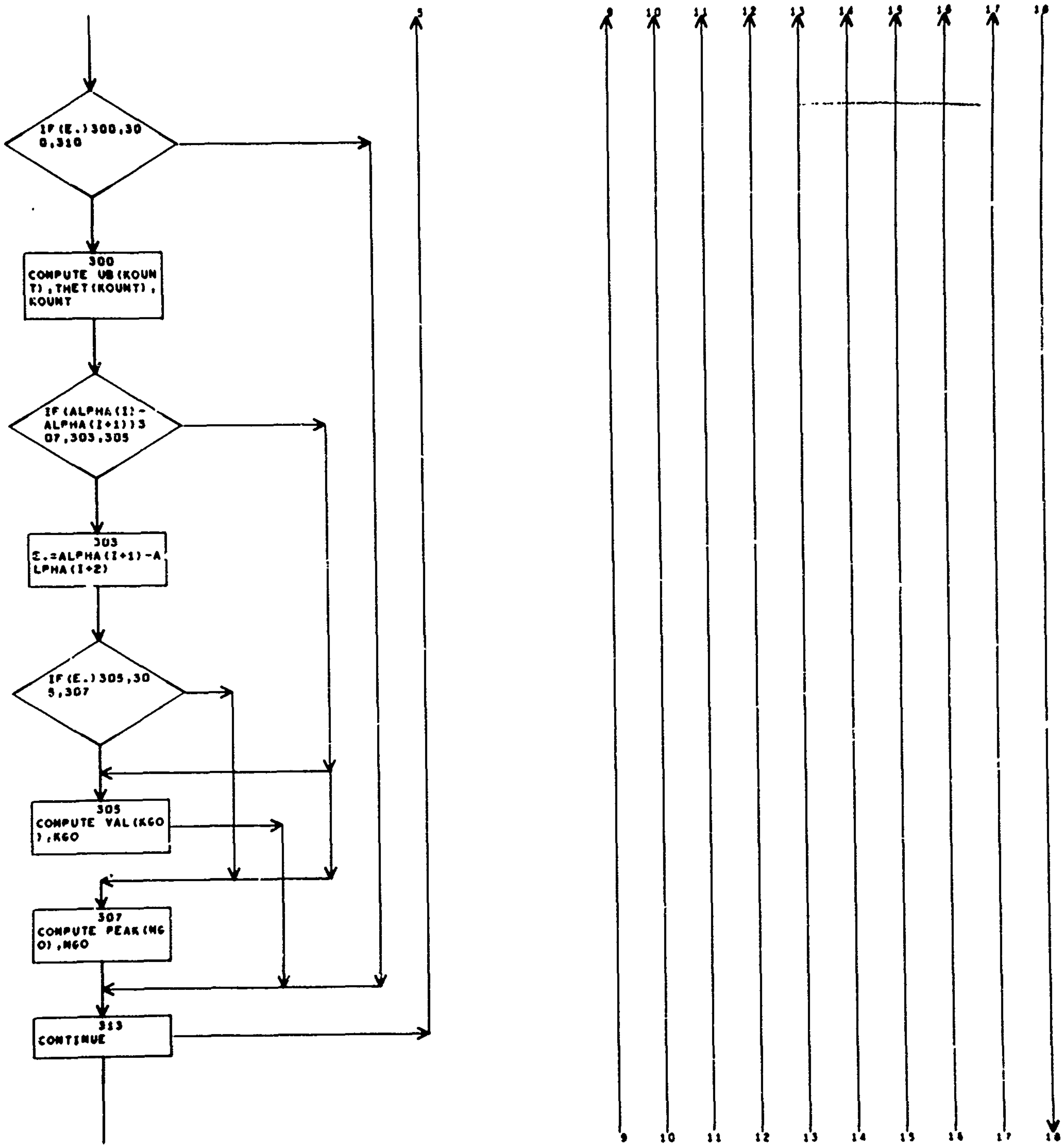


WRITE(6,1)ALPHA(LK),RIP1,THETA,TENLOG,RIPDB,ABW
292 IF(LK-1)293,293,294
293 COMPUTE TABW,UBW,THETA
294 COMPUTE THETA
295 COMPUTE NGO,NPAGE,ZPG
296 COMPUTE N,KGO,VAL(1),JGO,KOUNT
DO313I=2,JGO
E.=(ALPHA(I)-ALPHA(I+1))*(ALPHA(I+1)-ALPHA(I+2))



IF (E.) 300,30 0,310
300
COMPUTE UB(KOUN T),THET(KOUNT), KOUNT
IF (ALPHA(I)- ALPHA(I+1))3 07,303,305
303
E.=ALPHA(I+1)-A LPHA(I+2)
IF (E.) 305,30 5,307
305
COMPUTE VAL(KGO),KGO
307
COMPUTE PEAK(MG O),MGO
313
CONTINUE
5
10
11
12
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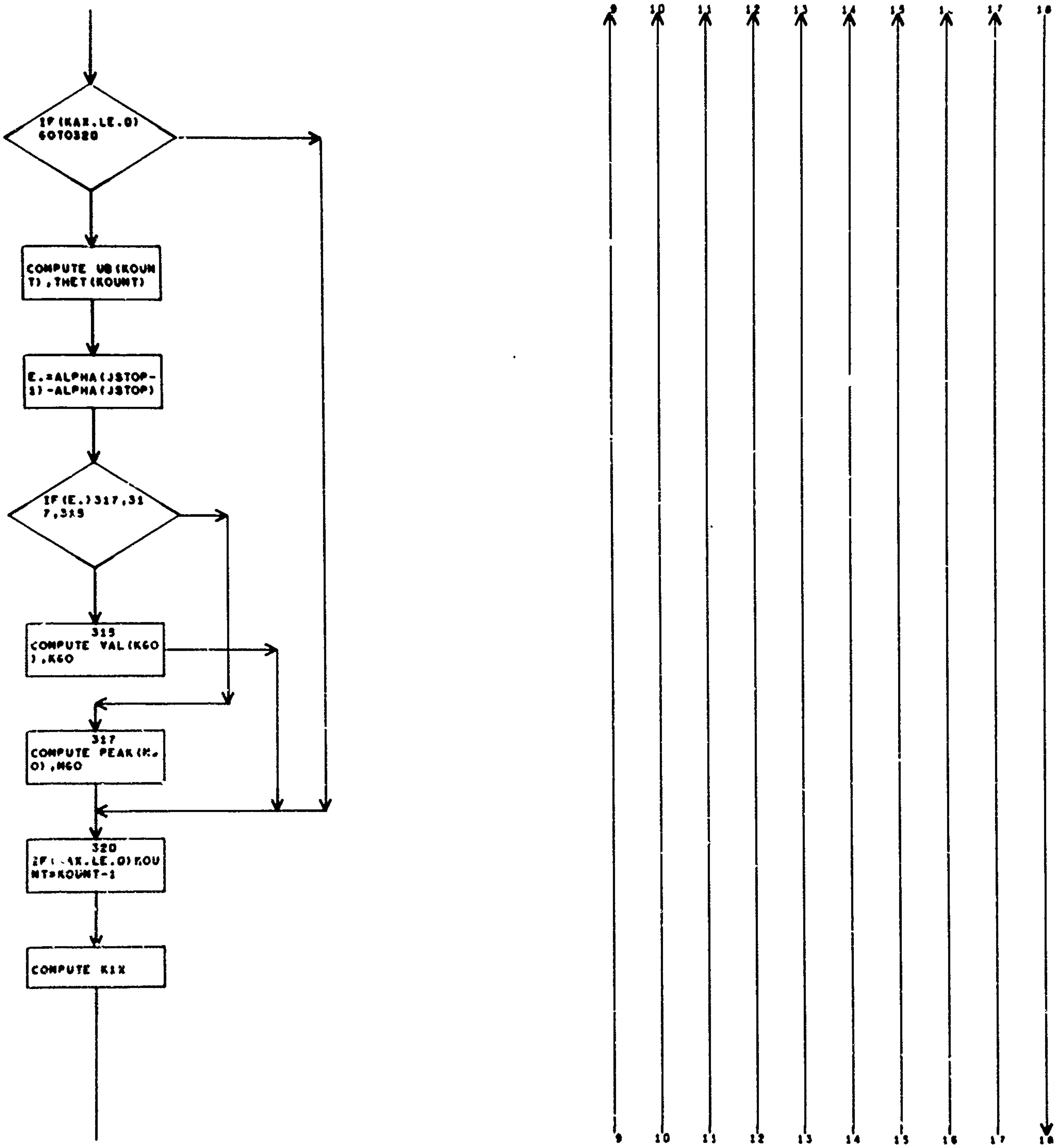
9


IF(KAX.LE.0) GOTO320
COMPUTE UB(KOUNT),THET(KOUNT)
E.=ALPHA(JSTOP-1)-ALPHA(JSTOP)
IF(E.)317,317,315
315 COMPUTE VAL(KGO),KGO
317 COMPUTE PEAK(KGO),KGO
320
COMPUTE K1X
9
10
11
12
13
14
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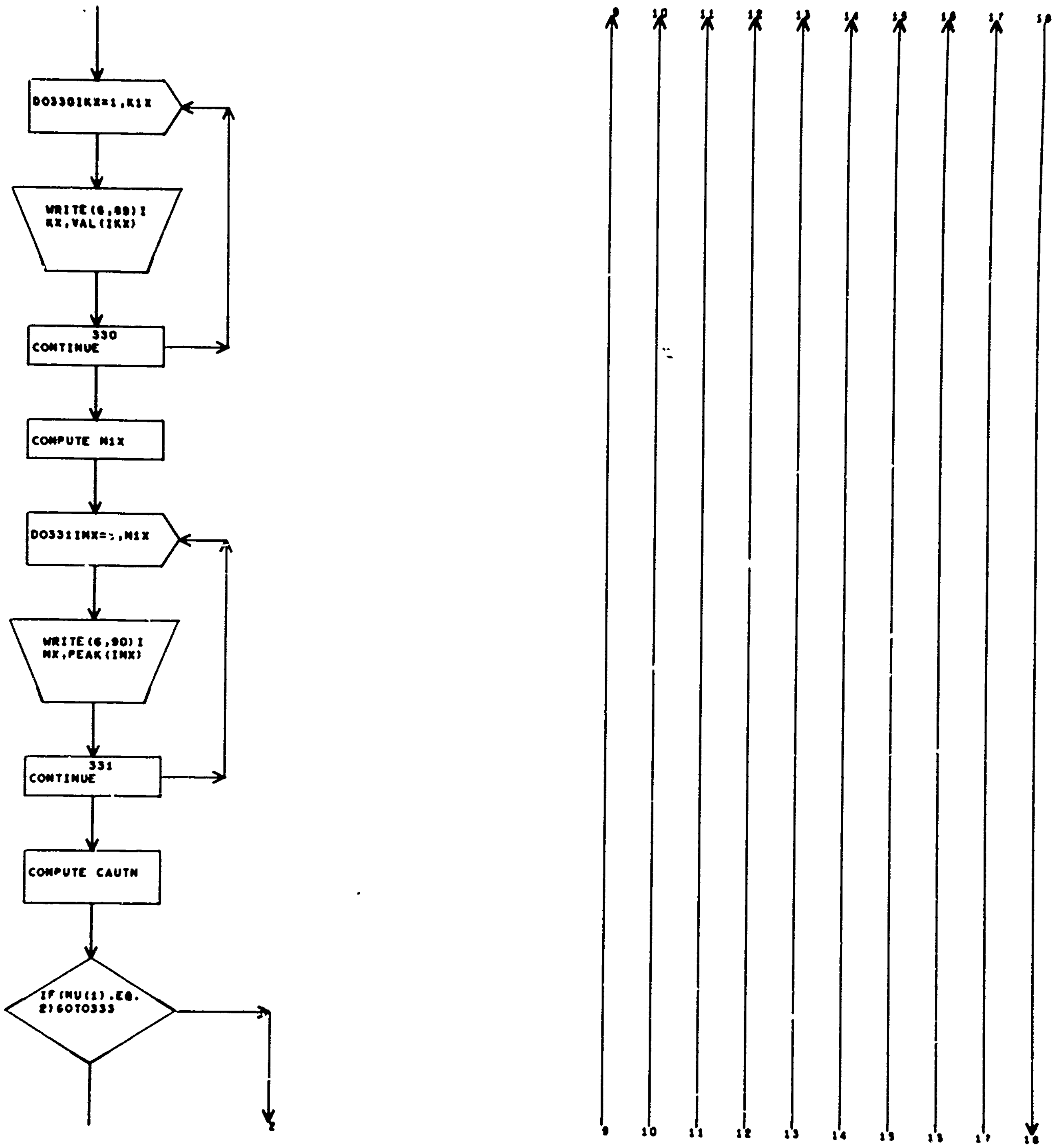
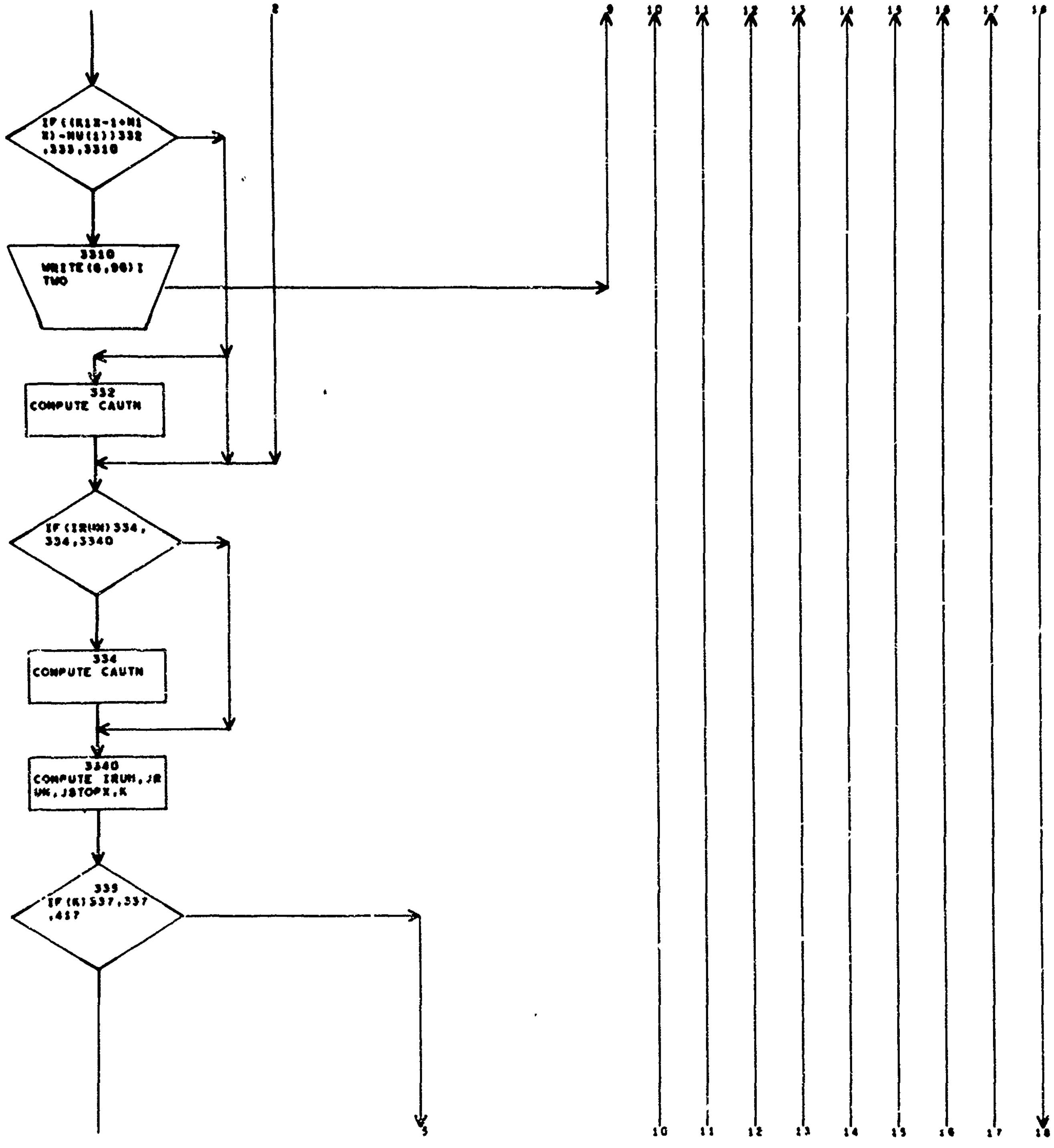
17
18



DO330IKX=1,K1X
WRITE(6,89)I
KX,VAL(IKX)
330
CONTINUE
COMPUTE M1X
DO331INX=1,M1X
WRITE(6,90)I
NX,PEAK(INX)
331
CONTINUE
COMPUTE CAUTN
IF(NU(1).EQ.
2)GOTO333


8
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17
18
IF((K1X-1+NI
X)-NU(I))332
,333,3310
3310
WRITE(6,96)I
TWO
332
COMPUTE CAUTN
IF(IRUN)334,
334,3340
334
COMPUTE CAUTN
3340
COMPUTE IRUN,JR
UN,JSTOPX,K
335
IF(K)537,337
,437
5
10
11
12
13
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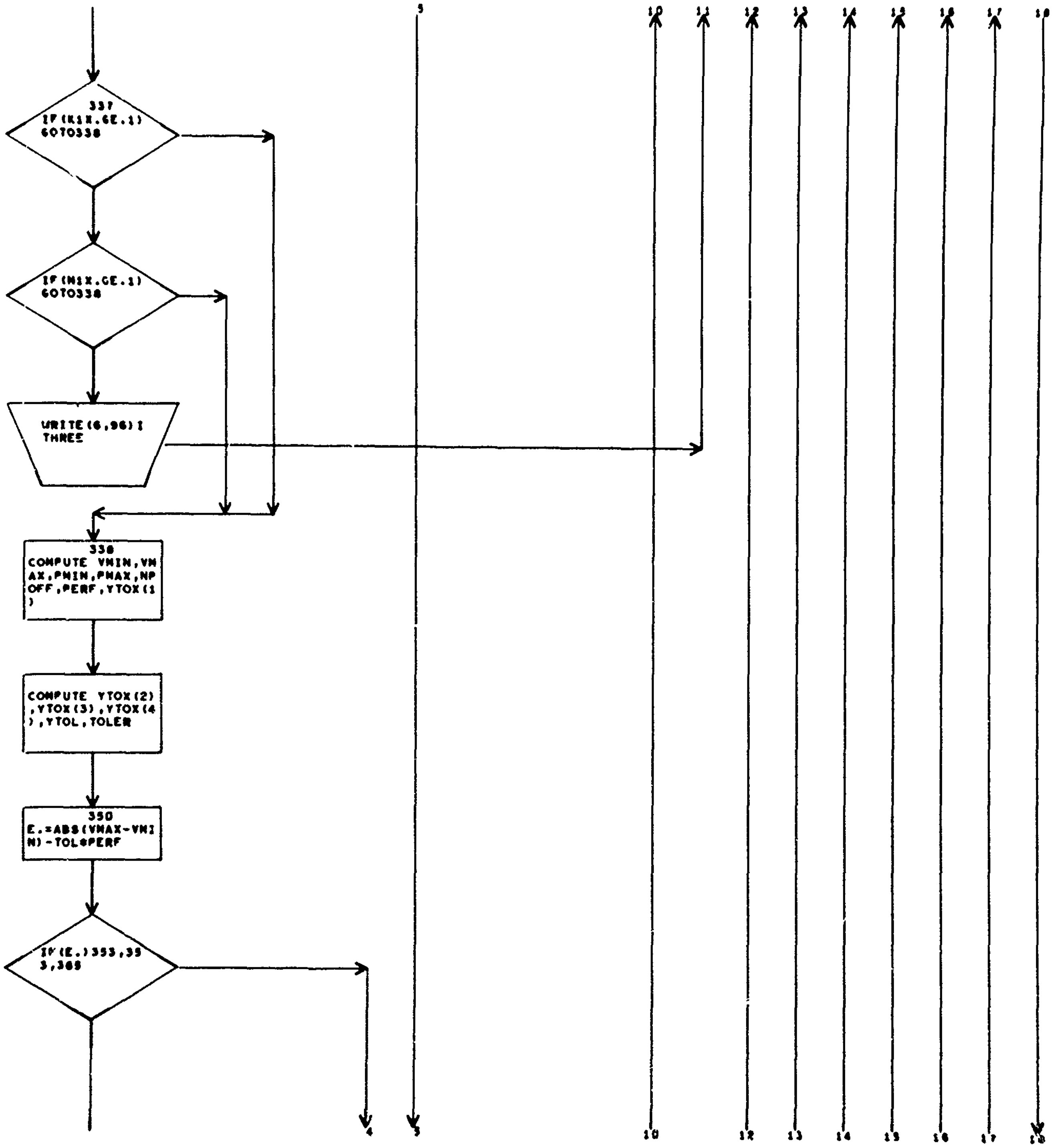
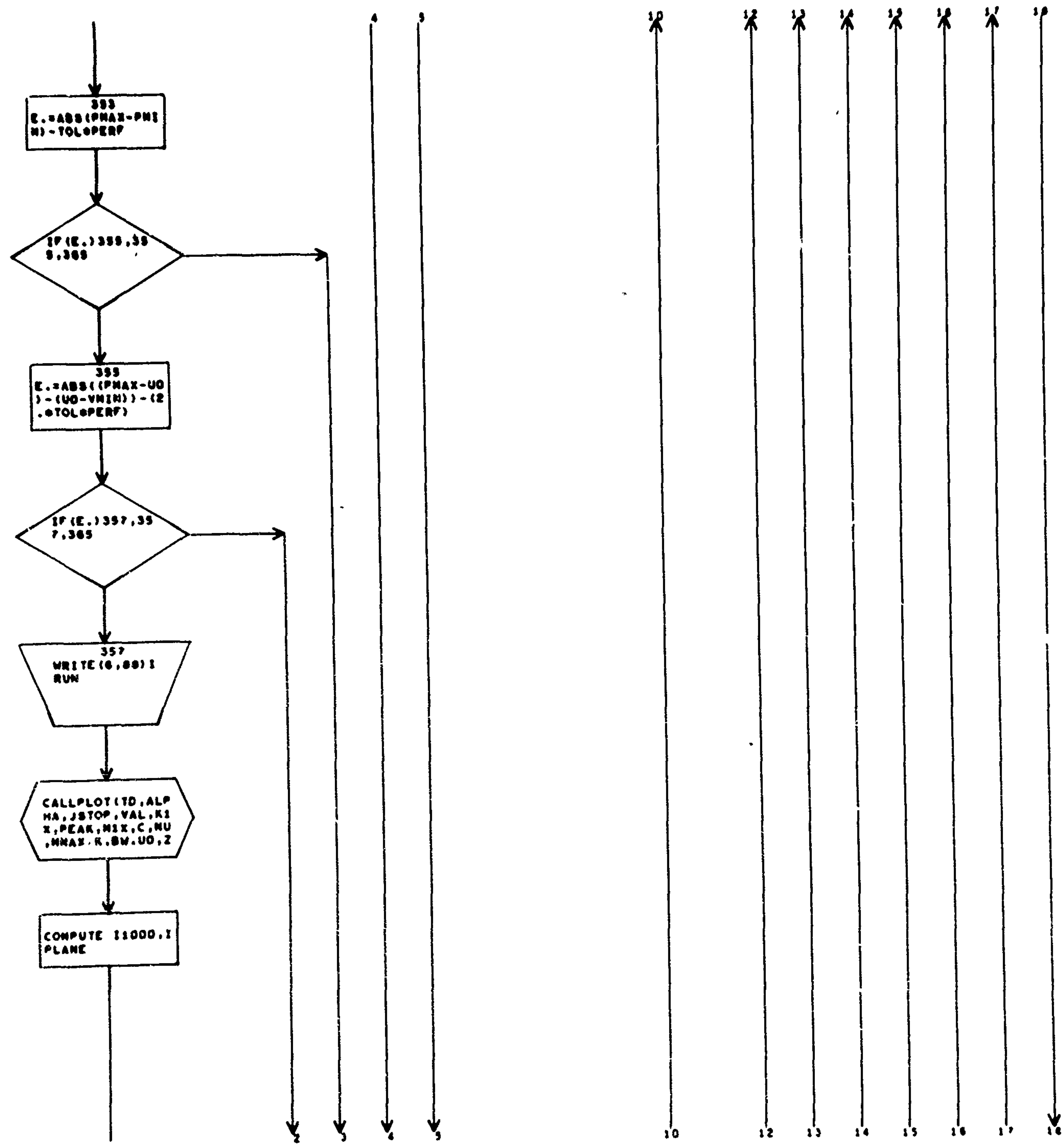
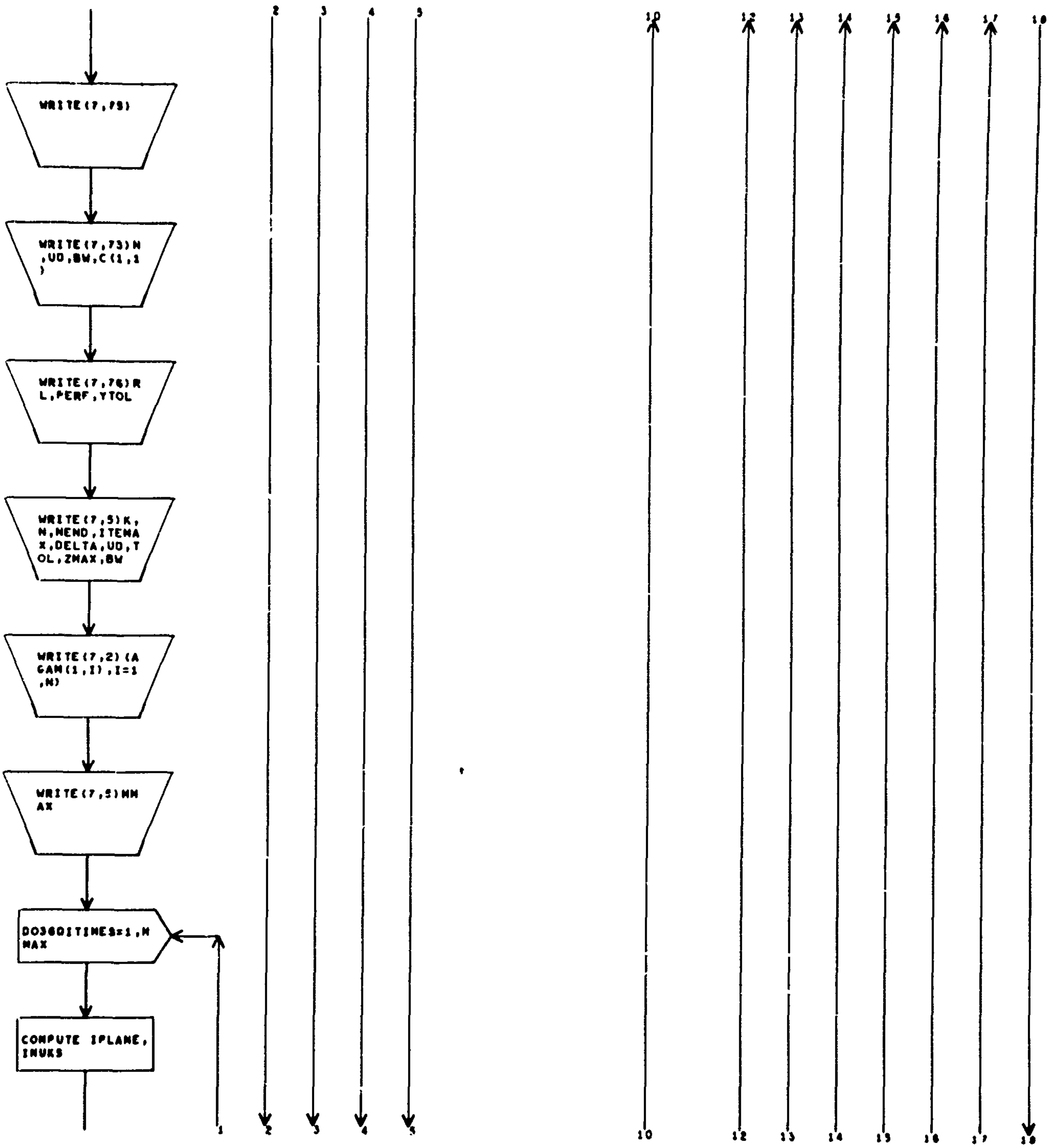
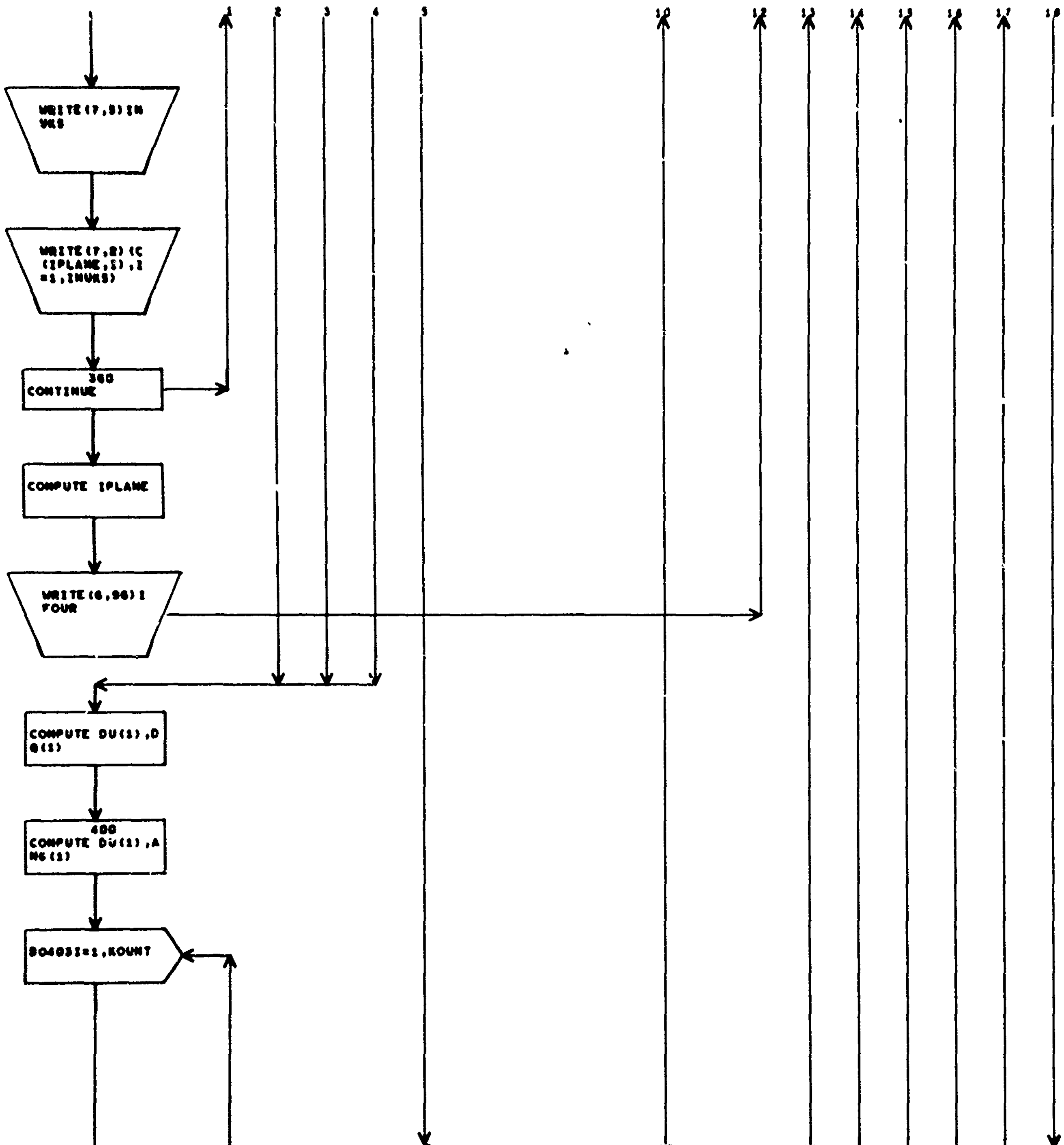
18

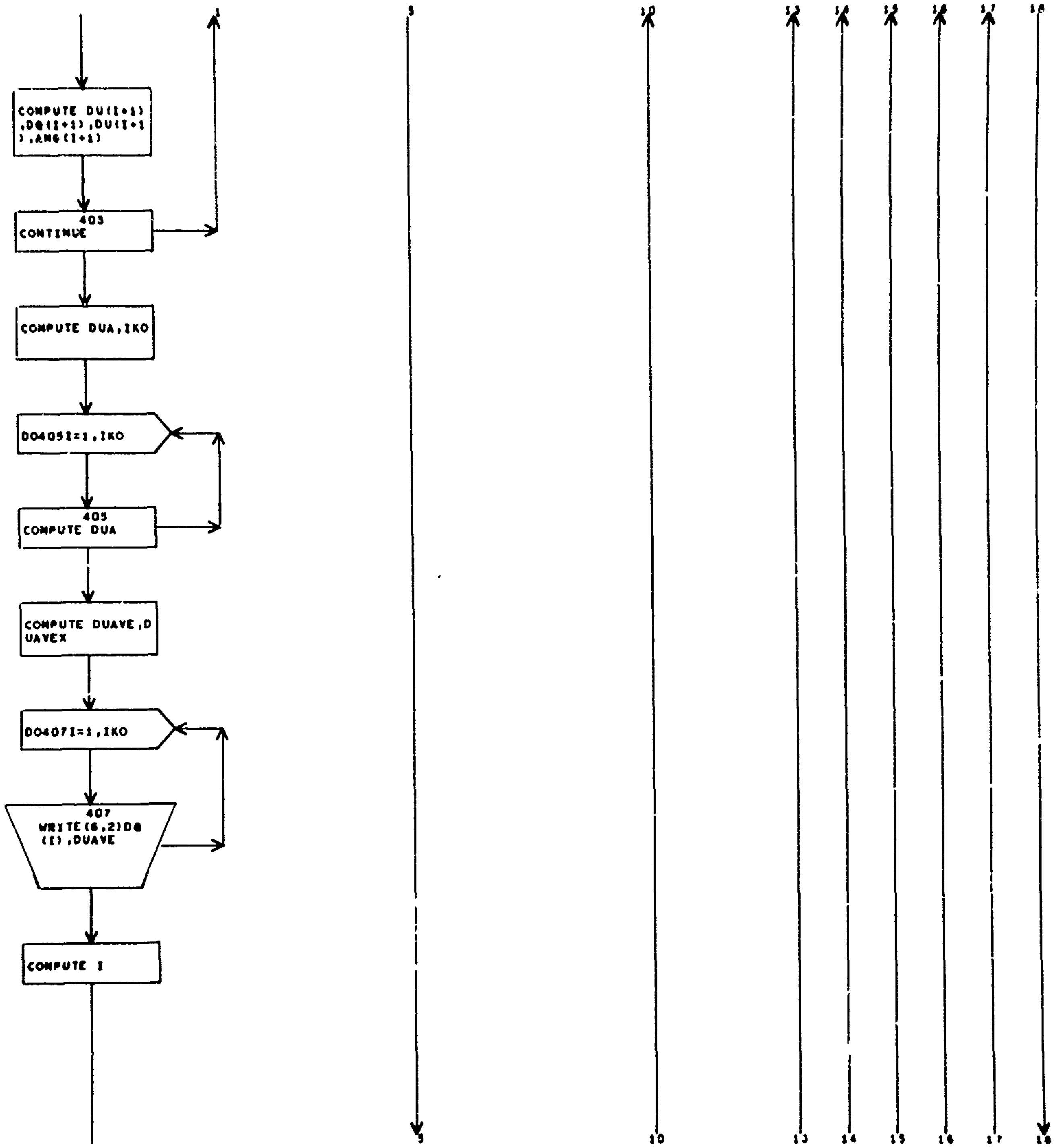

337
IF(K1X.GE.1)
GOTO338
IF(N1X.GE.1)
GOTO338
WRITE(6,96)I
THREE
338
COMPUTE VMIN,VM
AX,PMIN,PMAX,NP
OFF,PERF,YTOX(1
)
COMPUTE YTOX(2)
,YTOX(3),YTOX(4
),YTOL,TOLER
350
E.=ABS(VMAX-VMI
N)-TOL*PERF
IF(E.)353,35
3,365

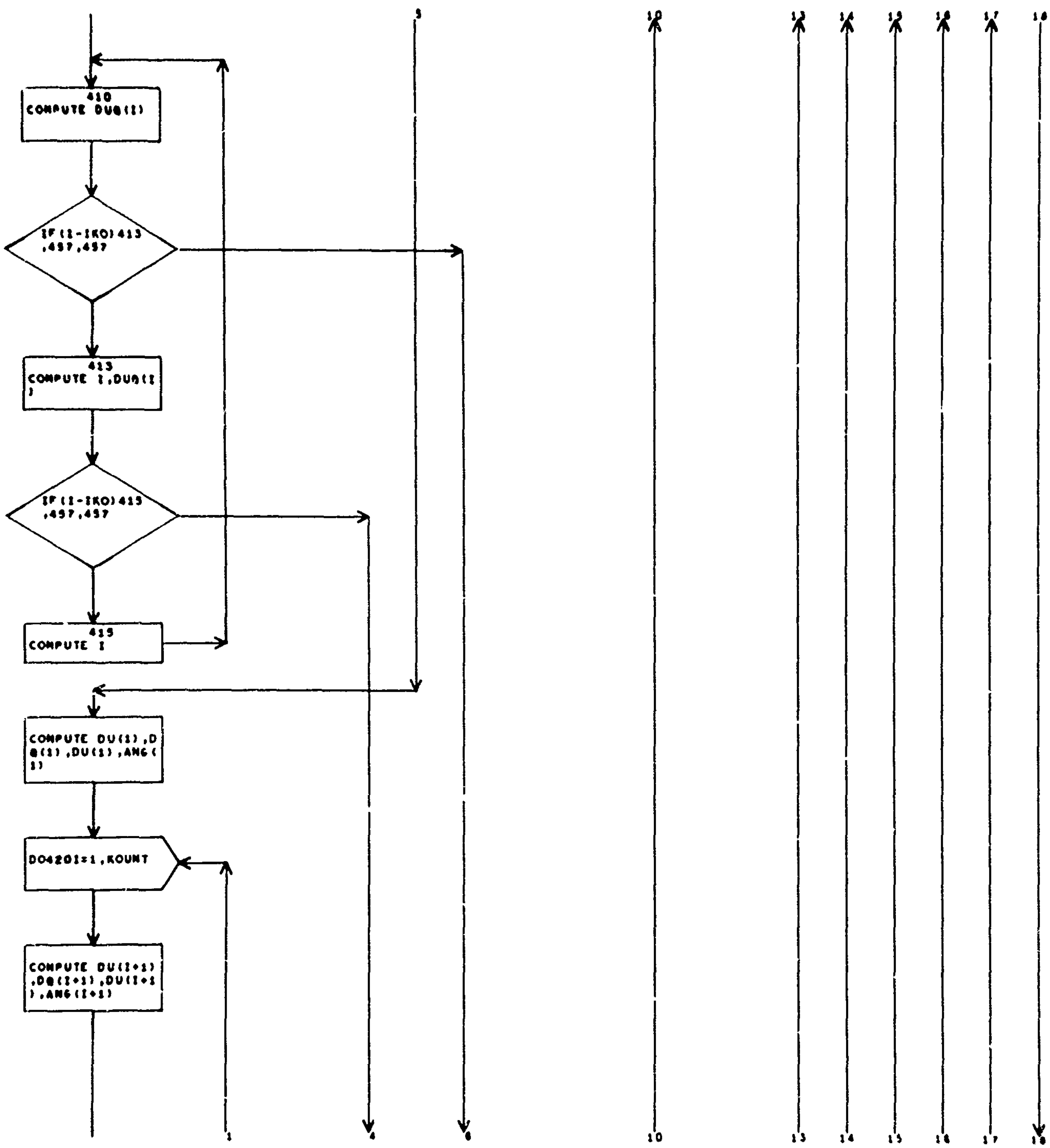

353
E.=ABS(PMAX-PMI
N)-TOL*PERF
IF(E.)355,35
5,365
355
E.=ABS((PMAX-UO
)-(UO-VMIN))-(2
.*TOL*PERF)
IF(E.)357,35
7,365
357
WRITE(6,88)I
RUN
CALLPLOT(TD,ALP
HA,JSTOP,VAL,K1
X,PEAK,MIX,C,NU
,MMAX,K,BW,UO,Z
COMPUTE I1000,I
PLANE

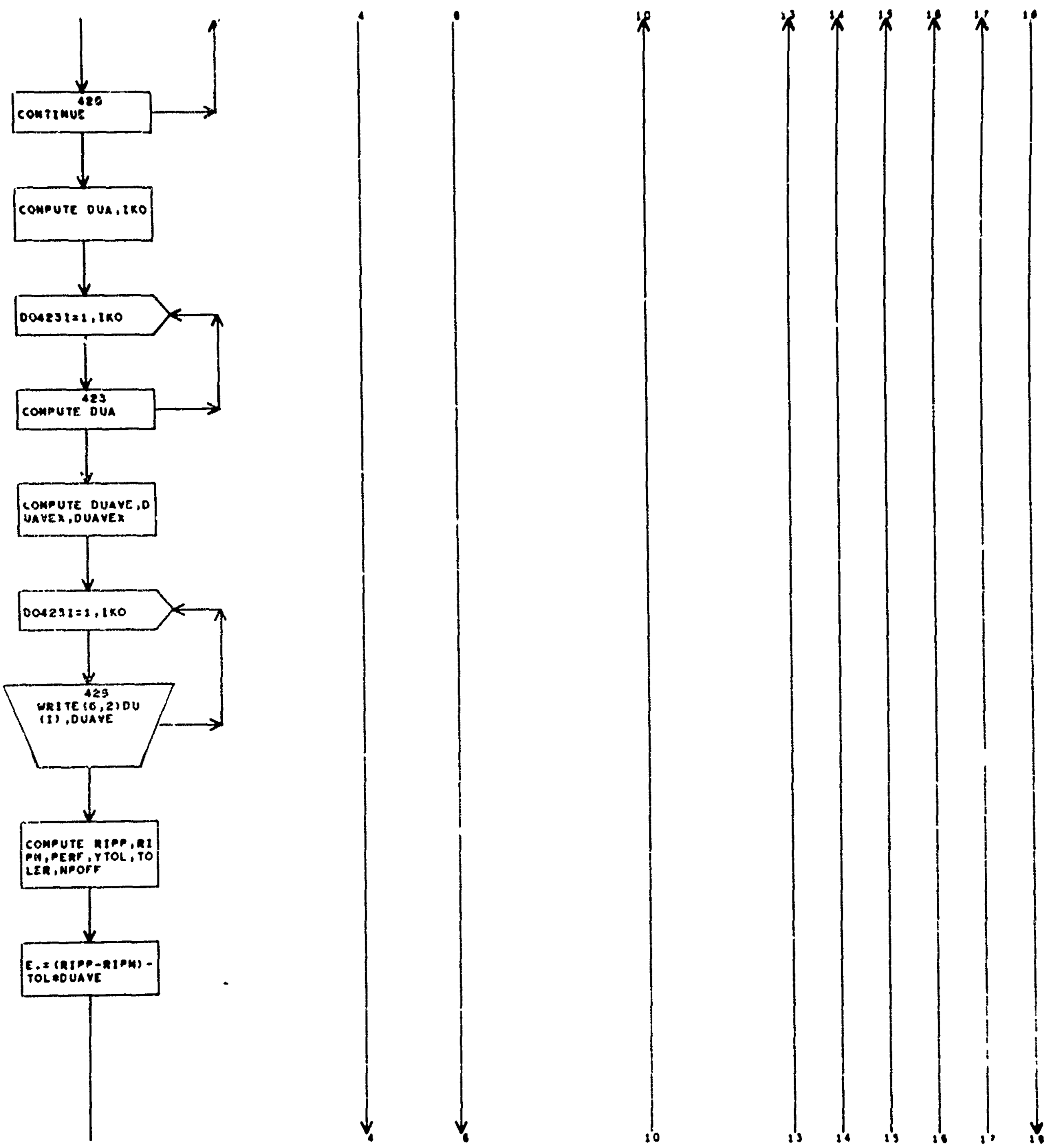


WRITE(7,75)
WRITE(7,73)N,UD,BW,C(1,1)
WRITE(7,76)RL,PERF,YTOL
WRITE(7,5)K,N,NEND,ITEMAX,DELTA,UD,TOL,ZMAX,BW
WRITE(7,2)(AGAM(1,I),I=1,N)
WRITE(7,5)MMAX
DO360ITIMES=1,MMAX
COMPUTE IPLANE, INUKS
2
3
4
5
10
12
13
14
15
16
17
18
1


WRITE(7,5)INVKS
WRITE(7,8)(C(IPLANE,I),I=1,INVKS)
360 CONTINUE
COMPUTE IPLANE
WRITE(6,96)IFOUR
COMPUTE DU(I),DB(I)
400 COMPUTE DU(I),ANG(I)
DO403I=1,KOUNT


COMPUTE DU(I+1),DQ(I+1),DU(I+1),ANG(I+1)
403
CONTINUE
COMPUTE DUA,IKO
DO405I=1,IKO
405
COMPUTE DUA
COMPUTE DUAVE,DUAVEX
DO407I=1,IKO
407
WRITE(6,2)DQ(I),DUAVE
COMPUTE I
1
5
10
13
14
15
16
17
18


410
COMPUTE DUQ(I)
IF(I-IKO)413
,457,457
413
COMPUTE I,DUQ(I
)
IF(I-IKO)415
,457,457
415
COMPUTE I
COMPUTE DU(I),D
Q(I),DU(I),ANG(
I)
DO420I=1,KOUNT
COMPUTE DU(I+1)
,DQ(I+1),DU(I+1
),ANG(I+1)
3
10
13
14
15
16
17
18
1
4
6
10
13
14
15
16
17
18


425
CONTINUE
COMPUTE DUA,IKO
DO423I=1,IKO
423
COMPUTE DUA
COMPUTE DUAVE,D
UAVEX,DUAVEX
DO425I=1,IKO
425
WRITE(6,2)DU
(I),DUAVE
COMPUTE RIPP,RI
PM,PERF,YTOL,TO
LER,NPOFF
E.=(RIPP-RIPM)-
TOL*DUAVE
4
6
10
13
14
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16
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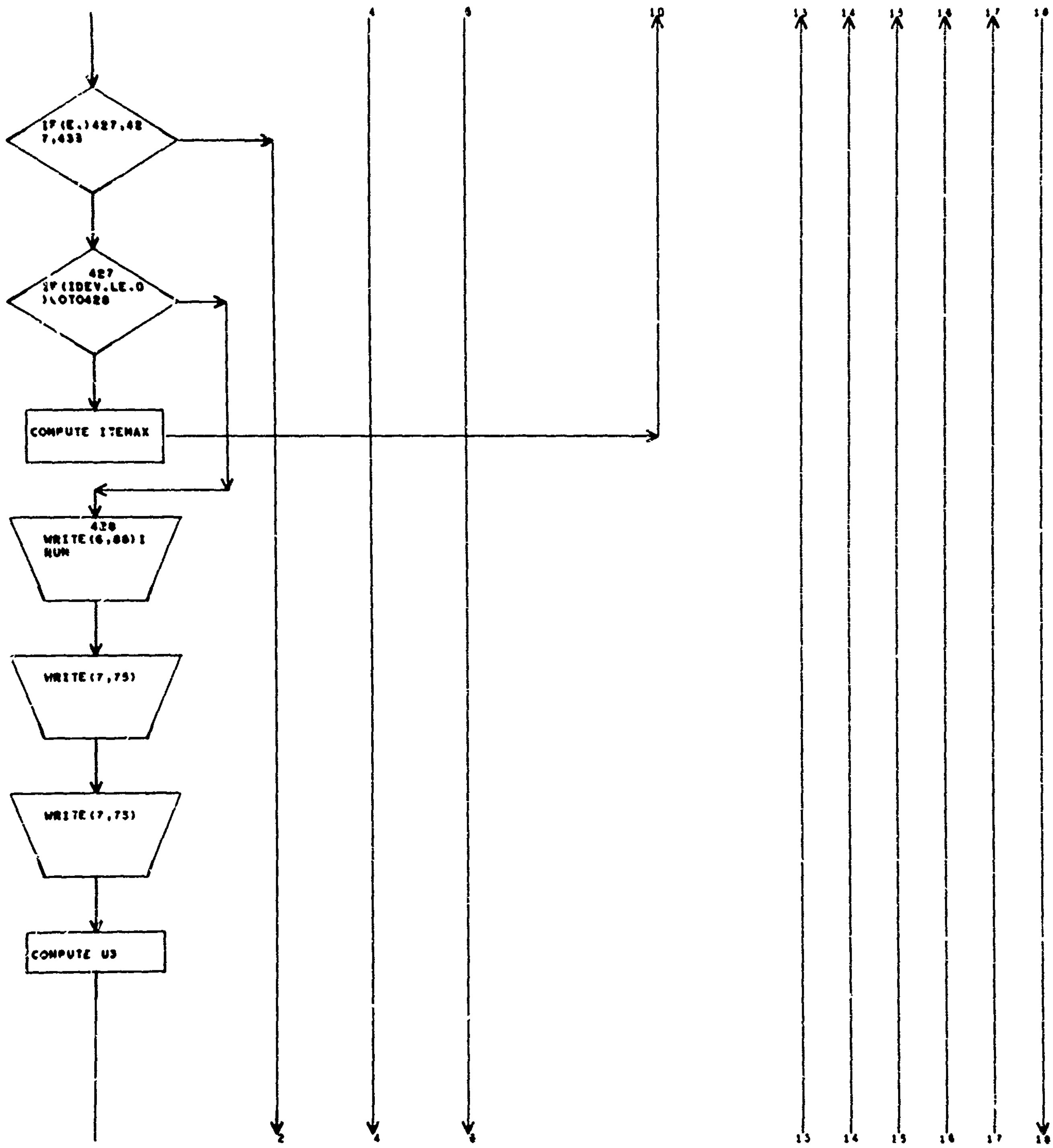
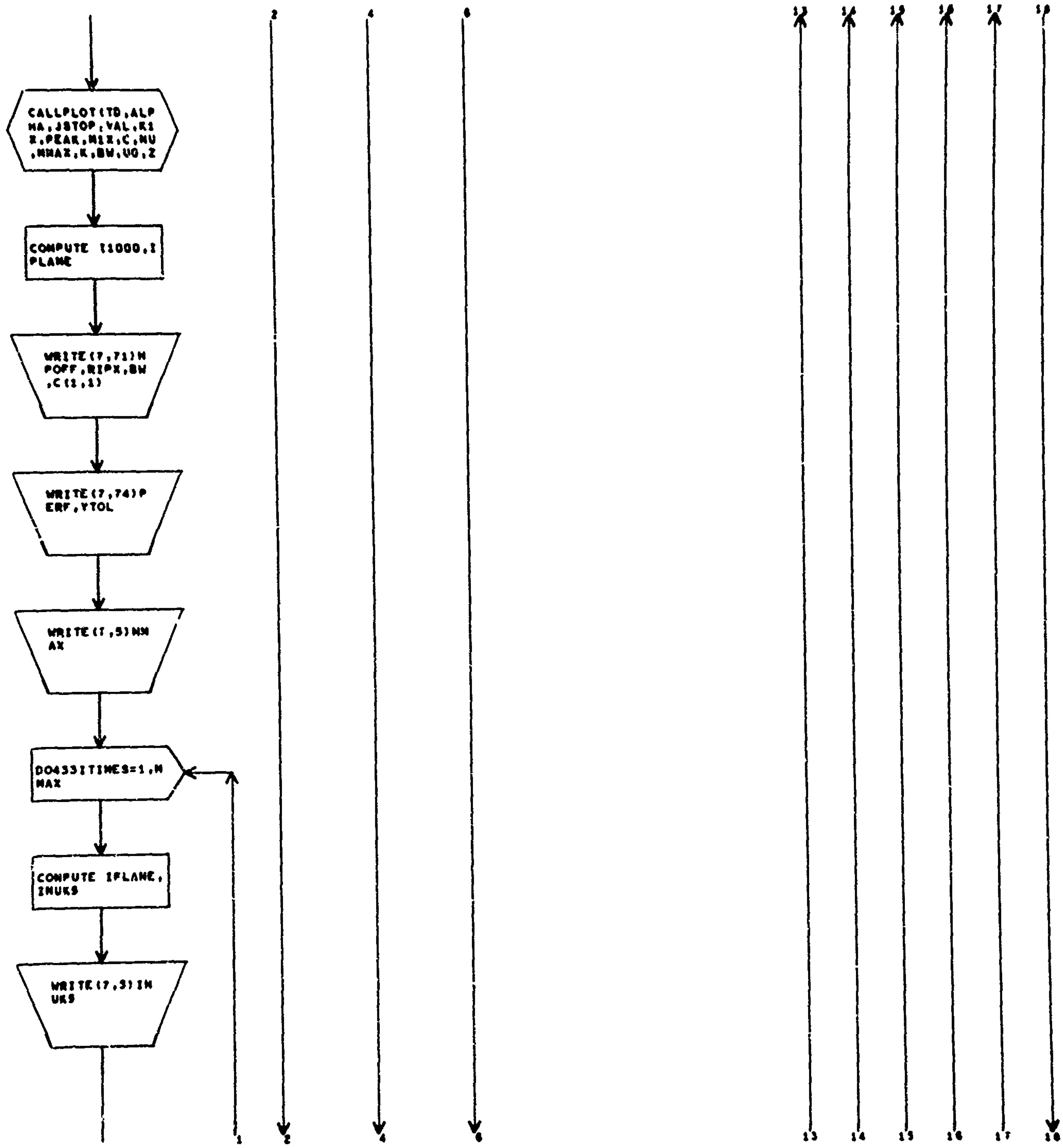
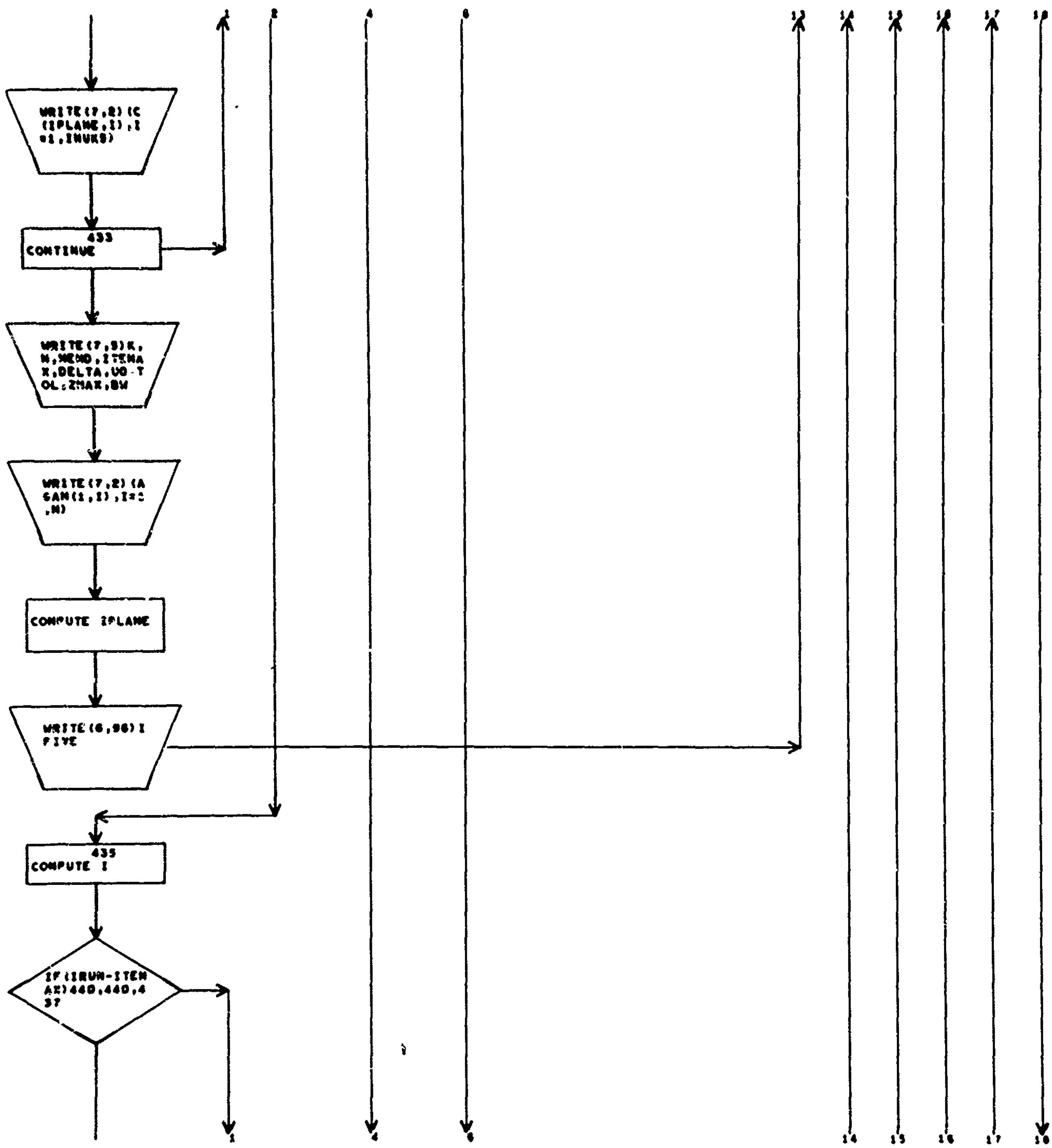
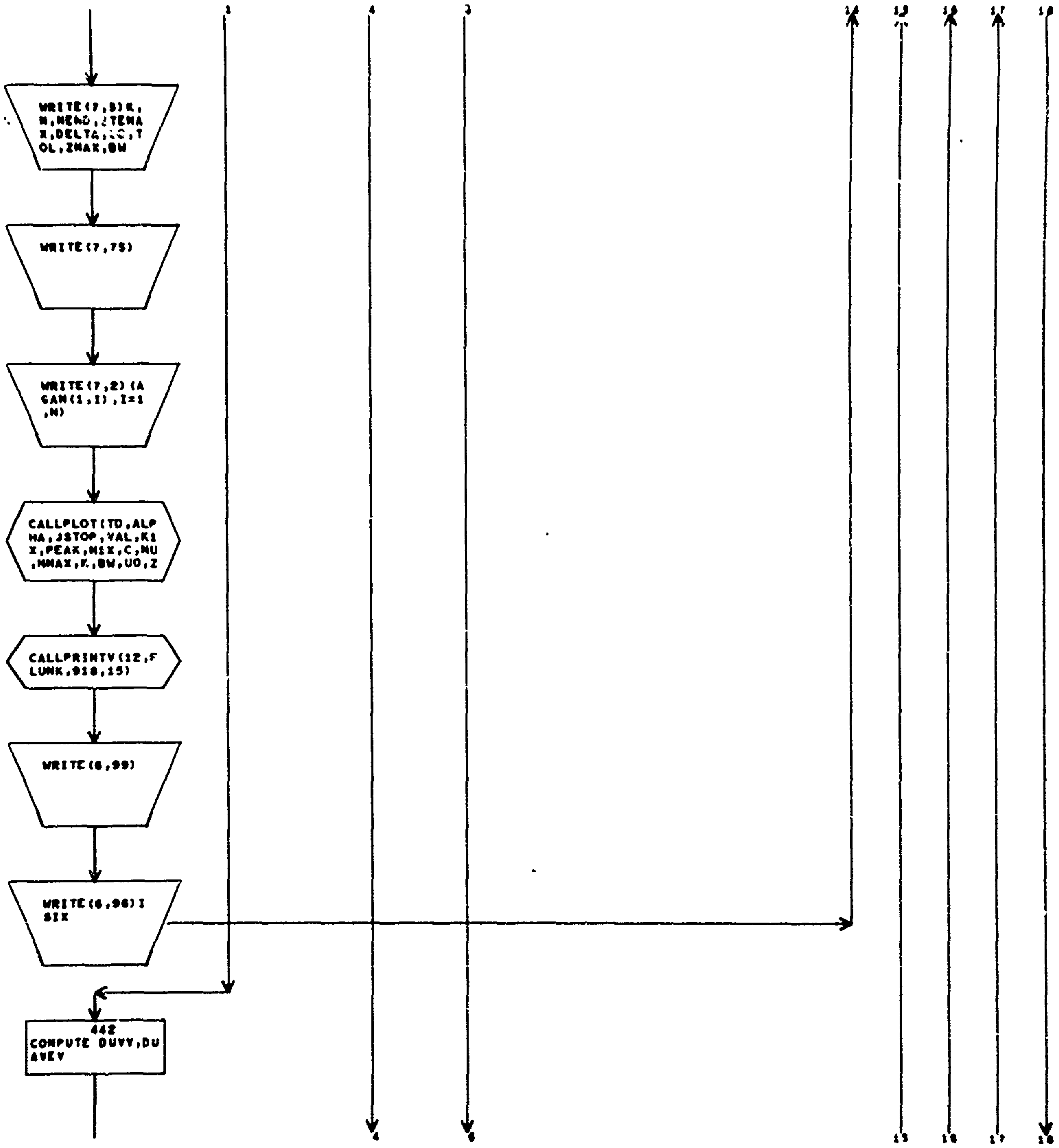
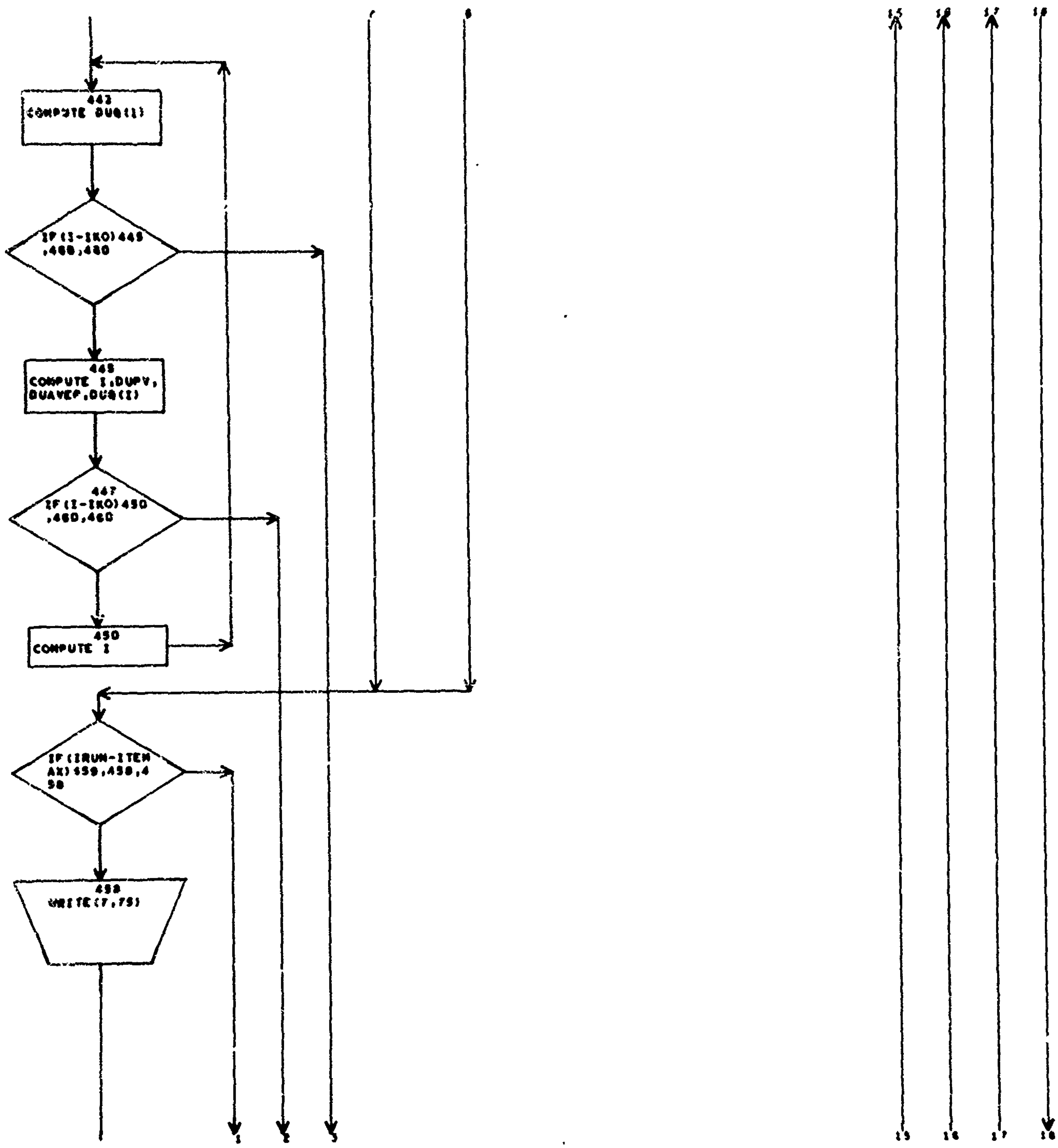
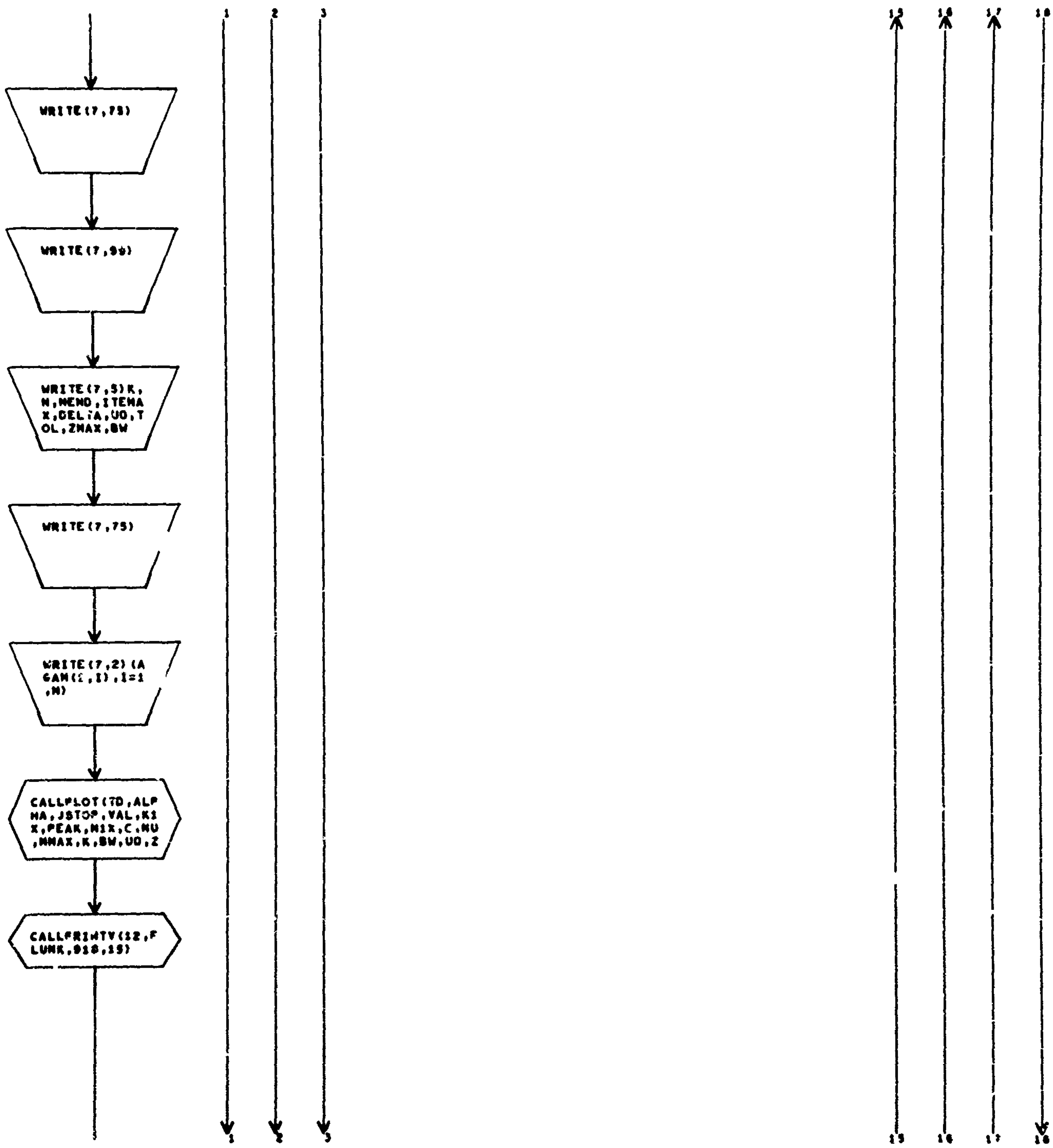

IF(E.)427,42
7,433
427
IF(IDEV.LE.0
)GOTO428
COMPUTE ITEMAX
428
WRITE(6,88)I
NUM
WRITE(7,75)
WRITE(7,73)
COMPUTE U3

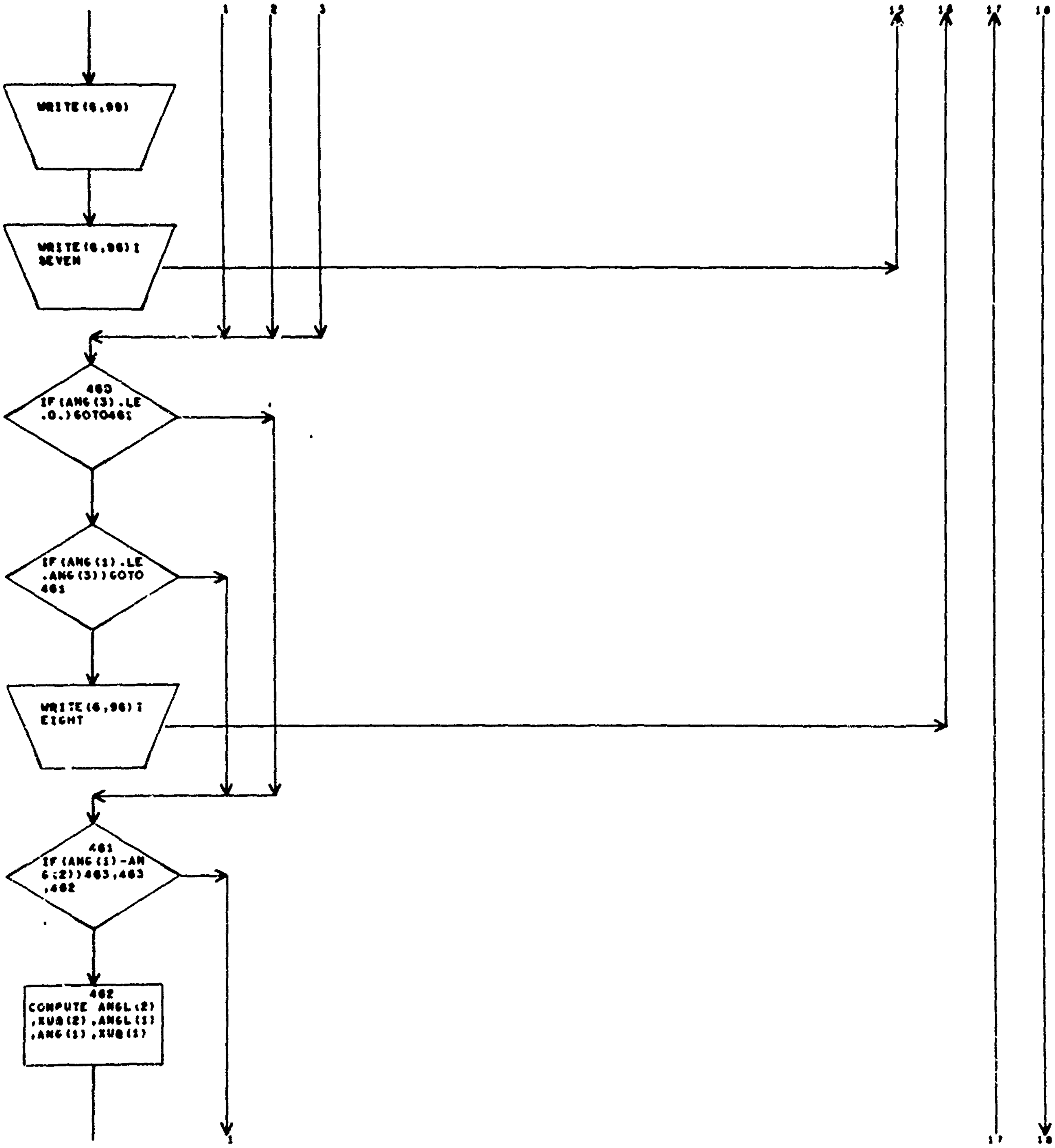

CALLPLOT(TD,ALP
HA,JSTOP,VAL,K1
X,PEAK,MIX,C,NU
,NMAX,K,BW,UO,Z
COMPUTE I1000,I
PLANE
WRITE(7,71)N
POFF,RIPX,BW
,C(1,1)
WRITE(7,74)P
ERF,YTOL
WRITE(7,5)NN
AX
DO433ITIMES=1,N
MAX
COMPUTE IPLANE,
INUKS
WRITE(7,3)IN
UKS
2
4
6
13
14
15
16
17
18
1
2
4
6
13
14
15
16
17
18

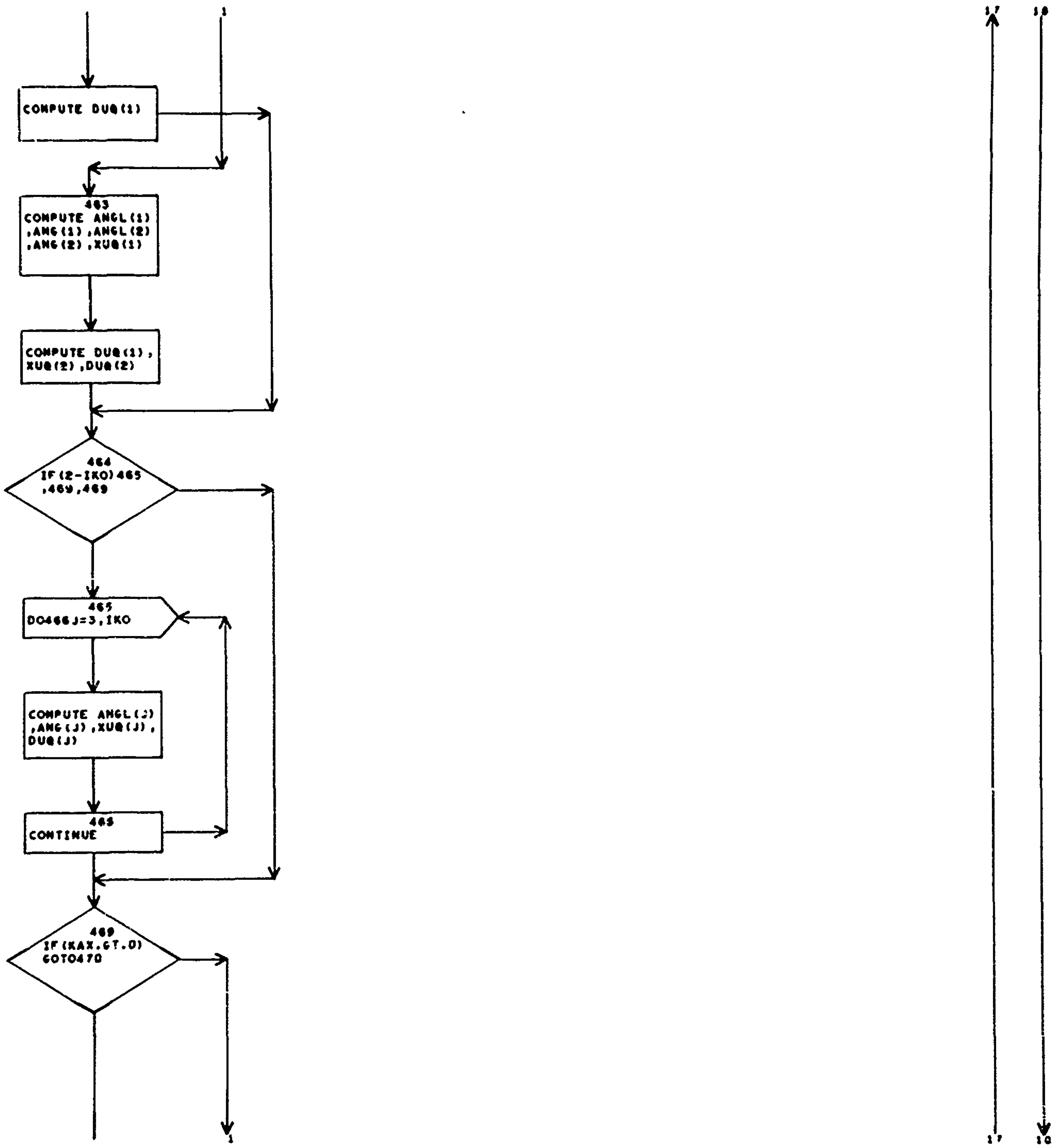

WRITE(7,2)(C(IPLANE,I),I=1,INUKS)
433 CONTINUE
WRITE(7,5)K,N,NEND,ITEMAX,DELTA,UO-TOL,ZMAX,BW
WRITE(7,2)(ASAN(1,I),I=1,N)
COMPUTE IPLANE
WRITE(6,96)IFIVE
435 COMPUTE I
IF(IRUN-ITEMAX)440,440,437

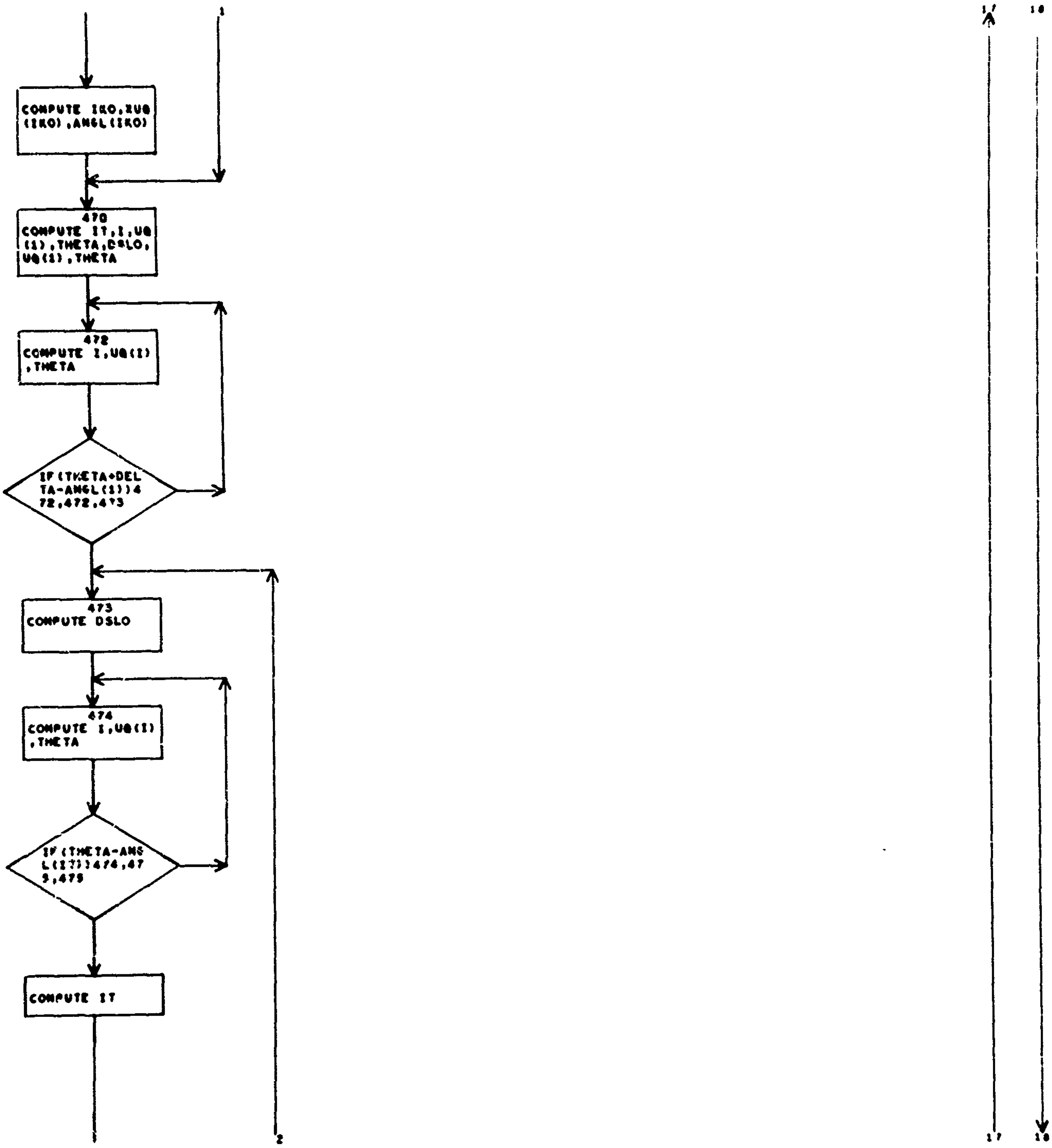

WRITE(7,3)K,
N,NEND,ITEMA
X,DELTA,UO,T
OL,ZMAX,BW
WRITE(7,75)
WRITE(7,2)(A
GAN(1,I),I=1
,N)
CALLPLOT(TD,ALP
HA,JSTOP,VAL,K1
X,PEAK,MIX,C,NU
,NMAX,K,BW,UO,Z
CALLPRINTV(12,F
LUNK,918,15)
WRITE(6,99)
WRITE(6,96)I
SIX
442
COMPUTE DUVV,DU
AVEV

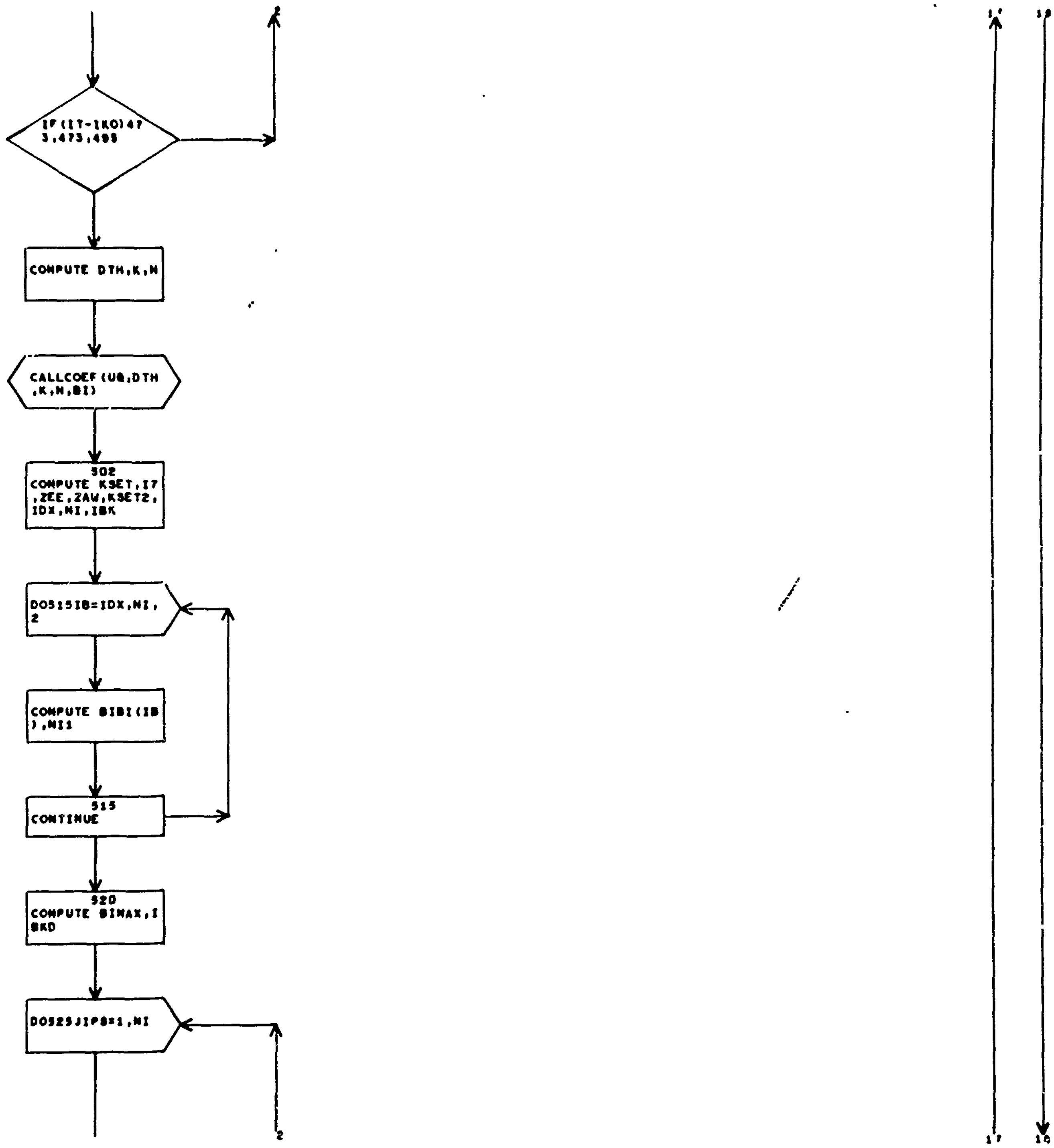

443
COMPUTE DUQ(I)
IF(I-IKO)445
,460,460
445
COMPUTE I,DUPV,
DUAVEF,DUQ(I)
447
IF(I-IKO)450
,460,460
450
COMPUTE I
IF(IRUN-ITEM
AX)459,458,4
58
458
WRITE(7,75)

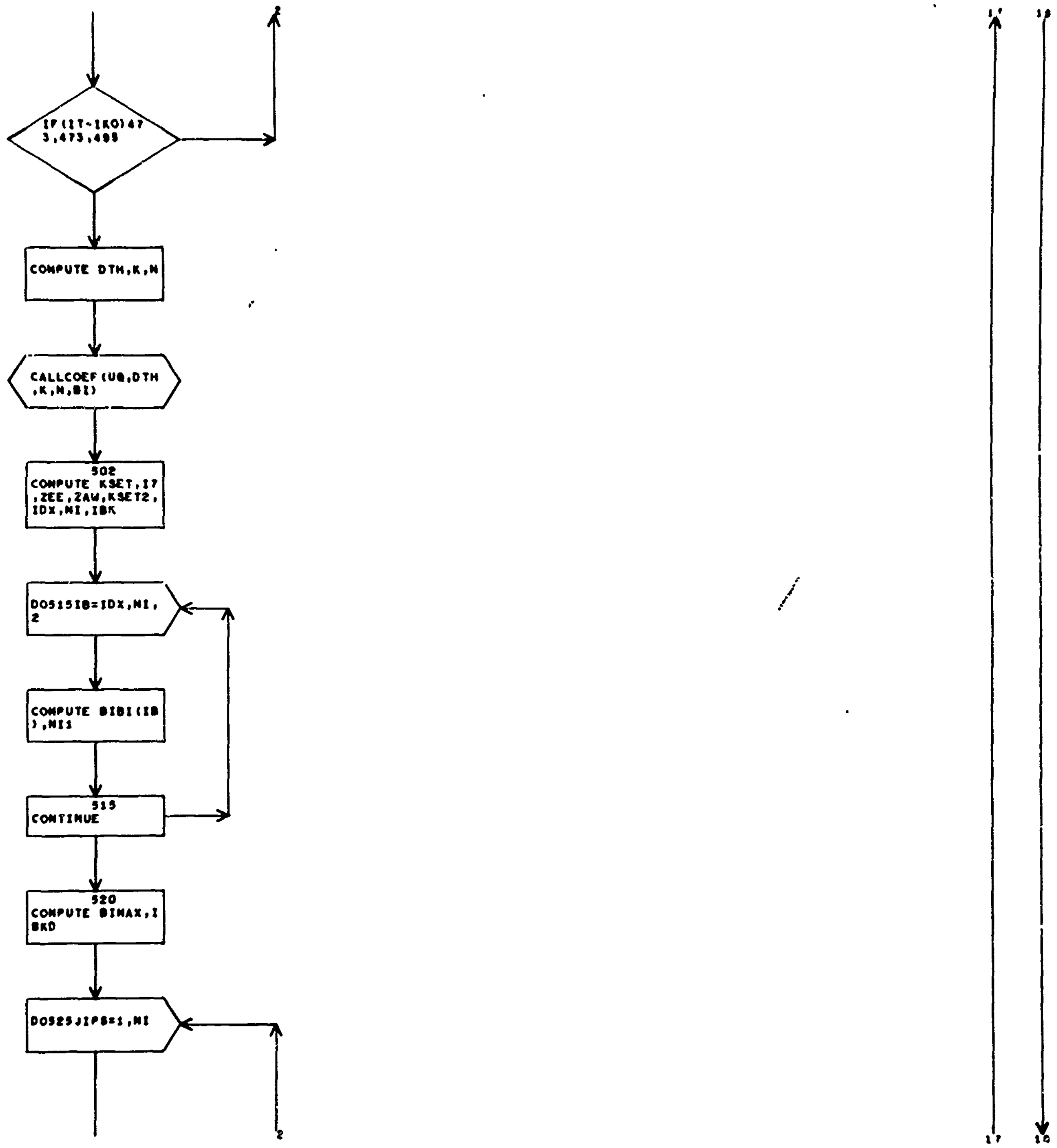

1
2
3
15
16
17
18
WRITE(7,75)
WRITE(7,99)
WRITE(7,5)K,N,NEND,ITEMAX,DELTA,UO,TOL,ZMAX,BW
WRITE(7,75)
WRITE(7,2)(AGAM(1,I),I=1,N)
CALLPLOT(TD,ALPHA,JSTOP,VAL,KIX,PEAK,MIX,C,MU,MMAX,K,BW,UO,Z
CALLPRINTV(12,FLUNK,918,15)
1
2
3
15
16
17
18


1
2
3
15
16
17
18
WRITE(6,99)
WRITE(6,96)I
SEVEN
460
IF(ANG(3).LE
.0.)GOTO461
IF(ANG(1).LE
.ANG(3))GOTO
461
WRITE(6,96)I
EIGHT
461
IF(ANG(1)-AN
G(2))463,463
,462
462
COMPUTE ANGL(2)
,XUB(2),ANGL(1)
,ANG(1),XUB(1)
1
17
18

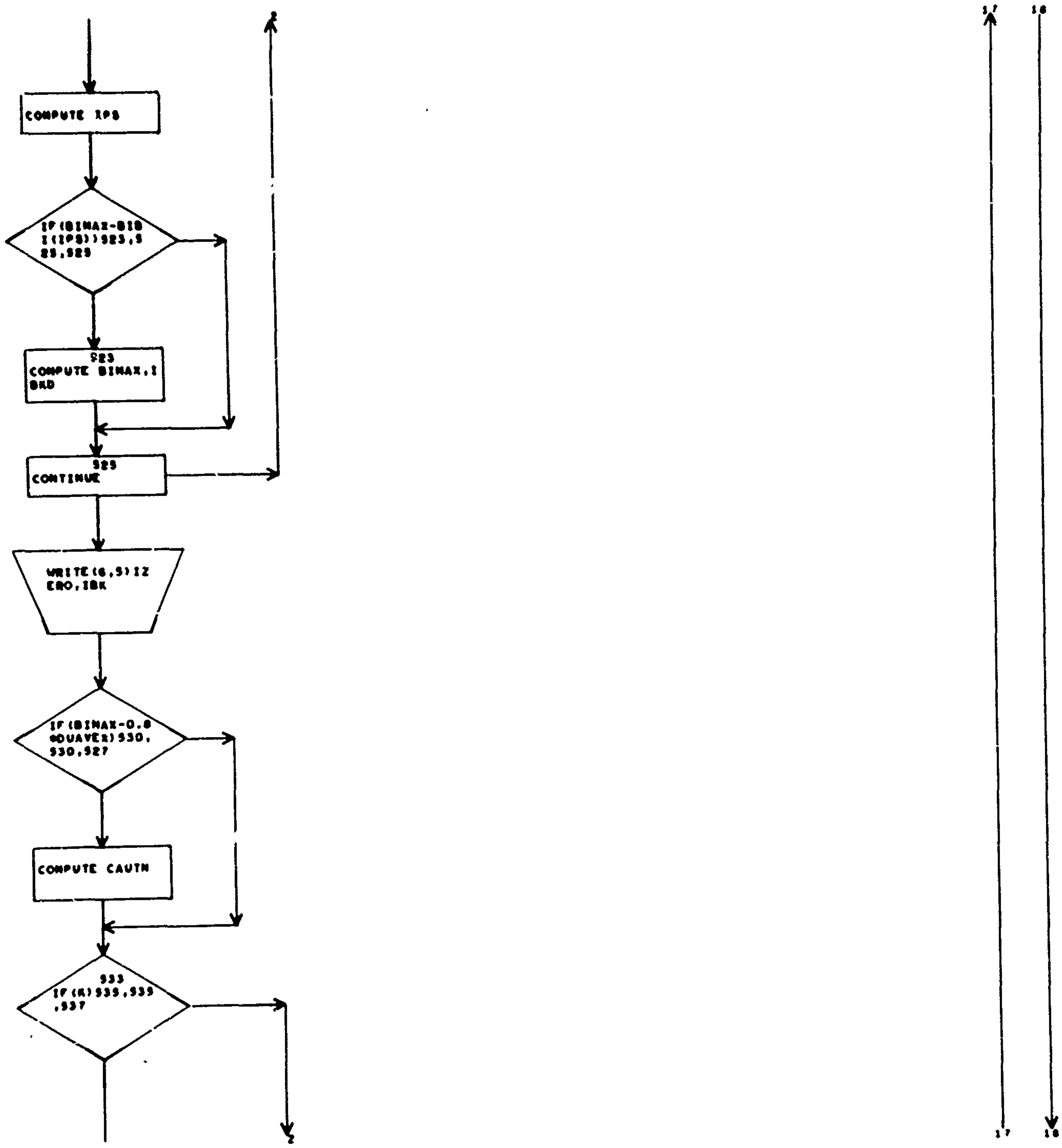

COMPUTE DUQ(1)
463
COMPUTE ANGL(1)
,ANG(1),ANGL(2)
,ANG(2),XUQ(1)
COMPUTE DUQ(1),
XUQ(2),DUQ(2)
464
IF(2-IKO)465
,469,469
465
DO466J=3,IKO
COMPUTE ANGL(J)
,ANG(J),XUQ(J),
DUQ(J)
466
CONTINUE
469
IF(KAX.GT.0)
GOTO470

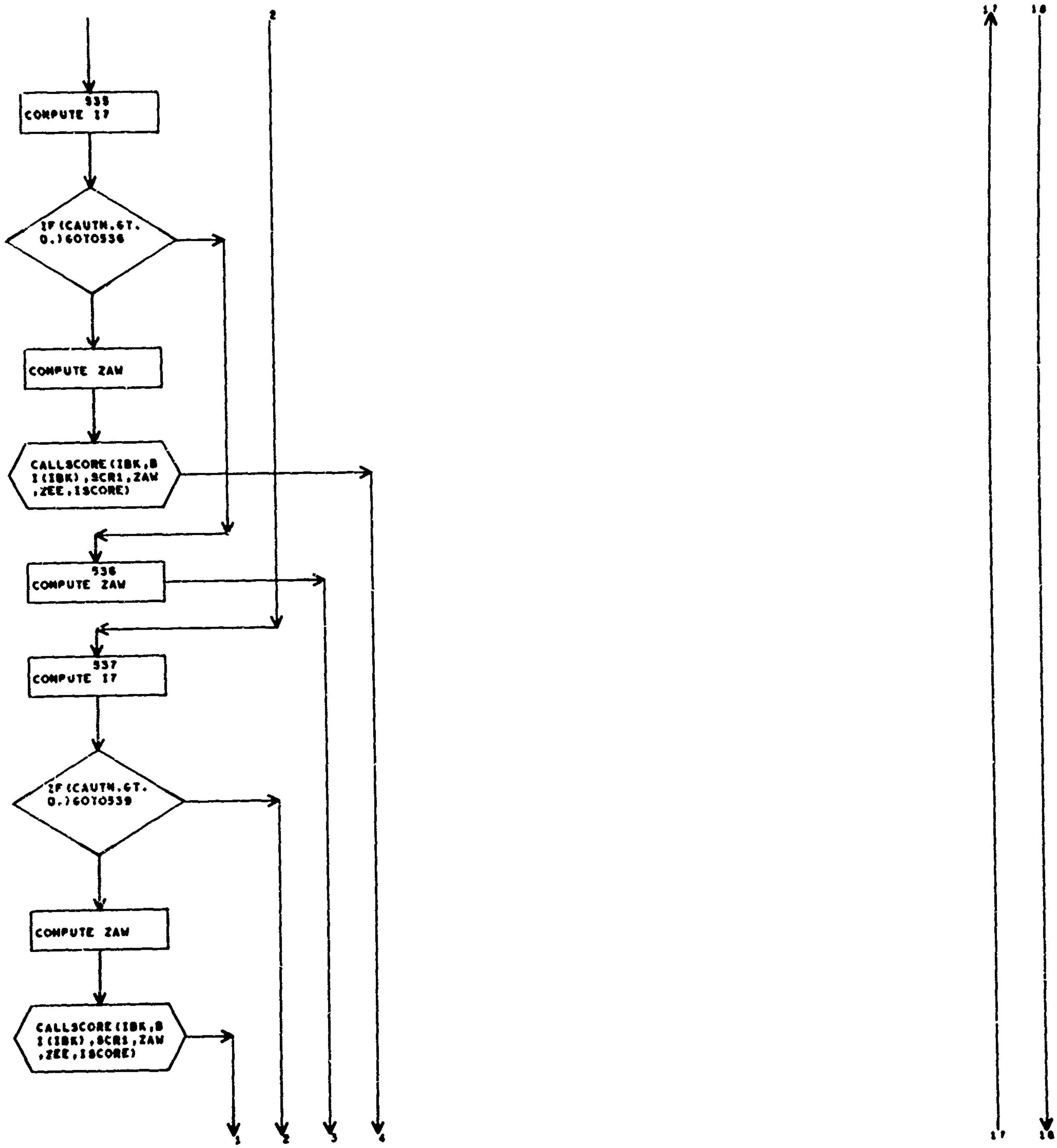

1
17
18
COMPUTE IKO,XUQ (IKO),ANGL(IKO)
470
COMPUTE IT,I,UQ (I),THETA,DSLO, UQ(I),THETA
472
COMPUTE I,UQ(I) ,THETA
IF(THETA+DEL TA-ANGL(I))4 72,472,473
473
COMPUTE DSLO
474
COMPUTE I,UQ(I) ,THETA
IF(THETA-ANG L(IT))474,47 5,475
COMPUTE IT
2
17
18


IF(IT-IKO)47
3,473,493
COMPUTE DTH,K,N
CALLCOEF(UQ,DTH
,K,N,BI)
502
COMPUTE KSET,I7
,ZEE,ZAW,KSET2,
IDX,NI,IBK
DO515IB=IDX,NI,
2
COMPUTE BIBI(IB
),NI1
515
CONTINUE
520
COMPUTE BIMAX,I
BKD
DO525JIPS=1,NI
2

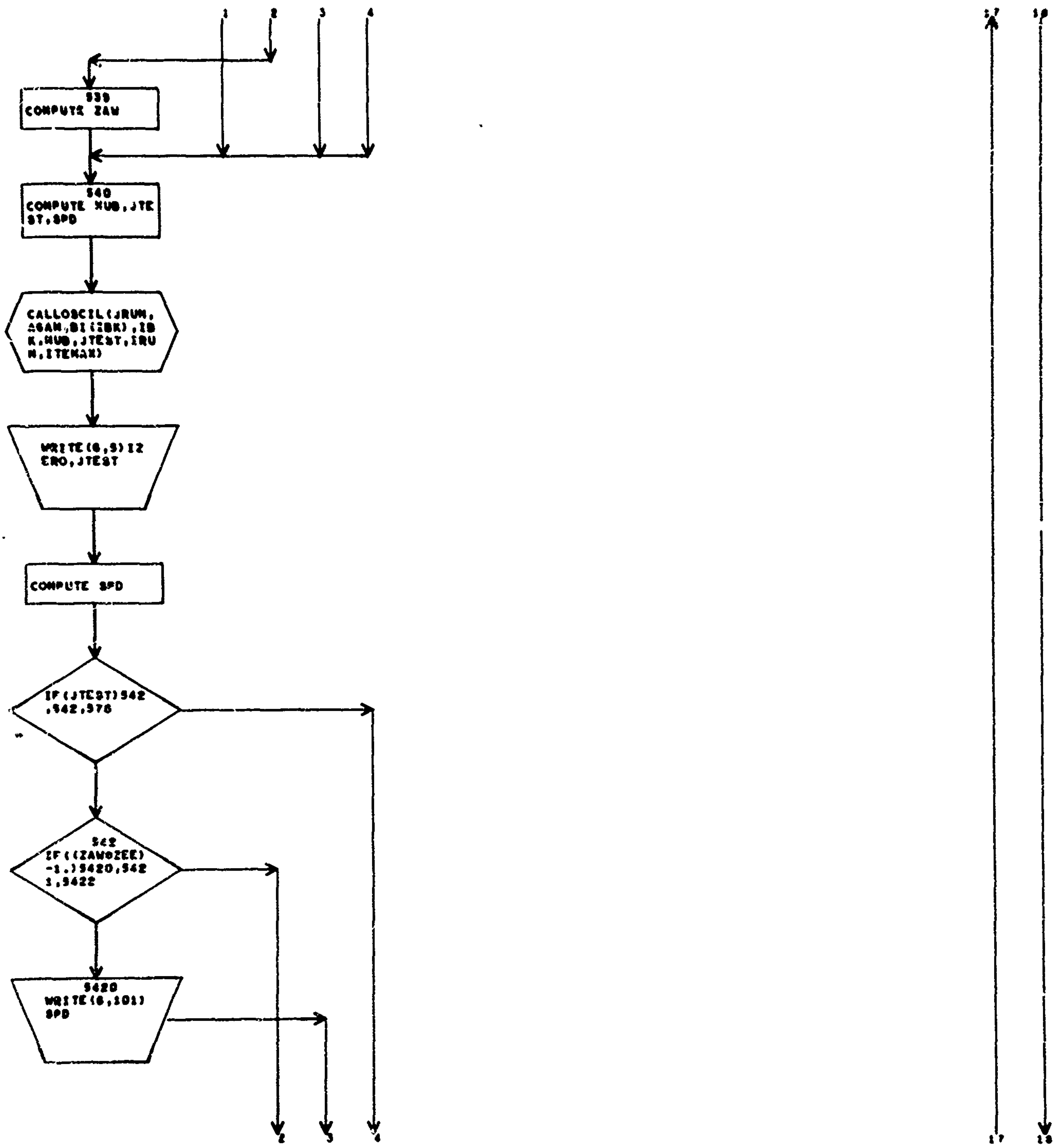


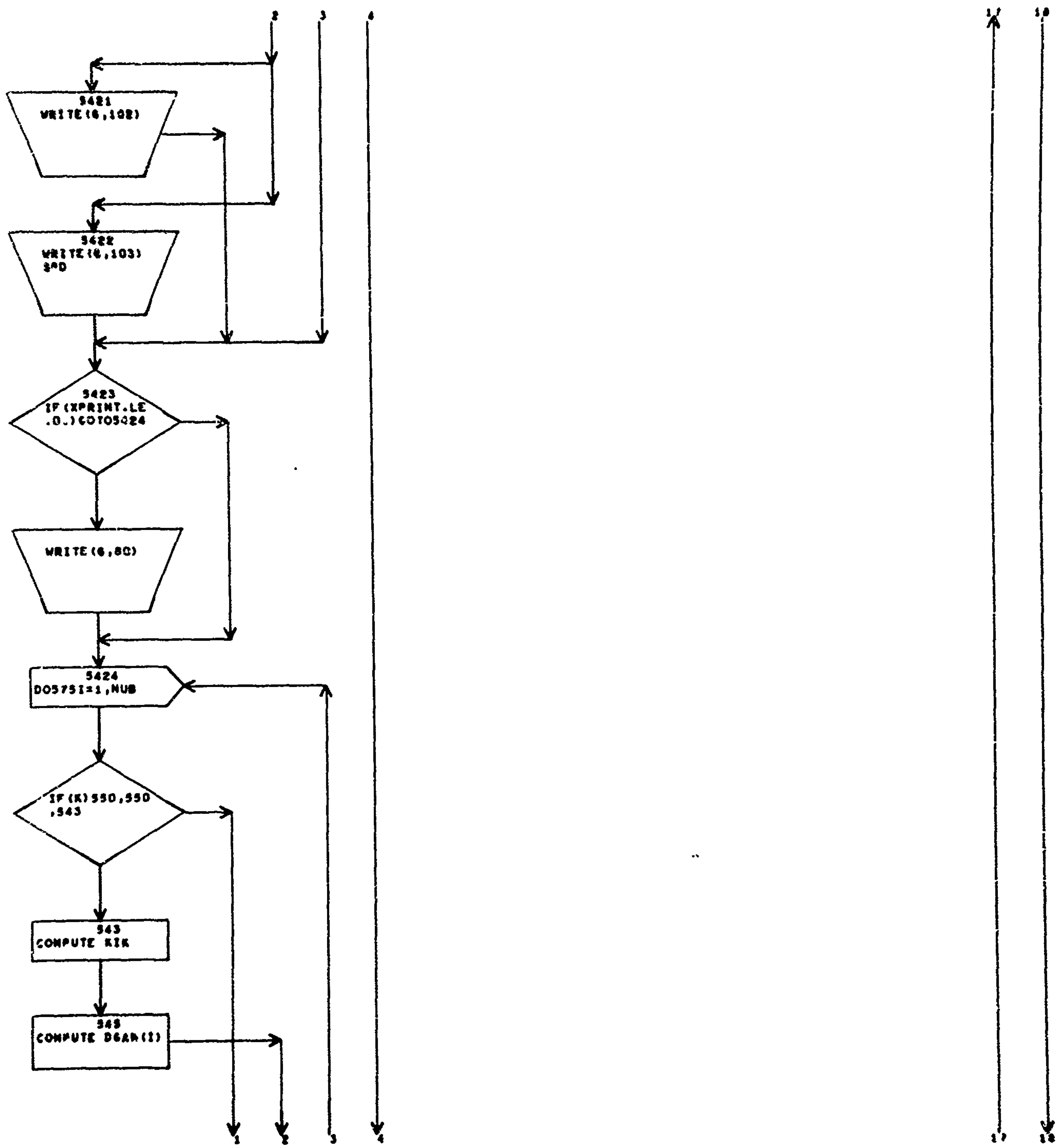
IF(IT-IKO)47
3,473,495
COMPUTE DTH,K,N
CALLCOEF(UQ,DTH
,K,N,BI)
502
COMPUTE KSET,I7
,ZEE,ZAW,KSET2,
IDX,NI,IBK
DO515IB=IDX,NI,
2
COMPUTE BIBI(IB
),NI1
515
CONTINUE
520
COMPUTE BIMAX,I
BKD
DO525JIPS=1,NI
2
2


COMPUTE IPS
IF(BIMAX-BIS I(IPS))523,5 25,525
523 COMPUTE BIMAX,I BKD
525 CONTINUE
WRITE(6,5)IZ ERO,IBK
IF(BIMAX-0.8 *QUAVEX)530, 530,527
COMPUTE CAUTN
533 IF(K)535,535 ,537
2
17
18

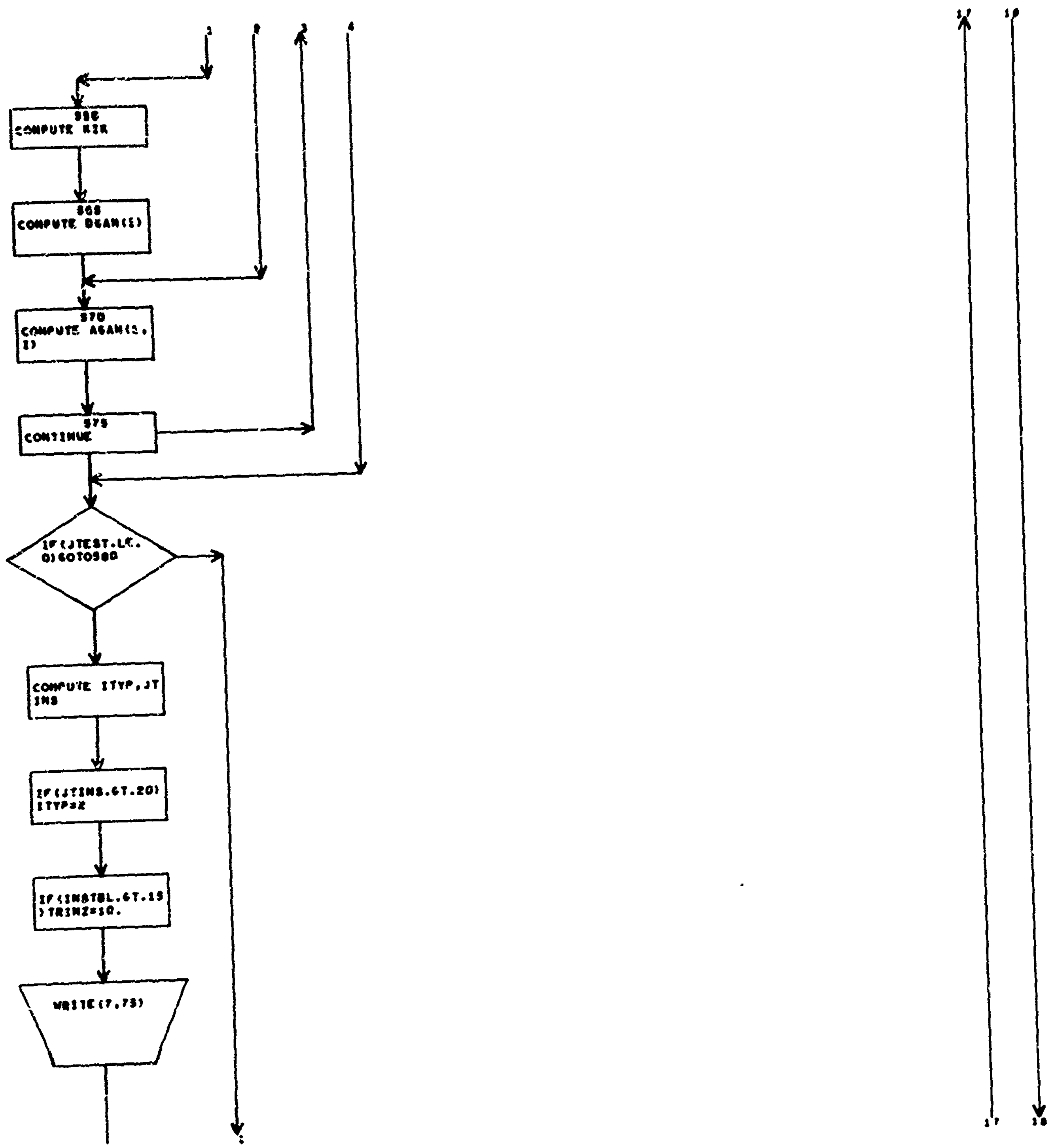


2
17
18
535
COMPUTE I7
IF(CAUTN.GT.
0.)GOTO536
COMPUTE ZAW
CALLSCORE(IBK,B
I(IBK),SCR1,ZAW
,ZEE,ISCORE)
536
COMPUTE ZAW
537
COMPUTE I7
IF(CAUTN.GT.
0.)GOTO539
COMPUTE ZAW
CALLSCORE(IBK,B
I(IBK),SCR1,ZAW
,ZEE,ISCORE)
1
2
3
4
17
18

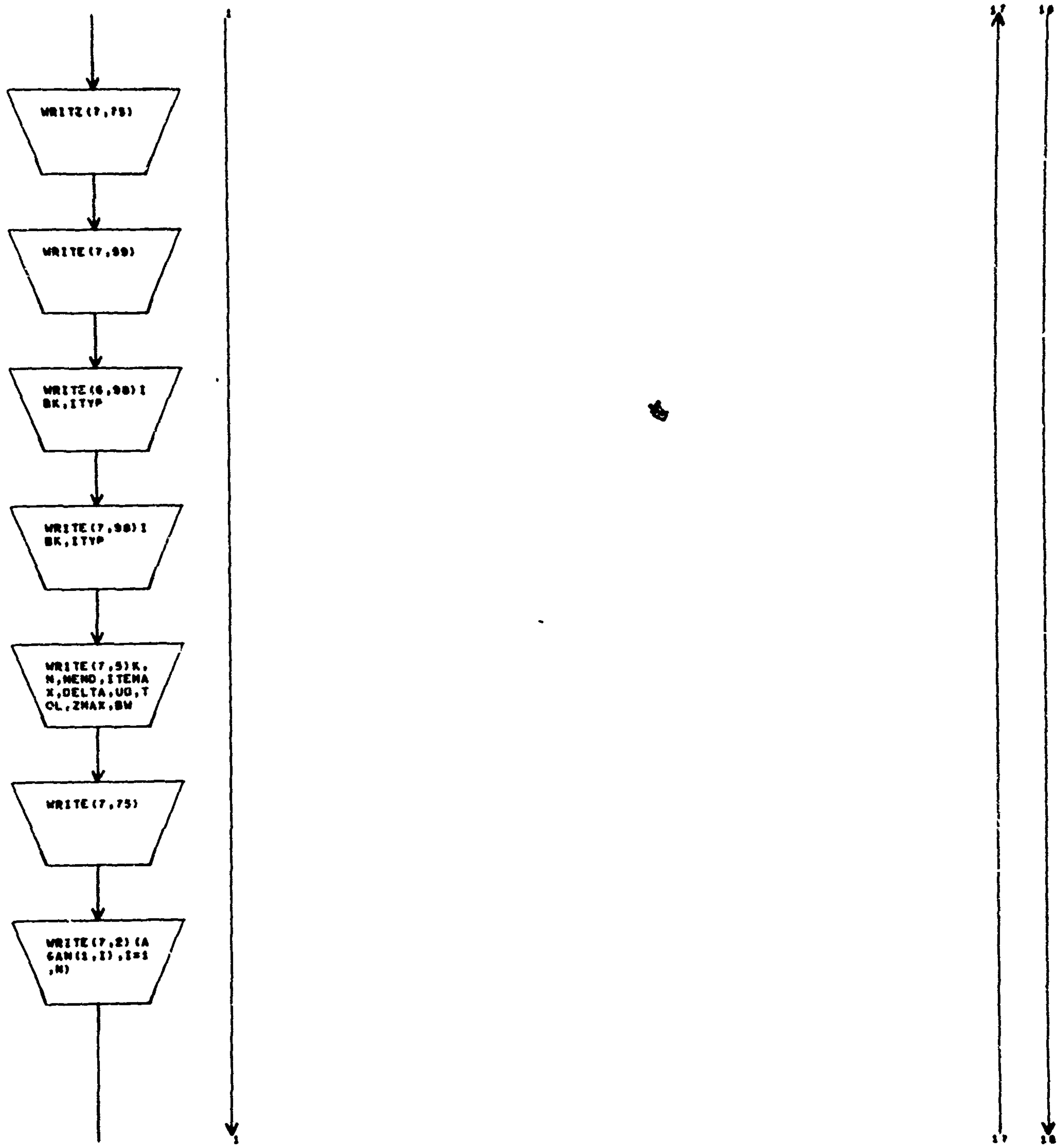

1
2
3
4
17
18
539
COMPUTE ZAW
540
COMPUTE XUB,JTE
ST,SPD
CALLOSCIL(JRUN,
AGAM,BI(IBK),IB
K,XUB,JTEST,IRU
N,ITEMAX)
WRITE(6,5)IZ
ERO,JTEST
COMPUTE SPD
IF(JTEST)542
,542,376
542
IF((ZAW*ZEE)
-1.)5420,542
1,5422
5420
WRITE(6,101)
SPD
2
3
4
17
18

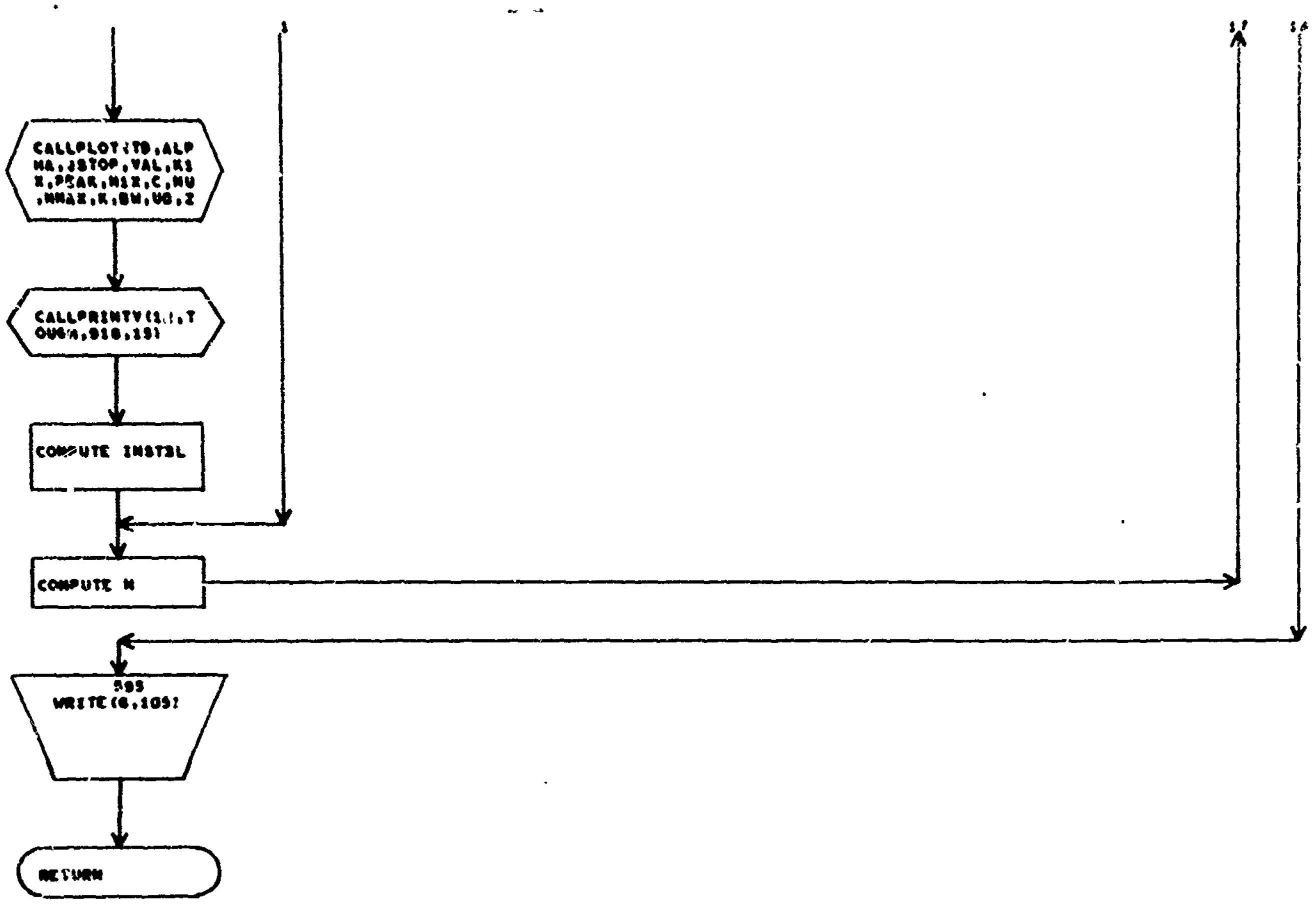


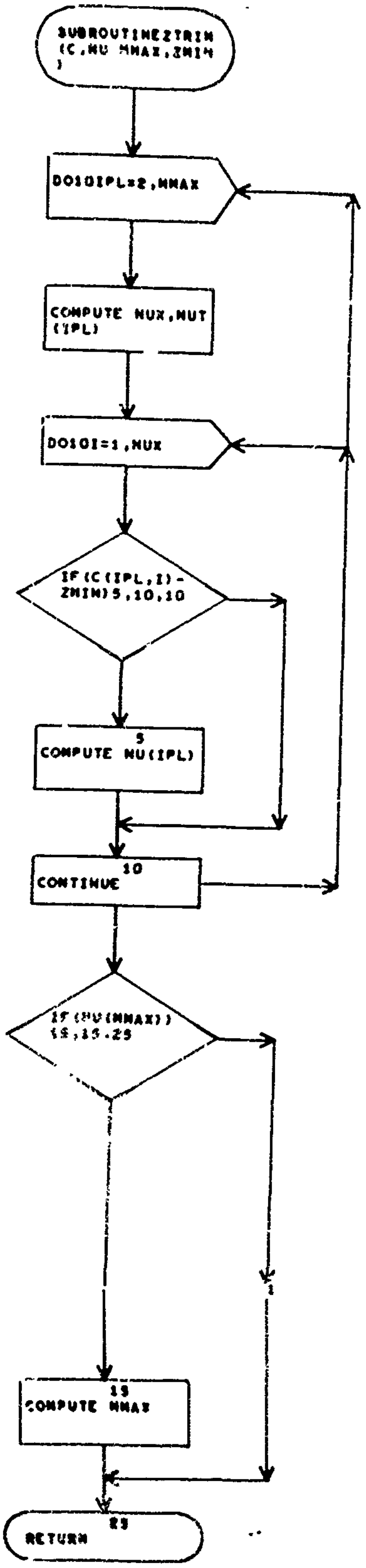
5421
WRITE(6,102)
5422
WRITE(6,103)
5423
IF(XPRINT.LE
.0.)GOTO5424
WRITE(6,80)
5424
DO575I=1,NUB
IF(K)550,550
,543
543
COMPUTE KIK
COMPUTE DEAR(I)

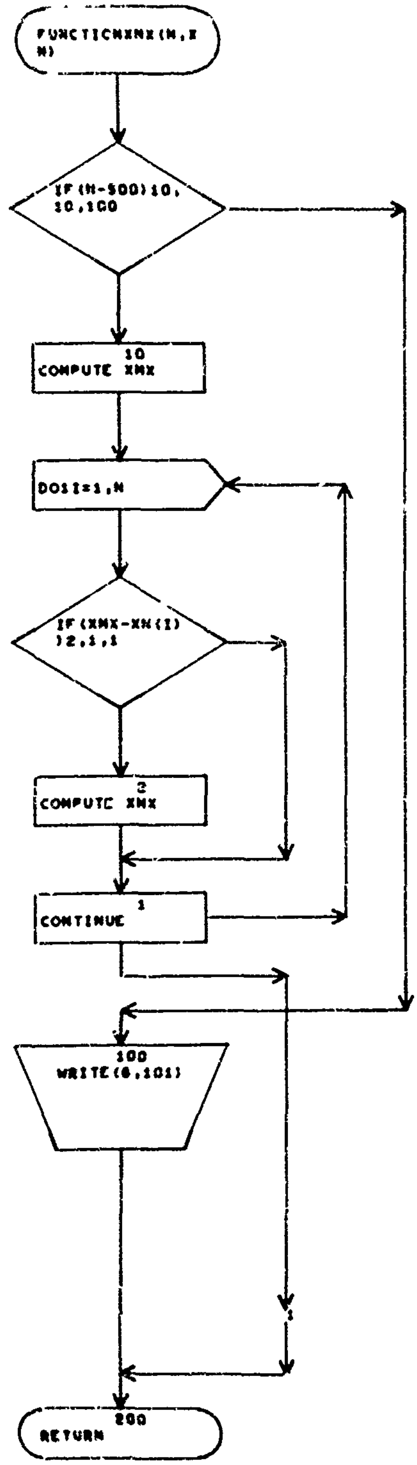


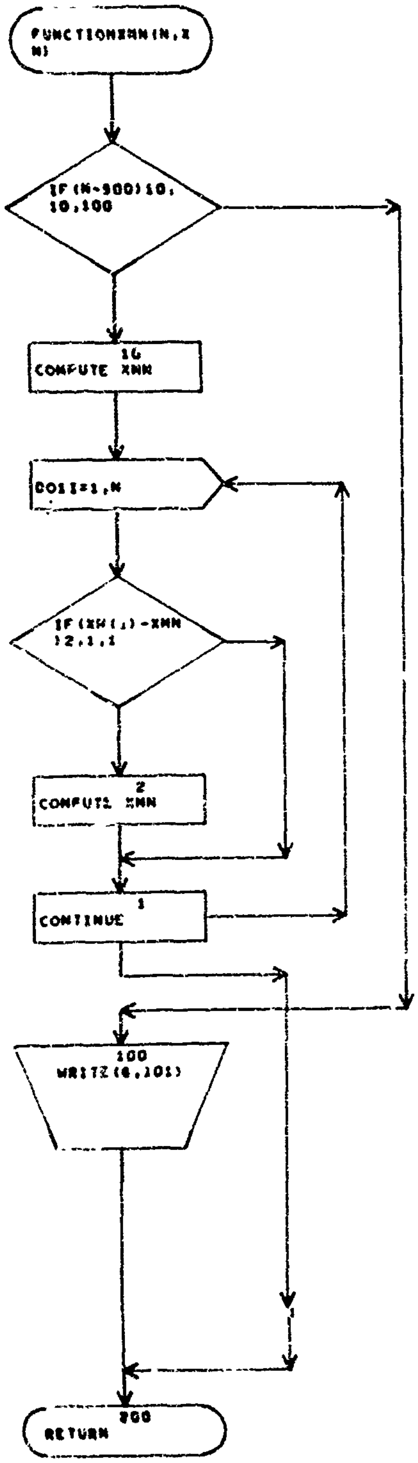
556
COMPUTE KIR
565
COMPUTE DGAN(I)
570
COMPUTE AGAN(I, I)
575
CONTINUE
IF(JTEST.LE. 0)GOTO580
COMPUTE ITYP,JT INS
IF(JTINS.GT.20) ITYP=2
IF(INSTBL.GT.15)TRINZ=10.
WRITE(7,73)

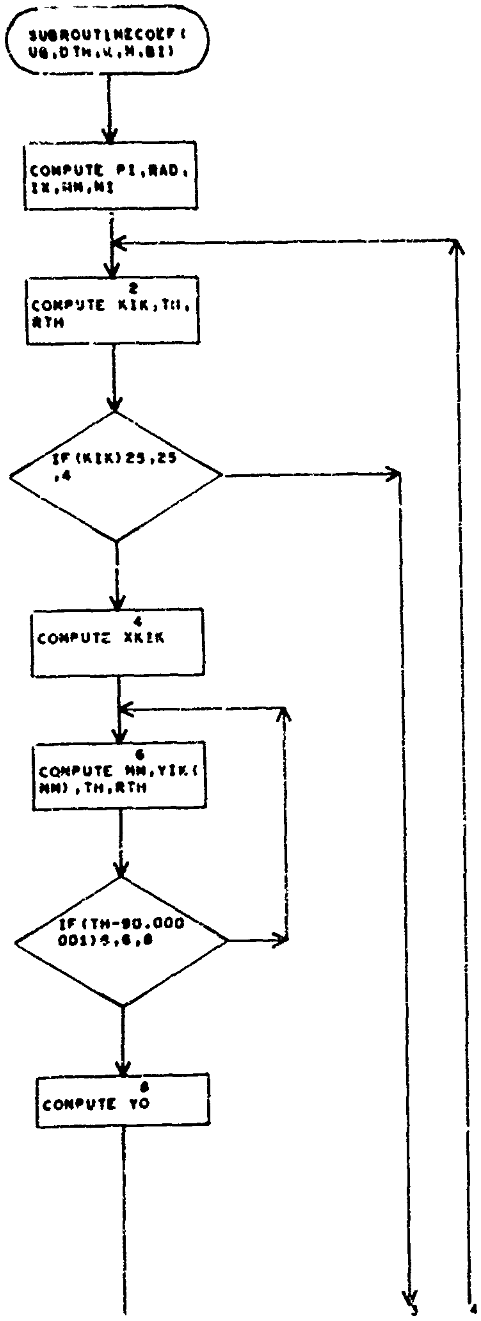

WRITE(7,75)
WRITE(7,99)
WRITE(6,98)IBK,ITYP
WRITE(7,98)IBK,ITYP
WRITE(7,5)K,N,NEND,ITEMAX,DELTA,UO,TOL,ZMAX,BW
WRITE(7,75)
WRITE(7,2)(AGAN(1,I),I=1,N)
1
18
1
17
18

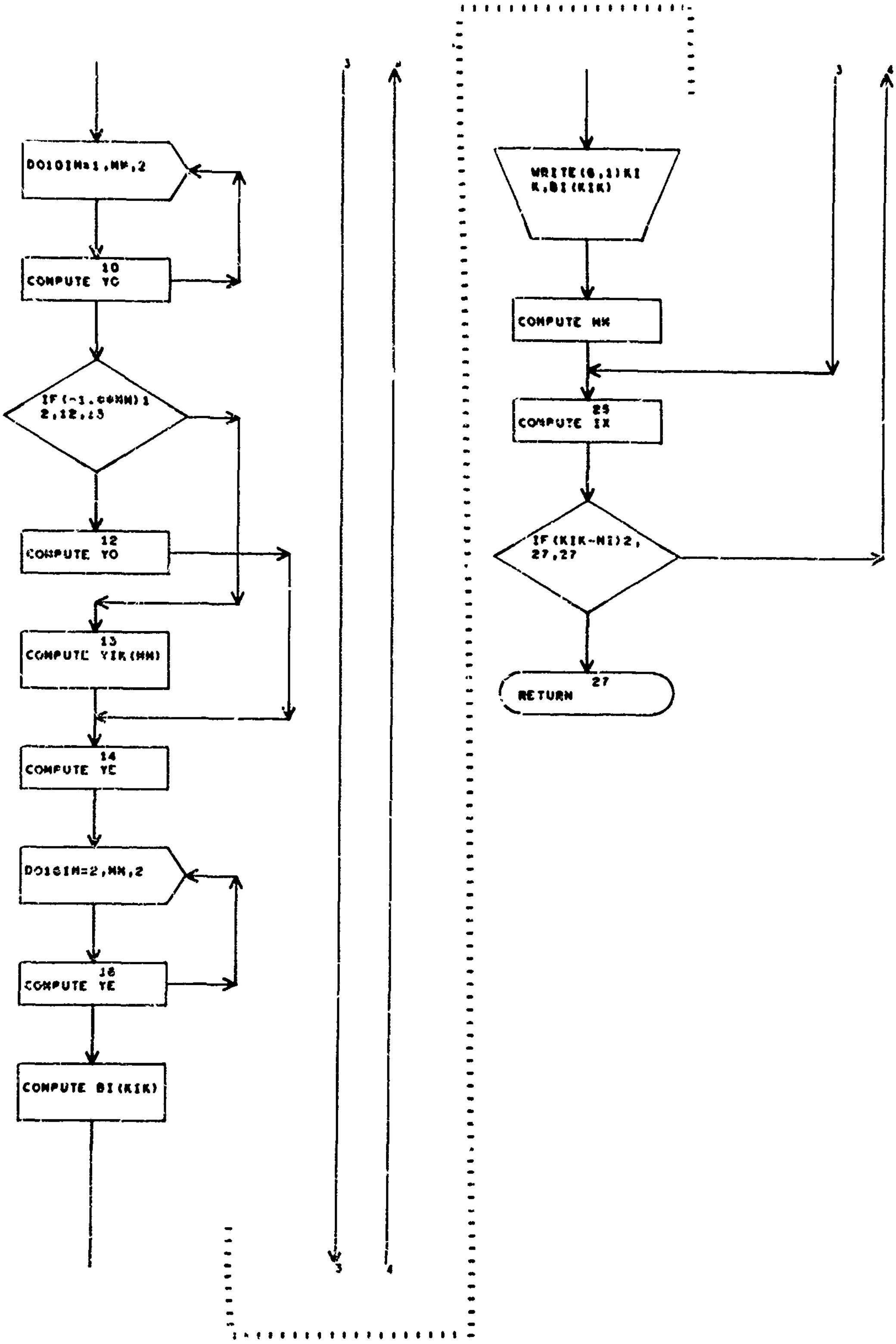

CALLPLOT(TD,ALPHA,JSTOP,VAL,KIX,PEAK,NIX,C,NU,NMAX,K,BW,UG,Z
CALLPRINTV(1,I,TOUGH,D18,15)
COMPUTE INSTBL
COMPUTE N
595
WRITE(6,105)
RETURN

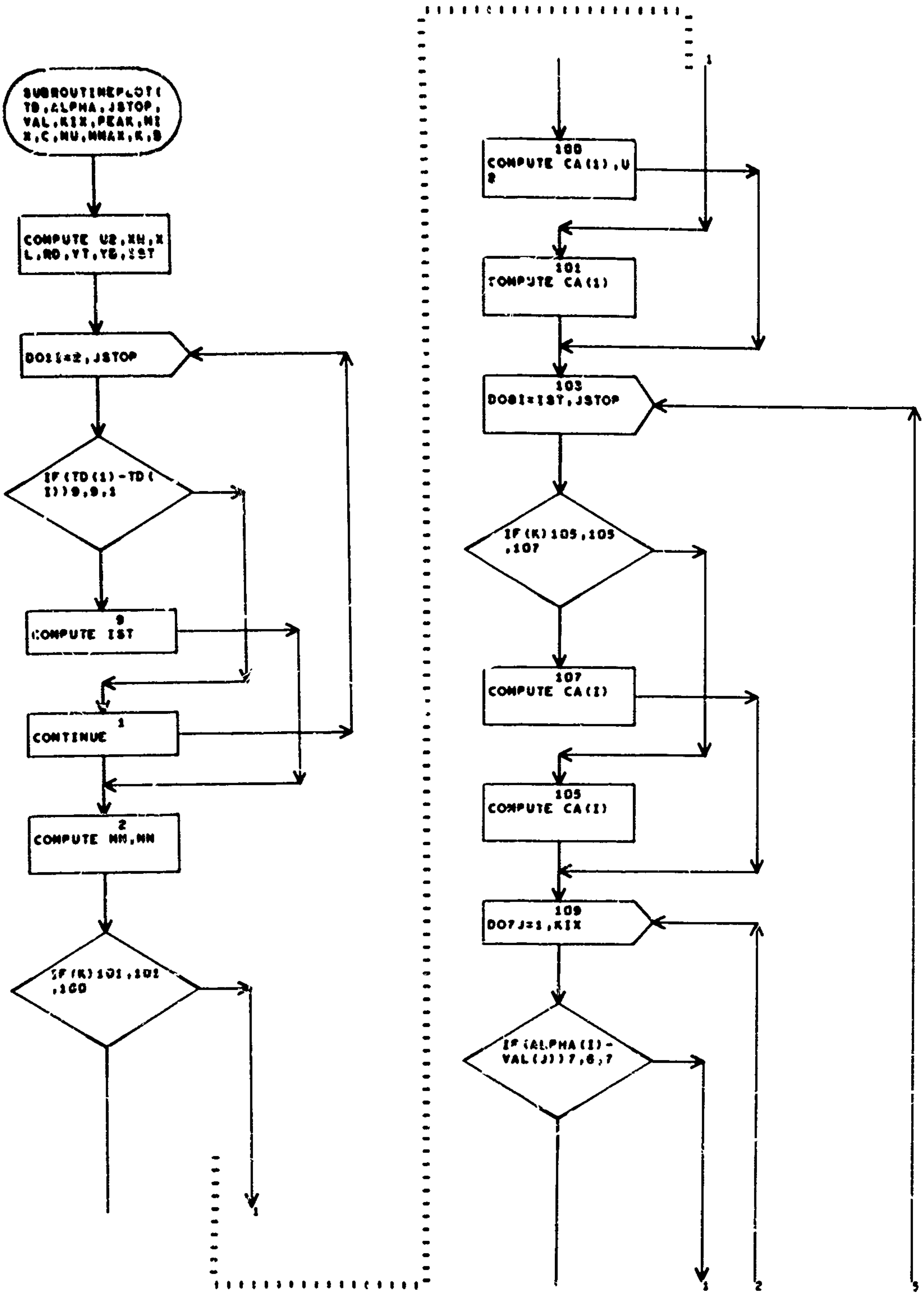

SUBROUTINEZTRIM (C,NU MMAX,ZMIN)
DO10IPL=2,MMAX
COMPUTE NUX,NUT (IPL)
DO10I=1,NUX
IF(C(IPL,I)-ZMIN)5,10,10
5
COMPUTE NU(IPL)
10
CONTINUE
IF(NU(MMAX)) 15,15,25
15
COMPUTE MMAX
25
RETURN

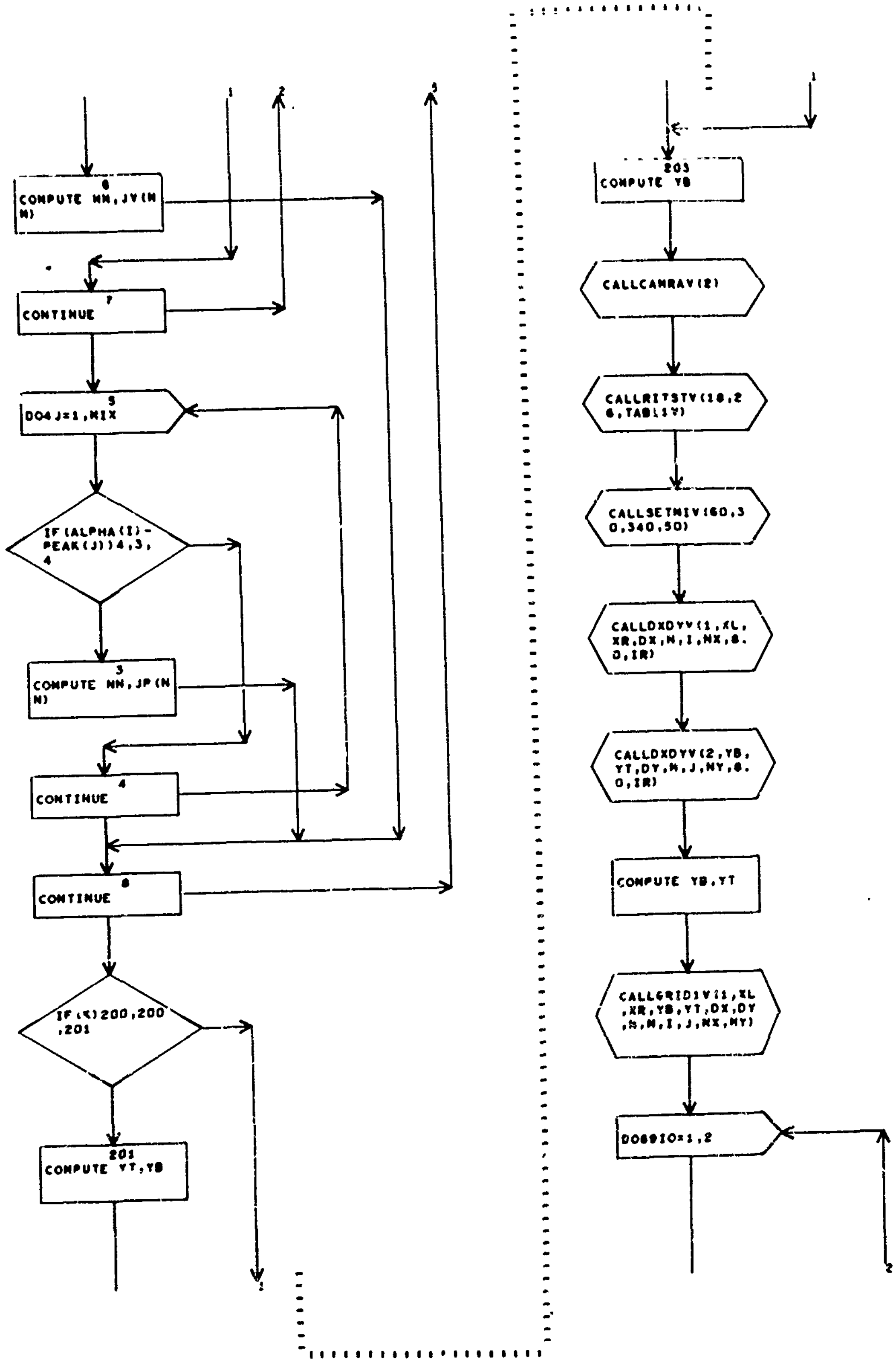

FUNCTIONXMX(N,X N)
IF(N-500)10, 10,100
10
COMPUTE XMX
DO1I=1,N
IF(XMX-XN(I))2,1,1
2
COMPUTE XMX
1
CONTINUE
100
WRITE(6,101)
200
RETURN

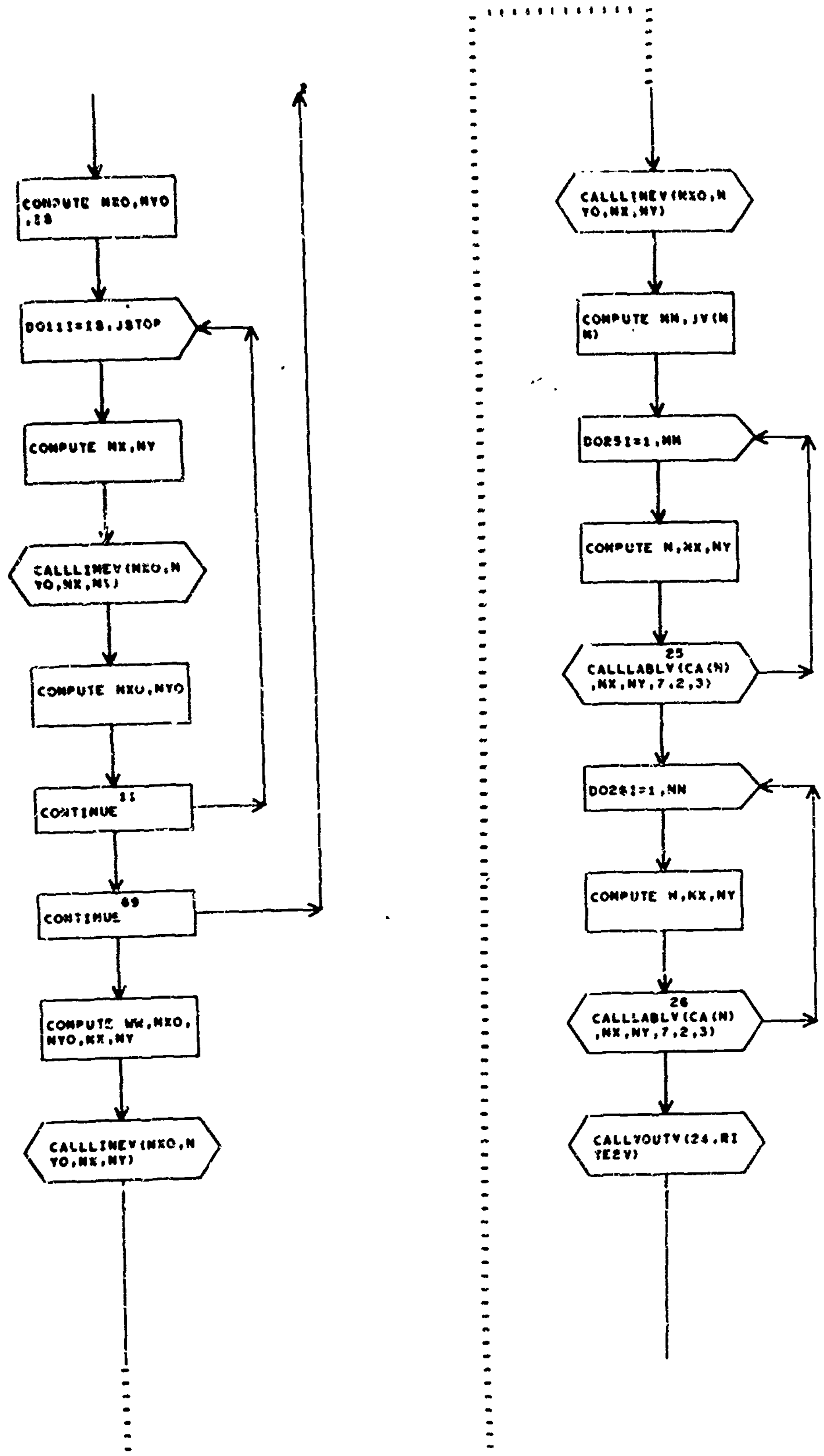

FUNCTIONXMN(N,X
N)
IF(N-300)10,
10,100
10
COMPUTE XMN
DO1I=1,N
IF(XN(I)-XMN
)2,1,1
2
COMPUTE XMN
1
CONTINUE
100
WRITE(6,101)
200
RETURN

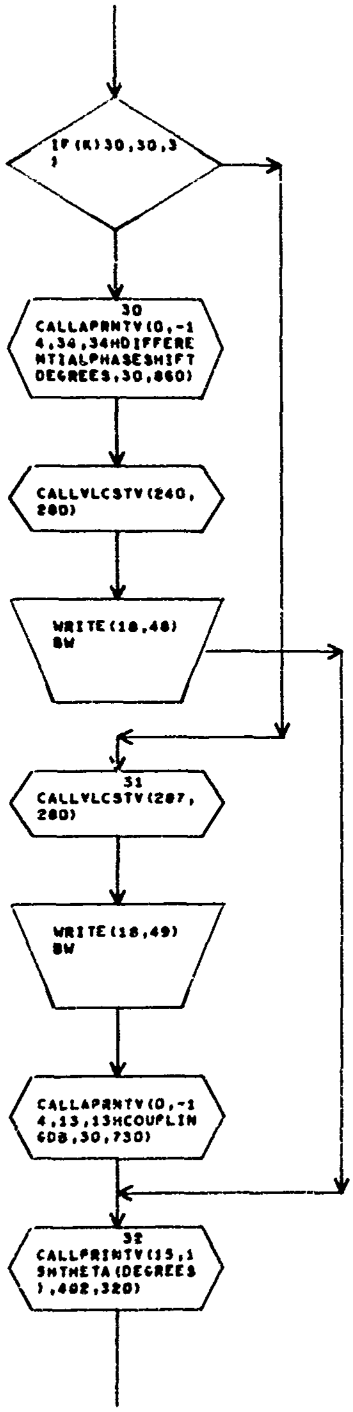

SUBROUTINECOEF(
UG,DTH,K,M,BI)
COMPUTE PI,RAD,
IX,MM,MI
2
COMPUTE KIK,TH,
RTH
IF(KIK)25,25
,4
4
COMPUTE XKIK
6
COMPUTE MM,YIK(
MM),TH,RTH
IF(TH-90.000
001)6,6,8
8
COMPUTE YO
3
4

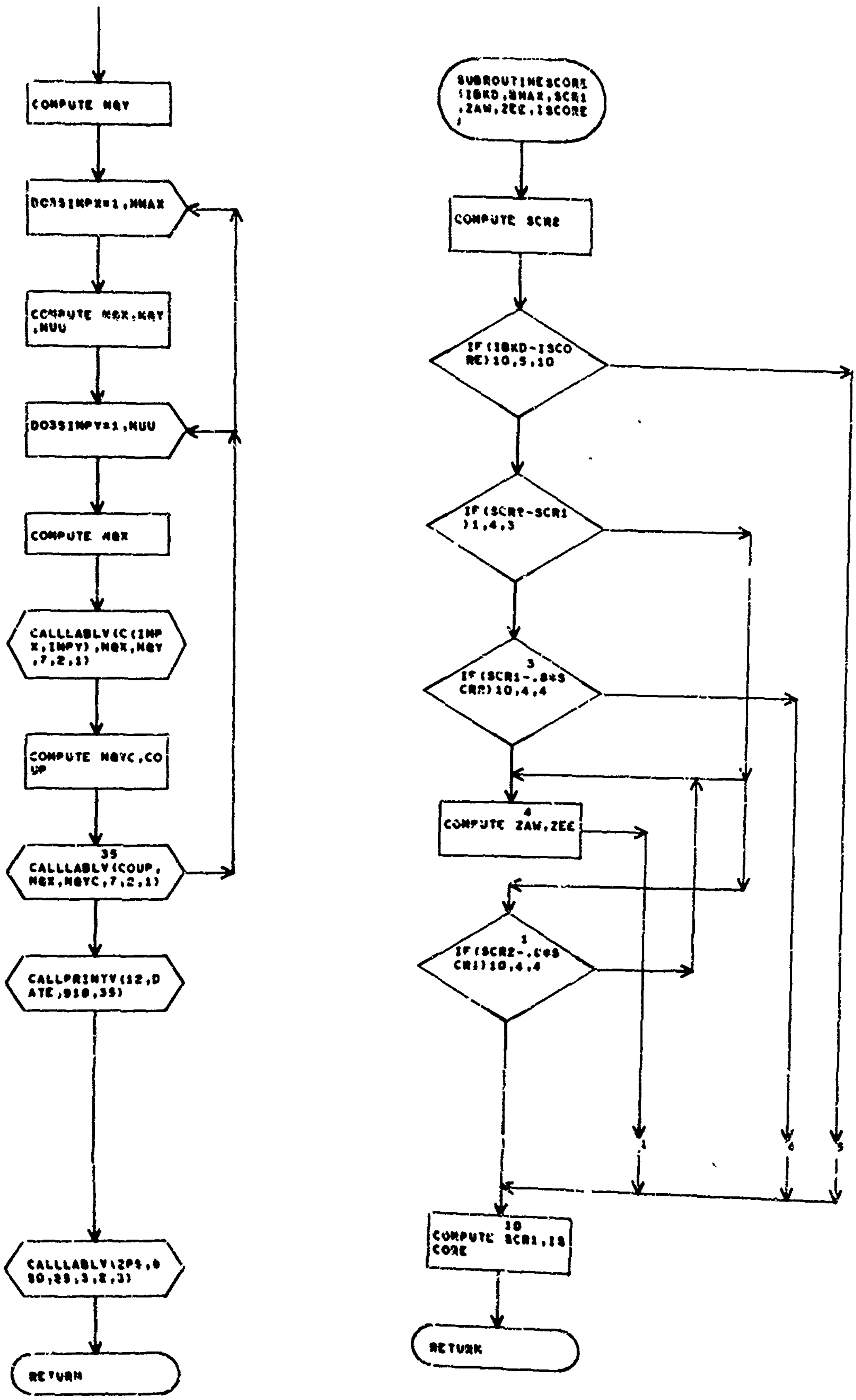

DO10IM=1,MM,2
10
COMPUTE YC
IF(-1.0**MM)12,12,13
12
COMPUTE YO
13
COMPUTE YIK(MM)
14
COMPUTE YE
DO16IM=2,MM,2
16
COMPUTE YE
COMPUTE BI(KIK)
3
4
WRITE(6,1)KIK,BI(KIK)
COMPUTE MM
25
COMPUTE IX
IF(KIK-NI)2,27,27
27
RETURN

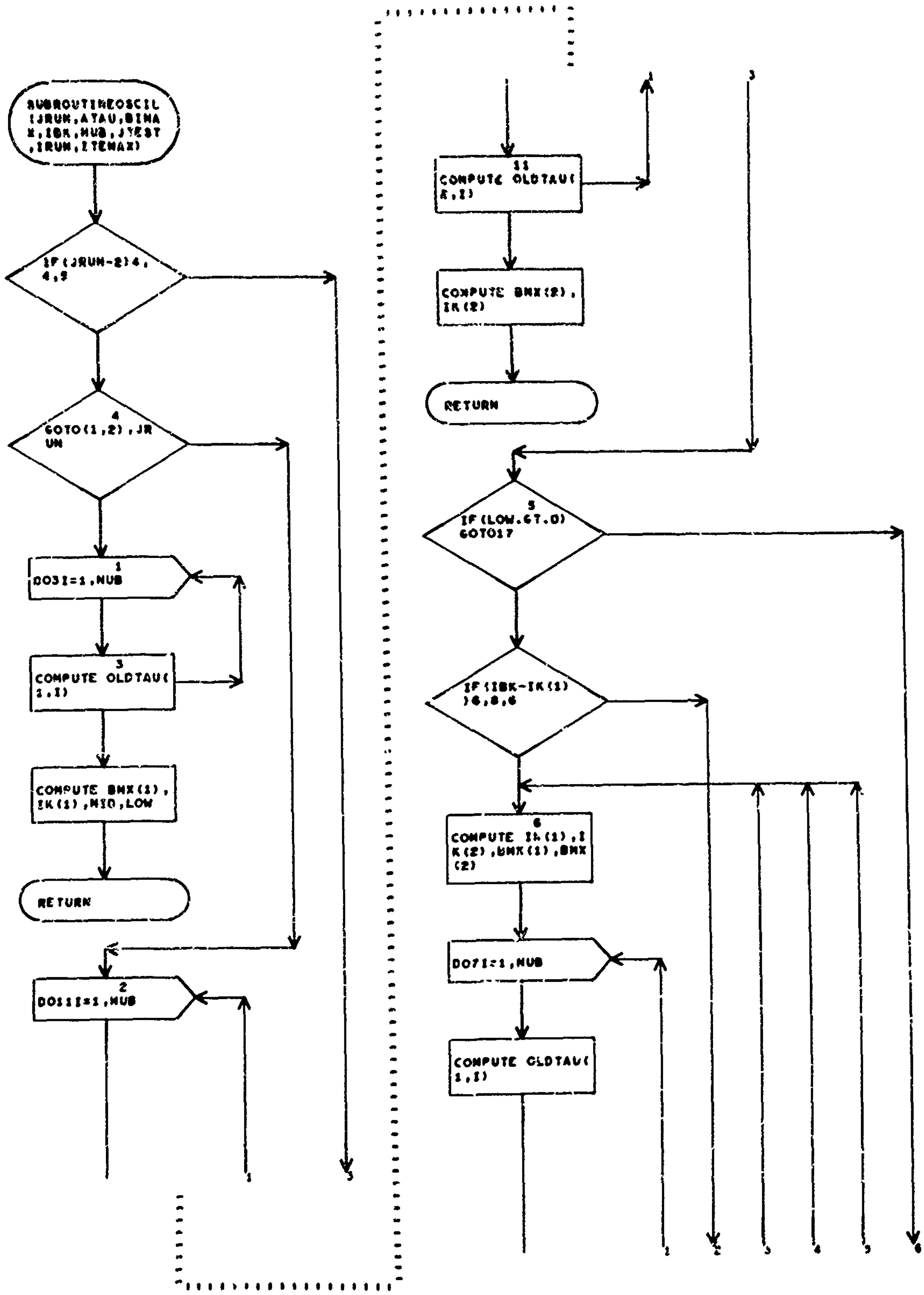

SUBROUTINEPLOT(TD,ALPHA,JSTOP,VAL,KIX,PEAK,MIX,C,NU,NMAX,K,B
COMPUTE U2,XH,XL,RO,YT,YB,IST
DO1I=2,JSTOP
IF(TD(1)-TD(I))9,9,1
9 COMPUTE IST
1 CONTINUE
2 COMPUTE MN,NN
IF(K)101,101,100
1
100 COMPUTE CA(1),U2
101 COMPUTE CA(1)
103 DO8I=IST,JSTOP
IF(K)105,105,107
107 COMPUTE CA(I)
105 COMPUTE CA(I)
109 DO7J=1,KIX
IF(ALPHA(I)-VAL(J))7,6,7
1
2
3

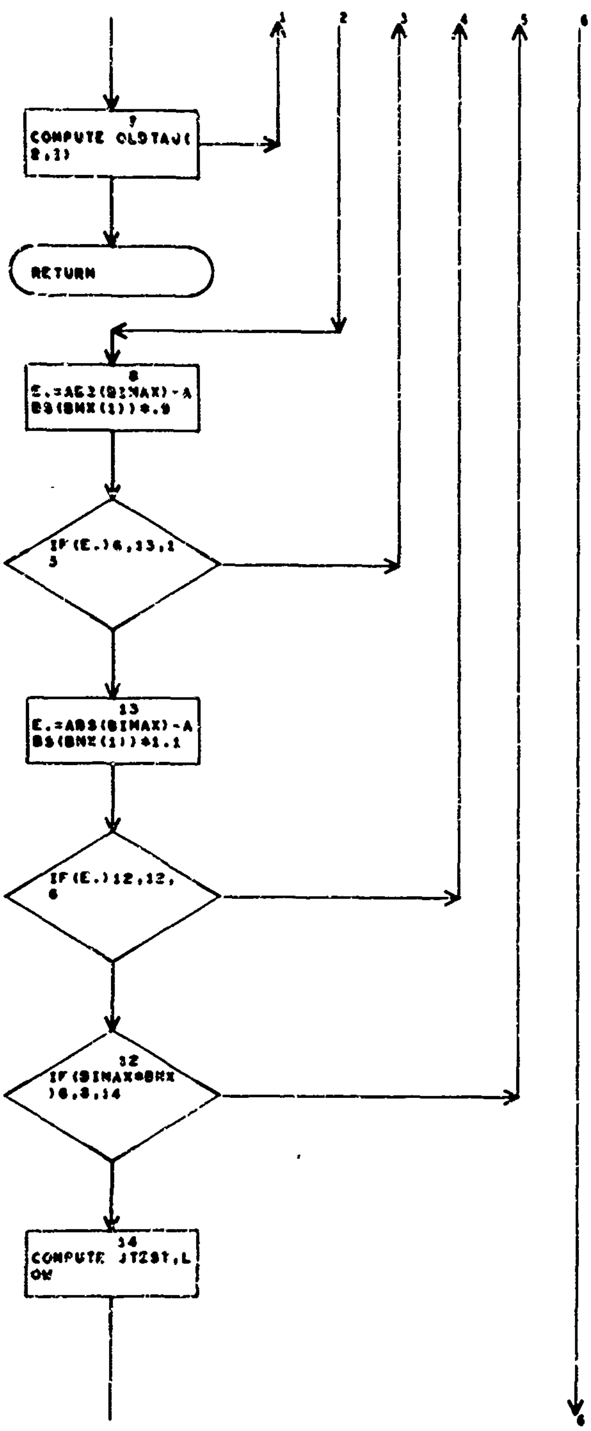

6
COMPUTE NN,JV(N
N)
7
CONTINUE
5
DO4 J=1,NIX
IF(ALPHA(I)-
PEAK(J))4,3,
4
3
COMPUTE NN,JP(N
N)
4
CONTINUE
8
CONTINUE
IF(K)200,200
,201
201
COMPUTE YT,YB
203
COMPUTE YB
CALLCAMRAV(2)
CALLRITSTV(18,2
6,TAB(1V)
CALLSETMIV(60,3
0,340,50)
CALLDXDYV(1,XL,
XR,DX,N,I,NX,8.
0,IR)
CALLDXDYV(2,YB,
YT,DY,N,J,NY,8.
0,IR)
COMPUTE YB,YT
CALLGRID1V(1,XL
,XR,YB,YT,DX,DY
,N,N,I,J,NX,NY)
DO89IO=1,2

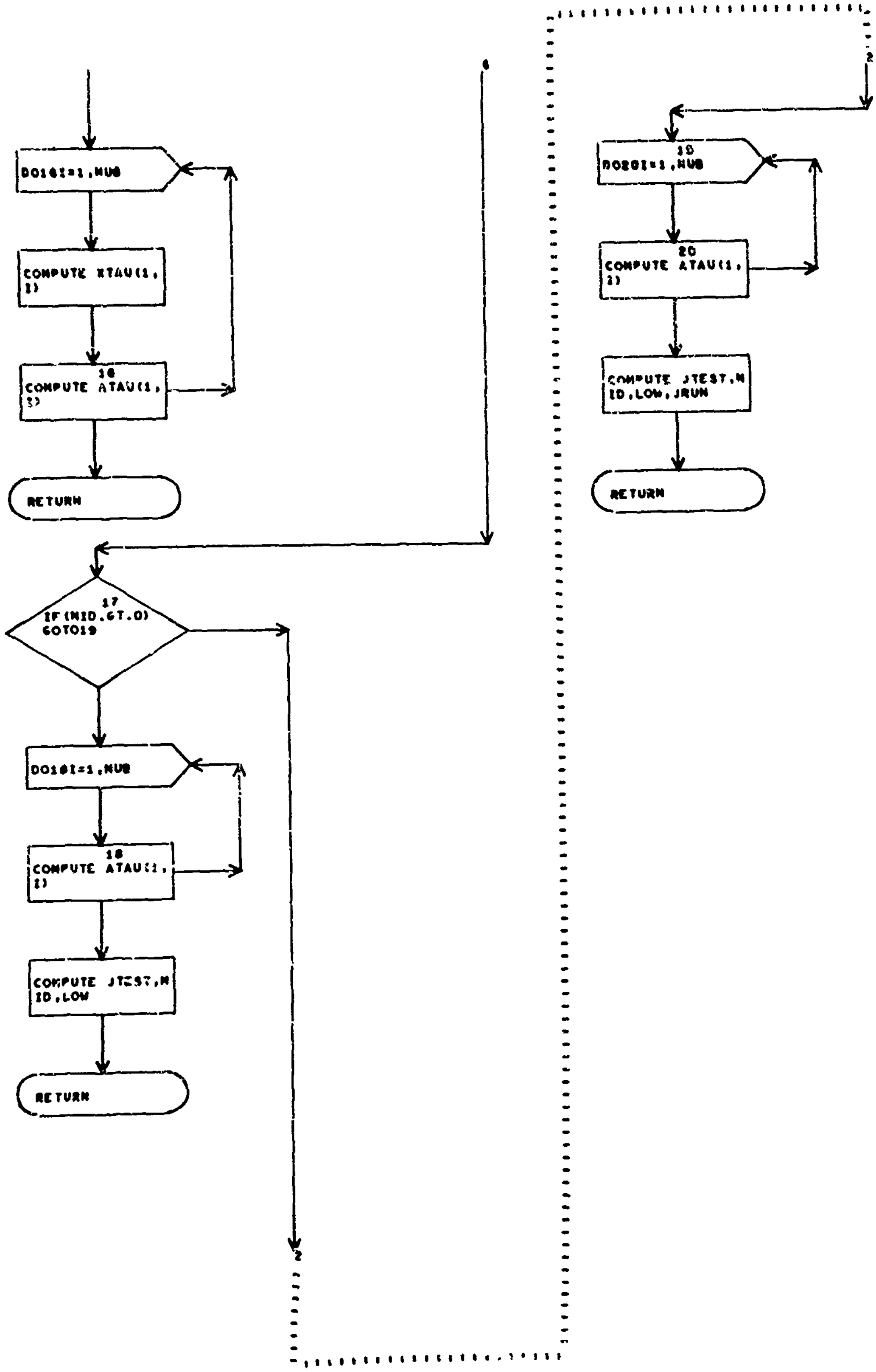

COMPUTE NXO,NYO ,IS
DO11I=IS,JSTOP
COMPUTE NX,NY
CALLLINEV(NXO,N YO,NX,NY)
COMPUTE NXO,NYO
11 CONTINUE
69 CONTINUE
CALLLINEV(NXO,N YO,NX,NY)
CALLLINEV(NXO,N YO,NX,NY)
COMPUTE NN,JV(N N)
DO25I=1,NN
COMPUTE N,NX,NY
25 CALLLABLV(CA(N) ,NX,NY,7,2,3)
DO26I=1,NN
COMPUTE N,NX,NY
26 CALLLABLV(CA(N) ,NX,NY,7,2,3)


IF(K)30,30,3
1
30
CALLAPRNTV(0,-1
4,34,34HDIFFERE
NTIALPHASESHIFT
DEGREES,30,860)
CALLVLCSTV(240,
280)
WRITE(18,48)
BW
31
CALLVLCSTV(287,
280)
WRITE(18,49)
BW
CALLAPRNTV(0,-1
4,13,13HCOUPLIN
GDB,30,730)
32
CALLPRINTV(15,1
5HTHETA(DEGREES
),402,320)

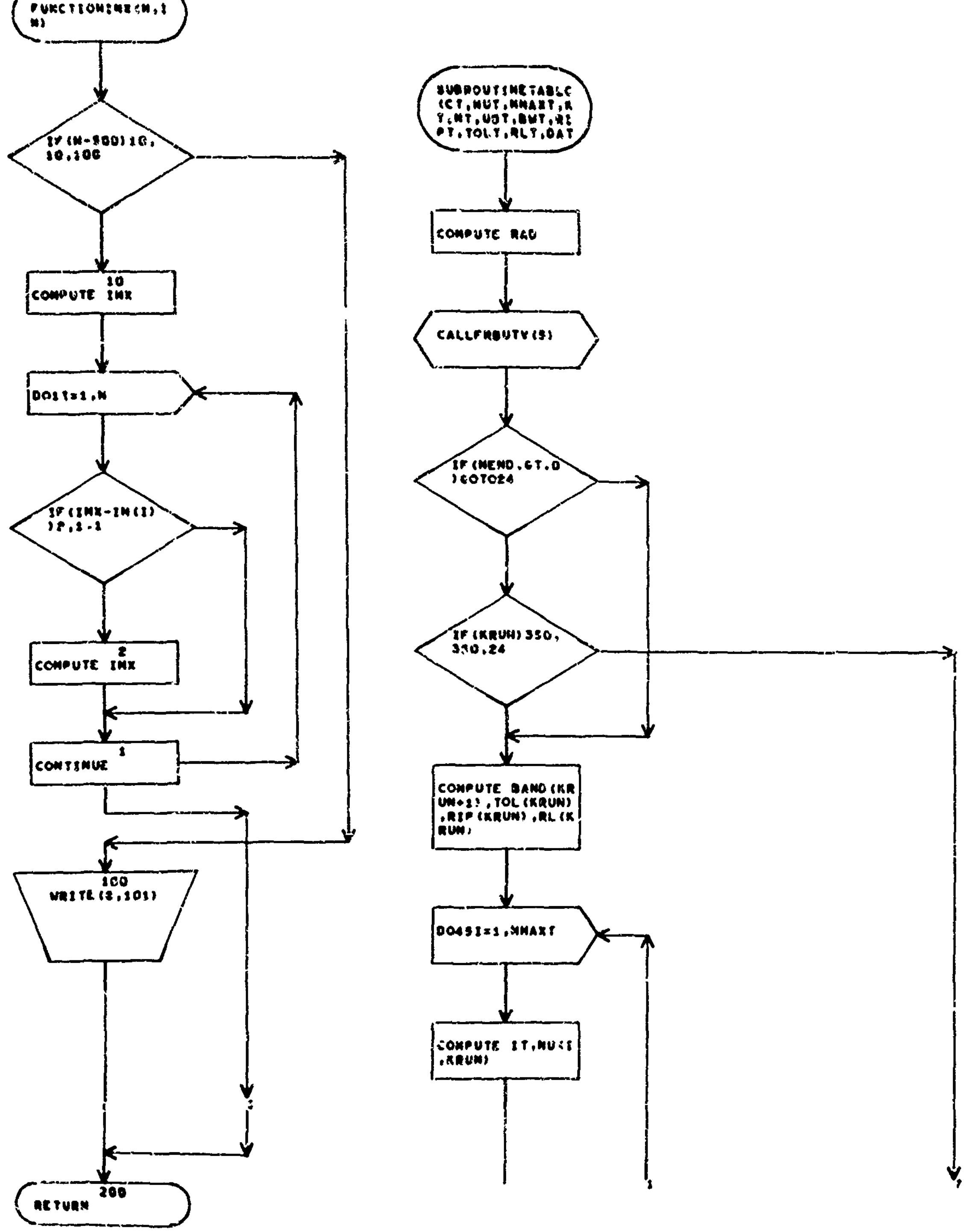

COMPUTE NQY
DO35INPX=1,NMAX
COMPUTE NQX,KQY ,NUU
DO35INPY=1,NUU
COMPUTE NQX
CALLLABLV(C(INPX,INPY),NQX,NQY,7,2,1)
COMPUTE NQYC,COUP
35 CALLLABLV(COUP,NQX,NQYC,7,2,1)
CALLPRINTV(12,DATE,910,35)
CALLLABLV(ZPS,880,35,3,2,3)
RETURN
SUBROUTINESCORE(IBKD,BMAX,SCR1,ZAW,ZEE,ISCORE)
COMPUTE SCR2
IF(IBKD-ISCORE)10,5,10
IF(SCR2-SCR1)1,4,3
3 IF(SCR1-.8*SCR2)10,4,4
4 COMPUTE ZAW,ZEE
1 IF(SCR2-.C*SCR1)10,4,4
10 COMPUTE SCR1,ISCORE
RETURN

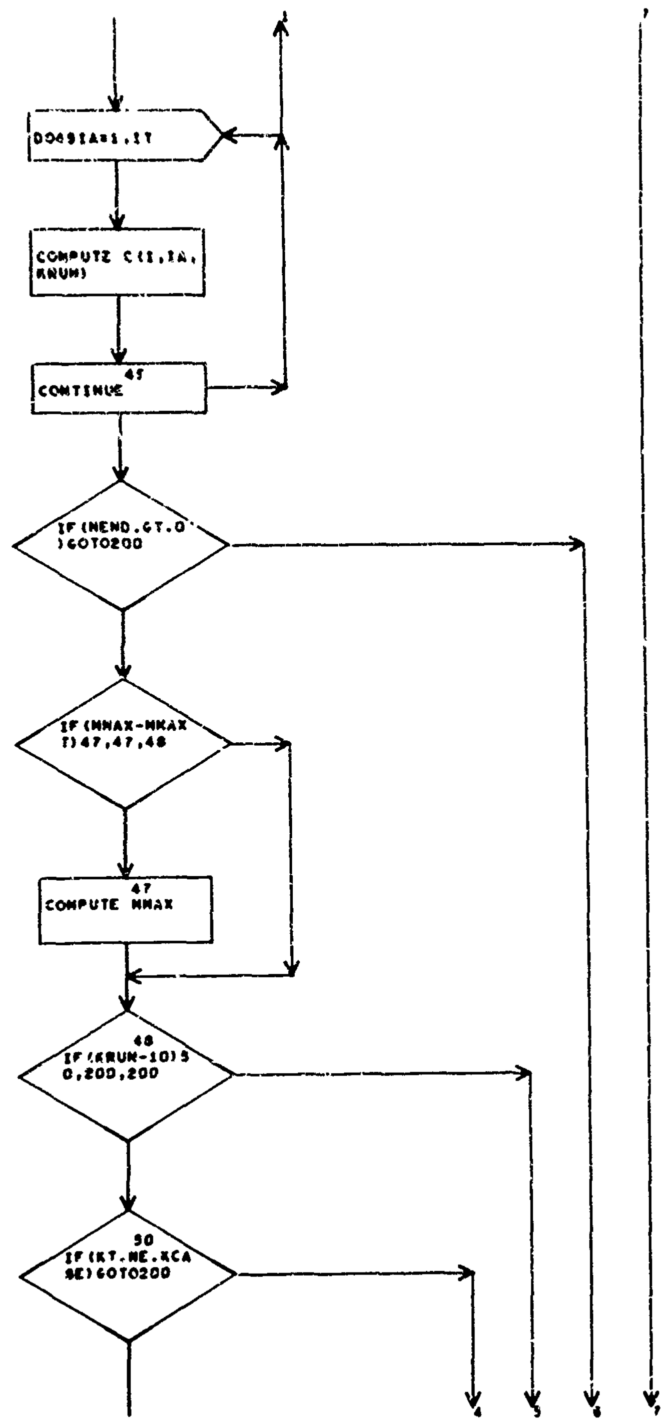

SUBROUTINEOSCIL (JRUN,ATAU,BINAX,IBK,NUB,JTEST,IRUN,ITEMAX)
IF(JRUN-2)4,4,5
4
GOTO(1,2),JRUN
1
DO3I=1,NUB
3
COMPUTE OLDTAU(1,I)
COMPUTE BNX(1),IK(1),MID,LOW
RETURN
2
DO11I=1,NUB
11
COMPUTE OLDTAU(2,I)
COMPUTE BNX(2),IK(2)
RETURN
5
IF(LOW.GT.0) GOTO17
IF(IBK-IK(1))6,8,6
6
COMPUTE IK(1),IK(2),BNX(1),BNX(2)
DO7I=1,NUB
COMPUTE OLDTAU(1,I)


1
2
3
4
5
6
9
COMPUTE OLDTAU(
2,1)
RETURN
8
E.=ABS(BIMAX)-A
BS(BNX(1))*.9
IF(E.)6,13,1
5
13
E.=ABS(BIMAX)-A
BS(BNX(1))*1.1
IF(E.)12,12,
6
12
IF(BIMAX*BNX
)6,3,14
14
COMPUTE JTZST,L
OW
6

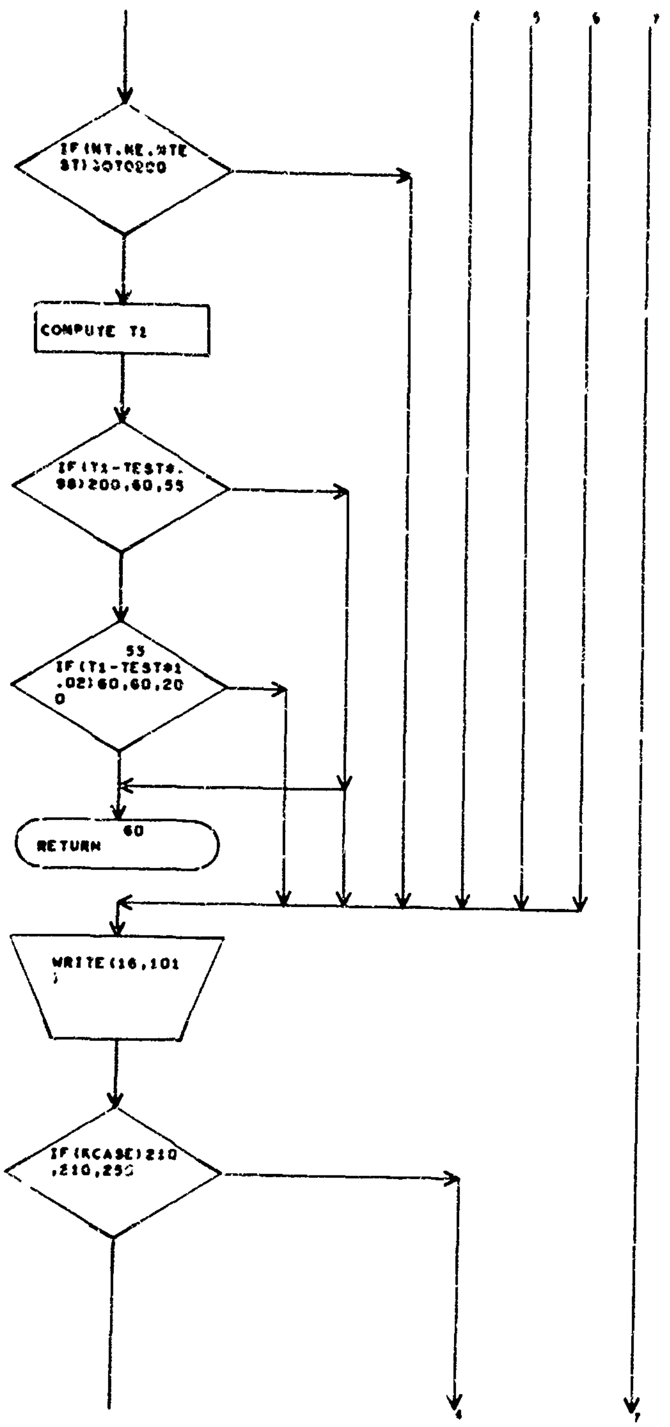

DO16I=1,NUB
COMPUTE XTAU(I,J)
16
COMPUTE ATAU(I,J)
RETURN
17
IF(NID.GT.0)
GOTO19
DO18I=1,NUB
18
COMPUTE ATAU(I,J)
COMPUTE JTEST,MID,LOW
RETURN
19
DO20I=1,NUB
20
COMPUTE ATAU(I,J)
COMPUTE JTEST,MID,LOW,JRUN
RETURN

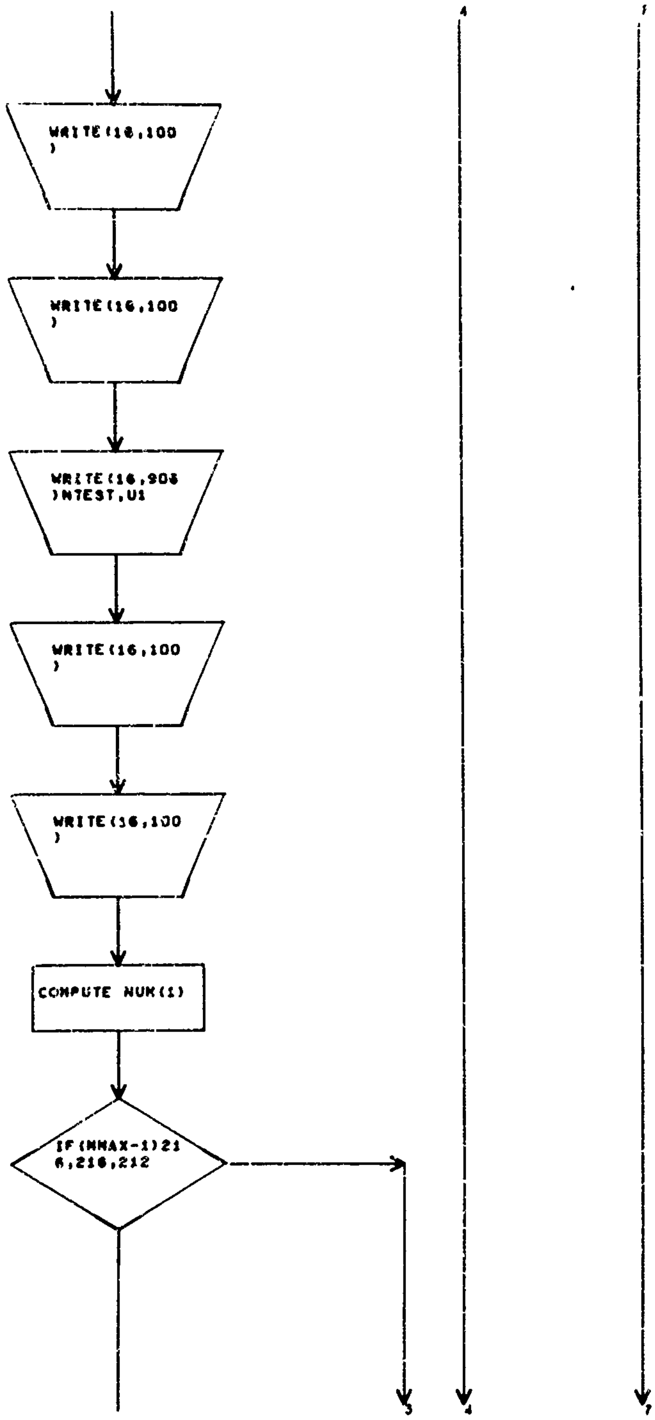
1-100560

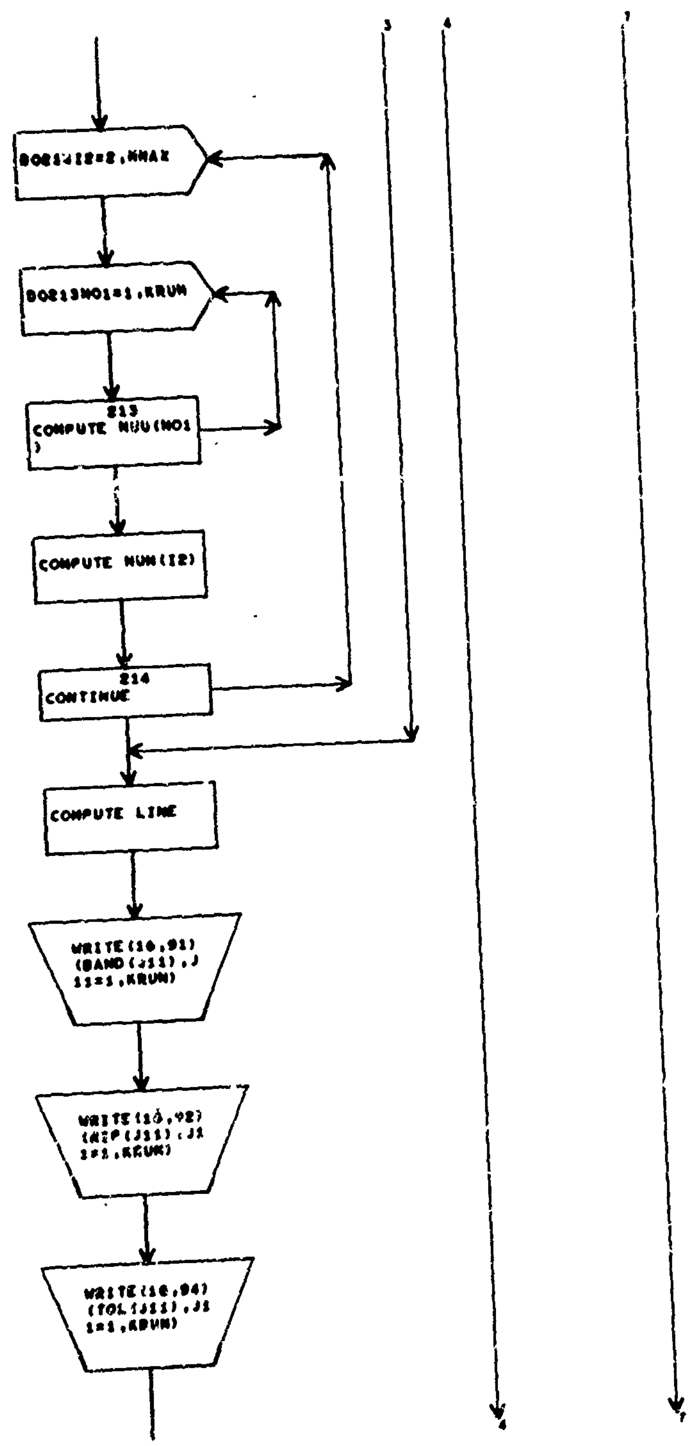

FUNCTIONINX(N,I
N)
IF(N-500)10,
10,100
10
COMPUTE INX
DO1I=1,N
IF(INX-IN(I)
)2,1,1
2
COMPUTE INX
1
CONTINUE
100
WRITE(3,101)
200
RETURN
SUBROUTINETABLC
(CT,NUT,MMAXT,K
T,NT,UDT,BWT,RI
PT,TOLT,RLT,DAT
COMPUTE RAD
CALLFRBUTY(5)
IF(NEND.GT.0
)GOTO24
IF(KRUN)350,
350,24
COMPUTE BAND(KR
UN+1),TOL(KRUN)
,RIP(KRUN),RL(K
RUN)
DO45I=1,MMAXT
COMPUTE IT,NU(I
,KRUN)

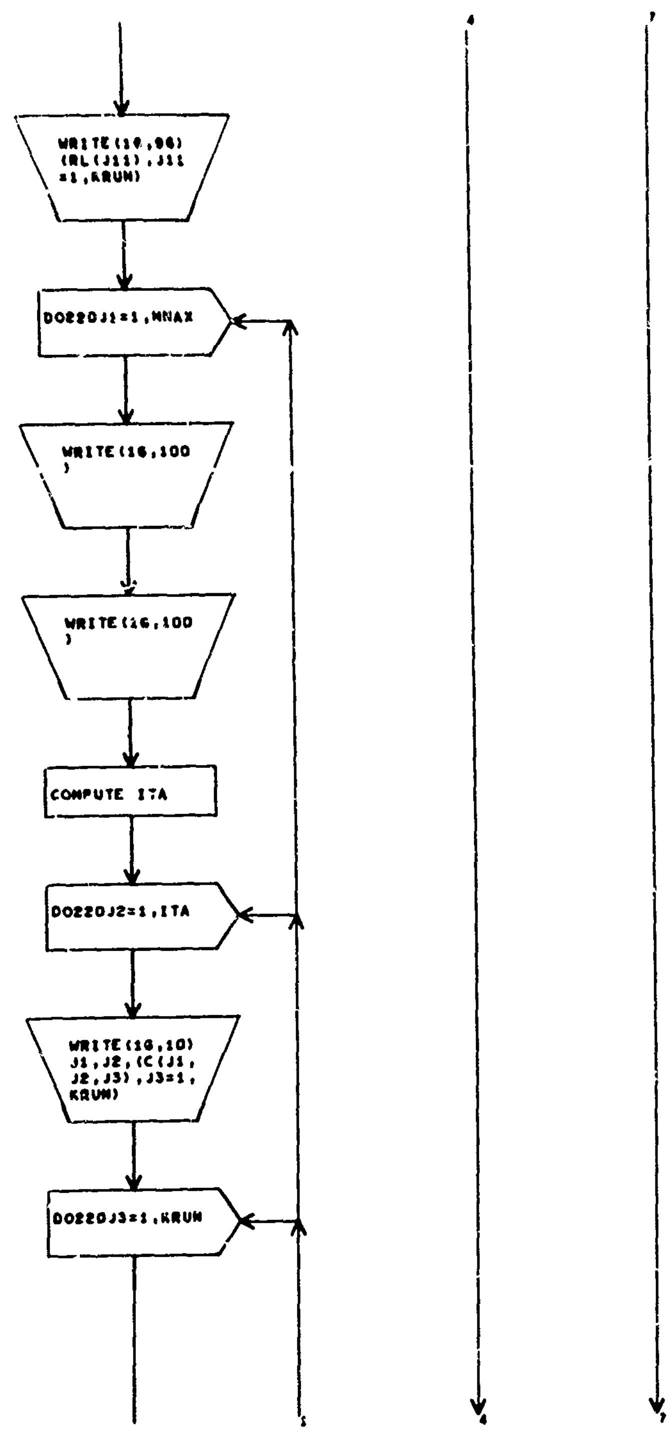


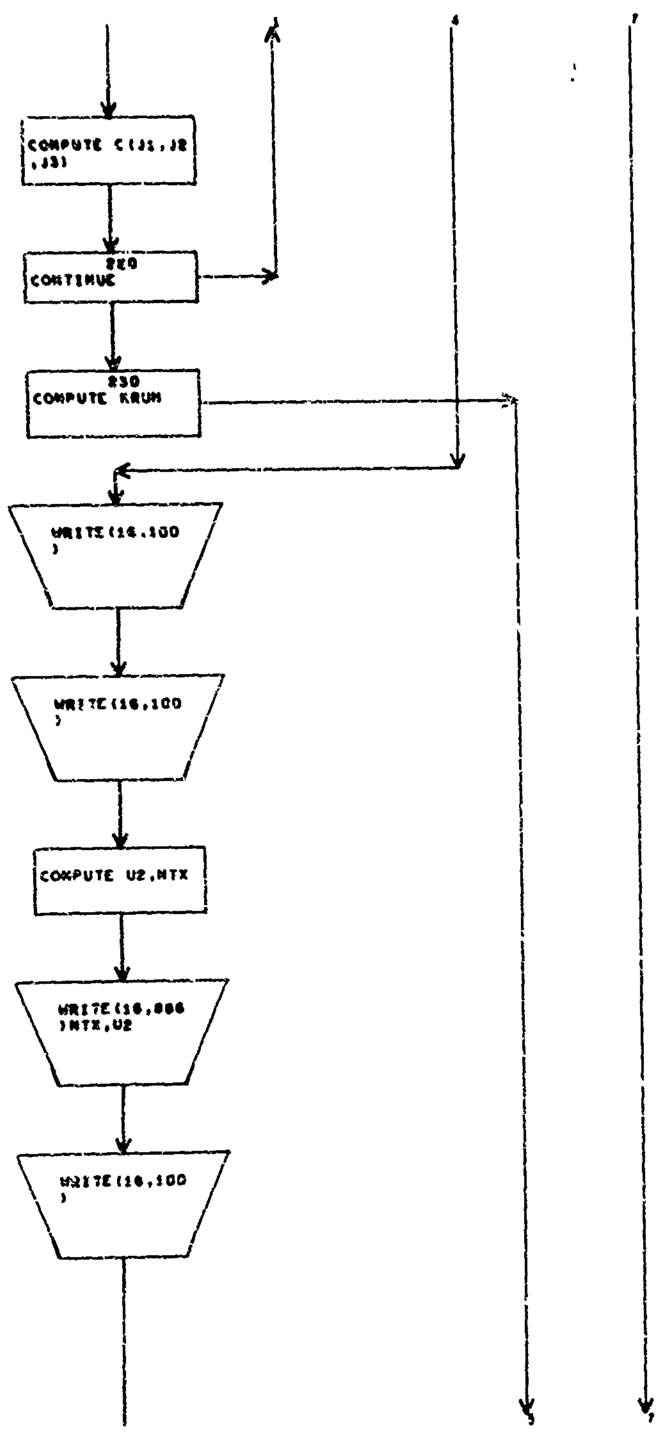
DO49IA=1,IT
COMPUTE C(I,IA,KRUN)
45
CONTINUE
IF(NEND.GT.0)GOTO200
IF(MMAX-MMAXT)47,47,48
47
COMPUTE MMAX
48
IF(KRUN-10)50,200,200
50
IF(KT.NE.KCASE)GOTO200

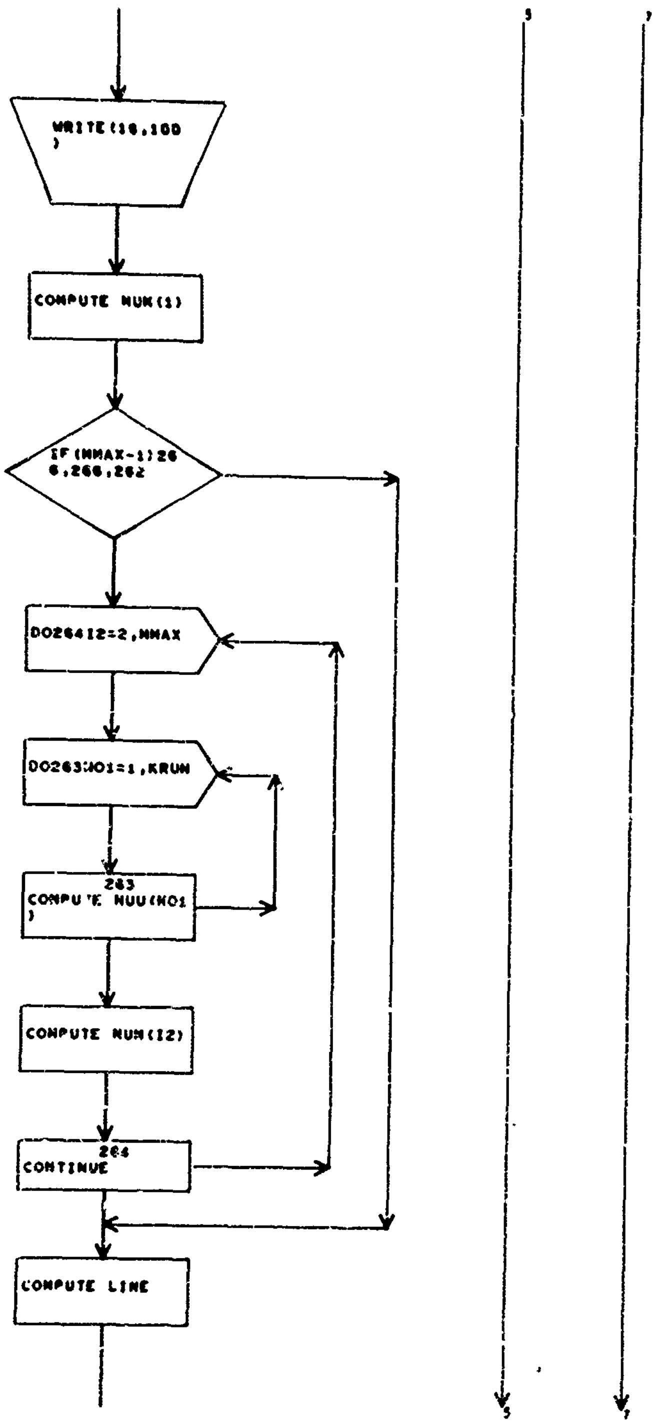

IF(INT.NE.NTE
ST)GOTO200
COMPUTE T1
IF(T1-TEST*.
98)200,60,55
55
IF(T1-TEST*1
.02)60,60,20
0
60
RETURN
WRITE(16,101
)
IF(KCASE)210
,210,250

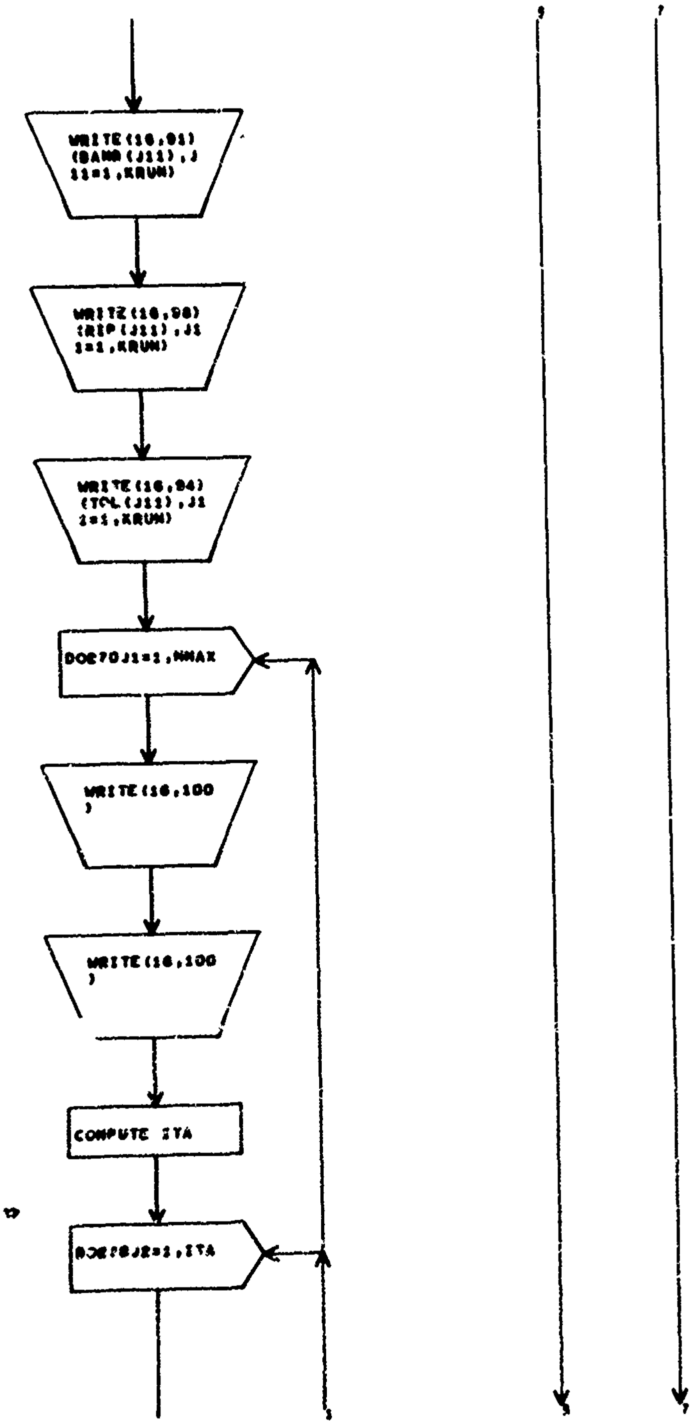

WRITE(16,100
)
WRITE(16,100
)
WRITE(16,906
)NTEST,U1
WRITE(16,100
)
WRITE(16,100
)
COMPUTE NUM(1)
IF(NMAX-1)21
6,216,212
5
4
7

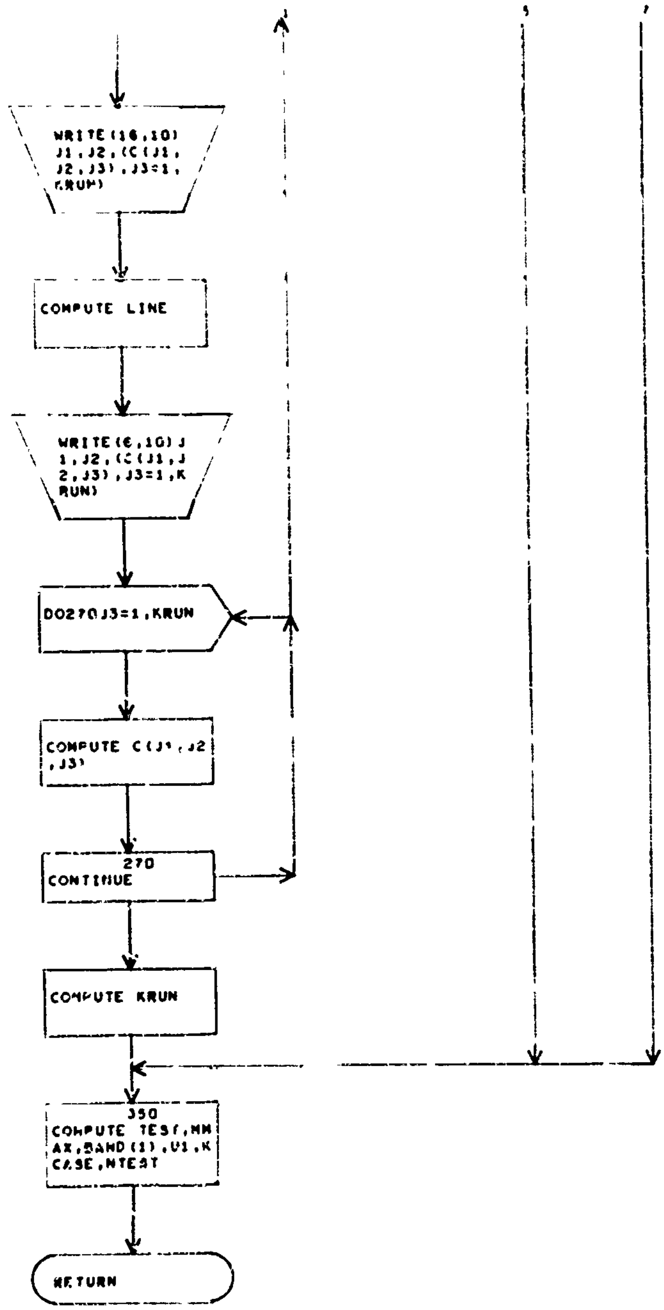

3
4
7
DO214I2=2,NMAX
DO213NO1=1,KRUN
213
COMPUTE NUU(NO1
)
COMPUTE NUM(I2)
214
CONTINUE
COMPUTE LINE
WRITE(16,91)
(BAND(J11),J
11=1,KRUN)
WRITE(16,92)
(NIP(J11),J1
1=1,KRUN)
WRITE(16,94)
(TOL(J11),J1
1=1,KRUN)
4
7


WRITE(16,96) (RL(J11),J11 =1,KRUN)
DO220J1=1,MMAX
WRITE(16,100)
WRITE(16,100)
COMPUTE ITA
DO220J2=1,ITA
WRITE(16,10) J1,J2,(C(J1, J2,J3),J3=1, KRUN)
DO220J3=1,KRUN


COMPUTE C(J1,J2
,J3)
220
CONTINUE
230
COMPUTE KRUM
WRITE(16,100
)
WRITE(16,100
)
COMPUTE U2,NTX
WRITE(16,886
)NTX,U2
WRITE(16,100
)


WRITE(16,100
)
COMPUTE NUM(1)
IF(NMAX-1)26
6,266,262
DO264I2=2,NMAX
DO263NO1=1,KRUN
263
COMPUTE NUU(NO1
)
COMPUTE NUM(I2)
264
CONTINUE
COMPUTE LINE


WRITE(16,100
)
WRITE(16,100
)
COMPUTE ITA


WRITE(16,10) J1,J2,(C(J1, J2,J3),J3=1, KRUN)
COMPUTE LINE
WRITE(6,10)J 1,J2,(C(J1,J 2,J3),J3=1,K RUN)
DO270J3=1,KRUN
COMPUTE C(J1,J2 ,J3)
270 CONTINUE
COMPUTE KRUN
350 COMPUTE TEST,MM AX,BAND(1),U1,K CASE,NTEST
RETURN

Section 4. SAMPLE APPLICATIONS

Example A
Type 1 Data

If it is desired to design a 17:1 bandwidth, -3 db-coupler, which has a normalized Zoe ± 1.8343 limitation on it, one needs the Chebyshev antenna distributions for 15 elements at 19.6 db side lobes:

1.0, 0.962, 0.890, 0.789, 0.663, 0.536, 0.837

Assuming that three iterations are allowed (1% tolerance (.01) is desired) and that neither development (IDEV=0) nor printed performance (XPRINT=0) data are required, then the punched input data cards are as shown in Fig. 1. The total output data is shown in Fig. 2, 3, and 4.

The computer execution time was 5.93 seconds.

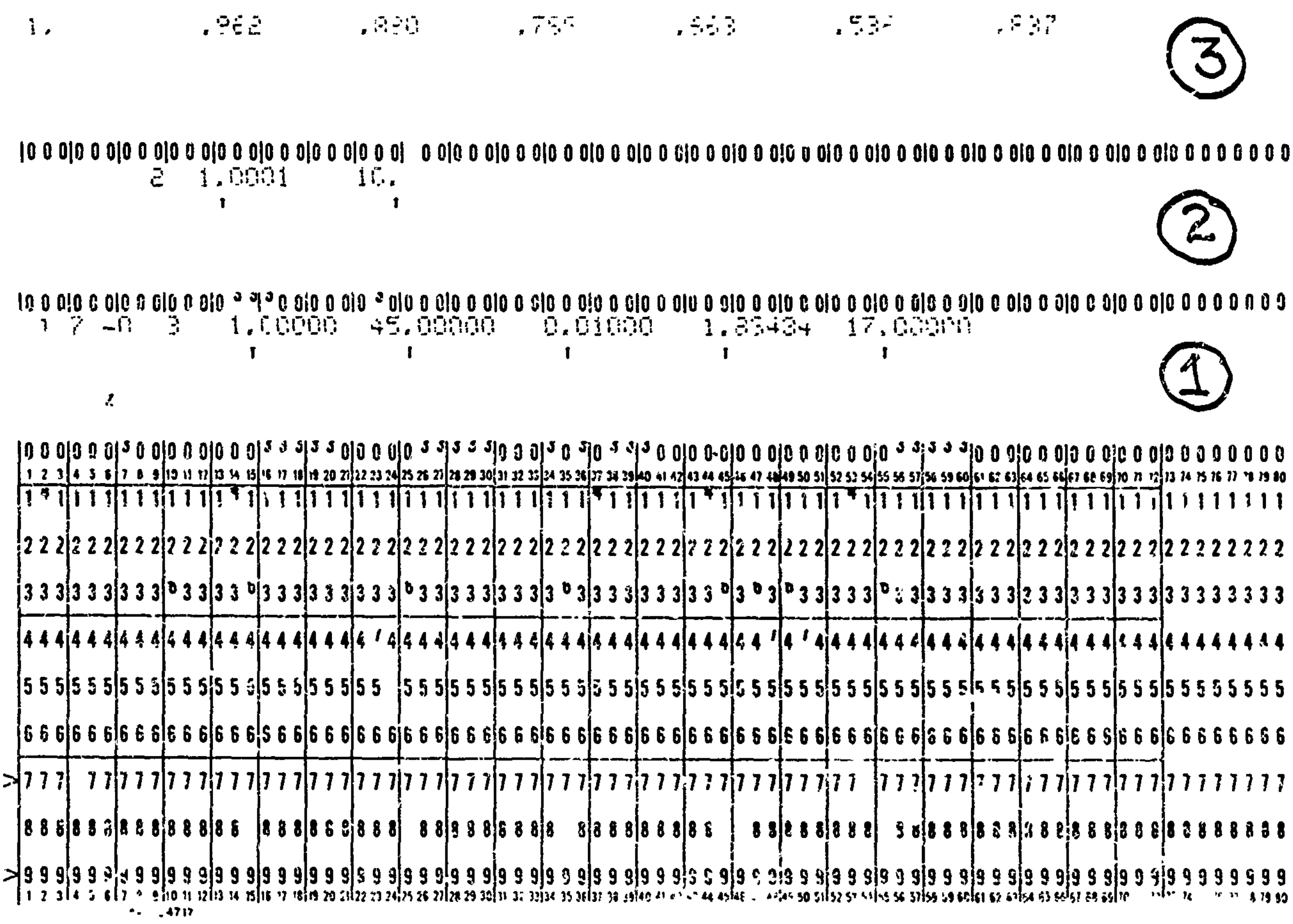


FIG. 1. Input Data Cards.[2]

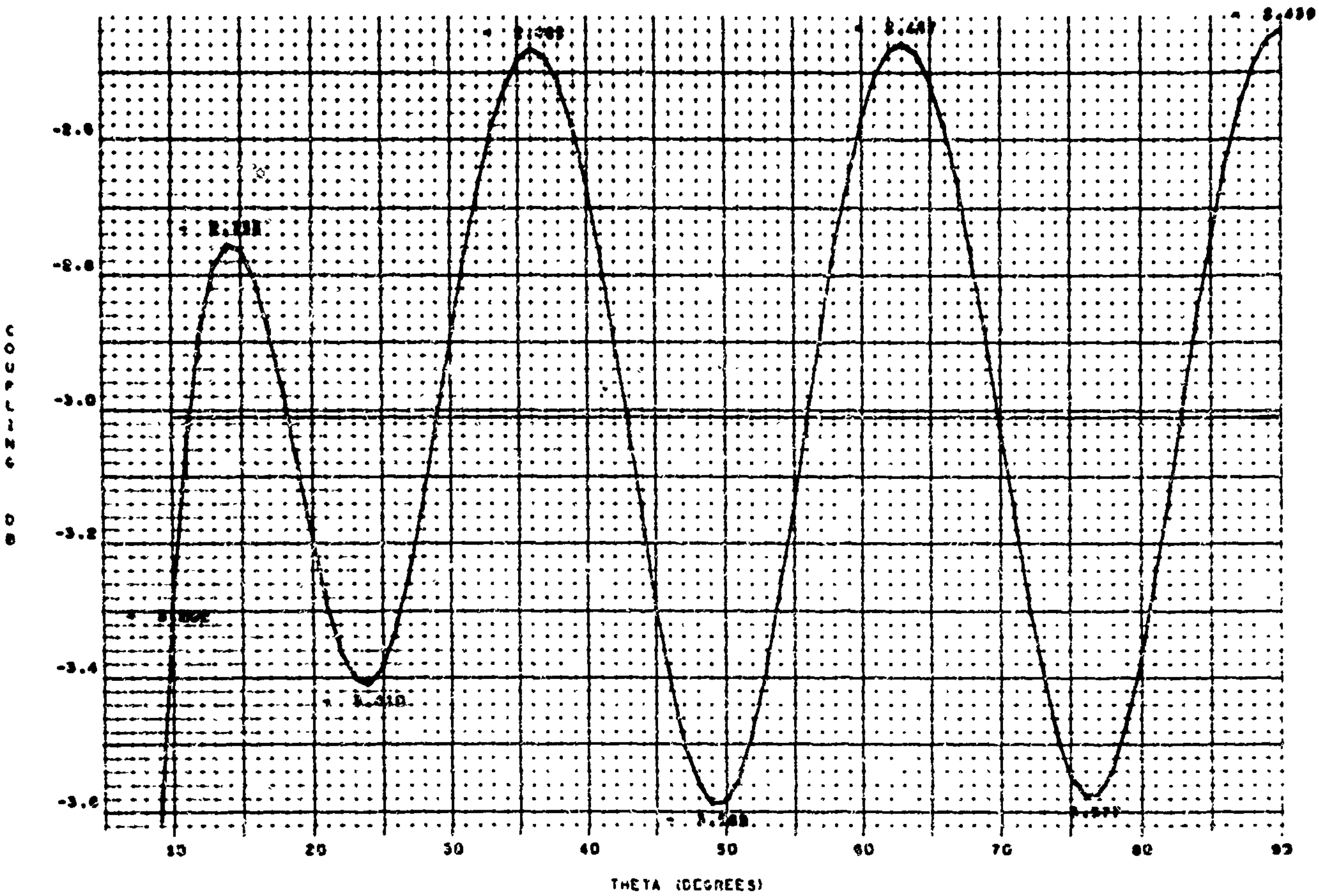
[2]Assuming this to be the first design problem for the machine, then these input data would be preceded by five cards:

1) Instable B's
2) Failed
3)
4) Theta (degrees)
5) Coupling (db)

with the reference

12345 ------ 0 5 0 5 0

Note - Card 3 was left blank since the plots (see Fig. 6, 7, and 8) were not desired to be titled on the top.



17.000 TO 1.0 BANDWIDTH COUPLER

1.03434	1.03434	1.04797	1.38001	1.23440	1.14520	1.08948
0.54178	0.54178	0.46175	0.31139	0.20752	0.13475	0.08549
1.03434	1.22380					
0.54178	0.19026					
1.03434						
0.54178						
1.01247						
0.01239						

FIG. 2. Response Curve and Design of Coupler.

```
EXIT 1  IMPEDANCES ARE LESS THAN 1.0
EXIT 2  TOO MANY PEAKS/VALLEYS IN RESPONSE CURVE
EXIT 3  TOO FEW PEAKS/VALLEYS FOR ERROR ANALYSIS
EXIT 4  DESIGN OF PHASE SHIFTER NOW COMPLETED
EXIT 5  DESIGN OF COUPLER NOW COMPLETED
EXIT 6  DESIGN OF COUPLER USED MAX. ALLOWABLE ITERATIONS
EXIT 7  DESIGN OF PHASE SHIFTER USED MAX. ALLOW. ITERATIONS
EXIT 8  A PEAK AND VALLEY ARE BEYOND BANDWIDTH EDGE

UO = 45.0000   BW =17.000   ZMAX = 1.83434   TOLERANCE= 0.01000   THE MAX. ALLOWABLE ITERATION(S) ARE =  3
   GAMMA(1, 1 ) =  0.43412  }
   GAMMA(1, 2 ) =  0.20881  }
   GAMMA(1, 3 ) =  0.12879  }  Γ's before maximum coupling restriction (Z max) is considered.
   GAMMA(1, 4 ) =  0.08563  }
   GAMMA(1, 5 ) =  0.05756  }
   GAMMA(1, 6 ) =  0.03878  }
   GAMMA(1, 7 ) =  0.05191
Z( 1, 1 )= 1.83434   GAMMA ( 1, 1 )=.        COUPLING = 0.54179  }
Z( 1, 2 )= 1.83434   GAMMA ( 1, 2 )=.        COUPLING = 0.54179  }
Z( 1, 3 )= 1.83434   GAMMA ( 1, 3 )=.06901   COUPLING = 0.54179  }
Z( 1, 4 )= 1.59751   GAMMA ( 1, 4 )=.08563   COUPLING = 0.43695  }  This section shows
Z( 1, 5 )= 1.34550   GAMMA ( 1, 5 )=.05756   COUPLING = 0.28835  }   1. Zoe's per tandem device
Z( 1, 6 )= 1.19903   GAMMA ( 1, 6 )=.03878   COUPLING = 0.17954  }   2. Γ's per tandem device
Z( 1, 7 )= 1.10950   GAMMA ( 1, 7 )=.05191   COUPLING = 0.10354  }   3. Voltage-coupling coeff.
Z( 2, 1 )= 1.83434   GAMMA ( 2, 1 )=.03155   COUPLING = 0.54179  }      per section per tandem
Z( 2, 2 )= 1.72213   GAMMA ( 2, 2 )=.20881   COUPLING = 0.49568  }      coupler/phase shifter
Z( 2, 3 )= 1.12716   GAMMA ( 2, 3 )=.05978   COUPLING = 0.11914  }
Z( 3, 1 )= 1.83434   GAMMA ( 3, 1 )=.29437   COUPLING = 0.54179  }
Z( 4, 1 )= 1.24266   GAMMA ( 4, 1 )=.10820   COUPLING = 0.21390  }
                                       ---> Typically,
                                            First subscript for which tandem coupler
                                            phase shifter
                                            Second subscript for which section in
                                            that tandem coupler/phase shifter
VAL( 1)=   56.15720 <---> Response at lower band edge
VAL( 2)=   44.44338 }
VAL( 3)=   35.74314 }  Relative minima in response curve (in degrees for
VAL( 4)=   30.03631 }  phase shifters; in "degree" coupling for couplers)
PEAK( 1) =   59.48249 }
PEAK( 2) =   47.91320 }  Relative maxima in response curve
PEAK( 3) =   40.65606 }
PEAK( 4) =   37.66095 }
  1.39781 }  1.28228 }
  1.71514 }  1.28228 }
  0.08521 }  1.28228 }
  0.41990 }  1.28228 }  Average ripple in response curve
  1.65918 }  1.28228 }
  0.71119 }  1.28228 }  The amount that the response curve should be shifted at
  3.00077 }  1.28228 }  proper θ's so that relative maximum and minimum response
  1.26905 }  1.28228 }  values become "equal ripple".
B( 1 )= 8.56393  }
B( 3 )=-6.03899  }
B( 5 )=-4.09009  }
B( 7 )=-2.82457  }  Fourier coefficients of error curve.  Note that also higher than the last usable harmonic is
B( 9 )=-2.32504  }  calculated (for special reference).
B(11 )=-1.51086  }
B(13 )= 1.08131  }
B(15 )=-2.98318  }
0 1
0 0
   CAUTIOUS ERROR CORRECTION ( 0.500X)   {Error correction in this case (.500X) operates only with 50% of what B's, above,
                                         {suggested.
   GAMMA(1, 1 ) =  0.47149
   GAMMA(1, 2 ) =  0.18246
   GAMMA(1, 3 ) =  0.11094
   GAMMA(1, 4 ) =  0.07331
   GAMMA(1, 5 ) =  0.04742
   GAMMA(1, 6 ) =  0.03219
   GAMMA(1, 7 ) =  0.05663
```

FIG. 3. "Written" Machine Output.

```
Z( 1, 1 )= 1.83434        GAMMA ( 1, 1 )=.          COUPLING = 0.54179
Z( 1, 2 )= 1.83434        GAMMA ( 1, 2 )=.          COUPLING = 0.54179
Z( 1, 3 )= 1.83434        GAMMA ( 1, 3 )=.09329     COUPLING = 0.54179
Z( 1, 4 )= 1.52129        GAMMA ( 1, 4 )=.07331     COUPLING = 0.39656
Z( 1, 5 )= 1.31349        GAMMA ( 1, 5 )=.04742     COUPLING = 0.26612
Z( 1, 6 )= 1.19456        GAMMA ( 1, 6 )=.03219     COUPLING = 0.17593
Z( 1, 7 )= 1.12005        GAMMA ( 1, 7 )=.05663     COUPLING = 0.11289
Z( 2, 1 )= 1.83434        GAMMA ( 2, 1 )=.10082     COUPLING = 0.54179
Z( 2, 2 )= 1.49835        GAMMA ( 2, 2 )=.18246     COUPLING = 0.38368
Z( 2, 3 )= 1.03594        GAMMA ( 2, 3 )=.01765     COUPLING = 0.03529
Z( 3, 1 )= 1.83434        GAMMA ( 3, 1 )=.29437     COUPLING = 0.54179
Z( 4, 1 )= 1.16521        GAMMA ( 4, 1 )=.07630     COUPLING = 0.15172
 VAL( 1)=    51.08599
 VAL( 2)=    43.43703
 VAL( 3)=    37.97557
 VAL( 4)=    35.22722
 PEAK( 1) =    53.99906
 PEAK( 2) =    49.13146
 PEAK( 3) =    46.52244
 PEAK( 4) =    44.51455
   0.83089   0.76460
   1.16935   0.76460
   0.24353   0.76460
   0.58318   0.76460
   1.20760   0.76460
   0.23912   0.76460
   1.76889   0.76460
   0.07422   0.76460
 B( 1 )= 3.48228
 B( 3 )=-3.10427
 B( 5 )=-2.12313
 B( 7 )=-1.69765
 B( 9 )=-1.25150
 B(11 )=-0.74873
 B(13 )=-0.67101
 B(15 )=-0.76311
 0 1
 0 0
     NORMAL ERROR CORRECTION <------> Error correction by 100% of what B's, above, suggested.
    GAMMA(1, 1 ) =  0.50188
    GAMMA(1, 2 ) =  0.15537
    GAMMA(1, 3 ) =  0.09241
    GAMMA(1, 4 ) =  0.05679
    GAMMA(1, 5 ) =  0.03650
    GAMMA(1, 6 ) =  0.02566
    GAMMA(1, 7 ) =  0.05077
Z( 1, 1 )= 1.83434        GAMMA ( 1, 1 )=.          COUPLING = 0.54179
Z( 1, 2 )= 1.83434        GAMMA ( 1, 2 )=.04080     COUPLING = 0.54179
Z( 1, 3 )= 1.69052        GAMMA ( 1, 3 )=.09241     COUPLING = 0.48158
Z( 1, 4 )= 1.40450        GAMMA ( 1, 4 )=.05679     COUPLING = 0.32719
Z( 1, 5 )= 1.25355        GAMMA ( 1, 5 )=.03650     COUPLING = 0.22221
Z( 1, 6 )= 1.16527        GAMMA ( 1, 6 )=.02566     COUPLING = 0.15177
Z( 1, 7 )= 1.10697        GAMMA ( 1, 7 )=.05077     COUPLING = 0.10128
Z( 2, 1 )= 1.83434        GAMMA ( 2, 1 )=.18607     COUPLING = 0.54179
Z( 2, 2 )= 1.25879        GAMMA ( 2, 2 )=.11457     COUPLING = 0.22617
Z( 3, 1 )= 1.83434        GAMMA ( 3, 1 )=.29437     COUPLING = 0.54179
Z( 4, 1 )= 1.04381        GAMMA ( 4, 1 )=.02144     COUPLING = 0.04285
 VAL( 1)=    44.43801
 VAL( 2)=    42.24631
 VAL( 3)=    40.21688
 VAL( 4)=    40.98947
 PEAK( 1) =    47.41599
 PEAK( 2) =    49.83838
 PEAK( 3) =    49.85015
 PEAK( 4) =    50.09895
```

FIG. 3. (Continued)

```
      0.08604    0.54705
      0.35123    0.54705
      0.43819    0.54705
      0.67476    0.54705
      0.78932    0.54705
      0.67627    0.54705
      0.65268    0.54705
      0.70794    0.54705
    B( 1 )=-0.19122
    B( 3 )=-0.13889
    B( 5 )=-0.44933
    B( 7 )=-0.12524
    B( 9 )= 0.11318
    B(11 )=-0.08311
    B(13 )=-0.91037
    B(15 )=-0.20937
    0 1
    0 0
        GØRMAL ERRØR CØRRECTIØN
         GAMMA(1, 1 ) =  0.50021
         GAMMA(1, 2 ) =  0.15416
         GAMMA(1, 3 ) =  0.08849
         GAMMA(1, 4 ) =  0.05570
         GAMMA(1, 5 ) =  0.03749
         GAMMA(1, 6 ) =  0.02493
         GAMMA(1, 7 ) =  0.04283
     Z( 1, 1 )= 1.83434         GAMMA ( 1, 1 )=.                COUPLING = 0.54179
     Z( 1, 2 )= 1.83434         GAMMA ( 1, 2 )=.05352           COUPLING = 0.54179
     Z( 1, 3 )= 1.64797         GAMMA ( 1, 3 )=.08849           COUPLING = 0.46176
     Z( 1, 4 )= 1.38001         GAMMA ( 1, 4 )=.05570           COUPLING = 0.31140
     Z( 1, 5 )= 1.23440         GAMMA ( 1, 5 )=.03749           COUPLING = 0.20752
     Z( 1, 6 )= 1.14520         GAMMA ( 1, 6 )=.02493           COUPLING = 0.13475
     Z( 1, 7 )= 1.08948         GAMMA ( 1, 7 )=.04283           COUPLING = 0.08550
     Z( 2, 1 )= 1.83434         GAMMA ( 2, 1 )=.19964           COUPLING = 0.54179
     Z( 2, 2 )= 1.22380         GAMMA ( 2, 2 )=.10064           COUPLING = 0.19926
     Z( 3, 1 )= 1.83434         GAMMA ( 3, 1 )=.29437           COUPLING = 0.54179
     Z( 4, 1 )= 1.01247         GAMMA ( 4, 1 )=.00620           COUPLING = 0.01255
     VAL( 1)=    43.25768
     VAL( 2)=    42.47450
     VAL( 3)=    41.41489
     VAL( 4)=    41.48553
     PEAK( 1) =    46.74080
     PEAK( 2) =    48.83987
     PEAK( 3) =    48.90138
     PEAK( 4) =    49.04991
        0.27233    0.46793
        0.25604    0.46793
        0.40025    0.46793
        0.54474    0.46793
        0.57901    0.46793
        0.55288    0.46793
        0.56685    0.46793
        0.57128    0.46793
       THE DESIGN DØES NØT MEET THE SPECIFICATIØNS -- FAIL
                                            EXIT BY 6
```

FIG. 3. End.

```
 1 7 -0  3   1.00000  45.00000   0.01000   1.83434  17.00000
    0.50021   0.15416   0.08849   0.05570   0.03749   0.02493   0.04283
       FOR REFERENCE
  123456789012345    0    5    0    5    0    5    0    5    0    5    012
```

FIG. 4. Punched Output Data.

Example B
Type 2 Data

To improve further on a coupler design, one on which data are available but in terms of reflection coefficients (such data are part of the output from previous calculations; e.g., Fig. 4), assume that the data are as in Fig. 5 below:

$\Gamma_1 = 0.4989$, $\Gamma_2 = 0.1536$, $\Gamma_3 = 0.0881$, $\Gamma_4 = 0.0575$,

$\Gamma_5 = 0.0403$, $\Gamma_6 = 0.0277$, $\Gamma_7 = 0.0303$,

with six allowable iterations, required development data, and 1% tolerance, the input data will then be as shown in Fig. 6.

The output data for this computation are shown in Fig. 7–11.

The computer execution time was 6.30 seconds.

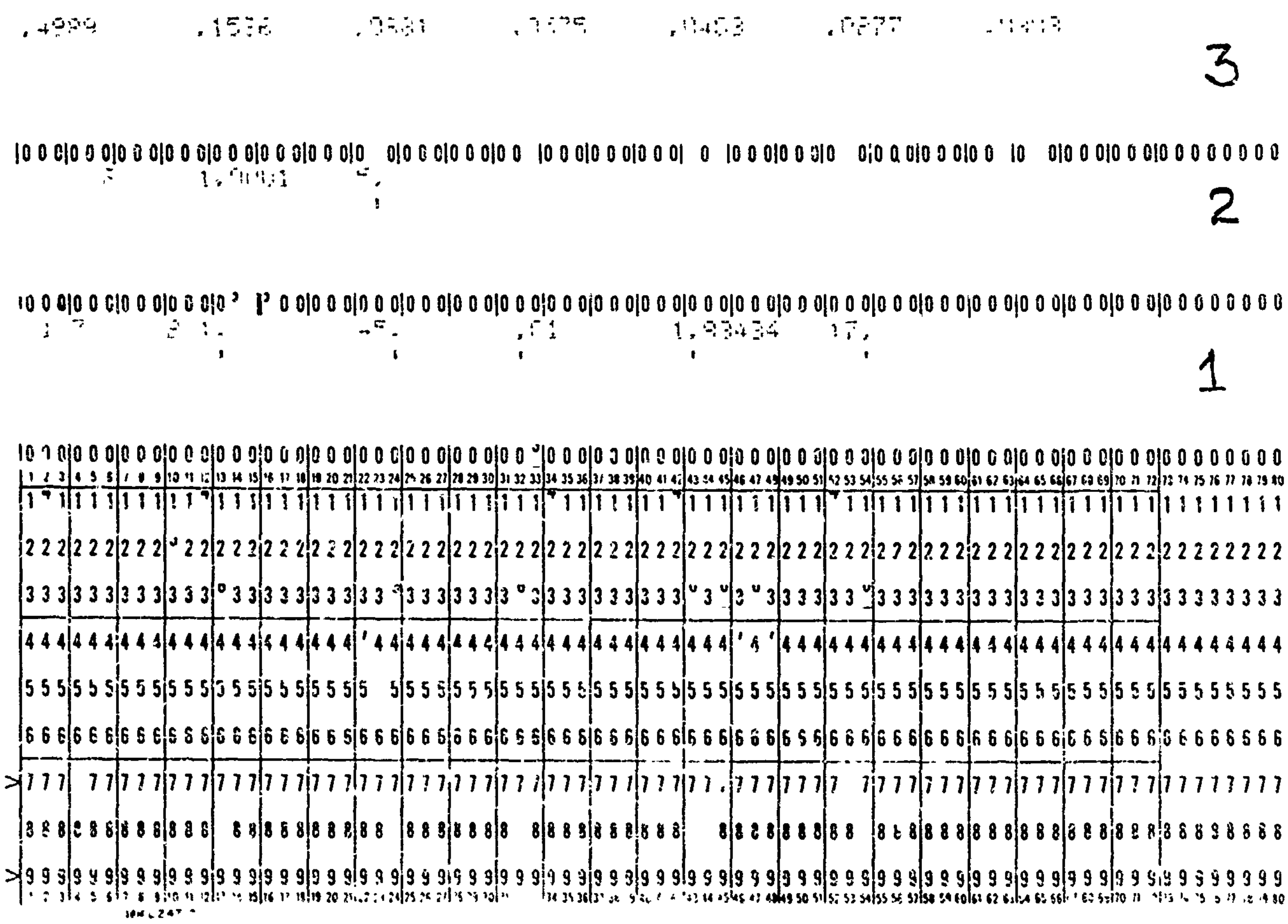
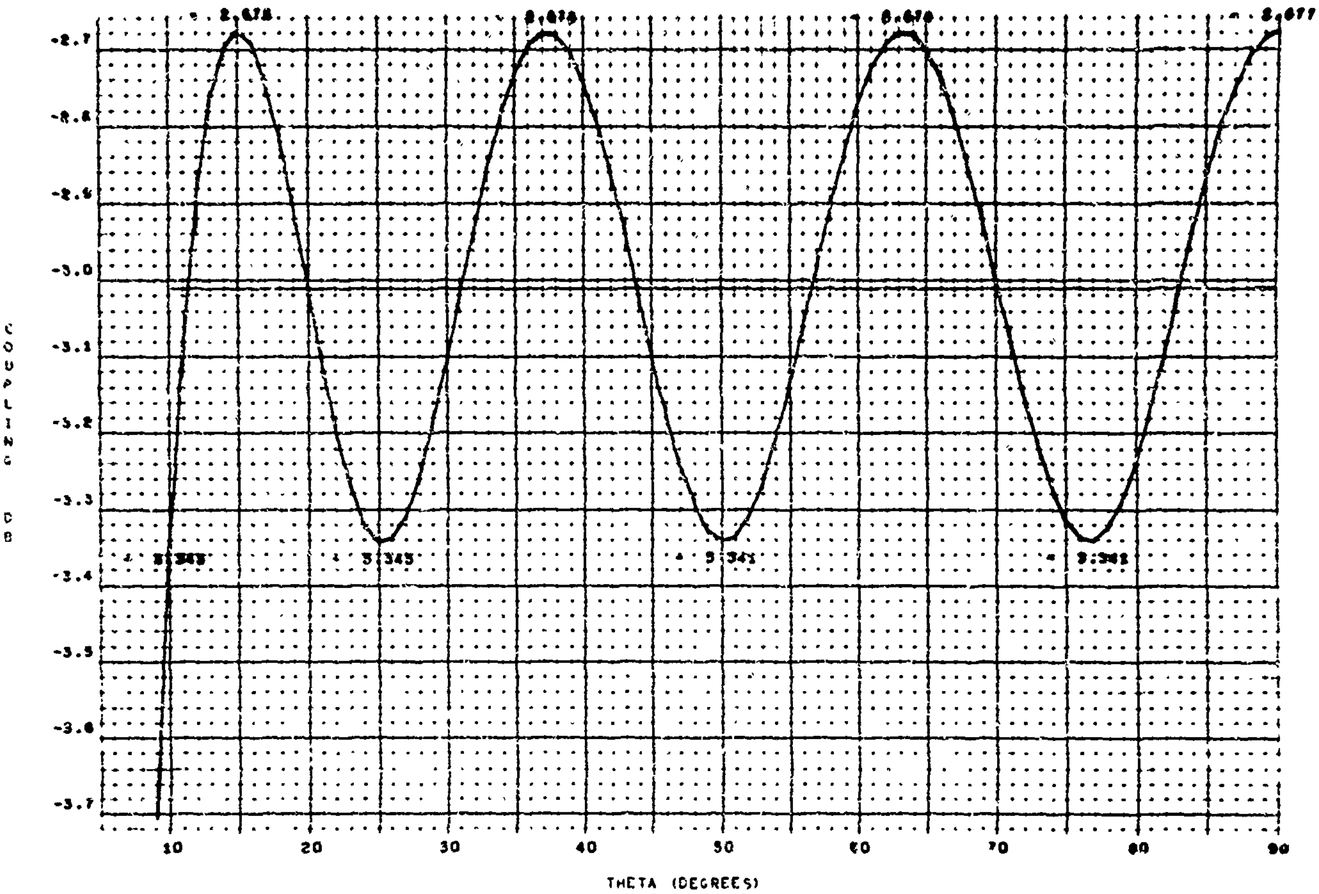


FIG. 5. Input Data Cards.



17.000 TO 1.0 BANDWIDTH COUPLER

1.83434	1.83434	1.62977	1.36591	1.21737	1.12308	1.09254
0.54178	0.54178	0.45287	0.30209	0.19419	0.11555	0.06059

1.83434	1.20888
0.54178	0.18743

1.83029
0.54022

FIG. 6. Response Curve and Design of Coupler.

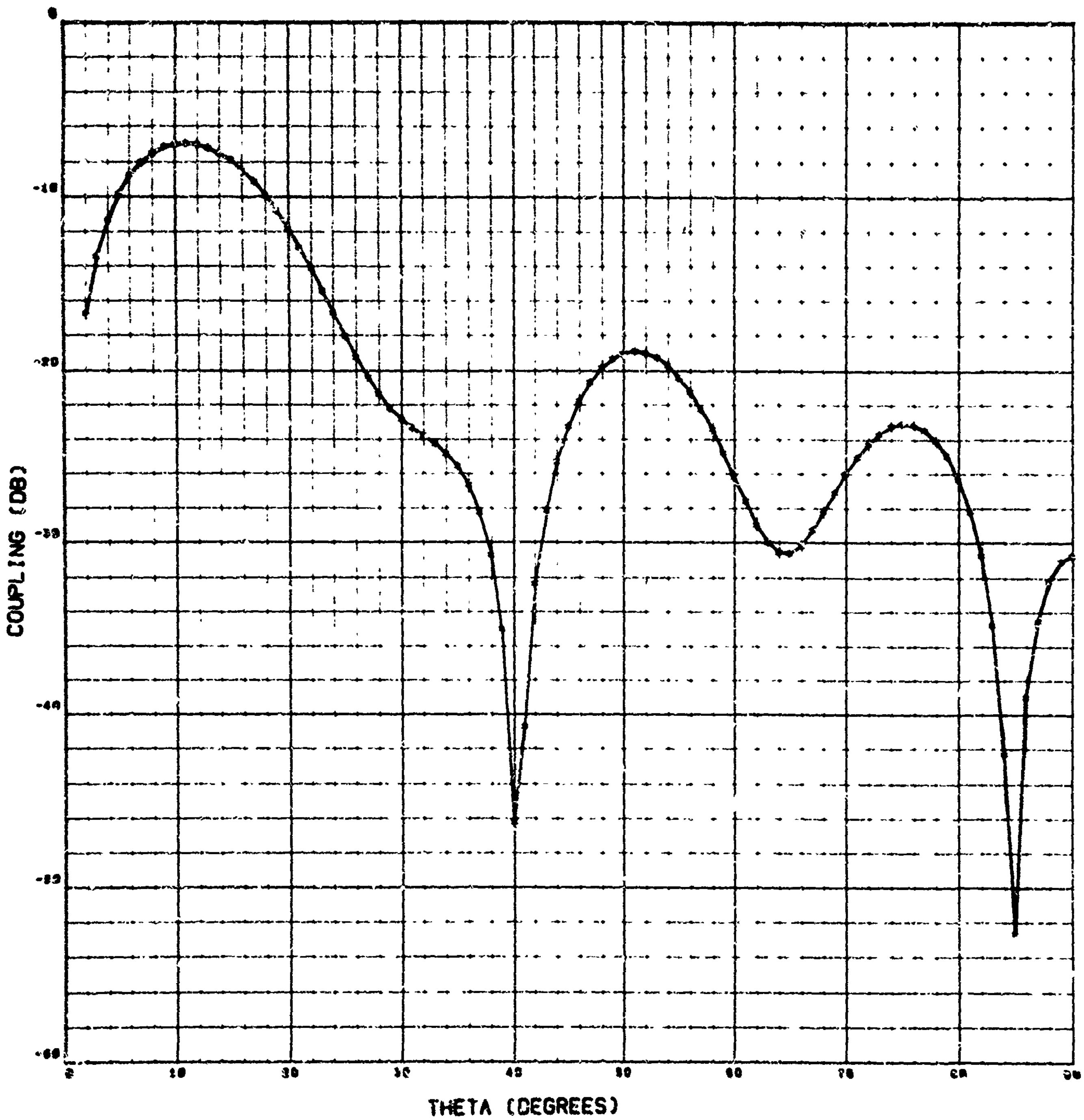


FIG. 7. Response C rve of First Tandem Coupler of Solution.

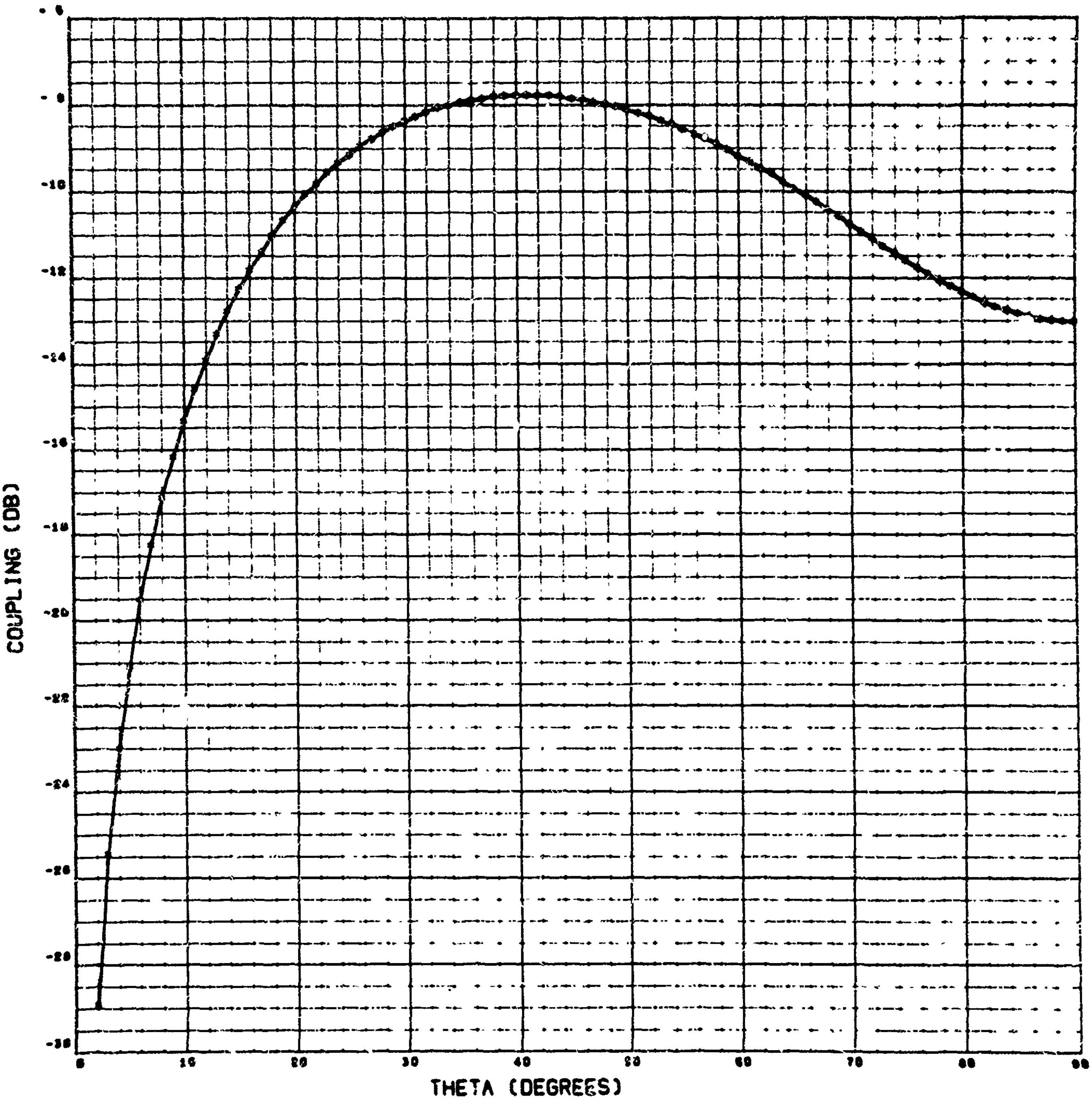


FIG. 8. Response Curve of Second Tandem Coupler of Solution.

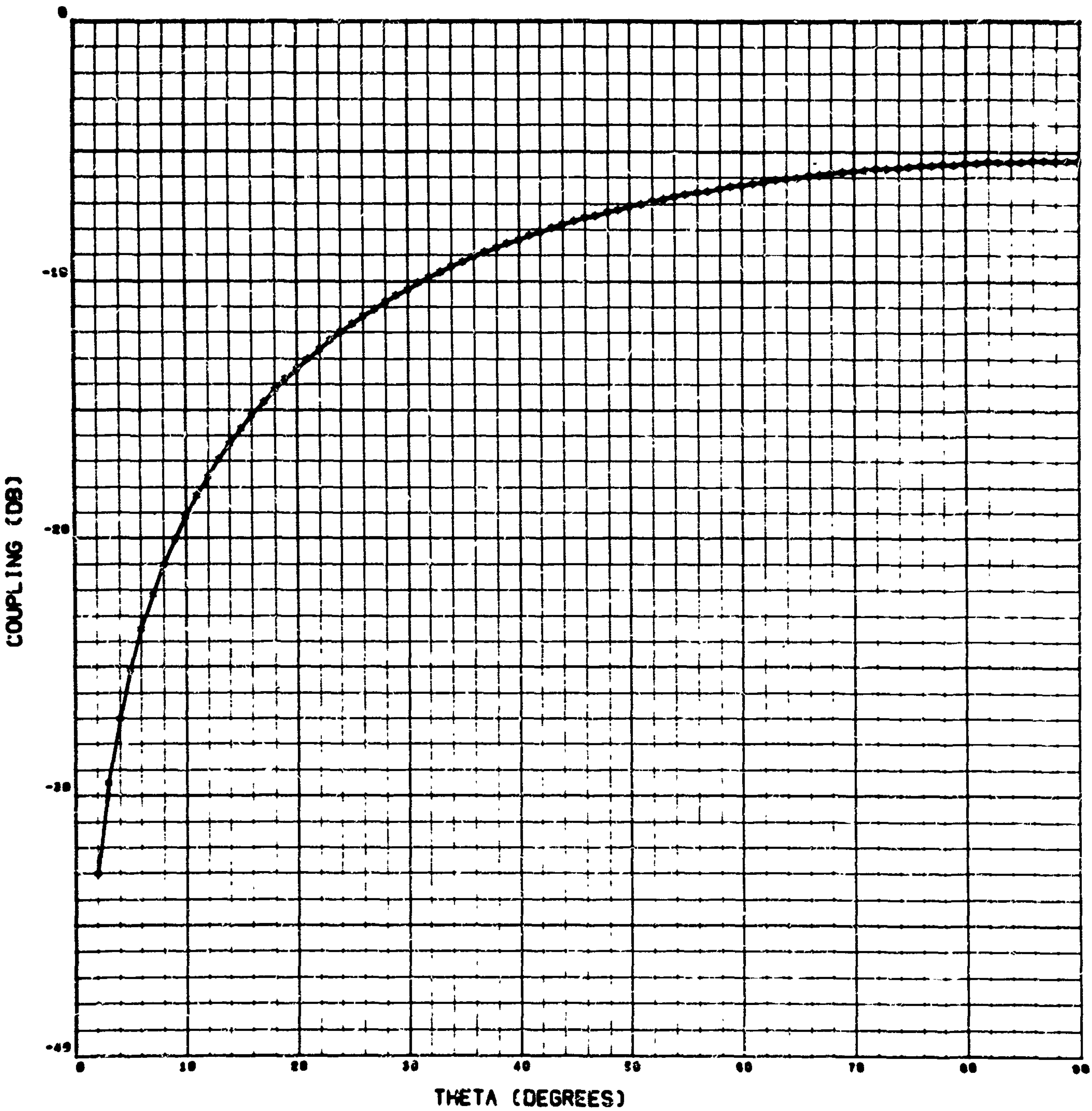


FIG. 9. Third Tandem Coupler's Response.

```
UO = 45.0000    BW =17.000    ZMAX = 1.83434    TLLERANCE=  0.01000    THE MAX. ALLOWABLE ITERATION(S) ARE =  2
     GAMMA(1, 1 ) =   0.49890
     GAMMA(1, 2 ) =   0.15360
     GAMMA(1, 3 ) =   0.08810
     GAMMA(1, 4 ) =   0.05750
     GAMMA(1, 5 ) =   0.04030
     GAMMA(1, 6 ) =   0.02770
     GAMMA(1, 7 ) =   0.03030
Z( 1, 1 )= 1.83434          GAMMA ( 1, 1 )=.              COUPLING = 0.54179
Z( 1, 2 )= 1.83434          GAMMA ( 1, 2 )=.05904         COUPLING = 0.54179
Z( 1, 3 )= 1.62981          GAMMA ( 1,   )=.08810         COUPLING = 0.45299
Z( 1, 4 )= 1.36589          GAMMA ( 1, 4 )=.05750         COUPLING = 0.30298
Z( 1, 5 )= 1.21735          GAMMA ( 1, 5 )=.04030         COUPLING = 0.19418
Z( 1, 6 )= 1.12303          GAMMA ( 1, 6 )=.02770         COUPLING = 0.11551
Z( 1, 7 )= 1.06249          GAMMA ( 1, 7 )=.03030         COUPLING = 0.06054
Z( 2, 1 )= 1.83434          GAMMA ( 2, 1 )=.20553         COUPLING = 0.54179
Z( 2, 2 )= 1.20886          GAMMA ( 2, 2 )=.09456         COUPLING = 0.18744
Z( 3, 1 )= 1.83033          GAMMA ( 3, 1 )=.29337         COUPLING = 0.54024
VAL( 1)=    42.88393
VAL( 2)=    42.88560
VAL( 3)=    42.89409
VAL( 4)=    42.90123
PEAK( 1) =     47.29667
PEAK( 2) =     47.27319
PEAK( 3) =     47.26911
PEAK( 4) =     47.28414
  0.33294    0.33205
  0.33457    0.33205
  0.33267    0.33205
  0.33129    0.33205
  0.33128    0.33205
  0.33071    0.33205
  0.33012    0.33205
  0.33282    0.33205
B( 1 )=-0.00209
B( 3 )= 0.00254
B( 5 )=-0.00433
B( 7 )=-0.00013
B( 9 )=-0.00282
B(11 )=-0.00077
B(13 )= 0.00534
B(15 )= 0.00079
0 1
0 0
   CAUTIOUS ERROR CORRECTION ( 0.500X)
     GAMMA(1, 1 ) =   0.49869
     GAMMA(1, 2 ) =   0.15361
     GAMMA(1, 3 ) =   0.08808
     GAMMA(1, 4 ) =   0.05750
     GAMMA(1, 5 ) =   0.04029
     GAMMA(1, 6 ) =   0.02770
     GAMMA(1, 7 ) =   0.03032
Z( 1, 1 )= 1.83434          GAMMA ( 1, 1 )=.              COUPLING = 0.54179
Z( 1, 2 )= 1.83434          GAMMA ( 1, 2 )=.05905         COUPLING = 0.54179
Z( 1, 3 )= 1.62977          GAMMA ( 1, 3 )=.08808         COUPLING = 0.45298
Z( 1, 4 )= 1.36591          GAMMA ( 1, 4 )=.05750         COUPLING = 0.30209
Z( 1, 5 )= 1.21737          GAMMA ( 1, 5 )=.04029         COUPLING = 0.19419
Z( 1, 6 )= 1.12308          GAMMA ( 1, 6 )=.02770         COUPLING = 0.11555
Z( 1, 7 )= 1.06254          GAMMA ( 1, 7 )=.03032         COUPLING = 0.06059
Z( 2, 1 )= 1.83434          GAMMA ( 2, 1 )=.20553         COUPLING = 0.54179
Z( 2, 2 )= 1.20886          GAMMA ( 2, 2 )=.09456         COUPLING = 0.18744
```

FIG. 10. "Written" Machine Output.

```
Z( 3, 1 )= 1.83029          GAMMA ( 3, 1 )=.29336          COUPLING = 0.54022
VAL( 1)=   42.88294
VAL( 2)=   42.88415
VAL( 3)=   42.89208
VAL( 4)=   42.89609
PEAK( 1) =    47.29357
PEAK( 2) =    47.27663
PEAK( 3) =    47.27294
PEAK( 4) =    47.28145
  0.33310   0.33227
  0.33414   0.33227
  0.33291   0.33227
  0.33177   0.33227
  0.33161   0.33227
  0.33125   0.33227
  0.33056   0.33227
  0.33244   0.33227
    GAMMA(1, 1 ) =   0.49889
    GAMMA(1, 2 ) =   0.15361
    GAMMA(1, 3 ) =   0.08808
    GAMMA(1, 4 ) =   0.05750
    GAMMA(1, 5 ) =   0.04029
    GAMMA(1, 6 ) =   0.02770
    GAMMA(1, 7 ) =   0.03032
Z( 1, 1 )= 1.83434          GAMMA ( 1, 1 )=.               COUPLING = 0.54179
Z( 1, 2 )= 1.83434          GAMMA ( 1, 2 )=.05905          COUPLING = 0.54179
Z( 1, 3 )= 1.62977          GAMMA ( 1, 3 )=.08808          COUPLING = 0.45298
Z( 1, 4 )= 1.36591          GAMMA ( 1, 4 )=.05750          COUPLING = 0.30209
Z( 1, 5 )= 1.21737          GAMMA ( 1, 5 )=.04029          COUPLING = 0.19419
Z( 1, 6 )= 1.12308          GAMMA ( 1, 6 )=.02770          COUPLING = 0.11555
Z( 1, 7 )= 1.06254          GAMMA ( 1, 7 )=.03032          COUPLING = 0.06059
Z( 2, 1 )= 1.83434          GAMMA ( 2, 1 )=.20553          COUPLING = 0.54179
Z( 2, 2 )= 1.20886          GAMMA ( 2, 2 )=.09456          COUPLING = 0.18744
Z( 3, 1 )= 1.83029          GAMMA ( 3, 1 )=.29336          COUPLING = 0.54022
VAL( 1)=   42.88294
VAL( 2)=   42.88415
VAL( 3)=   42.89208
VAL( 4)=   42.89609
PEAK( 1) =    47.29357
PEAK( 2) =    47.27663
PEAK( 3) =    47.27294
PEAK( 4) =    47.28145
  0.33310   0.33227
  0.33414   0.33227
  0.33291   0.33227
  0.33177   0.33227
  0.33161   0.33227
  0.33125   0.33227
  0.33056   0.33227
  0.33244   0.33227
THE DESIGN DOES MEET THE SPECIFICATIONS, AFTER  3  ITERATIONS
                                        EXIT BY 5
   Z(1, 1)     1.83434  1.83434
   Z(1, 2)     1.83434  1.83434
   Z(1, 3)     1.64797  1.62977
   Z(1, 4)     1.38001  1.36591
   Z(1, 5)     1.23440  1.21737
   Z(1, 6)     1.14520  1.12308
   Z(1, 7)     1.08948  1.06254
   Z(2, 1)     1.83434  1.83434
   Z(2, 2)     1.22380  1.20886
   Z(3, 1)     1.83434  1.83029
   Z(4, 1)     1.01247  ......
```

FIG. 10. End.

```
      N=13        COUPLING= -3.0103 DB          BANDWIDTH=17.000     1.834
                     RIPPLF= 0.3325   DB         TOLFRANCF=0.0016
 3
 7
   1.83434   1.83434   1.62977   1.36591   1.21737   1.12308   1.06254
 2
   1.83434   1.20886
 1
   1.83029
 1 7 -0  2   1.00000  45.00000   0.01000   1.83434  17.00000
   0.49889   0.15361   0.08808   0.05750   0.04029   0.02770   0.03032

      FOR REFERENCE
123456789012345    0    5    0    5    0    5    0    5    0    5    012
```

FIG. 11.

Example C
Type 3 Data (Phase Shifter)

Let it be required to check and improve, if necessary, a phase shifter design that is in terms of even mode impedances: specifically, the 17:1 bandwidth, 90 degree phase shifter of Ref. 12. Thus, the input data are as in Fig. 12 with the output data as shown in Fig. 13-15.

The computer execution time was 2.85 seconds.

Example D
Type 3 Data (Coupler)

Entertain the request for a 7.50:1 bandwidth, -3 db, re-entrant nine-section coupler with a normalized Zoe = 4.5 for the maximum coupled section. Note Ref. 10, which contains such a coupler design, except that Zoe = 4.93133 and that the bandwidth is 7.365:1. Therefore, let this published data be the starting point of the desired data. Thus, the input data cards are prepared according to Fig. 16 with the output data shown in Fig. 17-19.

The computer execution time was 7.65 seconds.

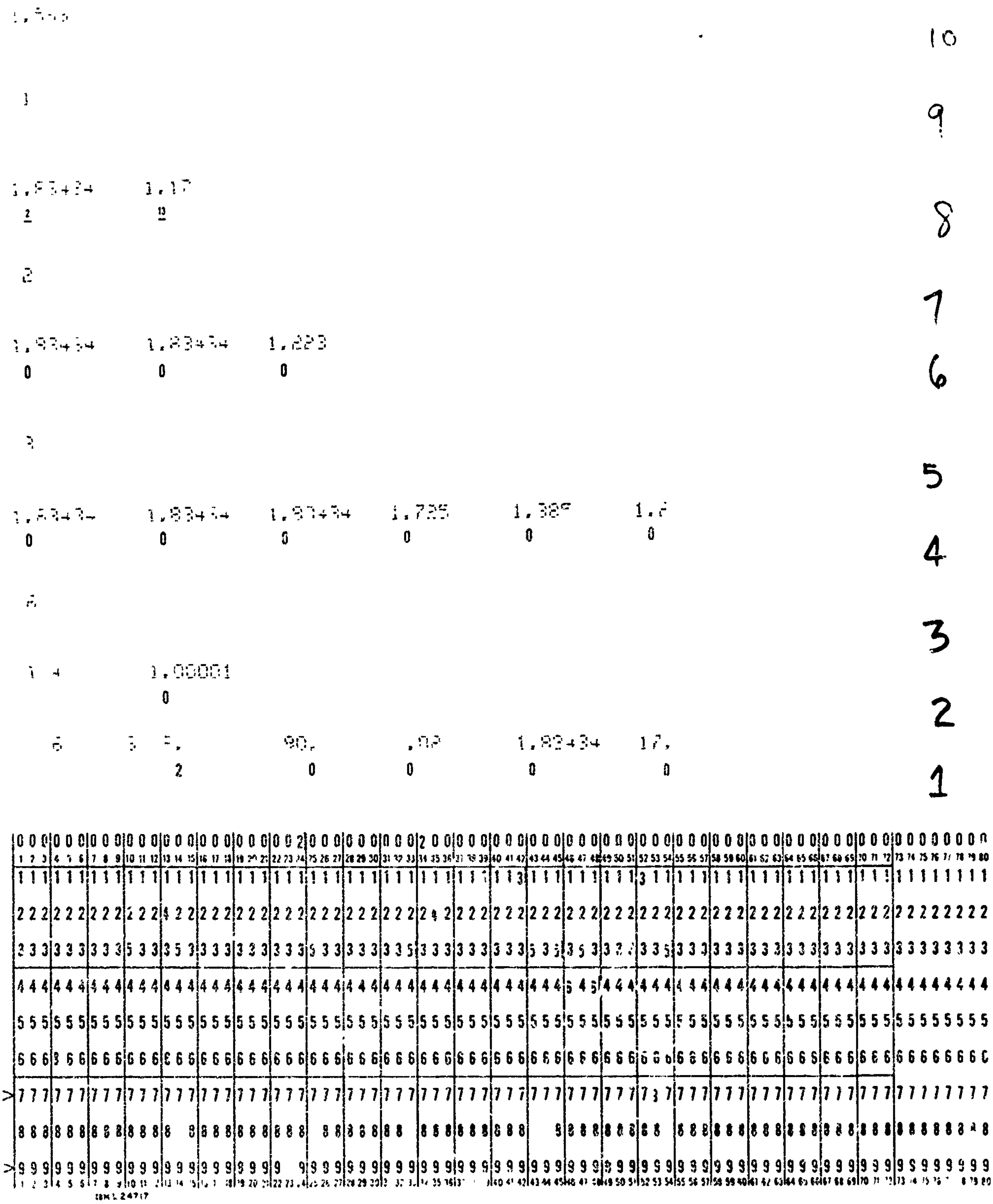
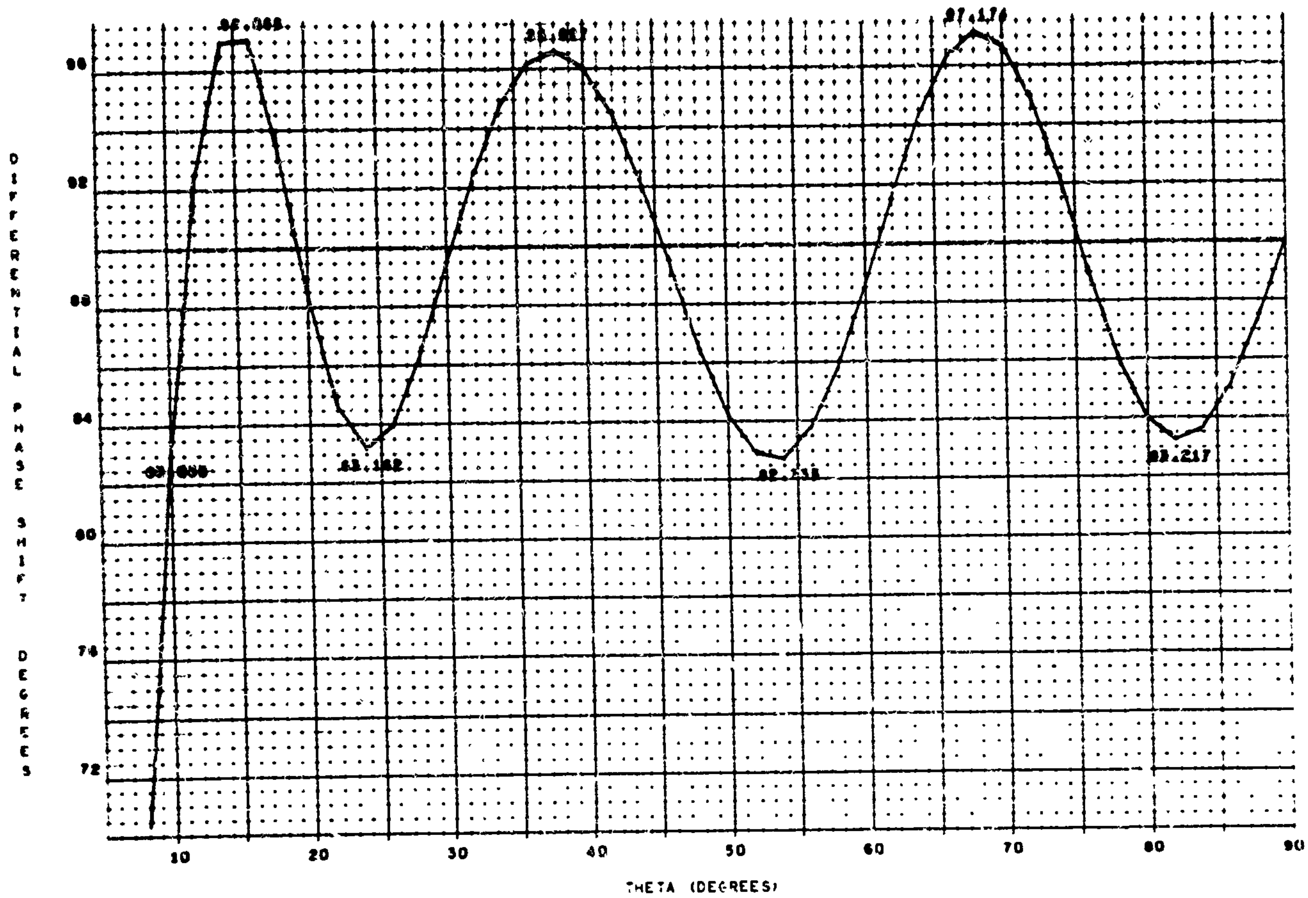


FIG. 12. Input Data Cards.



17.000 TO 1.0 BANDWIDTH PHASE SHIFTER

1.83434	1.83434	1.83434	1.63993	1.37341	1.19036
0.54178	0.54178	0.54178	0.48130	0.30705	0.17251

1.83434	1.83434	1.24892
0.54178	0.54178	0.21868

1.83434	1.18060
0.54178	0.16491

1.55408
0.41437

FIG. 13. Response Curve and Design of Phase Shifter.

```
U0 = 90.0000     BW =17.000     ZMAX = 1.83434     TOLERANCE=  0.02000     THE MAX. ALLOWABLE ITERATION(S) ARE =  3
  1.83434    1.83434    1.83434    1.72500    1.38500    1.20000
  1.83434    1.83434    1.22300
  1.83434    1.17000
  1.56600
    GAMMA(1, 1 ) =   0.54170
    GAMMA(1, 2 ) =   0.27830
    GAMMA(1, 3 ) =   0.13103
    GAMMA(1, 4 ) =   0.10932
    GAMMA(1, 5 ) =   0.07157
    GAMMA(1, 6 ) =   0.09091
Z( 1, 1 )= 1.83434          GAMMA ( 1, 1 )=.                COUPLING = 0.54179
Z( 1, 2 )= 1.83434          GAMMA ( 1, 2 )=.                COUPLING = 0.54179
Z( 1, 3 )= 1.83434          GAMMA ( 1, 3 )=.03672           COUPLING = 0.54179
Z( 1, 4 )= 1.72500          GAMMA ( 1, 4 )=.10932           COUPLING = 0.49693
Z( 1, 5 )= 1.38500          GAMMA ( 1, 5 )=.07157           COUPLING = 0.31465
Z( 1, 6 )= 1.20000          GAMMA ( 1, 6 )=.09091           COUPLING = 0.18033
Z( 2, 1 )= 1.83434          GAMMA ( 2, 1 )=.                COUPLING = 0.54179
Z( 2, 2 )= 1.83434          GAMMA ( 2, 2 )=.19996           COUPLING = 0.54179
Z( 2, 3 )= 1.22300          GAMMA ( 2, 3 )=.10031           COUPLING = 0.19863
Z( 3, 1 )= 1.83434          GAMMA ( 3, 1 )=.22113           COUPLING = 0.54179
Z( 3, 2 )= 1.17000          GAMMA ( 3, 2 )=.07834           COUPLING = 0.15573
Z( 4, 1 )= 1.56600          GAMMA ( 4, 1 )=.22058           COUPLING = 0.42069

VAL( 1)=    82.90401
VAL( 2)=    81.86882
VAL( 3)=    84.37637
VAL( 4)=    80.59766
PEAK( 1) =    96.30284
PEAK( 2) =    99.49004
PEAK( 3) =    96.03380
   7.09599    7.43712
  -6.30284    7.43712
   8.11118    7.43712
  -9.49004    7.43712
   5.62363    7.43712
  -6.03380    7.43712
   9.40234    7.43712
B( 2 )=-0.54761
B( 4 )=-0.36671
B( 6 )= 1.60211
B( 8 )=-0.39615
B(10 )=-0.12363
B(12 )=-0.26380
B(14 )=-0.18032
0 2
0 0
    CAUTIOUS ERROR CORRECTION ( 0.500X)
    GAMMA(1, 1 ) =   0.43652
    GAMMA(1, 2 ) =   0.27510
    GAMMA(1, 3 ) =   0.14502
    GAMMA(1, 4 ) =   0.10587
    GAMMA(1, 5 ) =   0.07049
    GAMMA(1, 6 ) =   0.08861
Z( 1, 1 )= 1.83434          GAMMA ( 1, 1 )=.                COUPLING = 0.54179
Z( 1, 2 )= 1.83434          GAMMA ( 1, 2 )=.                COUPLING = 0.54179
Z( 1, 3 )= 1.83434          GAMMA ( 1, 3 )=.03761           COUPLING = 0.54179
Z( 1, 4 )= 1.70135          GAMMA ( 1, 4 )=.10587           COUPLING = 0.48647
Z( 1, 5 )= 1.37560          GAMMA ( 1, 5 )=.07049           COUPLING = 0.30850
Z( 1, 6 )= 1.19444          GAMMA ( 1, 6 )=.08861           COUPLING = 0.17583
Z( 2, 1 )= 1.83434          GAMMA ( 2, 1 )=.                COUPLING = 0.54179
```

Normalized Zoe's of input data (arranged by tandem phase shifters).

FIG. 14. "Written" Machine Output.

```
Z( 2, 2 )= 1.83434          GAMMA ( 2, 2 )=.19307          COUPLING = 0.54179
Z( 2, 3 )= 1.24065          GAMMA ( 2, 3 )=.10740          COUPLING = 0.21235
Z( 3, 1 )= 1.83434          GAMMA ( 3, 1 )=.21759          COUPLING = 0.54179
Z( 3, 2 )= 1.17872          GAMMA ( 3, 2 )=.08203          COUPLING = 0.16296
Z( 4, 1 )= 1.56190          GAMMA ( 4, 1 )=.21933          COUPLING = 0.41853

VAL( 1)=    83.04439
VAL( 2)=    82.89876
VAL( 3)=    83.32242
VAL( 4)=    82.14023
PEAK( 1) =    96.83940
PEAK( 2) =    97.61372
PEAK( 3) =    96.92165
   6.95561   7.13843
  -6.83940   7.13843
   7.10124   7.13843
  -7.61372   7.13843
   6.67758   7.13843
  -6.92166   7.13843
   7.85977   7.13843
B( 2 )=-0.18053
B( 4 )=-0.13787
B( 6 )= 0.38067
B( 8 )=-0.14559
B(10 )= 0.09203
B(12 )=-0.09727
B(14 )=-0.02150
0 2
0 0
      NORMAL ERROR CORRECTION
     GAMMA(1, 1 ) =  0.43377
     GAMMA(1, 2 ) =  0.27269
     GAMMA(1, 3 ) =  0.15166
     GAMMA(1, 4 ) =  0.10333
     GAMMA(1, 5 ) =  0.07140
     GAMMA(1, 6 ) =  0.08691
Z( 1, 1 )= 1.83434          GAMMA ( 1, 1 )=.               COUPLING = 0.54179
Z( 1, 2 )= 1.83434          GAMMA ( 1, 2 )=.               COUPLING = 0.54179
Z( 1, 3 )= 1.83434          GAMMA ( 1, 3 )=.04098          COUPLING = 0.54179
Z( 1, 4 )= 1.68993          GAMMA ( 1, 4 )=.10333          COUPLING = 0.48131
Z( 1, 5 )= 1.37341          GAMMA ( 1, 5 )=.07140          COUPLING = 0.30708
Z( 1, 6 )= 1.19035          GAMMA ( 1, 6 )=.08691          COUPLING = 0.17252
Z( 2, 1 )= 1.83434          GAMMA ( 2, 1 )=.               COUPLING = 0.54179
Z( 2, 2 )= 1.83434          GAMMA ( 2, 2 )=.18987          COUPLING = 0.54179
Z( 2, 3 )= 1.24892          GAMMA ( 2, 3 )=.11068          COUPLING = 0.21869
Z( 3, 1 )= 1.83434          GAMMA ( 3, 1 )=.21683          COUPLING = 0.54179
Z( 3, 2 )= 1.18060          GAMMA ( 3, 2 )=.08282          COUPLING = 0.16451
Z( 4, 1 )= 1.55408          GAMMA ( 4, 1 )=.21694          COUPLING = 0.41438

VAL( 1)=    83.03312
VAL( 2)=    83.10235
VAL( 3)=    82.73561
VAL( 4)=    83.21724
PEAK( 1) =    97.06552
PEAK( 2) =    96.62776
PEAK( 3) =    97.17409
   6.96588   6.95986
  -7.06552   6.95986
   6.83765   6.95986
  -6.62776   6.95986
   7.26439   6.95986
  -7.17409   6.95986
   6.78276   6.95986
    THE DESIGN DOES NOT MEET THE SPECIFICATIONS -- FAIL
                                              EXIT BY 7
```

FIG. 14. End.

```
   THE DESIGN DOES NOT MEET THE SPECIFICATIONS -- FAIL
-0 6 -0  3   2.00000  90.00000   0.02000   1.83434  17.00000

    0.43377   0.27269   0.15166   0.10333   0.07140   0.08691

   FOR REFERENCE
123456789012345    0    5    0    5    0    5    0    5    0    5   012
```

FIG. 15.

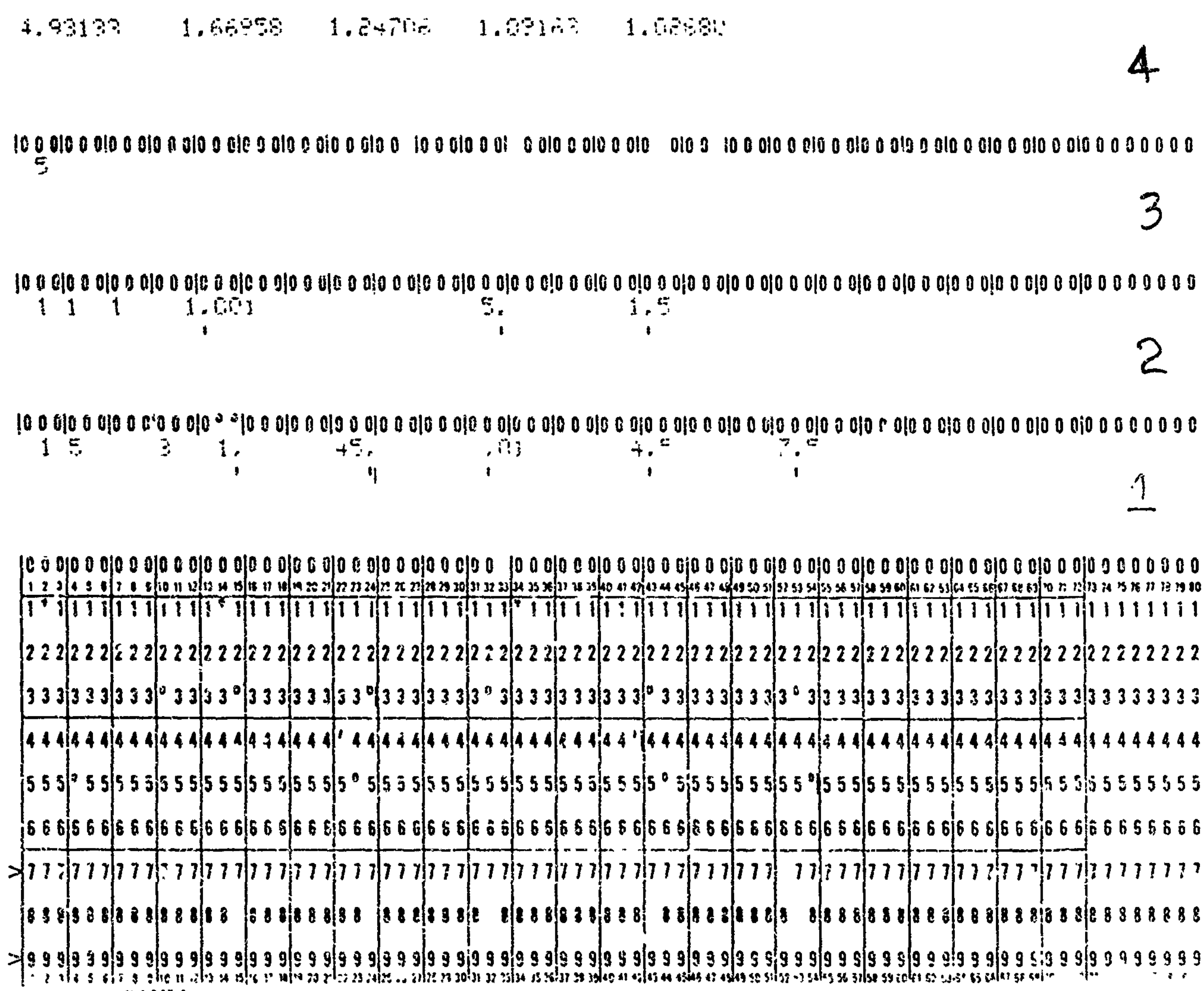
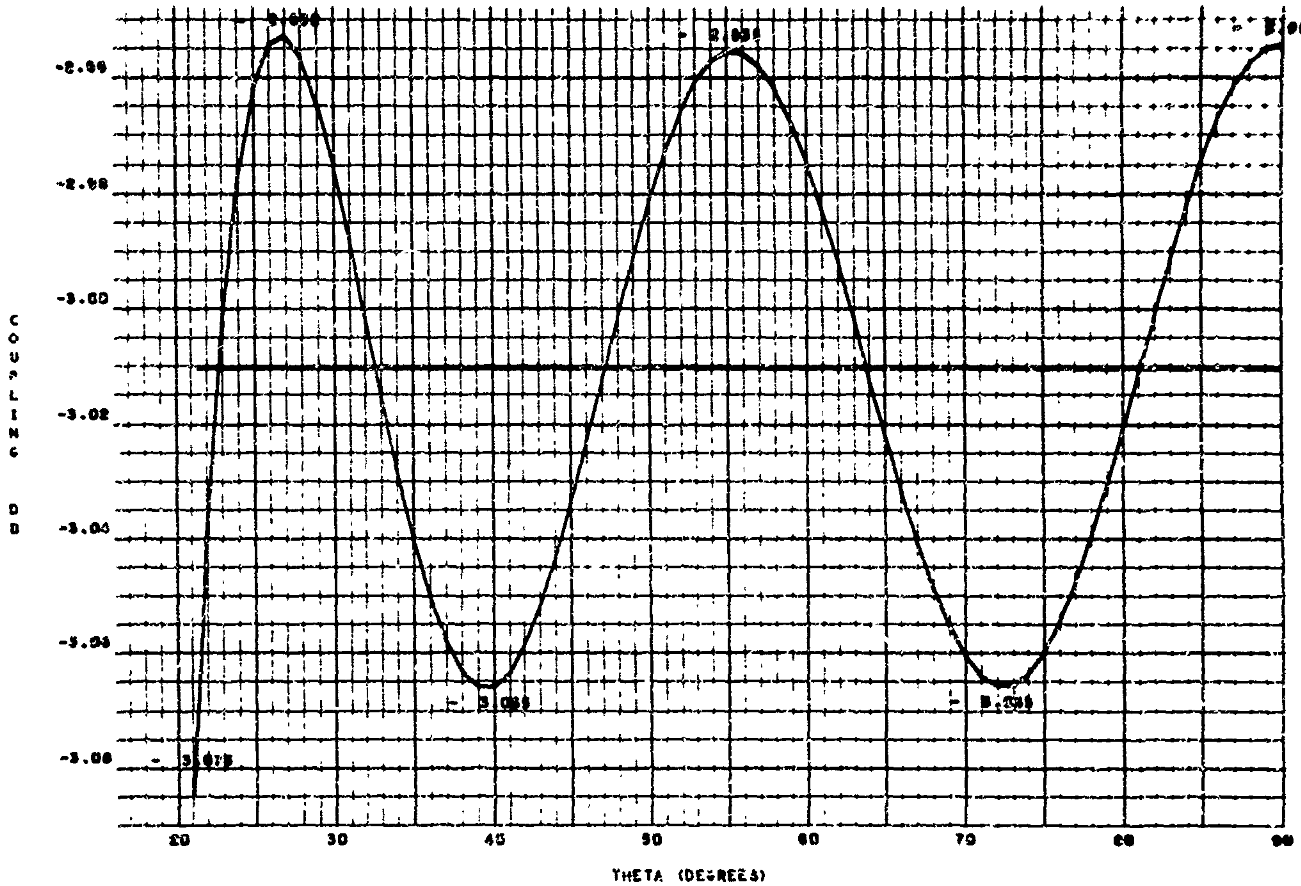


FIG. 16. Input Data Cards.



7.500 TO 1.0 BANDWIDTH COUPLER

4.50000	1.65714	1.25700	1.09534	1.02781
0.90588	0.48457	0.22462	0.09083	0.02748

1.68712
0.88434

FIG. 17. Response and Design of Coupler.

```
UO = 45.0000    BW = 7.500    ZMAX = 4.50000    TOLERANCE= 0.01000    THE MAX. ALLOWABLE ITERATION(S) ARE = 3
  4.93133   1.66958   1.24706   1.09163   1.02680
     GAMMA(1, 1 ) =  0.49414
     GAMMA(1, 2 ) =  0.14487
     GAMMA(1, 3 ) =  0.06646
     GAMMA(1, 4 ) =  0.03060
     GAMMA(1, 5 ) =  0.01322
Z( 1, 1 )= 4.50000          GAMMA ( 1, 1 )=.45877          COUPLING = 0.90588
Z( 1, 2 )= 1.66958          GAMMA ( 1, 2 )=.14487          COUPLING = 0.47195
Z( 1, 3 )= 1.24706          GAMMA ( 1, 3 )=.06646          COUPLING = 0.21727
Z( 1, 4 )= 1.09163          GAMMA ( 1, 4 )=.03060          COUPLING = 0.08745
Z( 1, 5 )= 1.02680          GAMMA ( 1, 5 )=.01322          COUPLING = 0.02644
Z( 2, 1 )= 1.07333          GAMMA ( 2, 1 )=.03537          COUPLING = 0.07064
```

ALPHA (DEGREES)	RIPPLE (DEGREES)	THETA (DEGREES)	COUPLING (DB)	RIPPLE (DB)	BANDWIDTH RATIO
44.10265	0.89735	21.176	-3.14849	0.13819	7.50000
7.82773	37.17227	2.000	-17.31677	14.30647	89.00000
11.59611	33.40389	3.000	-13.93558	10.92528	59.00000
15.20140	29.79860	4.000	-11.62692	8.61662	44.00000
18.60626	26.39374	5.000	-9.92247	6.91217	35.00000
21.78443	23.21557	6.000	-8.60982	5.59952	29.00000
24.72024	20.27976	7.000	-7.57257	4.56227	24.71429
27.40728	17.59272	8.000	-6.73894	3.72864	21.50000
29.84660	15.15340	9.000	-6.06100	3.05070	19.00000
32.04479	12.95521	10.000	-5.50495	2.49465	17.00000
34.01232	10.98768	11.000	-5.04600	2.03570	15.36364
35.76205	9.23795	12.000	-4.66549	1.65519	14.00000
37.30818	7.69182	13.000	-4.34909	1.33879	12.84615
38.66538	6.33462	14.000	-4.08558	1.07528	11.85714
39.84629	5.15171	15.000	-3.86613	0.85583	11.00000
40.87114	4.12886	16.000	-3.68367	0.67337	10.25000
41.74760	3.25240	17.000	-3.53247	0.52217	9.58824
42.49065	2.50935	18.000	-3.40788	0.39758	9.00000
43.11258	1.88742	19.000	-3.30607	0.29577	8.47368
43.62502	1.37498	20.000	-3.22383	0.21353	8.00000
44.03901	0.96099	21.000	-3.15845	0.14815	7.57143
44.36505	0.63495	22.000	-3.10763	0.09733	7.18182
44.61314	0.38686	23.000	-3.06934	0.05904	6.82609
44.79288	0.20712	24.000	-3.04181	0.03151	6.50000
44.91348	0.08652	25.000	-3.02344	0.01314	6.20000
44.98376	0.01624	26.000	-3.01276	0.00246	5.92308
45.01222	-0.01222	27.000	-3.00845	-0.00185	5.66667
45.00694	-0.00694	28.000	-3.00925	-0.00105	5.42857
44.97560	0.02440	29.000	-3.01400	0.00370	5.20690
44.92543	0.07457	30.000	-3.02162	0.01132	5.00000
44.86311	0.13689	31.000	-3.03110	0.02080	4.80645
44.79475	0.20525	32.000	-3.04153	0.03123	4.62500
44.72580	0.27420	33.000	-3.05207	0.04177	4.45455
44.66097	0.33903	34.000	-3.06200	0.05170	4.29412
44.60426	0.39574	35.000	-3.07071	0.06041	4.14286
44.55881	0.44119	36.000	-3.07770	0.06740	4.00000
44.52696	0.47304	37.000	-3.08261	0.07231	3.86486
44.51025	0.48975	38.000	-3.08518	0.07488	3.73684
44.50940	0.49060	39.000	-3.08531	0.07501	3.61538
44.52438	0.47562	40.000	-3.08300	0.07270	3.50000
44.55453	0.44547	41.000	-3.07836	0.06806	3.39024
44.59855	0.40145	42.000	-3.07159	0.06129	3.28571
44.65465	0.34535	43.000	-3.06297	0.05267	3.18605

FIG. 18. "Written" Machine Output.

44.72065	0.27935	44.000	-3.05286	0.04256	3.09091
44.79409	0.20591	45.000	-3.04163	0.03133	3.00000
44.87232	0.12768	46.000	-3.02970	0.01940	2.91304
44.95264	0.04736	47.000	-3.01749	0.00719	2.82979
45.03237	-0.03237	48.000	-3.00540	-0.00490	2.75000
45.10897	-0.10897	49.000	-2.99381	-0.01649	2.67347
45.18008	-0.18008	50.000	-2.98309	-0.02721	2.60000
45.24363	-0.24363	51.000	-2.97352	-0.03678	2.52941
45.29786	-0.29786	52.000	-2.96538	-0.04492	2.46154
45.34138	-0.34138	53.000	-2.95885	-0.05145	2.39623
45.37321	-0.37321	54.000	-2.95409	-0.05621	2.33333
45.39274	-0.39274	55.000	-2.95117	-0.05913	2.27273
45.39982	-0.39982	56.000	-2.95011	-0.06019	2.21429
45.39468	-0.39468	57.000	-2.95088	-0.05942	2.15789
45.37793	-0.37793	58.000	-2.95338	-0.05692	2.10345
45.35057	-0.35057	59.000	-2.95748	-0.05282	2.05085
45.31391	-0.31391	60.000	-2.96297	-0.04733	2.00000
45.26953	-0.26953	61.000	-2.96963	-0.04067	1.95082
45.21924	-0.21924	62.000	-2.97719	-0.03311	1.90323
45.16503	-0.16503	63.000	-2.98535	-0.02495	1.85714
45.10898	-0.10898	64.000	-2.99381	-0.01649	1.81250
45.05322	-0.05322	65.000	-3.00224	-0.00806	1.76923
44.99984	0.00016	66.000	-3.01032	0.00002	1.72727
44.95084	0.04916	67.000	-3.01776	0.00746	1.68657
44.90804	0.09196	68.000	-3.02426	0.01396	1.64706
44.87307	0.12693	69.000	-3.02959	0.01929	1.60870
44.84725	0.15275	70.000	-3.03352	0.02322	1.57143
44.83160	0.16840	71.000	-3.03590	0.02560	1.53521
44.82679	0.17321	72.000	-3.03664	0.02634	1.50000
44.83312	0.16688	73.000	-3.03567	0.02537	1.46575
44.85050	0.14950	74.000	-3.03302	0.02272	1.43243
44.87848	0.12152	75.000	-3.02876	0.01846	1.40000
44.91626	0.08374	76.000	-3.02301	0.01271	1.36842
44.96271	0.03729	77.000	-3.01596	0.00566	1.33766
45.01642	-0.01642	78.000	-3.00781	-0.00249	1.30769
45.07574	-0.07574	79.000	-2.99883	-0.01147	1.27848
45.13888	-0.13888	80.000	-2.98930	-0.02100	1.25000
45.20390	-0.20390	81.000	-2.97950	-0.03080	1.22222
45.26882	-0.26882	82.000	-2.96974	-0.04056	1.19512
45.33167	-0.33167	83.000	-2.96031	-0.04999	1.16867
45.39055	-0.39055	84.000	-2.95150	-0.05880	1.14286
45.44369	-0.44369	85.000	-2.94356	-0.06674	1.11765
45.48951	-0.48951	86.000	-2.93672	-0.07358	1.09302
45.52663	-0.52663	87.000	-2.93119	-0.07911	1.06897
45.55396	-0.55396	88.000	-2.92713	-0.08317	1.04545
45.57069	-0.57069	89.000	-2.92464	-0.08566	1.02247
45.57632	-0.57632	90.000	-2.92380	-0.08650	1.00000

VAL(1)= 44.10265
VAL(2)= 44.50940
VAL(3)= 44.82679
PEAK(1) = 45.01222
PEAK(2) = 45.39982
PEAK(3) = 45.57632

0.13819	0.06468
0.00183	0.06468
0.07501	0.06468
0.06019	0.06468
0.02634	0.06468
0.06650	0.06468

B(1)=-0.02196
B(3)= 0.28169
B(5)= 0.12511
B(7)= 0.04376
B(9)= 0.01792
B(11)=-0.06792
0 1

FIG. 18. (Continued)

0 0

CAUTIOUS ERROR CORRECTION (0.750X)

GAMMA(1, 1) = 0.49399
GAMMA(1, 2) = 0.14671
GAMMA(1, 3) = 0.06728
GAMMA(1, 4) = C.03089
GAMMA(1, 5) = 0.01334

Z(1, 1)= 4.50000	GAMMA (1, 1)=.45631	COUPLING = 0.90588
Z(1, 2)= 1.68000	GAMMA (1, 2)=.14671	COUPLING = 0.47677
Z(1, 3)= 1.25012	GAMMA (1, 3)=.06728	COUPLING = 0.21961
Z(1, 4)= 1.09251	GAMMA (1, 4)=.03089	COUPLING = 0.08825
Z(1, 5)= 1.02704	GAMMA (1, 5)=.01334	COUPLING = 0.02668
Z(2, 1)= 1.07831	GAMMA (2, 1)=.03768	COUPLING = 0.07526

ALPHA (DEGREES)	RIPPLE (DEGREES)	THETA (DEGREES)	COUPLING (DB)	RIPPLE (DB)	BANDWIDTH RATIO
44.29152	0.70848	21.176	-3.11904	0.10874	7.50000
7.87846	37.12154	2.000	-17.26101	14.25071	89.00000
11.67032	33.32968	3.000	-13.80094	10.97064	59.00000
15.29704	29.70296	4.000	-11.57374	8.55344	44.00000
18.72097	26.27903	5.000	-9.87099	6.86069	35.00000
21.91570	23.08430	6.000	-8.56019	5.54999	29.00000
24.86561	20.13439	7.000	-7.52486	4.51456	24.71429
27.56442	17.43558	8.000	-6.69315	3.68285	21.50000
30.01339	14.98661	9.000	-6.01708	3.00678	19.00000
32.21938	12.78062	10.000	-5.46281	2.45251	17.00000
34.19309	10.80691	11.000	-5.00553	1.99523	15.36364
35.94762	9.05238	12.000	-4.62657	1.61627	14.00000
37.49735	7.50265	13.000	-4.31158	1.30128	12.84615
38.85714	6.14286	14.000	-4.04938	1.03908	11.85714
40.04174	4.95826	15.000	-3.83111	0.82081	11.00000
41.06552	3.93448	16.000	-3.64973	0.63943	10.25000
41.94220	3.05780	17.000	-3.49952	0.48922	9.58824
42.68481	2.31519	18.000	-3.37586	0.36556	9.00000
43.30570	1.69430	19.000	-3.27490	0.26460	8.47368
43.81652	1.18348	20.000	-3.19347	0.18317	8.00000
44.22832	0.77168	21.000	-3.12887	0.11857	7.57143
44.55161	0.44839	22.000	-3.07881	0.06851	7.18182
44.79641	0.20359	23.000	-3.04127	0.03097	6.82609
44.97231	0.02769	24.000	-3.01450	0.00420	6.50000
45.08854	-0.08854	25.000	-2.99690	-0.01340	6.20000
45.15394	-0.15394	26.000	-2.98703	-0.02327	5.92308
45.17701	-0.17701	27.000	-2.98355	-0.02675	5.66667
45.16587	-0.16587	28.000	-2.98523	-0.02507	5.42857
45.12823	-0.12823	29.000	-2.99090	-0.01940	5.20690
45.07136	-0.07136	30.000	-2.99950	-0.01080	5.00000
45.00199	-0.00199	31.000	-3.01000	-0.00030	4.80645
44.92628	0.07372	32.000	-3.02149	0.01119	4.62500
44.84973	0.15027	33.000	-3.03314	0.02284	4.45455
44.77715	0.22285	34.000	-3.04422	0.03392	4.29412
44.71255	0.28745	35.000	-3.05410	0.04380	4.14286
44.65917	0.34083	36.000	-3.06228	0.05198	4.00000
44.61939	0.38061	37.000	-3.06838	0.05808	3.86486
44.59481	0.40519	38.000	-3.07216	0.06186	3.73684
44.58621	0.41379	39.000	-3.07349	0.06319	3.61538
44.59360	0.40640	40.000	-3.07235	0.06205	3.50000
44.61633	0.38367	41.000	-3.06885	0.05855	3.39024
44.65314	0.34686	42.000	-3.06320	0.05290	3.28571
44.70226	0.29774	43.000	-3.05567	0.04537	3.18605
44.76151	0.23849	44.000	-3.04661	0.03631	3.09091
44.92842	0.17158	45.000	-3.03639	0.07609	3.00000

FIG. 18. (Continued)

```
44.90035   0.09965   46.000  -3.02543   0.01513  2.91304
44.97457   0.02543   47.000  -3.01416   0.00386  2.82979
45.04840  -0.04840   48.000  -3.00297  -0.00733  2.75000
45.11924  -0.11924   49.000  -2.99226  -0.01804  2.67347
45.18474  -0.18474   50.000  -2.98238  -0.02792  2.60000
45.24279  -0.24279   51.000  -2.97365  -0.03665  2.52941
45.29160  -0.29160   52.000  -2.96632  -0.04398  2.46154
45.32977  -0.32977   53.000  -2.96059  -0.04971  2.39623
45.35628  -0.35628   54.000  -2.95662  -0.05368  2.33333
45.37054  -0.37054   55.000  -2.95449  -0.05581  2.27273
45.37236  -0.37236   56.000  -2.95422  -0.05608  2.21429
45.36197  -0.36197   57.000  -2.95577  -0.05453  2.15789
45.34000  -0.34000   58.000  -2.95906  -0.05124  2.10345
45.30743  -0.30743   59.000  -2.96394  -0.04636  2.05085
45.26558  -0.26558   60.000  -2.97022  -0.04008  2.00000
45.21607  -0.21607   61.000  -2.97767  -0.03263  1.95082
45.16073  -0.16073   62.000  -2.98600  -0.02430  1.90323
45.10156  -0.10156   63.000  -2.99493  -0.01537  1.85714
45.04068  -0.04068   64.000  -3.00414  -0.00616  1.81250
44.98025   0.01975   65.000  -3.01330   0.00300  1.76923
44.92238   0.07762   66.000  -3.02208   0.01178  1.72727
44.86911   0.13089   67.000  -3.03019   0.01989  1.68657
44.82231   0.17769   68.000  -3.03732   0.02702  1.64706
44.78360   0.21640   69.000  -3.04323   0.03293  1.60870
44.75436   0.24564   70.000  -3.04770   0.03740  1.57143
44.73561   0.26439   71.000  -3.05057   0.04027  1.53521
44.72804   0.27196   72.000  -3.05173   0.04143  1.50000
44.73194   0.26806   73.000  -3.05113   0.04083  1.46575
44.74724   0.25276   74.000  -3.04879   0.03849  1.43243
44.77348   0.22652   75.000  -3.04478   0.03448  1.40000
44.80984   0.19016   76.000  -3.03922   0.02892  1.36842
44.85517   0.14483   77.000  -3.03231   0.02201  1.33766
44.90805   0.09195   78.000  -3.02426   0.01396  1.30769
44.96679   0.03321   79.000  -3.01534   0.00504  1.27848
45.02956  -0.02956   80.000  -3.00582  -0.00448  1.25000
45.09440  -0.09440   81.000  -2.99601  -0.01429  1.22222
45.15927  -0.15927   82.000  -2.98622  -0.02408  1.19512
45.22219  -0.22219   83.000  -2.97675  -0.03355  1.16867
45.28122  -0.28122   84.000  -2.96788  -0.04242  1.14286
45.33454  -0.33454   85.000  -2.95988  -0.05042  1.11765
45.38056  -0.38056   86.000  -2.95299  -0.05731  1.09302
45.41786  -0.41786   87.000  -2.94741  -0.06289  1.06897
45.44533  -0.44533   88.000  -2.94331  -0.06699  1.04545
45.46216  -0.46216   89.000  -2.94080  -0.06950  1.02247
45.46782  -0.46782   90.000  -2.93996  -0.07034  1.00000
VAL( 1)=   44.29152
VAL( 2)=   44.58671
VAL( 3)=   44.72804
PEAK( 1) =   45.17701
PEAK( 2) =   45.37236
PEAK( 3) =   45.46782
  0.10874   0.06109
  0.02675   0.06109
  0.06319   0.06109
  0.05608   0.06109
  0.04143   0.06109
  0.07034   0.06109
B( 1 )=-0.00327
B( 3 )= 0.15447
B( 5 )= 0.06174
B( 7 )= 0.04126
B( 9 )= 0.01684
B(11 )=-0.04364
0 1
0 0
      NORMAL ERROR CORRECTION
```

FIG. 18. (Continued)

GAMMA(1, 1) = C.49395
GAMMA(1, 2) = 0.14873
GAMMA(1, 3) = 0.06835
GAMMA(1, 4) = 0.03143
GAMMA(1, 5) = C.01356

Z(1, 1)= 4.50000	GAMMA (1, 1)=.45322	COUPLING = 0.90588
Z(1, 2)= 1.69316	GAMMA (1, 2)=.14873	COUPLING = 0.48278
Z(1, 3)= 1.25472	GAMMA (1, 3)=.06835	COUPLING = 0.22310
Z(1, 4)= 1.09418	GAMMA (1, 4)=.03143	COUPLING = 0.08976
Z(1, 5)= 1.02749	GAMMA (1, 5)=.01356	COUPLING = 0.02712
Z(2, 1)= 1.08493	GAMMA (2, 1)=.06073	COUPLING = 0.08133

ALPHA (DEGREES)	RIPPLE (DEGREES)	THETA (DEGREES)	COUPLING (DB)	RIPPLE (DB)	BANDWIDTH RATIO
44.51956	0.48044	21.176	-3.08275	0.07345	7.50000
7.94770	37.05230	2.000	-17.10549	14.17519	89.00000
11.77142	33.22858	3.000	-13.80707	10.79677	59.00000
15.42704	29.57296	4.000	-11.50200	8.49170	44.00000
18.87643	26.12357	5.000	-9.80176	6.79146	35.00000
22.09300	22.90700	6.000	-8.49368	5.48338	29.00000
25.06115	19.93885	7.000	-7.46118	4.45088	24.71429
27.77484	17.22516	8.000	-6.63232	3.62202	21.50000
30.23563	14.76437	9.000	-5.95902	2.94872	19.00000
32.45073	12.54927	10.000	-5.40740	2.39710	17.00000
34.43122	10.56878	11.000	-4.95263	1.94233	15.36364
36.19051	8.80949	12.000	-4.57601	1.56571	14.00000
37.74329	7.25671	13.000	-4.26320	1.25290	12.84615
39.10463	5.89537	14.000	-4.00301	0.99271	11.85714
40.28952	4.71048	15.000	-3.78661	0.77631	11.00000
41.31244	3.68756	16.000	-3.60695	0.59665	10.25000
42.18726	2.81274	17.000	-3.45836	0.44806	9.58824
42.92709	2.07291	18.000	-3.33620	0.32590	9.00000
43.54435	1.45565	19.000	-3.23668	0.22638	8.47368
44.05074	0.94926	20.000	-3.15662	0.14632	8.00000
44.45735	0.54265	21.000	-3.09335	0.08305	7.57143
44.77473	0.22527	22.000	-3.04458	0.03428	7.18182
45.01294	-0.01294	23.000	-3.00834	-0.00196	6.82609
45.18159	-0.18159	24.000	-2.98286	-0.02744	6.50000
45.28996	-0.28996	25.000	-2.96656	-0.04374	6.20000
45.34694	-0.34694	26.000	-2.95802	-0.05228	5.92308
45.36109	-0.36109	27.000	-2.95590	-0.05440	5.66667
45.34060	-0.34060	28.000	-2.95897	-0.05133	5.42857
45.29327	-0.29327	29.000	-2.96607	-0.04423	5.20690
45.22642	-0.22642	30.000	-2.97611	-0.03419	5.00000
45.14685	-0.14689	31.000	-2.98809	-0.02221	4.80645
45.06095	-0.06095	32.000	-3.00107	-0.00923	4.62500
44.97420	0.02580	33.000	-3.01421	0.00391	4.45455
44.89153	0.10847	34.000	-3.02678	0.01647	4.29412
44.81706	0.18294	35.000	-3.03812	0.02782	4.14286
44.75409	0.24591	36.000	-3.04774	0.03744	4.00000
44.70511	0.29489	37.000	-3.05523	0.04493	3.86486
44.67176	0.32824	38.000	-3.06035	0.05005	3.73684
44.65485	0.34515	39.000	-3.06294	0.05264	3.61538
44.65445	0.34555	40.000	-3.06300	0.05270	3.50000
44.66992	0.33008	41.000	-3.06063	0.05033	3.39024
44.69999	0.30001	42.000	-3.05602	0.04572	3.28571
44.74286	0.25714	43.000	-3.04946	0.03916	3.18605
44.79634	0.20366	44.000	-3.04128	0.03098	3.09091
44.85791	0.14209	45.000	-3.03189	0.02159	3.00000

FIG. 18. (Continued)

```
44.92487   0.07513   46.000  -3.02170   0.01140   2.91304
44.99445   0.00555   47.000  -3.01114   0.00084   2.82979
45.06388  -0.06388   48.000  -3.00063  -0.00967   2.75000
45.13054  -0.13054   49.000  -2.99056  -0.01974   2.67347
45.19196  -0.19196   50.000  -2.98130  -0.02900   2.60000
45.24601  -0.24601   51.000  -2.97317  -0.03713   2.52941
45.29084  -0.29084   52.000  -2.96643  -0.04367   2.46154
45.32497  -0.32497   53.000  -2.96131  -0.04899   2.39623
45.34738  -0.34738   54.000  -2.95796  -0.05234   2.33333
45.35742  -0.35742   55.000  -2.95645  -0.05385   2.27273
45.35487  -0.35487   56.000  -2.95683  -0.05347   2.21429
45.33997  -0.33997   57.000  -2.95907  -0.05123   2.15789
45.31332  -0.31332   58.000  -2.96306  -0.04724   2.10345
45.27593  -0.27593   59.000  -2.96867  -0.04163   2.05085
45.22914  -0.22914   60.000  -2.97570  -0.03460   2.00000
45.17456  -0.17456   61.000  -2.98392  -0.02638   1.95082
45.11408  -0.11408   62.000  -2.99304  -0.01726   1.90323
45.04975  -0.04975   63.000  -3.00277  -0.00754   1.85714
44.98371   0.01629   64.000  -3.01277   0.00247   1.81250
44.91819   0.08181   65.000  -3.02272   0.01242   1.76923
44.85535   0.14465   66.000  -3.03228   0.02198   1.72727
44.79728   0.20272   67.000  -3.04114   0.03084   1.68657
44.74590   0.25410   68.000  -3.04899   0.03869   1.64706
44.70288   0.29712   69.000  -3.05558   0.04528   1.60870
44.66964   0.33036   70.000  -3.06067   0.05037   1.57143
44.64723   0.35277   71.000  -3.06411   0.05381   1.53521
44.63639   0.36361   72.000  -3.06577   0.05547   1.50000
44.63741   0.36259   73.000  -3.06562   0.05532   1.46575
44.65025   0.34975   74.000  -3.06365   0.05335   1.43243
44.67442   0.32558   75.000  -3.05994   0.04964   1.40000
44.70911   0.29089   76.000  -3.05462   0.04432   1.36842
44.75315   0.24685   77.000  -3.04788   0.03758   1.33766
44.80508   0.19492   78.000  -3.03995   0.02965   1.30769
44.86320   0.13680   79.000  -3.03109   0.02079   1.27848
44.92561   0.07439   80.000  -3.02159   0.01129   1.25000
44.99032   0.00968   81.000  -3.01177   0.00147   1.22222
45.05525  -0.05525   82.000  -3.00193  -0.00837   1.19512
45.11835  -0.11835   83.000  -2.99240  -0.01791   1.16867
45.17765  -0.17765   84.000  -2.98345  -0.02685   1.14286
45.23130  -0.23130   85.000  -2.97538  -0.03492   1.11765
45.27763  -0.27763   86.000  -2.96842  -0.04188   1.09302
45.31521  -0.31521   87.000  -2.96278  -0.04752   1.06897
45.34291  -0.34291   88.000  -2.95863  -0.05168   1.04545
45.35988  -0.35988   89.000  -2.95608  -0.05422   1.02247
45.36559  -0.36559   90.000  -2.95523  -0.05507   1.00000
VAL( 1)=   44.51556
VAL( 2)=   44.65445
VAL( 3)=   44.63639
PEAK( 1) =   45.36109
PEAK( 2) =   45.35742
PEAK( 3) =   45.36559
  0.07345   0.05749
  0.05440   0.05749
  0.05270   0.05749
  0.05355   0.05749
  0.05547   0.05749
  0.05507   0.05749
B( 1 )= 0.00578
B( 3 )= 0.01472
B( 5 )= 0.02798
B( 7 )= 0.02729
B( 9 )= 0.01400
B(11 )=-0.01438
0 1
0 0
    NORMAL ERROR CORRECTION
```

FIG. 18. (Continued)

```
     GAMMA(1, 1 ) =  0.49403
     GAMMA(1, 2 ) =  0.14899
     GAMMA(1, 3 ) =  0.06872
     GAMMA(1, 4 ) =  0.03179
     GAMMA(1, 5 ) =  0.01374
Z( 1, 1 )= 4.50000          GAMMA ( 1, 1 )=.45228          COUPLING = 0.90588
Z( 1, 2 )= 1.65714          GAMMA ( 1, 2 )=.14899          COUPLING = 0.48457
Z( 1, 3 )= 1.25700          GAMMA ( 1, 3 )=.06872          COUPLING = 0.22482
Z( 1, 4 )= 1.09536          GAMMA ( 1, 4 )=.03179          COUPLING = 0.09083
Z( 1, 5 )= 1.02787          GAMMA ( 1, 5 )=.01374          COUPLING = 0.02748
Z( 2, 1 )= 1.08712          GAMMA ( 2, 1 )=.04174          COUPLING = 0.08334
```

ALPHA (DEGREES)	RIPPLE (DEGREES)	THETA (DEGREES)	COUPLING (DB)	RIPPLE (DB)	BANDWIDTH RATIO
44.57127	0.42873	21.176	-3.07578	0.06548	7.50000
7.97502	37.02498	2.000	-17.15589	14.14559	89.00000
11.81109	33.18891	3.000	-13.77826	10.76796	59.00000
15.47768	29.52232	4.000	-11.47423	8.46393	44.00000
18.93643	26.06357	5.000	-9.77520	6.76490	35.00000
22.16064	22.83936	6.000	-8.46846	5.45816	29.00000
25.13476	19.86524	7.000	-7.43736	4.42706	24.71429
27.85282	17.14718	8.000	-6.60991	3.59961	21.50000
30.31654	14.68346	9.000	-5.93801	2.92771	19.00000
32.53330	12.46670	10.000	-5.38775	2.37745	17.00000
34.51433	10.48567	11.000	-4.93428	1.92398	15.36364
36.27320	8.72680	12.000	-4.55891	1.54861	14.00000
37.82474	7.17526	13.000	-4.24727	1.23697	12.84615
39.18415	5.81585	14.000	-3.98820	0.97790	11.85714
40.36648	4.63352	15.000	-3.77287	0.76257	11.00000
41.38633	3.61367	16.000	-3.59423	0.58393	10.25000
42.25760	2.74240	17.000	-3.44661	0.43631	9.58824
42.99349	2.00651	18.000	-3.32539	0.31509	9.00000
43.60645	1.39355	19.000	-3.22678	0.21648	8.47368
44.10822	0.89178	20.000	-3.14762	0.13732	8.00000
44.50995	0.49005	21.000	-3.08523	0.07493	7.57143
44.82222	0.17778	22.000	-3.03733	0.02703	7.18182
45.05513	-0.05513	23.000	-3.00195	-0.00835	6.82609
45.21837	-0.21837	24.000	-2.97732	-0.03298	6.50000
45.32124	-0.32124	25.000	-2.96187	-0.04843	6.20000
45.37271	-0.37271	26.000	-2.95416	-0.05614	5.92308
45.38140	-0.38140	27.000	-2.95286	-0.05744	5.66667
45.35557	-0.35557	28.000	-2.95673	-0.05357	5.42857
45.30306	-0.30306	29.000	-2.96460	-0.04570	5.20690
45.23131	-0.23131	30.000	-2.97537	-0.03493	5.00000
45.14721	-0.14721	31.000	-2.98804	-0.02226	4.80645
45.05707	-0.05707	32.000	-3.00166	-0.00864	4.62500
44.96658	0.03342	33.000	-3.01537	0.00507	4.45455
44.88065	0.11935	34.000	-3.02843	0.01813	4.29412
44.80346	0.19654	35.000	-3.04020	0.02990	4.14286
44.73834	0.26166	36.000	-3.05015	0.03985	4.00000
44.68777	0.31223	37.000	-3.05789	0.04759	3.86486
44.65340	0.34660	38.000	-3.06316	0.05286	3.73684
44.63604	0.36396	39.000	-3.06583	0.05553	3.61538
44.63571	0.36429	40.000	-3.06588	0.05558	3.50000
44.65174	0.34826	41.000	-3.06342	0.05312	3.39024
44.68281	0.31719	42.000	-3.05865	0.04835	3.28571
44.72706	0.27294	43.000	-3.05187	0.04157	3.18605
44.78223	0.21777	44.000	-3.04344	0.03314	3.09091
44.84575	0.15425	45.000	-3.03375	0.02345	3.00000

FIG. 18. (Continued)

44.91485	0.08515	46.000	-3.02323	0.01293	2.91304
44.98666	0.01334	47.000	-3.01232	0.00202	2.82979
45.05837	-0.05837	48.000	-3.00146	-0.00884	2.75000
45.12728	-0.12728	49.000	-2.99105	-0.01925	2.67347
45.19090	-0.19090	50.000	-2.98146	-0.02884	2.60000
45.24700	-0.24700	51.000	-2.97302	-0.03728	2.52941
45.29371	-0.29371	52.000	-2.96600	-0.04430	2.46154
45.32953	-0.32953	53.000	-2.96063	-0.04967	2.39623
45.35337	-0.35337	54.000	-2.95706	-0.05324	2.33333
45.36460	-0.36460	55.000	-2.95538	-0.05492	2.27273
45.36297	-0.36297	56.000	-2.95562	-0.05468	2.21429
45.34872	-0.34872	57.000	-2.95776	-0.05254	2.15789
45.32245	-0.32245	58.000	-2.96169	-0.04861	2.10345
45.28519	-0.28519	59.000	-2.96728	-0.04302	2.05085
45.23828	-0.23828	60.000	-2.97433	-0.03597	2.00000
45.18338	-0.18338	61.000	-2.98259	-0.02771	1.95082
45.12239	-0.12239	62.000	-2.99179	-0.01851	1.90323
45.05738	-0.05738	63.000	-3.00161	-0.00869	1.85714
44.99056	0.00944	64.000	-3.01173	0.00143	1.81250
44.92417	0.07583	65.000	-3.02181	0.01151	1.76923
44.86042	0.13958	66.000	-3.03151	0.02121	1.72727
44.80143	0.19857	67.000	-3.04051	0.03021	1.68657
44.74916	0.25084	68.000	-3.04849	0.03819	1.64706
44.70533	0.29467	69.000	-3.05520	0.04490	1.60870
44.67136	0.32864	70.000	-3.06041	0.05011	1.57143
44.64835	0.35165	71.000	-3.06394	0.05364	1.53571
44.63704	0.36296	72.000	-3.06567	0.05537	1.50000
44.63776	0.36224	73.000	-3.06556	0.05526	1.46575
44.65043	0.34957	74.000	-3.06362	0.05332	1.43243
44.67462	0.32538	75.000	-3.05991	0.04961	1.40000
44.70947	0.29053	76.000	-3.05457	0.04427	1.36842
44.75382	0.24618	77.000	-3.04778	0.03748	1.33766
44.80618	0.19382	78.000	-3.03978	0.02948	1.30769
44.86484	0.13516	79.000	-3.03084	0.02054	1.27848
44.92788	0.07212	80.000	-3.02125	0.01095	1.25000
44.99326	0.00674	81.000	-3.01132	0.00102	1.22222
45.05890	-0.05890	82.000	-3.00138	-0.00892	1.19512
45.12271	-0.12271	83.000	-2.99174	-0.01856	1.16867
45.18268	-0.18268	84.000	-2.98269	-0.02761	1.14286
45.23695	-0.23695	85.000	-2.97453	-0.03577	1.11765
45.28382	-0.28382	86.000	-2.96749	-0.04281	1.09302
45.32186	-0.32186	87.000	-2.96178	-0.04852	1.06897
45.34989	-0.34989	88.000	-2.95758	-0.05272	1.04545
45.36705	-0.36705	89.000	-2.95501	-0.05529	1.02247
45.37284	-0.37284	90.000	-2.95415	-0.05615	1.00000

```
VAL( 1)=   44.57127
VAL( 2)=   44.63571
VAL( 3)=   44.63704
PEAK( 1) =    45.39140
PEAK( 2) =    45.36460
PEAK( 3) =    45.37284
  0.06548   0.05749
  0.05744   0.05749
  0.05558   0.05749
  0.05492   0.05749
  0.05537   0.05749
  0.05615   0.05749
 THE DESIGN DOES NOT MEET THE SPECIFICATIONS -- FAIL
                                        EXIT BY 6
```

FIG. 18. End.

```
 1 5 -0  3   1.00000  45.00000   0.01000   4.50000   7.50000

   0.49403   0.14899  0.06872   0.03179   0.01374

       FOR REFERENCE
123456789012345    0    5    0    5    0    5    0    5    0    5   012
```

FIG. 19.

Example E
Type 4 Data

Should it be desired to calculate a coupler similar to the presently completed one of example D except for Zoe = 3.0, then one could take the output data of example D (Fig. 19) to be the input now. However, one can save the punching of Γ's, Zoe's, etc., by punching CONT = 5. on the first data card. This simply saves the design data from the previous design to be the new starting data. Thus, Fig. 20 was prepared as input and Fig. 21-23 are its output.

One should use the Type 4 data input with some discretion. One would not, for instance, start the design of a 5-section phase shifter based on a previously completed design of a 6-section phase shifter.[3] However, one can start a solution by using a presently completed solution of basically the same device except changes in Z max. and BW, or both. Obviously, the greater the differences between the known and the desired designs, the longer the iteration process and the less efficient the method of design.

The computer execution time was 3.72 seconds.

---

[3] It is interesting to note that in preparing the input data for example C above, an error in copying data was made resulting in a deletion of a coupled section of Zoe = 1.8343. Thus, the machine started the design of a 5-section phase shifter with the data from basically a 6-section coupler (see Fig. 24 for actual input data cards). To see how the machine performed under this input, see Fig. 25 where the performance response's maxima/minima (peaks/valleys) are listed (between $\theta = 0$ degree to $\theta = 90$ degrees), also see Fig. 26 for final response plot. Thus, the initial response does not have the "proper" number of maxima/minima, but after one iteration, this has been rectified. No complete analysis has been made to specify, in general, how poor a starting solution can be and still have the machine converge on a meaningful result.

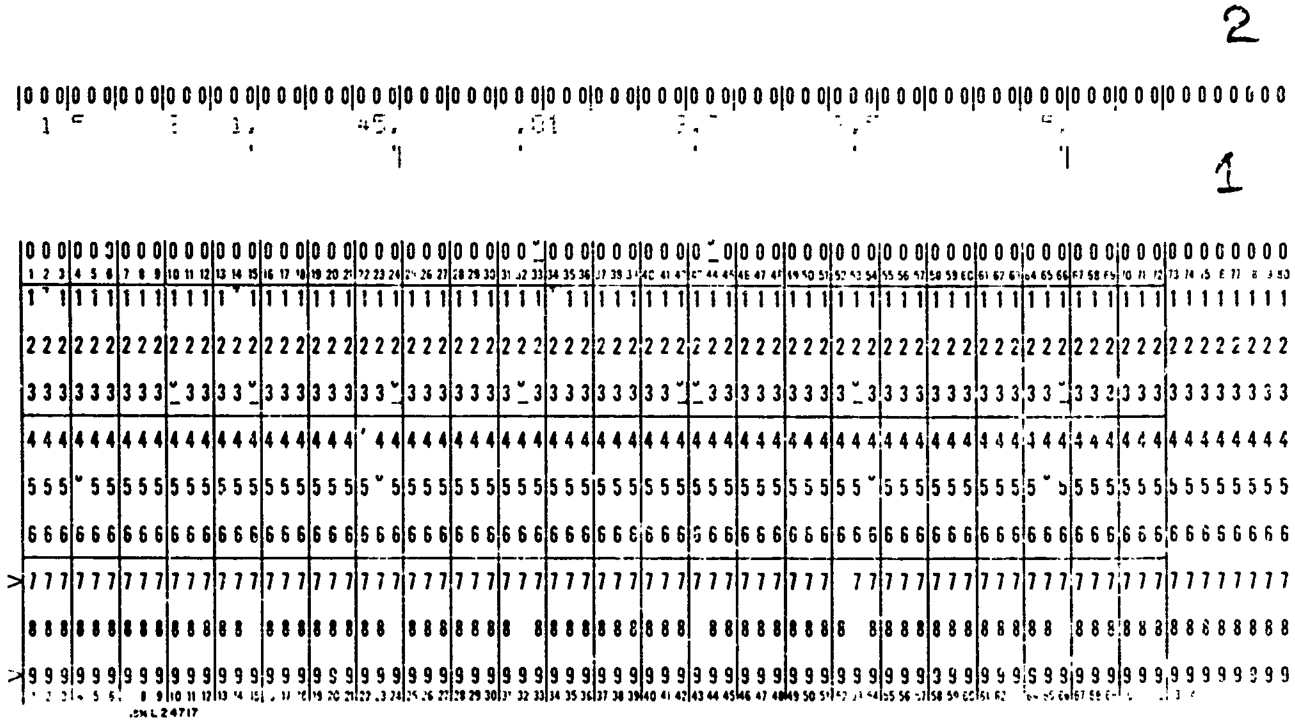
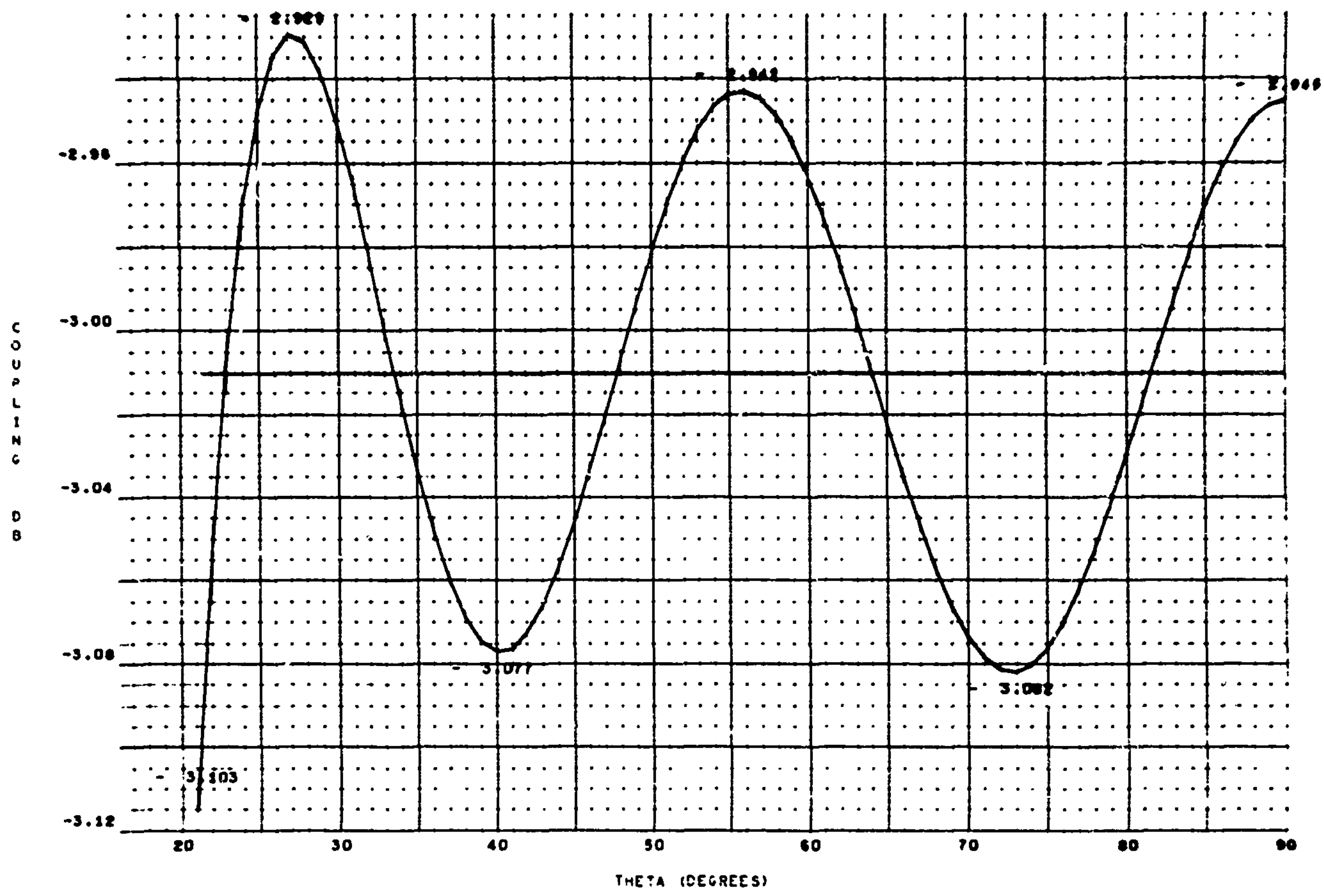


FIG. 20. Input Data Cards.



7.500 TO 1.0 BANDWIDTH COUPLER

3.00000	1.71721	1.27375	1.10174	1.02930
0.80000	0.49351	0.23734	0.09658	0.02887

1.56851
0.42200

FIG. 21. Response Curve and Design Data of Coupler.

```
UG = 45.0000     BW = 7.500     ZMAX = 3.00000     TOLERANCE=  0.01000     THE MAX. ALLOWABLE ITERATION(S) ARE =  3
      GAMMA(1, 1 ) =   0.49403
      GAMMA(1, 2 ) =   0.14899
      GAMMA(1, 3 ) =   0.06872
      GAMMA(1, 4 ) =   0.03179
      GAMMA(1, 5 ) =   0.01374
Z( 1, 1 )= 3.00000          GAMMA ( 1, 1 )=.27737          COUPLING = 0.80000
Z( 1, 2 )= 1.69714          GAMMA ( 1, 2 )=.14899          COUPLING = 0.48457
Z( 1, 3 )= 1.25700          GAMMA ( 1, 3 )=.06872          COUPLING = 0.22482
Z( 1, 4 )= 1.09536          GAMMA ( 1, 4 )=.03179          COUPLING = 0.09083
Z( 1, 5 )= 1.02787          GAMMA ( 1, 5 )=.01374          COUPLING = 0.02746
Z( 2, 1 )= 1.55315          GAMMA ( 2, 1 )=.21665          COUPLING = 0.41388
VAL( 1)=    44.03745
VAL( 2)=    44.98100
VAL( 3)=    45.50417
PEAK( 1) =    45.47265
PEAK( 2) =    45.76817
PEAK( 3) =    45.23379
   0.14840    0.07473
   0.07106    0.07473
   0.00288    0.07473
   0.11490    0.07473
   0.07582    0.07473
   0.03530    0.07473
B( 1 )=-0.10551
B( 3 )=-0.07071
B( 5 )= 0.30377
B( 7 )= 0.14159
B( 9 )= 0.02573
B(11 )=-0.07159
0 1
0 0
      CAUTIOUS ERROR CORRECTION ( 0.500X)
      GAMMA(1, 1 ) =   0.49357
      GAMMA(1, 2 ) =   0.14868
      GAMMA(1, 3 ) =   0.07004
      GAMMA(1, 4 ) =   0.03240
      GAMMA(1, 5 ) =   0.01385
Z( 1, 1 )= 3.00000          GAMMA ( 1, 1 )=.27576          COUPLING = 0.80000
Z( 1, 2 )= 1.70308          GAMMA ( 1, 2 )=.14868          COUPLING = 0.48724
Z( 1, 3 )= 1.26220          GAMMA ( 1, 3 )=.07004          COUPLING = 0.22874
Z( 1, 4 )= 1.09696          GAMMA ( 1, 4 )=.03240          COUPLING = 0.09228
Z( 1, 5 )= 1.02810          GAMMA ( 1, 5 )=.01386          COUPLING = 0.02771
Z( 2, 1 )= 1.55691          GAMMA ( 2, 1 )=.21781          COUPLING = 0.41588
VAL( 1)=    44.14386
VAL( 2)=    44.83016
VAL( 3)=    44.50542
PEAK( 1) =    45.48783
PEAK( 2) =    45.61377
PEAK( 3) =    45.29504
   0.13175    0.07385
   0.07333    0.07385
   0.02582    0.07385
   0.09206    0.07385
   0.07563    0.07385
   0.04450    0.07385
B( 1 )=-0.04063
B( 3 )=-0.03794
B( 5 )= 0.20366
B( 7 )= 0.11312
B( 9 )= 0.02819
```

FIG. 22. "Written" Machine Output.

```
B(11 )=-0.05401
0 1
0 0
        NORMAL ERROR CORRECTION
     GAMMA(1, 1 ) =  0.49321
     GAMMA(1, 2 ) =  C.14835
     GAMMA(1, 3 ) =  0.07182
     GAMMA(1, 4 ) =  0.03339
     GAMMA(1, 5 ) =  0.01410
Z( 1, 1 )= 3.00000            GAMMA ( 1, 1 )=.27328         COUPLING = 0.80000
Z( 1, 2 )= 1.71224            GAMMA ( 1, 2 )=.14835         COUPLING = 0.49132
Z( 1, 3 )= 1.[illegible]6985  GAMMA ( 1, 3 )=.07182         COUPLING = 0.23445
Z( 1, 4 )= 1.0[illegible]467  GAMMA ( 1, 4 )=.03339         COUPLING = 0.09473
Z( 1, 5 )= 1.02861            GAMMA ( 1, 5 )=.01410         COUPLING = 0.02820
Z( 2, 1 )= 1.56388            GAMMA ( 2, 1 )=.21993         COUPLING = 0.41957
VAL( 1)=   44.31430
VAL( 2)=   44.63572
VAL( 3)=   44.52018
PEAK( 1) =   45.52400
PEAK( 2) =   45.45020
PEAK( 3) =   45.38812
  0.10520   0.07319
  0.07883   0.07319
  0.05558   0.07319
  0.06772   0.07319
  0.07335   0.07319
  0.05844   0.07319
B( 1 )= 0.00761
B( 3 )=-0.00929
B( 5 )= 0.06779
B( 7 )= 0.06859
B( 9 )= 0.03875
B(11 )=-0.02927
0 1
0 0
        NORMAL ERROR CORRECTION
     GAMMA(1, 1 ) =  C.49328
     GAMMA(1, 2 ) =  C.14827
     GAMMA(1, 3 ) =  0.07241
     GAMMA(1, 4 ) =  0.03399
     GAMMA(1, 5 ) =  C.01444
Z( 1, 1 )= 3.00000            GAMMA ( 1, 1 )=.27194         COUPLING = 0.80000
Z( 1, 2 )= 1.71721            GAMMA ( 1, 2 )=.14827         COUPLING = 0.49352
Z( 1, 3 )= 1.27375            GAMMA ( 1, 3 )=.07241         COUPLING = 0.23735
Z( 1, 4 )= 1.10174            GAMMA ( 1, 4 )=.03399         COUPLING = 0.09659
Z( 1, 5 )= 1.02930            GAMMA ( 1, 5 )=.01444         COUPLING = 0.02887
Z( 2, 1 )= 1.56851            GAMMA ( 2, 1 )=.22134         COUPLING = 0.42200
VAL( 1)=   44.39341
VAL( 2)=   44.56303
VAL( 3)=   44.53014
PEAK( 1) =   45.53736
PEAK( 2) =   45.44840
PEAK( 3) =   45.43114
  0.09294   0.07409
  0.08070   0.07409
  0.06675   0.07409
  0.06745   0.07409
  0.07182   0.07409
  0.06487   0.07409
     THE DESIGN DOES NOT MEET THE SPECIFICATIONS -- FAIL
                                          EXIT BY 6
  Z(1, 1)     4.50000  3.00000
  Z(1, 2)     1.69714  1.71721
  Z(1, 3)     1.25700  1.27375
  Z(1, 4)     1.09536  1.10174
  Z(1, 5)     1.02787  1.02930
  Z(2, 1)     1.08712  1.56851
```

FIG. 22. End.

```
1 5 -0  3    1.00000  45.00000   0.01000   3.00000   7.50000
    0.49328   0.14827  0.07241   0.03399   0.01444

        FOR REFERENCE
123456789012345      0    5    0    5    0    5    0    5    0    5    012
```

FIG. 23.

1.566 10

1 9

1.83434 1.17 8
0 0

2 7

1.83434 1.83434 1.223 6
0 0 0

3 5

1.83434 1.83434 1.725 1.385 1.2 4
0 0 0 0 0

3

1 4 1.00001 2
0

5 5 2. 90. .03 1.83434 17. 1
2 0 0 0 0

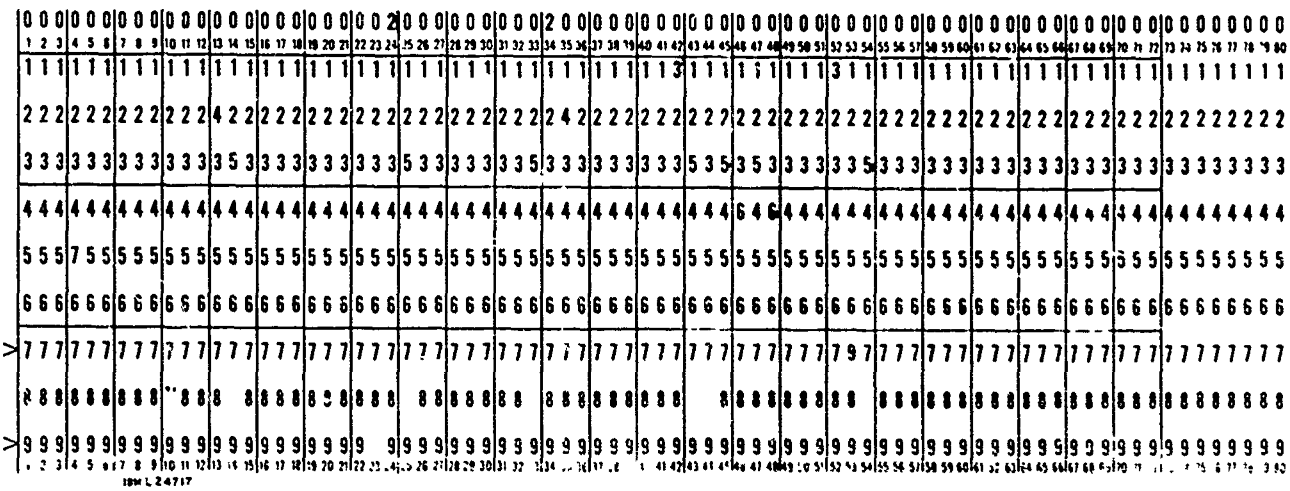


FIG. 24. Input Data Cards.

```
U0 = 90.0000    BW =17.000    ZMAX = 1.83434    TØLERANCE=  0.02000     THE MAX. ALLØWABLE ITERATIØN(S) ARE =  8
   1.83434    1.83434    1.72500    1.38500    1.20000
   1.83434    1.83434    1.22300
   1.83434    1.17000
   1.56600
     GAMMA(1, 1 ) =  0.44170
     GAMMA(1, 2 ) =  0.30902
     GAMMA(1, 3 ) =  0.20964
     GAMMA(1, 4 ) =  0.07157
     GAMMA(1, 5 ) =  0.09091
Z( 1, 1 )= 1.83434            GAMMA ( 1, 1 )=.             CØUPLING = 0.54179
Z( 1, 2 )= 1.83434            GAMMA ( 1, 2 )=.             CØUPLING = 0.54179
Z( 1, 3 )= 1.83434            GAMMA ( 1, 3 )=.13958        CØUPLING = 0.54179
Z( 1, 4 )= 1.38500            GAMMA ( 1, 4 )=.07157        CØUPLING = 0.31465
Z( 1, 5 )= 1.20000            GAMMA ( 1, 5 )=.09091        CØUPLING = 0.18033
Z( 2, 1 )= 1.83434            GAMMA ( 2, 1 )=.             CØUPLING = 0.54179
Z( 2, 2 )= 1.83434            GAMMA ( 2, 2 )=.22903        CØUPLING = 0.54179
Z( 2, 3 )= 1.15069            GAMMA ( 2, 3 )=.07006        CØUPLING = 0.13944
Z( 3, 1 )= 1.83434            GAMMA ( 3, 1 )=.21955        CØUPLING = 0.54179
Z( 3, 2 )= 1.17389            GAMMA ( 3, 2 )=.07999        CØUPLING = 0.15896
Z( 4, 1 )= 1.57121            GAMMA ( 4, 1 )=.22216        CØUPLING = 0.42342

VAL( 1)=    79.02715
VAL( 2)=    79.37369
PEAK( 1) =   108.53836
PEAK( 2) =   103.10774
  10.97285    8.87421
 -18.53836    8.87421
  10.62631    8.87421
 -13.10774    8.6 421
B( 2 )=-3.64270
B( 4 )=-2.84412
B( 6 )=-1.62745
B( 8 )= 2.09687
B(10 )= 0.30100
B(12 )= 1.70949
0 2
0 0
     CAUTIØUS ERRØR CØRRECTIØN ( 0.500X)
     GAMMA(1, 1 ) =  0.40991
     GAMMA(1, 2 ) =  0.28420
     GAMMA(1, 3 ) =  0.19544
     GAMMA(1, 4 ) =  0.08987
     GAMMA(1, 5 ) =  0.09354
Z( 1, 1 )= 1.83434            GAMMA ( 1, 1 )=.             CØUPLING = 0.54179
Z( 1, 2 )= 1.83434            GAMMA ( 1, 2 )=.             CØUPLING = 0.54179
Z( 1, 3 )= 1.83434            GAMMA ( 1, 3 )=.11886        CØUPLING = 0.54179
Z( 1, 4 )= 1.44461            GAMMA ( 1, 4 )=.08987        CØUPLING = 0.35210
Z( 1, 5 )= 1.20637            GAMMA ( 1, 5 )=.09354        CØUPLING = 0.18545
Z( 2, 1 )= 1.83434            GAMMA ( 2, 1 )=.             CØUPLING = 0.54179
Z( 2, 2 )= 1.83434            GAMMA ( 2, 2 )=.22281        CØUPLING = 0.54179
Z( 2, 3 )= 1.16586            GAMMA ( 2, 3 )=.07658        CØUPLING = 0.15226
Z( 3, 1 )= 1.83434            GAMMA ( 3, 1 )=.23727        CØUPLING = 0.54179
Z( 3, 2 )= 1.13080            GAMMA ( 3, 2 )=.06139        CØUPLING = 0.12231
Z( 4, 1 )= 1.41734            GAMMA ( 4, 1 )=.17264        CØUPLING = 0.33530

VAL( 1)=    77.66069
VAL( 2)=    84.04846
VAL( 3)=    80.13509
PEAK( 1) =   104.45723
PEAK( 2) =    85.22576
```

FIG. 25

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FIG. 25.

```
PEAK( 3) =    99.96368
 12.33931    9.55849
-14.45723    9.55849
  5.95154    9.55849
  4.77424    9.55849
  5.86491    9.55849
 -9.96368    9.55849
B( 2 )= 2.49336
B( 4 )=-1.94682
B( 6 )=-3.91717
B( 8 )= 1.50809
B(10 )= 3.73471
B(12 )= 0.53852
0 2
0 0
         NORMAL ERROR CORRECTION
      GAMMA(1, 1 ) =   C.45343
      GAMMA(1, 2 ) =   C.25022
      GAMMA(1, 3 ) =   0.12707
      GAMMA(1, 4 ) =   C.11619
      GAMMA(1, 5 ) =   C.15872
Z( 1, 1 )= 1.83434          GAMMA ( 1, 1 )=.            COUPLING = 0.54179
Z( 1, 2 )= 1.83434          GAMMA ( 1, 2 )=.            COUPLING = 0.54179
Z( 1, 3 )= 1.83434          GAMMA ( 1, 3 )=.02655       COUPLING = 0.54179
Z( 1, 4 )= 1.73945          GAMMA ( 1, 4 )=.11619       COUPLING = 0.50319
Z( 1, 5 )= 1.37733          GAMMA ( 1, 5 )=.15872       COUPLING = 0.30964
Z( 2, 1 )= 1.83434          GAMMA ( 2, 1 )=.            COUPLING = 0.54179
Z( 2, 2 )= 1.83434          GAMMA ( 2, 2 )=.19976       COUPLING = 0.54179
Z( 2, 3 )= 1.22351          GAMMA ( 2, 3 )=.10052       COUPLING = 0.19903
Z( 3, 1 )= 1.83434          GAMMA ( 3, 1 )=.24759       COUPLING = 0.54179
Z( 3, 2 )= 1.10628          GAMMA ( 3, 2 )=.05046       COUPLING = 0.10066
Z( 4, 1 )= 1.51841          GAMMA ( 4, 1 )=.20585       COUPLING = 0.39496

VAL( 1)=    81.11431
VAL( 2)=    75.76743
VAL( 3)=    81.71696
PEAK( 1) =    99.63038
PEAK( 2) =   105.58012
PEAK( 3) =   102.53235
  8.88569   11.52402
 -9.63038   11.52402
 14.23257   11.52402
-15.58012   11.52402
  8.28304   11.52402
-12.53235   11.52402
B( 2 )=-1.81499
B( 4 )= 2.15919
B( 6 )= 0.50667
B( 8 )=-0.96798
B(10 )=-1.03985
B(12 )=-0.60214
0 2
0 0
         NORMAL ERROR CORRECTION
      GAMMA(1, 1 ) =   C.42172
      GAMMA(1, 2 ) =   C.28790
      GAMMA(1, 3 ) =   C.13591
      GAMMA(1, 4 ) =   C.09929
      GAMMA(1, 5 ) =   C.14057
Z( 1, 1 )= 1.83434          GAMMA ( 1, 1 )=.            COUPLING = 0.54179
Z( 1, 2 )= 1.83434          GAMMA ( 1, 2 )=.            COUPLING = 0.54179
Z( 1, 3 )= 1.83434          GAMMA ( 1, 3 )=.06213       COUPLING = 0.54179
Z( 1, 4 )= 1.61972          GAMMA ( 1, 4 )=.09929       COUPLING = 0.44805
Z( 1, 5 )= 1.32712          GAMMA ( 1, 5 )=.14057       COUPLING = 0.27569
Z( 2, 1 )= 1.83434          GAMMA ( 2, 1 )=.            COUPLING = 0.54179
Z( 2, 2 )= 1.83434          GAMMA ( 2, 2 )=.22549       COUPLING = 0.54179
```

FIG. 25. (Continued)

```
Z( 2, 3 )= 1.15931          GAMMA ( 2, 3 )=.07378          COUPLING = 0.14676
Z( 3, 1 )= 1.83434          GAMMA ( 3, 1 )=.23629          COUPLING = 0.54179
Z( 3, 2 )= 1.13314          GAMMA ( 3, 2 )=.06242          COUPLING = 0.12435
Z( 4, 1 )= 1.45527          GAMMA ( 4, 1 )=.18543          COUPLING = 0.35853

VAL( 1)=   79.49659
VAL( 2)=   80.42321
VAL( 3)=   74.75529
PEAK( 1) =  100.30775
PEAK( 2) =   97.99684
PEAK( 3) =   93.39865
 10.50341  10.50469
-10.30775  10.50469
  9.57679  10.50469
 -7.99684  10.50469
 15.24471  10.50469
 -9.39865  10.50469
B( 2 )= 2.29813
B( 4 )=-2.09003
B( 6 )= 0.11327
B( 8 )= 0.55265
B(10 )=-0.01998
B(12 )= 0.17868
0 2
0 2
THE ERRØR CØEFFICIENT  2 IS ØSCILLATING, APPLY FIX 1
    GAMMA(1, 1 ) =  0.44075
    GAMMA(1, 2 ) =  0.26529
    GAMMA(1, 3 ) =  0.13061
    GAMMA(1, 4 ) =  0.10943
    GAMMA(1, 5 ) =  0.15146
Z( 1, 1 )= 1.83434          GAMMA ( 1, 1 )=.               COUPLING = 0.54179
Z( 1, 2 )= 1.83434          GAMMA ( 1, 2 )=.               COUPLING = 0.54179
Z( 1, 3 )= 1.83434          GAMMA ( 1, 3 )=.04082          COUPLING = 0.54179
Z( 1, 4 )= 1.69047          GAMMA ( 1, 4 )=.10943          COUPLING = 0.48155
Z( 1, 5 )= 1.35699          GAMMA ( 1, 5 )=.15146          COUPLING = 0.29613
Z( 2, 1 )= 1.83434          GAMMA ( 2, 1 )=.               COUPLING = 0.54179
Z( 2, 2 )= 1.83434          GAMMA ( 2, 2 )=.21013          COUPLING = 0.54179
Z( 2, 3 )= 1.19729          GAMMA ( 2, 3 )=.08979          COUPLING = 0.17814
Z( 3, 1 )= 1.83434          GAMMA ( 3, 1 )=.24316          COUPLING = 0.54179
Z( 3, 2 )= 1.11676          GAMMA ( 3, 2 )=.05516          COUPLING = 0.10999
Z( 4, 1 )= 1.49250          GAMMA ( 4, 1 )=.19759          COUPLING = 0.38034

VAL( 1)=   80.47932
VAL( 2)=   77.71130
VAL( 3)=   78.98535
PEAK( 1) =   99.94876
PEAK( 2) =  102.38905
PEAK( 3) =  101.21535
  9.52068  11.06286
 -9.94876  11.06286
 12.28870  11.06286
-12.38905  11.06286
 11.01465  11.06286
-11.21535  11.06286
B( 2 )=-0.12480
B( 4 )= 0.47764
B( 6 )= 0.30856
B( 8 )=-0.42259
B(10 )=-0.63875
B(12 )=-0.23670
0 2
0 2
THE ERRØR CØEFFICIENT  2 IS ØSCILLATING, APPLY FIX 1; because B(2)'s + 2.49 → - 1.82 → + 2.30
    GAMMA(1, 1 ) =  0.43440
    GAMMA(1, 2 ) =  0.27283
```

FIG. 25. (Continued)

```
     GAMMA(1, 3 ) =  0.13238
     GAMMA(1, 4 ) =  C.10605
     GAMMA(1, 5 ) =  C.14783
Z( 1, 1 )= 1.83434          GAMMA ( 1, 1 )=.                COUPLING = 0.54179
Z( 1, 2 )= 1.83434          GAMMA ( 1, 2 )=.                COUPLING = 0.54179
Z( 1, 3 )= 1.83434          GAMMA ( 1, 3 )=.04793           COUPLING = 0.54179
Z( 1, 4 )= 1.66653          GAMMA ( 1, 4 )=.10605           COUPLING = 0.47052
Z( 1, 5 )= 1.34695          GAMMA ( 1, 5 )=.14783           COUPLING = 0.28934
Z( 2, 1 )= 1.83434          GAMMA ( 2, 1 )=.                COUPLING = 0.54179
Z( 2, 2 )= 1.83434          GAMMA ( 2, 2 )=.21528           COUPLING = 0.54179
Z( 2, 3 )= 1.18446          GAMMA ( 2, 3 )=.08444           COUPLING = 0.16769
Z( 3, 1 )= 1.83434          GAMMA ( 3, 1 )=.24090           COUPLING = 0.54179
Z( 3, 2 )= 1.12213          GAMMA ( 3, 2 )=.05755           COUPLING = 0.11472
Z( 4, 1 )= 1.47988          GAMMA ( 4, 1 )=.19351           COUPLING = 0.37305

VAL( 1)=    80.15573
VAL( 2)=    78.61826
VAL( 3)=    77.59271
PEAK( 1) =   100.08380
PEAK( 2) =   100.77907
PEAK( 3) =   100.58876
  9.84427  10.84749
-10.08380  10.84749
 11.38174  10.84749
-10.77807  10.84749
 12.40729  10.84749
-10.58876  10.84749
B( 2 )= 0.69358
B( 4 )=-0.38295
B( 6 )= 0.23612
B( 8 )=-0.09466
B(10 )=-0.43602
B(12 )=-0.C9462
0 2
0 2
THE ERROR COEFFICIENT  2 IS OSCILLATING, APPLY FIX 1
     GAMMA(1, 1 ) =  0.43758
     GAMMA(1, 2 ) =  C.26906
     GAMMA(1, 3 ) =  C.13149
     GAMMA(1, 4 ) =  C.10774
     GAMMA(1, 5 ) =  0.14964
Z( 1, 1 )= 1.63434          GAMMA ( 1, 1 )=.                COUPLING = 0.54179
Z( 1, 2 )= 1.83434          GAMMA ( 1, 2 )=.                COUPLING = 0.54179
Z( 1, 3 )= 1.83434          GAMMA ( 1, 3 )=.04438           COUPLING = 0.54179
Z( 1, 4 )= 1.67845          GAMMA ( 1, 4 )=.1C774           COUPLING = 0.47606
Z( 1, 5 )= 1.35196          GAMMA ( 1, 5 )=.14964           COUPLING = 0.29273
Z( 2, 1 )= 1.83434          GAMMA ( 2, 1 )=.                COUPLING = 0.54179
Z( 2, 2 )= 1.83434          GAMMA ( 2, 2 )=.21271           COUPLING = 0.54179
Z( 2, 3 )= 1.19085          GAMMA ( 2, 3 )=.08711           COUPLING = 0.17292
Z( 3, 1 )= 1.83434          GAMMA ( 3, 1 )=.24203           COUPLING = 0.54179
Z( 3, 2 )= 1.11944          GAMMA ( 3, 2 )=.05635           COUPLING = 0.11235
Z( 4, 1 )= 1.48616          GAMMA ( 4, 1 )=.19555           COUPLING = 0.37669

VAL( 1)=    80.31802
VAL( 2)=    78.16516
VAL( 3)=    78.29124
PEAK( 1) =   100.01824
PEAK( 2) =   101.58523
PEAK( 3) =   100.89941
  9.68198  10.95474
-10.01824  10.95474
 11.83484  10.95474
-11.58523  10.95474
 11.70876  10.95474
-10.89941  10.95474
B( 2 )= 0.28324
```

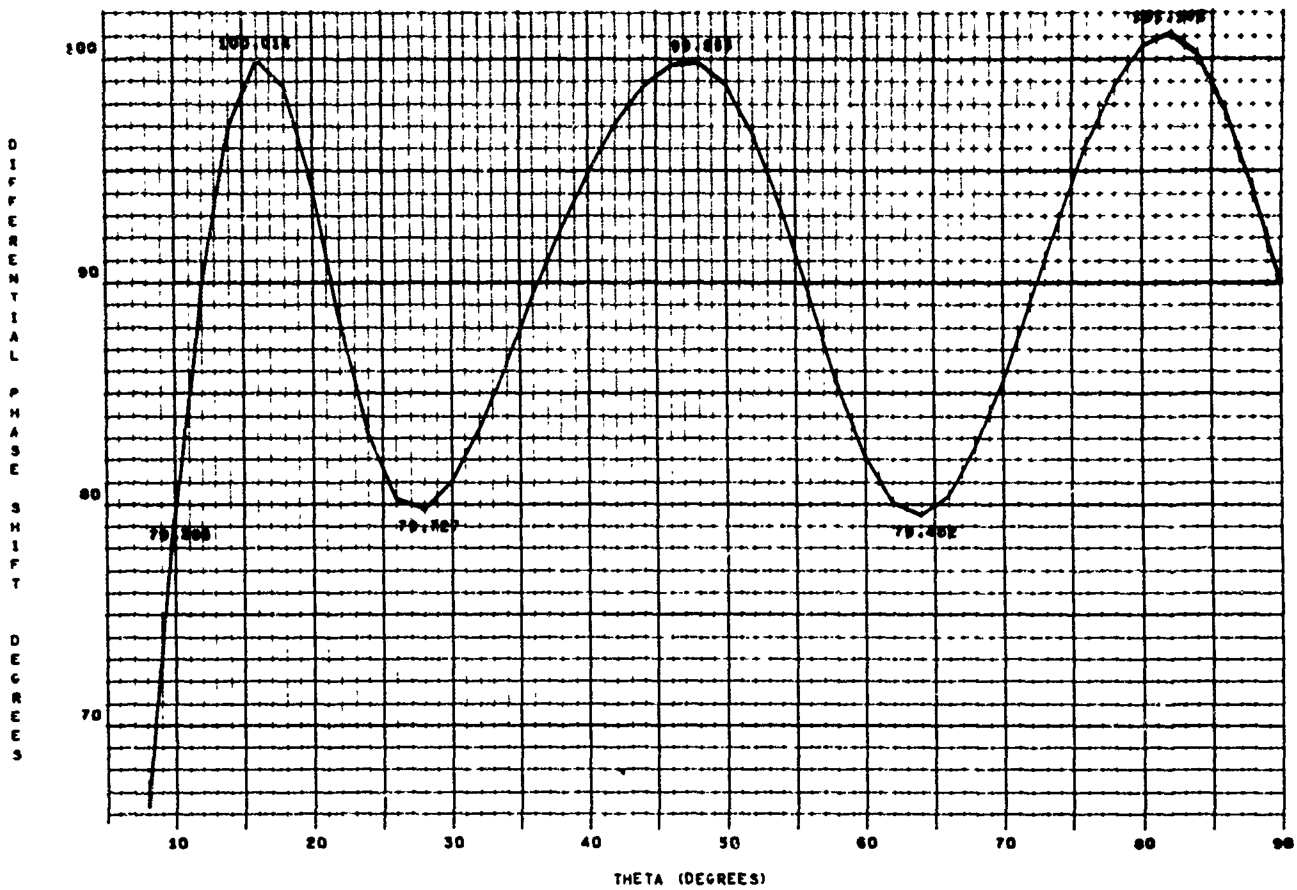
FIG. 25. (Continued)

```
B( 4 )= 0.04714
B( 6 )= 0.27264
B( 8 )=-0.25962
B(10 )=-0.53697
B(12 )=-0.16581
0 2
0 0
      NORMAL ERROR CORRECTION
    GAMMA(1, 1 ) =  0.44252
    GAMMA(1, 2 ) =  0.26589
    GAMMA(1, 3 ) =  0.13625
    GAMMA(1, 4 ) =  0.10321
    GAMMA(1, 5 ) =  0.14027
Z( 1, 1 )= 1.83434          GAMMA ( 1, 1 )=.            COUPLING = 0.54179
Z( 1, 2 )= 1.83434          GAMMA ( 1, 2 )=.            COUPLING = 0.54179
Z( 1, 3 )= 1.83434          GAMMA ( 1, 3 )=.05850       COUPLING = 0.54179
Z( 1, 4 )= 1.63160          GAMMA ( 1, 4 )=.10321       COUPLING = 0.45387
Z( 1, 5 )= 1.32632          GAMMA ( 1, 5 )=.14027       COUPLING = 0.27513
Z( 2, 1 )= 1.83434          GAMMA ( 2, 1 )=.            COUPLING = 0.54179
Z( 2, 2 )= 1.83434          GAMMA ( 2, 2 )=.22169       COUPLING = 0.54179
Z( 2, 3 )= 1.16862          GAMMA ( 2, 3 )=.07775       COUPLING = 0.15458
Z( 3, 1 )= 1.83434          GAMMA ( 3, 1 )=.24971       COUPLING = 0.54179
Z( 3, 2 )= 1.10128          GAMMA ( 3, 2 )=.04820       COUPLING = 0.09617
Z( 4, 1 )= 1.47772          GAMMA ( 4, 1 )=.19281       COUPLING = 0.37179

VAL( 1)=    79.39363
VAL( 2)=    79.72717
VAL( 3)=    79.48201
PEAK( 1) =  100.01439
PEAK( 2) =   99.85551
PEAK( 3) =  101.14183
 10.69637  10.40149
-10.01439  10.40149
 10.27283  10.40149
 -9.85551  10.40149
 10.51799  10.40149
-11.14183  10.40149
    THE DESIGN DOES NOT MEET THE SPECIFICATIONS -- FAIL
                                      EXIT BY 7

    EXIT 1  IMPEDANCES ARE LESS THAN 1.0
    EXIT 2  TOO MANY PEAKS/VALLEYS IN RESPONSE CURVE
    EXIT 3  TOO FEW PEAKS/VALLEYS FOR ERROR ANALYSIS
    EXIT 4  DESIGN OF PHASE SHIFTER NOW COMPLETED
    EXIT 5  DESIGN OF COUPLER NOW COMPLETED
    EXIT 6  DESIGN OF COUPLER USED MAX. ALLOWABLE ITERATIONS
    EXIT 7  DESIGN OF PHASE SHIFTER USED MAX. ALLOW. ITERATIONS
    EXIT 8  A PEAK AND VALLEY ARE BEYOND BANDWIDTH EDGE
```

FIG. 25. End.



17.000 TO 1.0 BANDWIDTH PHASE SHIFTER

1.83434	1.83434	1.83434	1.83180	1.32832
0.54178	0.54178	0.54178	0.49588	0.27313
1.83434	1.83434	1.16802		
0.54178	0.54178	0.15457		
1.83434	1.10128			
0.54178	0.08617			
1.47772				
0.37179				

FIG. 26. Final Response Curve and Design Data of Phase Shifter.

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13 ABSTRACT

ABSTRACT. This report discloses the full FORTRAN IV program (for an IBM 7094 digital computer) for the automatic design of arbitrary TEM quadrature couplers and differential phase shifters. The design is completely general in the sense that any number of coupled quarter wavelength sections, any nominal coupling value (or phase shift), and any design bandwidth of operation can be realized, although the user may specify any maximum coupling value in the design. This last degree of freedom in the specification to the machine, which is all-important in the physical realization of a theoretical design, is met by finding the proper number and types of tandem coupled junctions in the solution. This computer solution will be optimum. It will find the least ripple for the required bandwidth of operation for any (input) design complexity.

This report shows a complete flow chart of the total program. It also gives the special subroutines developed for automatic plotting of the coupler (or phase shifter) frequency-response functions. Various sample input data and machine outputs are also included.

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