

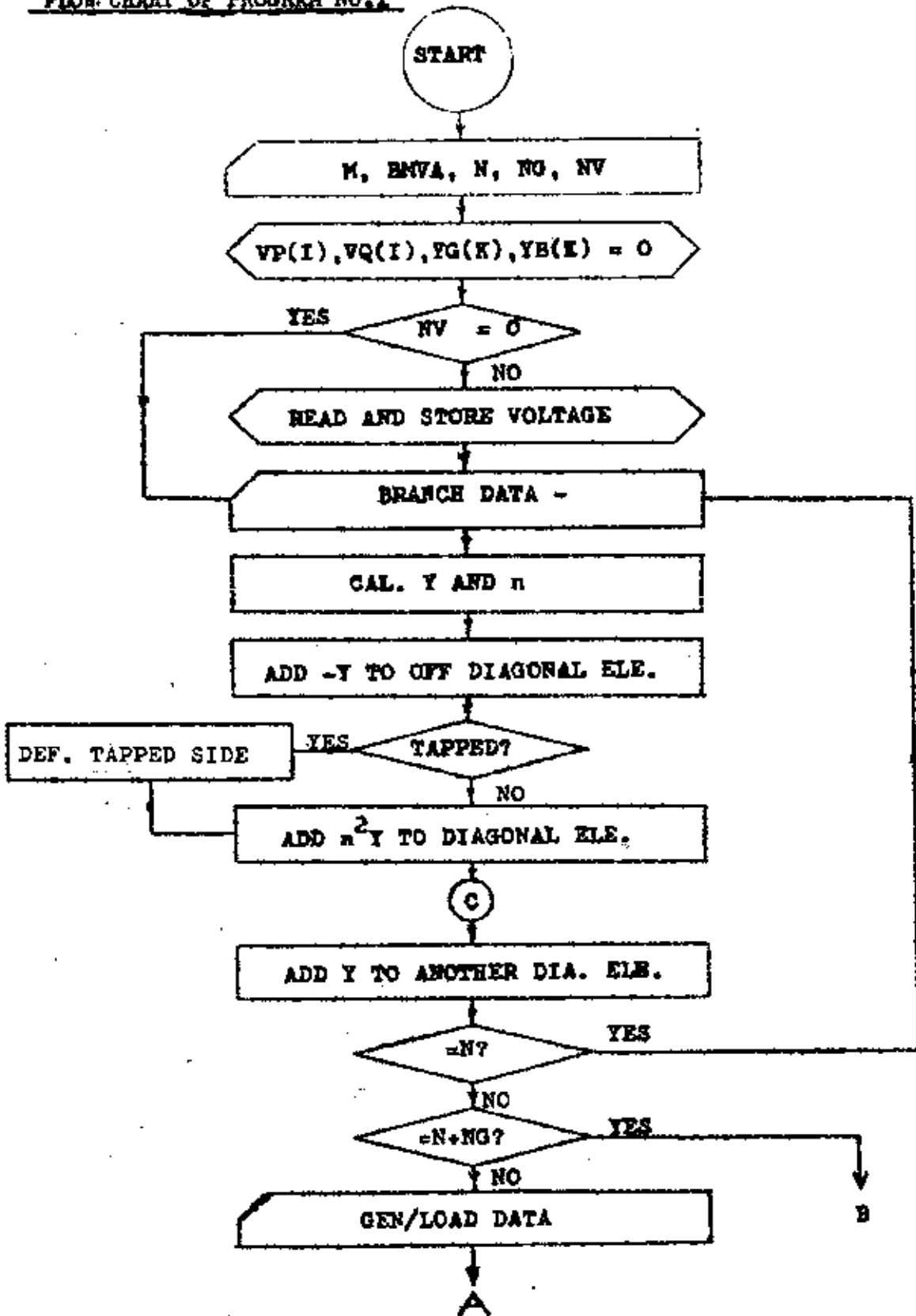
REFERENCES

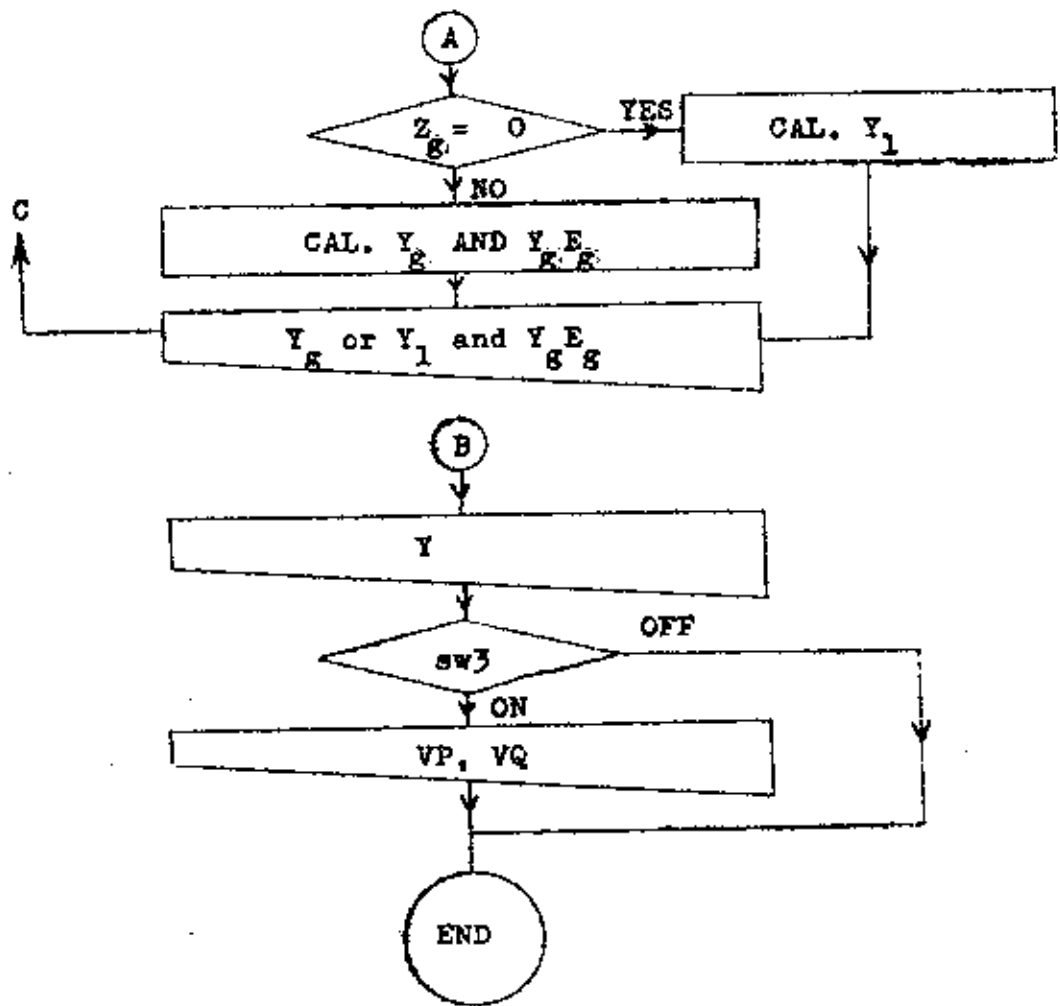
1. Brameller, A. and Deanmend, J.K. : 'Some Improved Methods for Digital Network Analysis', Proc. I.E.E., Vol. 109, Part A, No. 43, February 1962, p.p. 109-116 (paper No. 37785)
2. Day, J.E. and Parton, K.C.: 'Generalised Computer Program for Power-System Analysis', Proc. I.E.E., Vol 112, No. 12, December 1965, p.p. 2261-2274 (paper No. 4864P)
3. Ward, J.B., and Hale, H.W.: 'Digital Computer Solution of Power Flow Problems', Transactions of the American I.E.E., June, 1956.
4. Gupta, P.P. and Humphrey Davies, M.W.: 'Digital Computers in Power System Analysis', Proc. I.E.E. Vol. 108, Part A, No. 41, October 1961, p.p. 383-404 (paper No. 34845).
5. Stevenson, W.D. Elements of Power System Analysis, McGraw-Hill, 1962.
6. 'Electrical Transmission and Distribution Reference Book', Westinghouse Electric Corporation, East Pittsburgh, Pa., Fourth edition, 1950.
7. Edith Clarke, Circuit Analysis of A-C Power Systems, Vol. 1, Wiley, 1943.

8. Engineering Report No. 602/SD 10, 520 , Associated Electrical Industries Limited, England, 1963.
9. Engineering Report No. 602/SD 10, 524 , Associated Electrical Industries Limited, England, 1964.
10. Golden James T. : Programming and Computing, Prentice Hall Inc. 1965
11. Report No. 2 on Fault Level Study, Planning Department, Yankee Electricity Authority, 1965.

APPENDIX A

FLOW CHART OF PROGRAM NO. 1





```

C      PROGRAM NO. 1
C      FORMATION OF NODAL ADMITTANCE MATRIX
      DIMENSION YG(210),YB(210),VP(20),VQ(20)
      READ180,M
      READ184,BMVA
      READ180,N
      READ180,NG
      READ180,NV
      NN=N+NG
      PRINT199

      DO1001=1,M
      DO100J=1,M
      K=J*(J-1)/2+1
      VP{1}=0.
      VQ{1}=0.
      YG{K}=0.
100  YB{K}=0.
      KCH=0
      IF(NV)141,101,141
141  KV=0
143  READ183,1,VM,VD
      VD=VD/57.296
      VP{1}=VM*(COS(VD))
      VQ{1}=VM*(SIN(VD))
      KV=KV+1
      IF(KV-NV)143,101,101
101  READ181,1,J,L,TI,TJ,TR,IV,JV,G,B,Y,KSQ
      KCH=KCH+1
      TR= 100./(TR+100.)
      D=G*G+B*B
      G=G/D
      B=-B/D
      K=J*(J-1)/2+1
      YG{K}=YG{K}-TR*G
      YB{K}=YB{K}-TR*B
      IF(JV-IV)109,110,110
109  IB=1
      IS=J
      GO TO 111
110  IB=J
      IS=1
111  K=IB*(IB-1)/2+IB
      D=TR*TR
      YG{K}=YG{K}+D*G
      YB{K}=YB{K}+D*B+Y
130  K=IS*(IS-1)/2+IS
      YG{K}=YG{K}+G

```

```

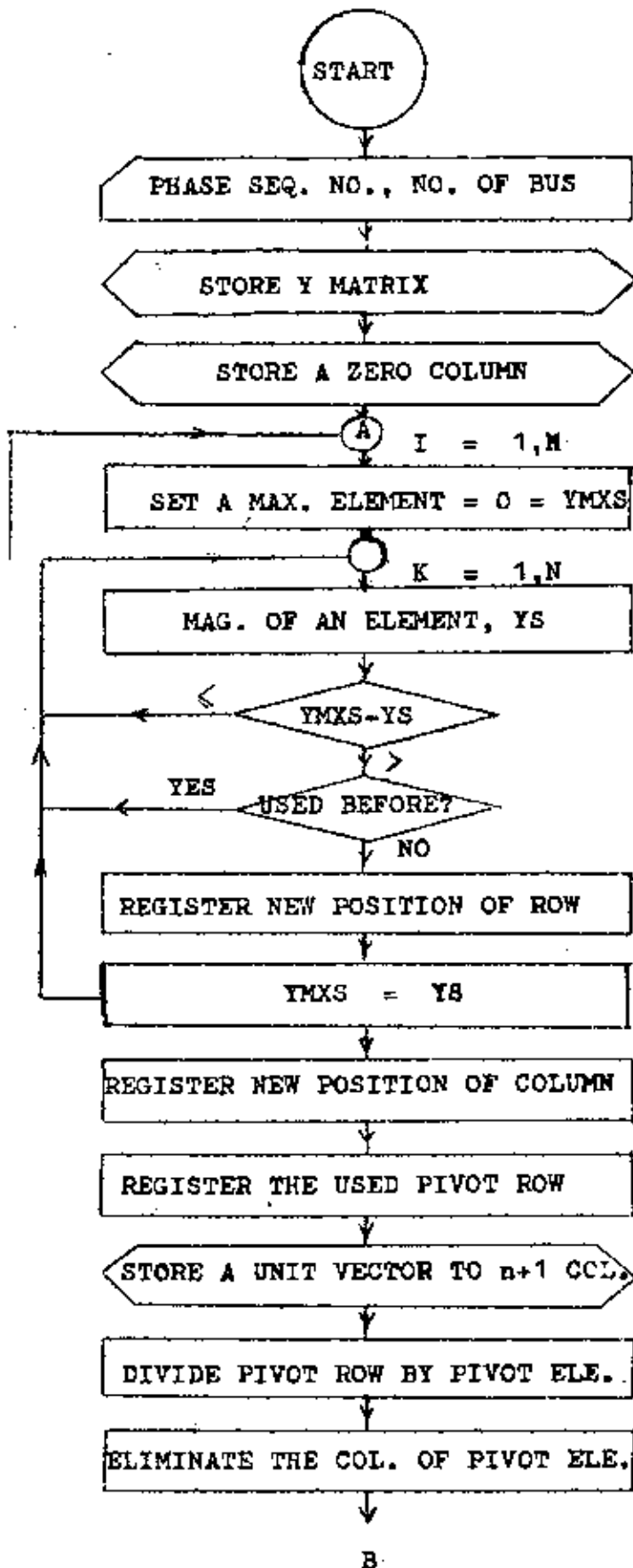
      YB(K)=YB(K)+B+Y
      IF(KCH-N)101,104,104
104  IF(KCH-NN)122,120,120
122  READ182,IS,L,TI,P,Q,G,B,KSQ
      KCH=KCH+1
      P=P/BMVA
      Q=Q/BMVA
      TR=VP(1S)
      TJ=VQ(1S)
      VM=TR*TR+TJ*TJ
      D=G*G+B*B
      IF(D)123,124,123
123  G=G/D
      B=-B/D
      IF(VM)125,126,125
126  CP=0.
      CQ=0.
      GO TO 129
125  CP=(TR*G-TJ*B)+(P*TR+Q*TJ)/VM
      CQ=(TR*B+TJ*G)+(P*TJ-Q*TR)/VM
      GO TO 129
124  G=-P/VM
      B=Q/VM
      CP=0.
      CQ=0.
129  Y=0.
      IF(SENSE SWITCH 1)106,107
106  PRINT196,IS,L,TI,G,B,CP,CQ,KSQ
107  PUNCH196,IS,L,TI,G,B,CP,CQ,KSQ
      GO TO 130
120  PRINT195
      DO105I=1,M
      DO105J=1,M
      K=J*(J-1)/2+1
      IF(SENSE SWITCH 1)116,105
116  PRINT192,I,J,YG(K),Y(K),KSQ
105  PUNCH192,I,J,YG(K),Y(K),KSQ
      IF(SENSE SWITCH 3)131,132
131  PRINT191
      DO133I=1,M
      IF(SENSE SWITCH 1)134,133
134  PRINT194,I,VP(I),VQ(I)
133  PUNCH194,I,VP(I),VQ(I)
132  CONTINUE
180  FORMAT(14)
184  FORMAT(F14.0)
183  FORMAT(13,F14.0,F14.0)
181  FORMAT(13,13,13,F5.0,F5.0,F5.0,11,11,F14.0,F14.0,F14.0,11)

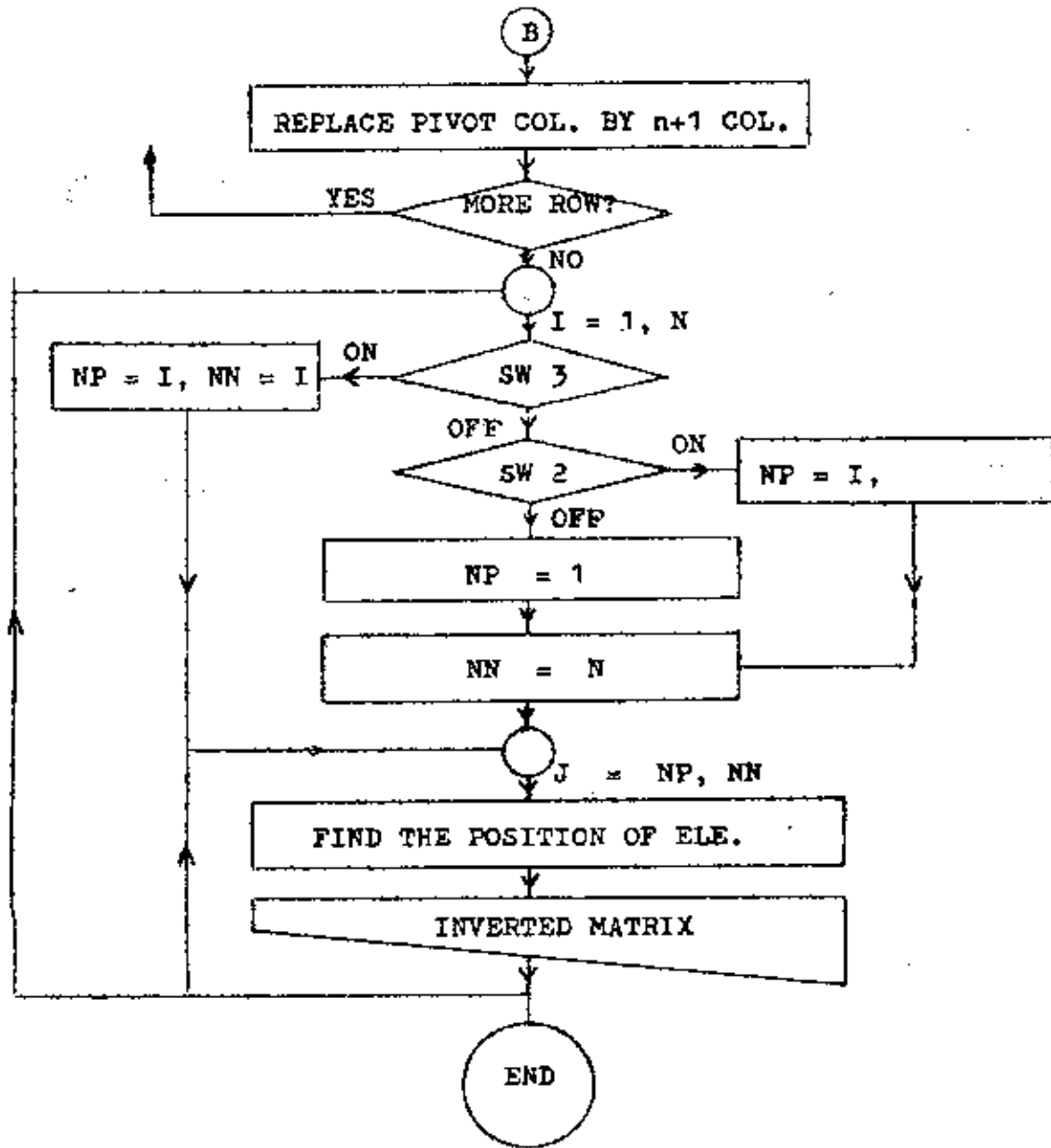
```

```
182 FORMAT(13,13,F5.0,F14.0,F14.0,F14.0,F14.0,11)
199 FORMAT(39H GEN/LOAD ADMITTANCE AND CURRENT SOURCE/)
196 FORMAT(13,14,F6.1,F15.5,F15.5,F15.5,F15.5,12)
195 FORMAT(/24H NODAL ADMITTANCE MATRIX/)
191 FORMAT(/26H NODE VOLTAGE IN RECT FORM/)
192 FORMAT(13,14,F15.5,F15.5,12)
194 FORMAT(13,F15.5,F15.5)
END
```

APPENDIX B

FLOW CHART OF PROGRAM NO.2





```

C     PROGRAM NO. 2
C     MATRIX INVERSION
5(15) DIMENSION G(15,16),B(15,16),KC(15),LOC(15),KOL(15),KB(15),K
      READ290,KSQ
      READ 290,N
      PRINT293
      NP=N+1
      DO 201 I=1,N
      DO 201 J=1,N
      READ291,IB,IS,G(I,J),B(I,J)
      KB(I)=IB
      KS(J)=IS
      G(J,I)=G(I,J)
201  B(J,I)=B(I,J)
      DO202 I=1,N
202  KC(I)=0
C     SELECT MAX. PIVOT ELEMENT IN THE ITH COLUMN
      DO 250 I=1,N
      YMXS=0.
      DO220K=1,N
      YS=G(K,I)*G(K,I)+B(K,I)*B(K,I)
      IF(YMXS-YS)217,220,220
217  IF(KC(K))220,219,220
219  LOC(I)=K
      YMXS=YS
220  CONTINUE
      IF(YMXS)221,222,221
222  PRINT292,K,I
      PAUSE
221  L=LOC(I)
      KOL(L)=I
      KC(L)=1
C     SET ZERO AND UNIT ELEMENTS TO THE N+1 COLUMN
      DO223J=1,N
      G(J,NP)=0.
223  B(J,NP)=0.
      G(L,NP)=1.
C     DIVIDE PIVOT ROW BY PIVOT ELEMENT
      AGL=G(L,I)
      ABL=B(L,I)
      YM=AGL*AGL+ABL*ABL
      DO230J=1,NP
      AG=G(L,J)
      AB=B(L,J)
      G(L,J)=(AGL*AG+ABL*AB)/YM
230  B(L,J)=(AGL*AB-ABL*AG)/YM
      DO240J=1,N

```

```

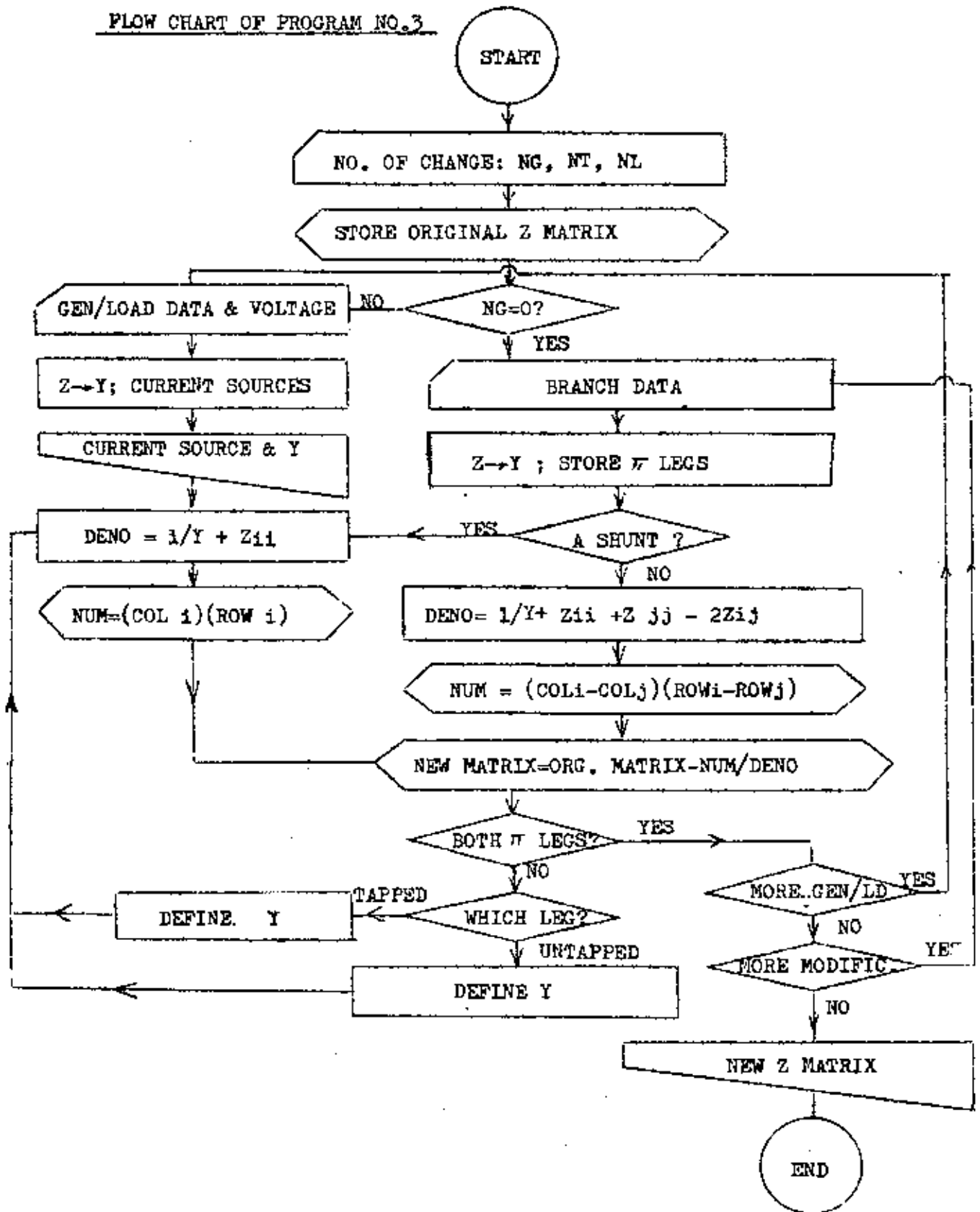
AG=G{J,I}
AB=B{J,I}
IF(J-L)231,240,231
231 DO240K=1,NP
G{J,K}=G{J,K}-AG*G{L,K}+AB*B{L,K}
B{J,K}=B{J,K}-AG*B{L,K}-AB*G{L,K}
240 CONTINUE
DO250J=1,N
G{J,I}=G{J,NP}
B{J,I}=B{J,NP}
250 CONTINUE
C OUTPUT PROGRAM
DO260I=1,N
L=LOC{I}
IB=KB{I}
IF(SENSE SWITCH 3)261,262
261 NN=I
NP=I
GO TO 266
262 IF(SENSE SWITCH 2)263,264
263 NP=I
GO TO 265
264 NP=1
265 NN=N
266 DO260J=NP,NN
IS=KS{J}
M=KOL{J}
IF(SENSE SWITCH 1)259,260
259 PRINT296,IB,IS,G{L,M},B{L,M},KSQ
260 PUNCH296,IB,IS,G{L,M},B{L,M},KSQ
290 FORMAT{14}
292 FORMAT{/ /21H PIVOT ELEMENT AT ROW,13,7H COLUMN,13,8H IS ZER
0) 293 FORMAT{23H NODAL IMPEDANCE MATRIX}
291 FORMAT{13,13,F14.0,F14.0}
296 FORMAT{13,14,F15.5,F15.5,12}
END

```



APPENDIX C

FLOW CHART OF PROGRAM NO. 3



```

C      PROGRAM NO. 3
C      MATRIX MODIFICATION
      DIMENSION RG(120),XB(120),A(15),E(15)
      READ 380,KSQ
      READ 380,M
      READ381,BMVA
      READ 380,NG
      READ 380,NT
      READ 380,NL
      DO 303 I=1,M
      DO 303 J=1,M
      IF(J-1)352,352,353
352  K=I*(I-1)/2+J
      GO TO 303
353  K=J*(J-1)/2+I
303  READ 383,RG(K),XB(K)
      NA=(NG+NT+NL)
      KCH=0
      IF(NG) 304,310,304
304  READ 384,I,L,TI,P,Q,GM,BM
      READ 385,RGJ,XBJ
      XBJ=XBJ/57.296
      VP=RGJ*(COS(XBJ))
      VQ=RGJ*(SIN(XBJ))
      TR=RGJ*RGJ
      P=P/BMVA
      Q=Q/BMVA
      D=GM*GM+BM*BM
      IF(D) 305,307,305
305  GM=GM/D
      BM=-BM/D
      RG I=VP*GM-VQ*BM+(P*VP+Q*VQ)/TR
      XBI=VP*BM+VQ*GM+(P*VQ-Q*VP)/TR
      GO TO 308
307  GM=-P/TR
      BM=Q/TR
      RG I=0.
      XBI=0.
308  II=I
      KK=3
      IF(SENSE SWITCH 2)309,368
309  PUNCH 391,I,L,TI,GM,BM,RG I,XBI      ,KSQ
      GO TO 368
310  READ386,I,J,TR,IV,JV,GM,BM,Y
      D=GM*GM+BM*BM
      GM=GM/D
      BM=-BM/D
      TR=100./(100.+TR)

```

```

312 IF(KCH-NT-NG) 311,312,312
    P=0.
    Q=Y
    VP=0.
    VQ=Y
301 IF(I-J)324,301,324
    I=I
    KK=3
    GO TO 368
311 F=TR*(TR-1.)
    P=F*GM
    Q=F*BM
    F=1.-TR
    VP=F*GM
    VQ=F*BM
    F=TR
    GM=F*GM
    BM=F*BM
324 IF(JV-IV) 324,324,325
    IS=I
    IB=J
    GO TO 326
325 IS=J
    IB=I
326 D=GM*GM+BM*BM
    GM=GM/D
    BM=-BM/D
    K=I*(I-1)/2+1
    RG I=RG(K)
    XB I=XB(K)
    K=J*(J-1)/2+J
    RG J=RG(K)
    XB J=XB(K)
    K=J*(J-1)/2+1
    RG IJ=RG(K)
    XB IJ=XB(K)
    DIVR=GM+RG I+RGJ-2.*RG IJ
    DIVX=BM+XB I+XBJ-2.*XB IJ
    DO320N=1,M
    IF(N-1)314,315,315
314 NJ=I*(I-1)/2+N
    GO TO 316
315 NI=N*(N-1)/2+I
316 IF(N-J)317,318,318
317 NJ=J*(J-1)/2+N
    GO TO 319
318 NJ=N*(N-1)/2+J
319 A(N)=RG(NI)-RG(NJ)

```

```

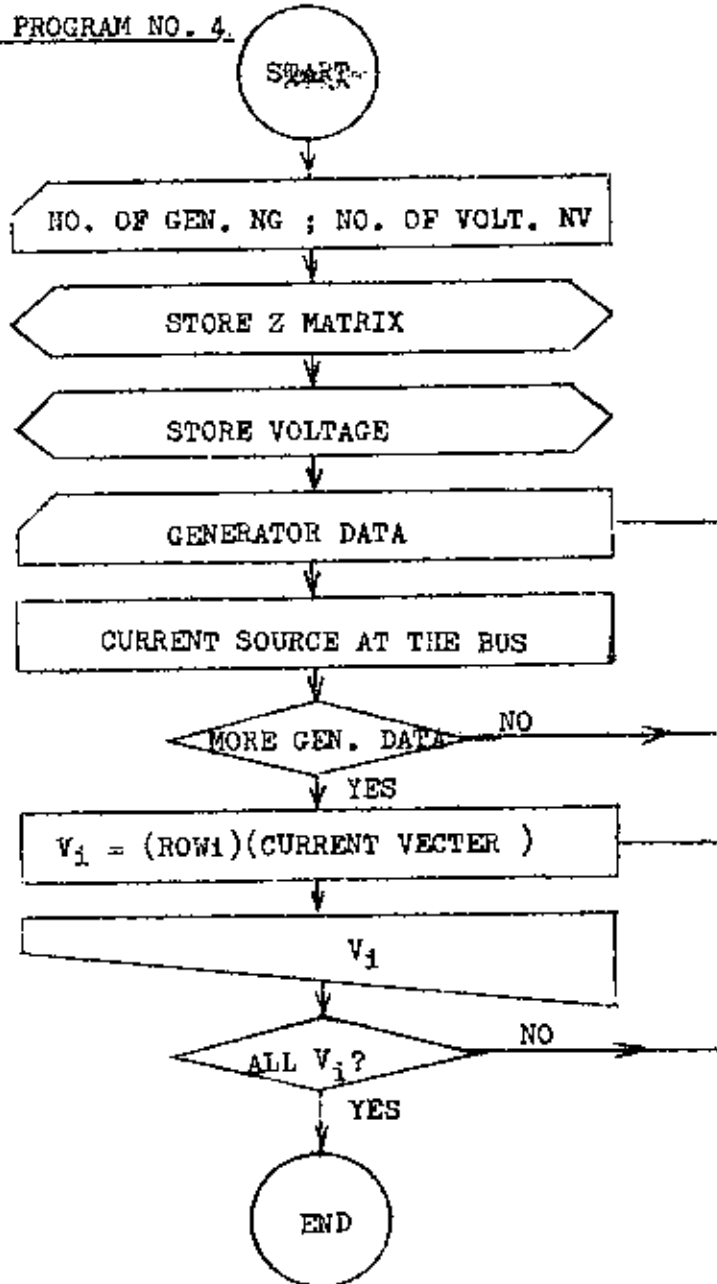
320 E(N)=XB(NI)-XB(NJ)
    KK=0
333 DIVS=DIVR*DIVR+DIVX*DIVX
    DIVR=DIVR/DIVS
    DIVX=-DIVX/DIVS
    DO321N=1,M
    DO321NN=N,M
    C=A(N)*A(NN)-E(N)*E(NN)
    D=E(N)*A(NN)+A(N)*E(NN)
    K=NN*(NN-1)/2+N
    RG(K)=RG(K)-(C*DIVR-D*DIVX)
321 XB(K)=XB(K)-(C*DIVX+D*DIVR)
367 KK=KK+1
    IF(KK-2)327,328,335
327 II=IS
    GM=P
    BM=Q
    GO TO 368
328 I=IB
    GM=VP
    BM=VQ
368 D=GM*GM+BM*BM
    IF(D)369,367,369
369 GM=GM/D
    BM=-BM/D
    K=II*(II-1)/2+II
    DIVR=GM+RG(K)
    DIVX=BM+XB(K)
    DO334N=1,M
    IF(N-II)330,331,331
330 K=II*(II-1)/2+N
    GO TO 332
331 K=N*(N-1)/2+II
332 A(N)=RG(K)
334 E(N)=XB(K)
    GO TO 333
335 KCH=KCH+1
    IF(KCH-NG) 304,306,306
306 IF(KCH-NA) 310,347,347
347 PRINT 399
    DO 349 I=1,M
    DO 349 J=1,M
    IF(I-J) 342,343,343
343 K=I*(I-1)/2+J
    GO TO 344
342 K=J*(J-1)/2+I
344 IF(SENSE SWITCH 1)348,349
348 PRINT 393,I,J,RG(K),XB(K),KSQ

```

```
349 PUNCH 393, I, J, RG(K), XB(K), KSQ
380 FORMAT(14)
381 FORMAT(F14.0)
383 FORMAT(7X, F14.0, F14.0)
384 FORMAT(13, 13, F5.0, F14.0, F14.0, F14.0, F14.0)
385 FORMAT(3X, F14.0, F14.0)
386 FORMAT(13, 13, 16X, F5.0, 11, 11, F14.0, F14.0, F14.0)
391 FORMAT(13, 14, F6.1, F15.5, F15.5, F15.5, F15.5, 12)
393 FORMAT(13, 14, F15.5, F15.5, 12)
399 FORMAT(32H MODIFIED NODAL IMPEDANCE MATRIX/)
END
```


APPENDIX D

FLOW CHART OF PROGRAM NO. 4.



```

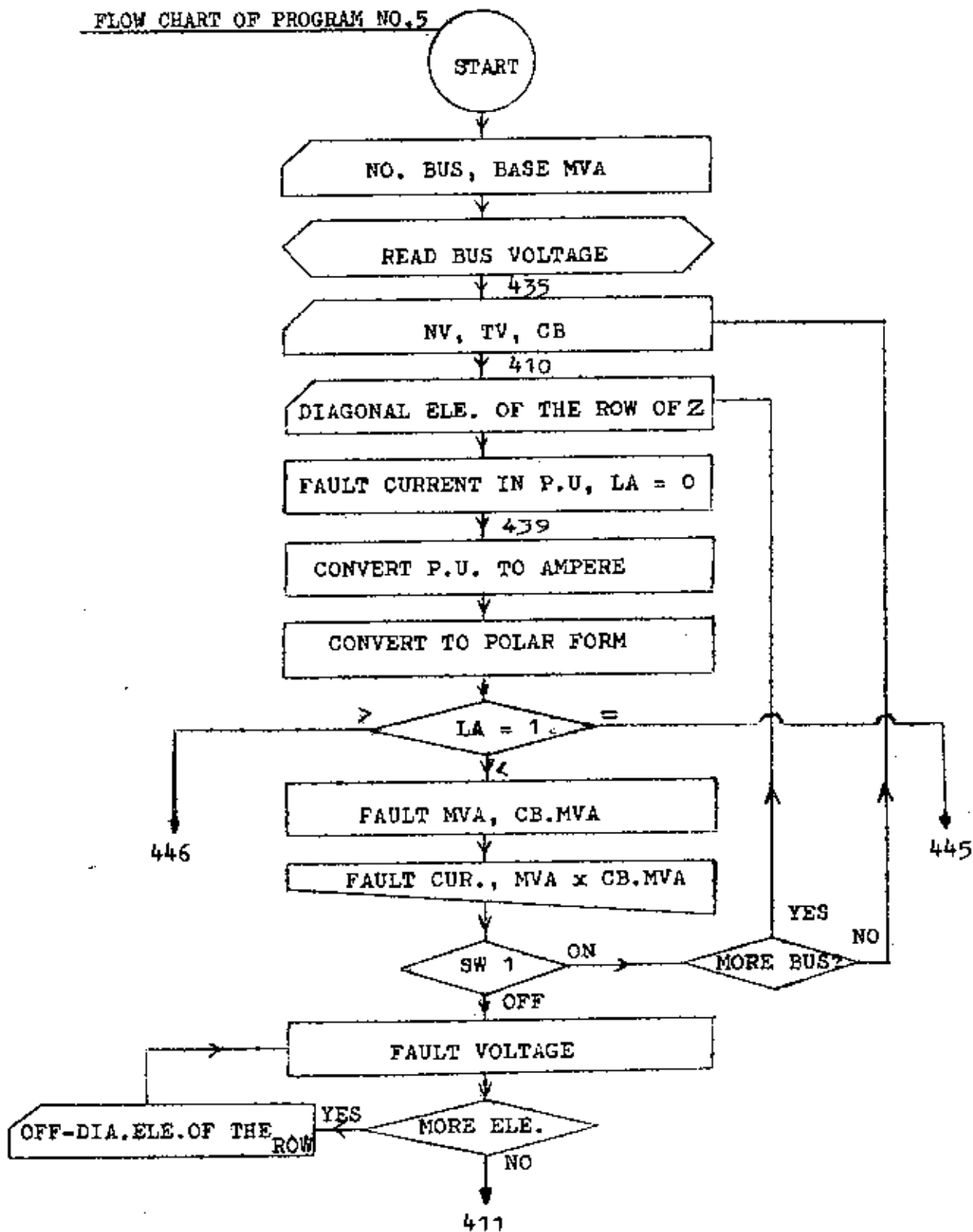
C      PROGRAM NO. 4
C      PRE-FAULT VOLTAGE CALCULATION
      DIMENSION RG(210),XB(210),CP(20),CQ(20),VTP(20),VTQ(20)
      READ380,M
      READ 381,BMVA
      READ380,NG
      READ 380,NV
      DO 303 I=1,M
      CP(I)=0.
      CQ(I)=0.
      VTP(I)=0.
      VTQ(I)=0.
      DO 303 J=1,M
      IF(I-J)305,306,306
305  K=J*(J-1)/2+1
      GO TO 303
306  K=I*(I-1)/2+J
303  READ383,RG(K),XB(K)
      KV=0
315  READ 385,I,VM,VD
      VO=VD/57.296
      VTP(I)=VM*(COS(VD))
      VTQ(I)=VM*(SIN(VD))
      KV=KV+1
      IF(KV-NV)315,318,318
318  KV=0
304  READ 384,I,L,TI,P,Q,GM,BM
      D=GM*GM+BM*BM
      GM=GM/D
      BM=-BM/D
      P=P/BMVA
      Q=Q/BMVA
      VP=VTP(I)
      VQ=VTQ(I)
      TR=VP*VP+VQ*VQ
      CP(I)=CP(I)+(VP*GM-VQ*BM)+(P*VP+Q*VQ)/TR
      CQ(I)=CQ(I)+(VP*BM+VQ*GM)+(P*VQ-Q*VP)/TR
      KV=KV+1
      IF(KV-NG)304,350,350
350  PRINT 398
      DO 359 I=1,M
      VP=0.
      VQ=0.
      DO 356 J=1,M
      IF(I-J) 357,357,358
357  K=J*(J-1)/2+1
      GO TO 351
358  K=I*(I-1)/2+J

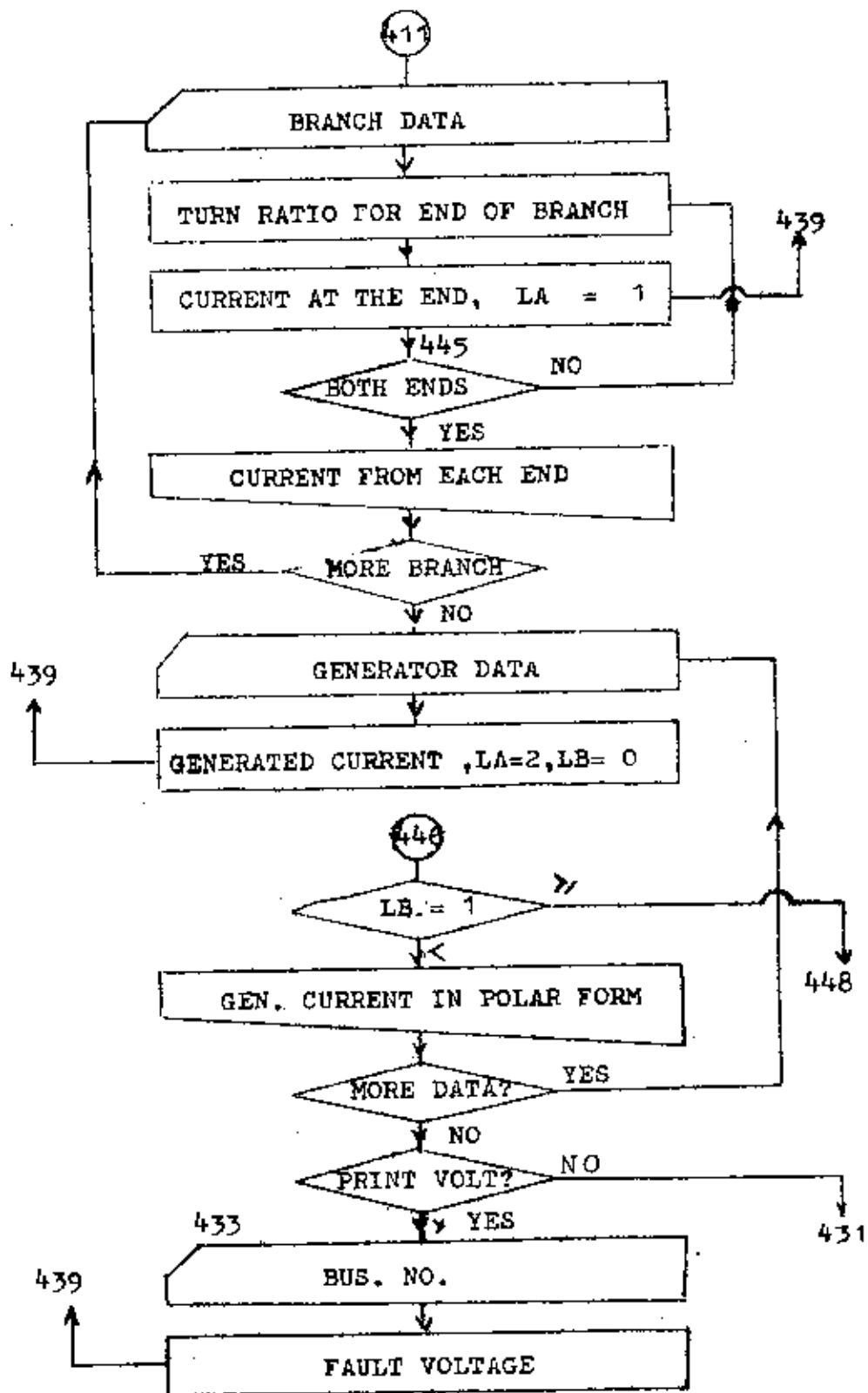
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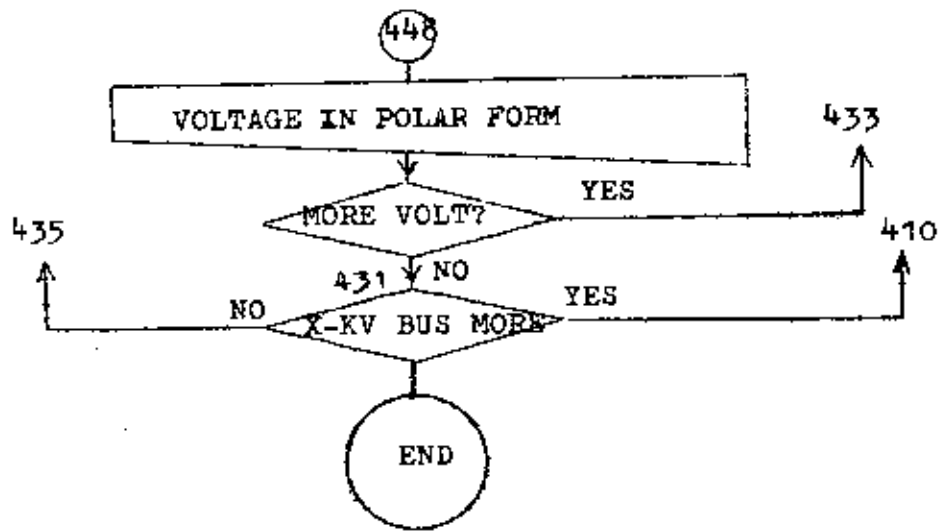
```
351 GM=RG(K)
    BM=XB(K)
    P=CP(J)
    Q=CQ(J)
    TR=GM*P-BM*Q
    VP=VP+TR
    TR=GM*Q+BM*P
356 VQ=VQ+TR
    IF(SENSE SWITCH 1) 352,359
352 PRINT 396,1,VP,VQ
359 PUNCH 396,1,VP,VQ
380 FORMAT(14)
381 FORMAT(F14.0)
383 FORMAT(7X,F14.0,F14.0)
385 FORMAT(13,F14.0,F14.0)
384 FORMAT(13,13,F5.0,F14.0,F14.0,F14.0,F14.0)
396 FORMAT(13,F15.5,F15.5)
398 FORMAT(/22H VOLTAGE IN RECT. FORM/)
END
```

APPENDIX E

FLOW CHART OF PROGRAM NO. 5







```

C      PROGRAM NO. 5
C      THREE-PHASE SHORT CIRCUIT STUDY
      DIMENSION VP(20),VQ(20),VFP(20),VFQ(20),CM(2),CD(2)
      READ481,M
      READ483,BMVA
      PRINT499
      DO402I=1,M
402  READ482,VP(I),VQ(I)
410  READ481,NV
      READ483,TV
      READ483,CB
      PRINT497,TV
      KK=0
435  PRINT493
400  READ480,I,J,RG,XB
      T=BMVA/(TV*.7321)
      KK=KK+1
      KN=1
      D=RG*RG+XB*XB
      VS I=VP(I)
      VS J=VQ(I)
      CP=(VS I*RG+VS J*XB)/D
      CQ=(VS J*RG-VS I*XB)/D
      LA=0
439  C=T*(SQRT(CP*CP+CQ*CQ))*1000.
      IF(CP)423,424,423
424  IF(CQ)425,460,426
425  D=-90.
      GO TO 441
460  D=0.
      GO TO 441
426  D=90.
      GO TO 441
423  D=57.296*(ATAN(CQ/CP))
      IF(CP)440,441,441
440  IF(CQ)442,443,443
442  D=D-180.
      GO TO 441
443  D=D+180.
441  IF(LA-1)444,445,446
444  P=(VS I*CP+VS J*CQ)*BMVA
      Q=(VS J*CP-VS I*CQ)*BMVA
      VS I=SQRT(P*P+Q*Q)
      VS J=CB*VS I
      PRINT495,I,C,D,VS I,VS J
      IF(SENSE SWITCH)401,405
401  IF(KK-NV)400,410,410
405  VFP(J)=VP(J)-(CP*RG-CQ*XB)

```

```

VFQ(J)=VQ(J)-(CP*XB+CQ*RG)
IF(KN-M)406,407,407
406 READ480,I,J,RG,XB
KN=KN+1
GO TO 405
407 PRINT498
READ481,NL
READ481,NG
READ481,NT
NK=NL+NG
KCH=0
IF(NL)411,412,411
411 READ484,I,J,L,TI,TJ,TR,IV,JV,G,B,Y
TR=100./(TR+100.)
D=G*G+B*B
G=TR*G/D
B=-TR*B/D
K=0
KCH=KCH+1
VSI=VFP(I)*VFP(I)+VFQ(I)*VFQ(I)
VSJ=VFP(J)*VFP(J)+VFQ(J)*VFQ(J)
KN=0
IF(VSI-VSJ)415,415,416
415 IB=J
IS=I
T=BMVA/(TJ*1.7321)
KN=KN+1
IF(JV-IV)418,422,422
418 RT=1./TR
GO TO 417
422 RT=TR
GO TO 417
416 IB=I
IS=J
T=BMVA/(TI*1.7321)
IF(IV-JV)418,422,422
417 C=VFP(IB)
D=VFQ(IB)
K=K+1
VSI=RT*C-VFP(IS)
VSJ=RT*D-VFQ(IS)
CP=VSI*G-VSJ*B-Y*D
CQ=VSI*B+VSJ*G+Y*C
KN=KN+1
LA=1
GO TO 439
445 CD(K)=D
CM(K)=C

```



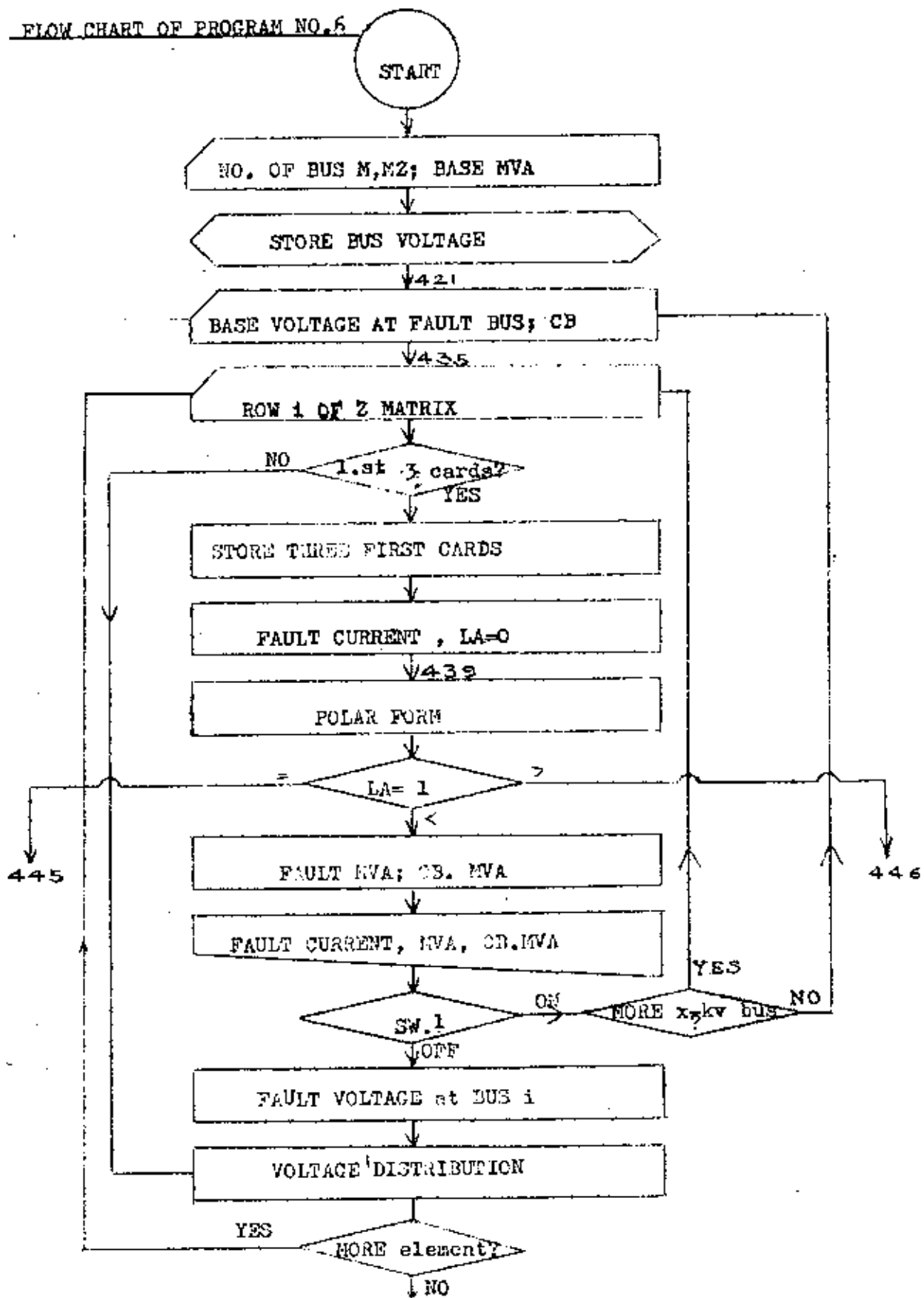
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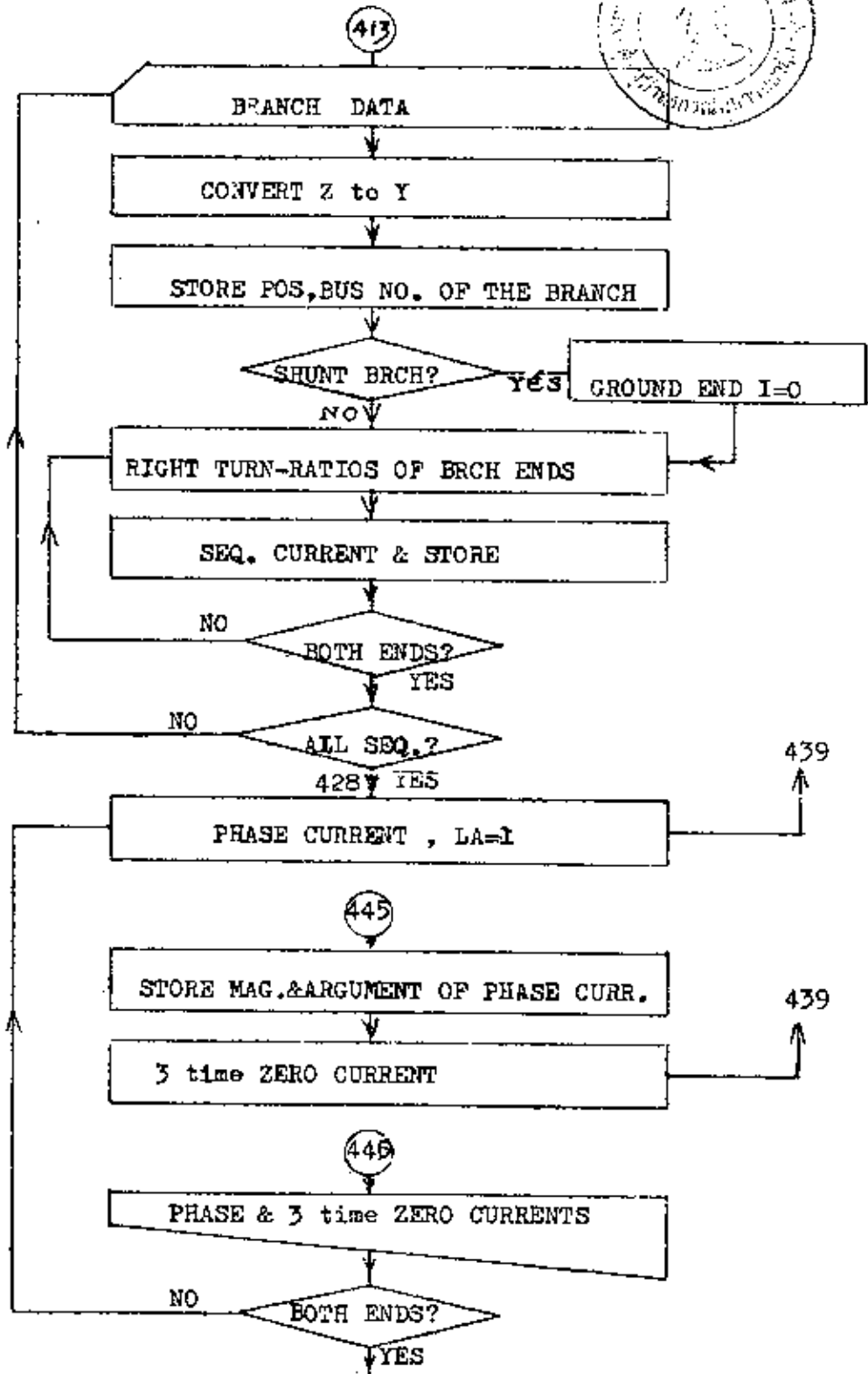
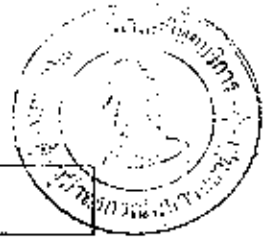
      IF(KN-2)415,416,427
427 PRINT496,L,I,S,IB,CM(1),CD(1),CM(2),CD(2)
      IF(KCH-NL)411,429,429
429 IF(KCH-NK)412,430,430
412 READ485,I,L,TI,G,B,CP,CQ
      KCH=KCH+1
      CP=CP-(VFP(1)*G-VFQ(1)*B)
      CQ=CQ-(VFP(1)*B+VFQ(1)*G)
      T=BMVA/(TI*1.7321)
      J=0
      LA=2
      LB=0
      GO TO 439
446 IF(LB-1)447,448,448
447 PRINT496,L,I,J,C,D
      IF(KCH-NK)412,430,430
430 IF(NT)432,431,432
432 PRINT492
      J=0
433 READ480,I
      CP=VFP(I)
      CQ=VFQ(I)
      LA=2
      LB=2
      T=1./1000.
      GO TO 439
448 PRINT491,I,C,D
      J=J+1
      IF(J-NT)433,431,431
431 IF(KK-NV)435,410,410
481 FORMAT(I4)
483 FORMAT(F14.0)
484 FORMAT(13,13,13,F5.0,F5.0,F5.0,11,11,F14.0,F14.0,F14.0)
485 FORMAT(13,13,F5.0,F14.0,F14.0,F14.0,F14.0)
499 FORMAT(32H THREE-PHASE SHORT CIRCUIT STUDY/)
497 FORMAT(/9H FAULT ON ,F7.1,7H KV-BUS)
493 FORMAT(/20H BUS          AMP+DEG,12X,16H MVA          CB,MVA/
)
495 FORMAT(14,F12.2,F9.2,F12.3,F12.3)
496 FORMAT(14,14,14,F12.2,F9.2,F15.2,F9.2)
498 FORMAT(/28H  L   I   J   AMP(I-J)+DEG,11X,13H AMP(J-1)
+DEG/)
492 FORMAT(/18H BUS          VOLT+DEG/)
491 FORMAT(14,F10.5,F8.2)
480 FORMAT(13,13,F14.0,F14.0)
482 FORMAT(4X,F14.0,F14.0)
      END

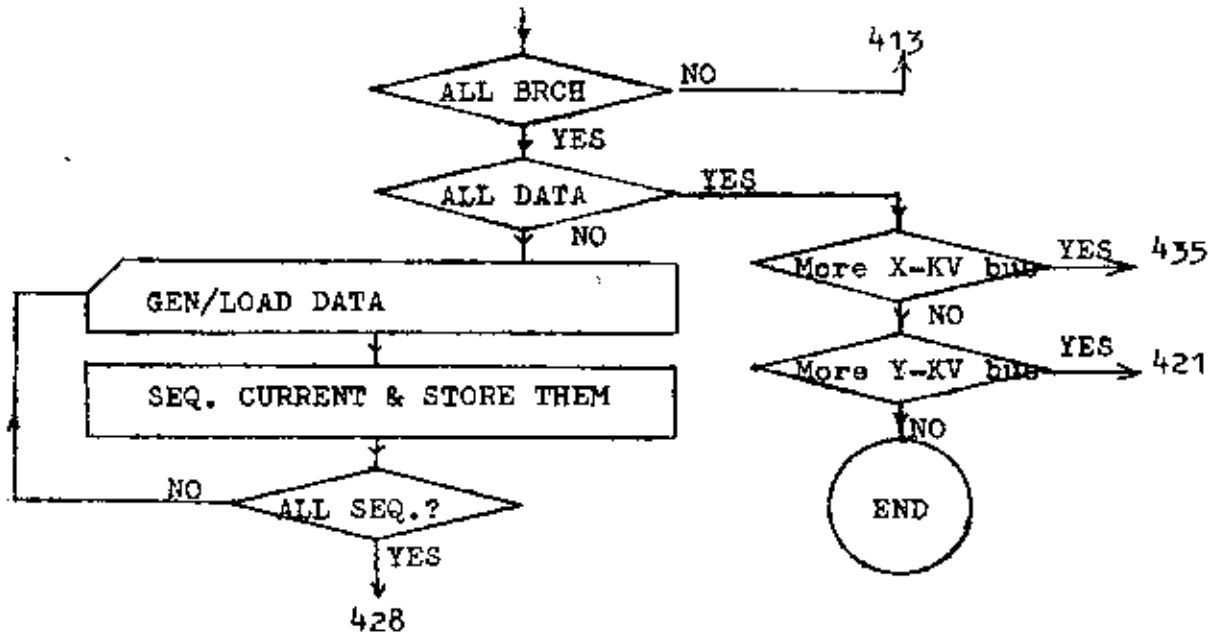
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APPENDIX F

FLOW CHART OF PROGRAM NO. 6







```

C   PROGRAM NO. 6
C   ONE-PHASE SHORT CIRCUIT STUDY
(3) DIMENSION VP(60),VQ(60),GR(3),BX(3),CP(3),CQ(3),PC(3),QC

      READ481,M
      READ481,MZ
      MM=M+M+MZ
      READ483,BMVA
      DO402 I=1,M
402  READ482,VP(I),VQ(I)
421  READ481,NV
      READ483,TV
      READ483,CB
      PRINT497,TV
      KV=0
435  PRINT499
      T=1000.*BMVA/(TV*1.7321)
400  KN=0
404  READ480,I,J,RG,XB,K
      KN=KN+1
      KO=3
      IF(K-3)471,470,471
470  IZ=1
      GO TO 472
471  II=1
472  IF(KN-3)403,403,475
403  GR(K)=RG
      BX(K)=XB
      IF(KN-3)404,405,405
405  VSI=GR(2)+GR(3)+GR(1)
      VSJ=BX(2)+BX(3)+BX(1)
      Q=VSI*VSI+VSJ*VSJ
      PC(1)=VP(II)
      QC(1)=VQ(II)
      CP(1)=(PC(1)*VSI+QC(1)*VSJ)/Q
      CQ(1)=(QC(1)*VSI-PC(1)*VSJ)/Q
      C=3.*CP(1)
      D=3.*CQ(1)
      LA=0
439  DA=T*SQRT(C*C+D*D)
      IF(C)423,424,423
424  IF(D)425,460,426
425  DB=-90.
      GO TO 441
460  DB=0.
      GO TO 441
426  DB=90.
      GO TO 441

```

```

423 DB=57.296*(ATAN(D/C))
    IF(C)440,441,441
440 IF(D)442,443,443
442 DB=DB-180.
    GO TO 441
443 DB=DB+180.
444 IF(LA-1)444,445,446
444 P={PC(1)*C+QC(1)*D}*BMVA
    Q={QC(1)*C-PC(1)*D}*BMVA
    VS I=SQRT(P*P+Q*Q)
    VSJ=CB*VS I
    PRINT492, I I, DA, DB, VS I, VSJ
    IF(SENSE SWITCH 1)474,409
474 KV=KV+I
    IF(KV-NV)400,421,421
409 KO=0
410 KO=KO+1
    K=KO
    RG=GR(K)
    XB=BX(K)
    IF(K-3)433,454,453
454 J=IZ
    GO TO 475
433 J=I I
475 N=M*K+J
    VP(N)=-{CP(1)*RG-CQ(1)*XB}
    VQ(N)=-{CP(1)*XB+CQ(1)*RG}
    IF(K-1)476,477,476
477 VP(N)=VP(N)+VP(J)
    VQ(N)=VQ(N)+VQ(J)
476 IF(KO-3)410,478,478
478 IF(KN-MM)404,407,407
407 PRINT498
    READ481, NL
    READ481, ND
    NL=3*NL
    ND=3*ND
    KO=NL+ND
    KC=0
    IF(NL)411,412,411
411 KCH=0
413 READ484, I, J, L, TI, TJ, TR, IV, JV, RG, XB, Y, K
    IF(K-1)455,456,455
456 I I=I
    I Z=J
455 TR=100./(100.+TR)
    D=RG*RG+XB*XB
    IF(D)463,464,463
463 RG=TR*RG/D

```

```

XB=-TR*XB/D
464 KCH=KCH+1
    KC=KC+1
    KN=0
    KK=0
    IB=J
    IS=1
    IF(I-J)457,450,457
458 PC(K)=0.
    QC(K)=0.
    KN=KN+1
    GO TO 416
457 IF(JV-IV)418,418,422
422 RT=TR
    GO TO 417
418 RT=1./TR
    GO TO 417
416 IB=I
    IS=J
    IF(IV-JV)410,410,422
417 KN=KN+1
    N=M*K+IB
    NN=M*K+IS
    IF(I-J)465,466,465
466 VS I=0.
    VSJ=0.
    GO TO 468
465 VS I=VP(NN)
    VSJ=VQ(NN)
468 C=VP(N)
    D=VQ(N)
    VS I=RT*C-VS I
    VSJ=RT*D-VS J
    DA=VS I*RG-VS J*XB-Y*D
    DB=VS I*XB+VS J*RG+Y*C
    IF(KN-2)451,452,452
451 PC(K)=DA
    QC(K)=DB
    GO TO 453
452 CP(K)=DA
    CQ(K)=DB
453 IF(KN-2)416,427,427
427 IF(KCH-3)413,428,428
428 T=1000.*BMVA/(T1*1.7321)
    C=CP(1)+CP(2)+CP(3)
    D=CQ(1)+CQ(2)+CQ(3)
    LA=1
    GO TO 439

```

```

445 VSJ=DA
    VSJ=DB
    C=3.*CP(3)
    D=3.*CQ(3)
    LA=2
    GO TO 439
446 PRINT496,L,II,VSJ,VSJ,DA,DB
    IF(KK-1)459,467,467
459 IF(KC-NL)461,461,467
461 II=I2
    TI=TJ
    DO462 K=1,3
    CP(K)=PC(K)
462 CQ(K)=QC(K)
    KK=KK+1
    GO TO 428
467 IF(KC-NL)411,414,414
414 IF(KC-KO)412,430,430
412 KCH=0
415 READ485,II,L,TI,RG,XB,DA,DB,K
    KCH=KCH+1
    KC=KC+1
    N=M*K+II
    CP(K)=DA-(VP(N)*RG-VQ(N)*XB)
    CQ(K)=DB-(VP(N)*XB+VQ(N)*RG)
    KK=1
    IF(KCH-3)415,428,428
430 KV=KV+1
    IF(KV-NV)435,421,421
481 FORMAT(14)
483 FORMAT(F14.0)
482 FORMAT(4X,F14.0,F14.0)
480 FORMAT(13,13,F14.0,F14.0,11)
484 FORMAT(13,13,13,F5.0,F5.0,F5.0,11,11,F14.0,F14.0,F14.0,1
1)
485 FORMAT(13,13,F5.0,F14.0,F14.0,F14.0,F14.0,11)
497 FORMAT(/27H ONE-PHASE SHORT CIRCUIT ON,F7.1,7H KV-BUS)
499 FORMAT(/20H BUS          AMP+DEG,12X,16H MVA          CB.MVA/
)
492 FORMAT(14,F12.2,F9.2,F12.3,F12.3)
498 FORMAT(/9H BRCH BUS,8X,33H AMP(A)+DEG          AMP(31(0))+
DEG/)
496 FORMAT(14,1X,14,F12.2,F9.2,F12.2,F9.2)
    ENO

```


APPENDIX G

MASTER SHEETS

COMPILED BY DATE SHEET NO.

CHECKED BY DATE RUN NO.

PROGRAM NO. 1 SW1 ; SW2 ; SW3 ; SW4 .

Total Number of Busbars	
Base MVA	
Total Number of Branch Data	
Total Number of Gen/Load Data	
Number of Required Voltage	
Data of the Prefault Voltage from Data Sheet No. ---	
Data of Branch Characteristics from Data Sheet No. ---	
Data of Gen/Load from Data Sheet No. ---	

Program No. 2 SW1 ; SW2 ; SW3 ; SW4 .

Sequence Number of the Network	
Total Number of Busbars	
Y-Matrix, Output of Program No. 1	

Program No. 3 SW1 ; SW2 ; SW3 ; SW4 .

Sequence No. of the Network	
Total No. of Busbars	
Base MVA	
No. of Gen./Load Data for Change	
No. of Branch Data for Change in Tap	
No. of Branch Data for Line Change	
Z-Matrix, Output of Program No. 2	
Gen/load Data and Voltage at the Busbar from Data Sheet No. --- and ---	
Branch Data for Tap Change from Data Sheet No. ---	
Branch Data for Line Change from Data Sheet No. ---	

Program No. 4 SW1 ; SW2 ; SW3 ; SW4 .

Total No. of BusBars	
Base MVA	
No. of Generators	
No. of Voltage at Generator Buses	
Z-Matrix, Output of Either Program No. 2 Or Program No. 3	
Gen. Data from Data Sheet No. ---	

Program No. 5 SW1 ; SW2 ; SW3 ; SW4 .

Total No. of Busbars	
Base MVA	
Prefault Voltage, Output of Program No.1 or Program No.4	
No. of Certain KV Buses to be Short Circuit	
Base KV of those Buses	
Circuit Breaker Constant	
The Row of Z-Matrix from either Prog.2 or Prog. 3	
No. of Branch Data	
No. of Gen. Data	
No. of Bus Numbers	
Required Branch Data from Data Sheet No. -----	
Required Gen. Data, Output of Program No.1	
Required Busbar Numbers	

Program No. 6 SW1 ; SW2 ; SW3 ; SW4 .

Total No. of Busbars	
Base MVA	
Prefault Voltage, Output of Progaam No.1 or 4	
No. of a Certain KV Buses to be Short Circuit -ed	
Base KV of Those Buses	
Circuit Breaker Constant	
The Rows of Each Sequence Matrix from Program No.2 or 3	
No. of Branches	
No. of Generators	
Required Branch Data for Each Sequence from Sheet No.--	
Required Gen. Data of Each Sequence from Data Sheet No.-	

APPENDIX I
GEN./LOAD DATA

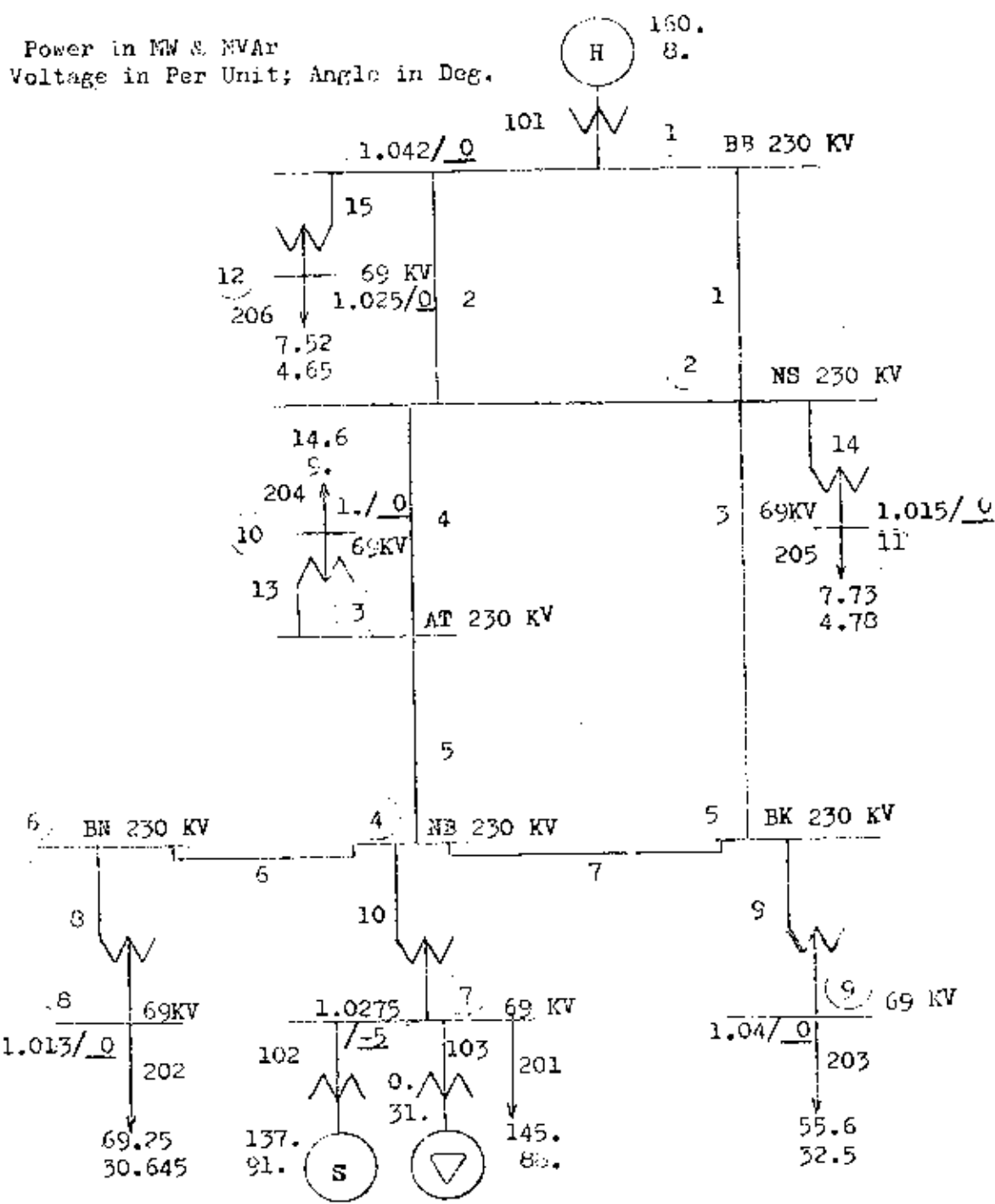
BUS NO.	LINE NO.	BASE K KV	P. MW	Q. MVAR	R in P.U.	X in P.U.	Seq No.

APPENDIX J

VOLTAGE DATA SHEET

BUS NO.	VOLTAGE MAG. in P.U.	ARGUMENT in DEGREE

APPENDIX K

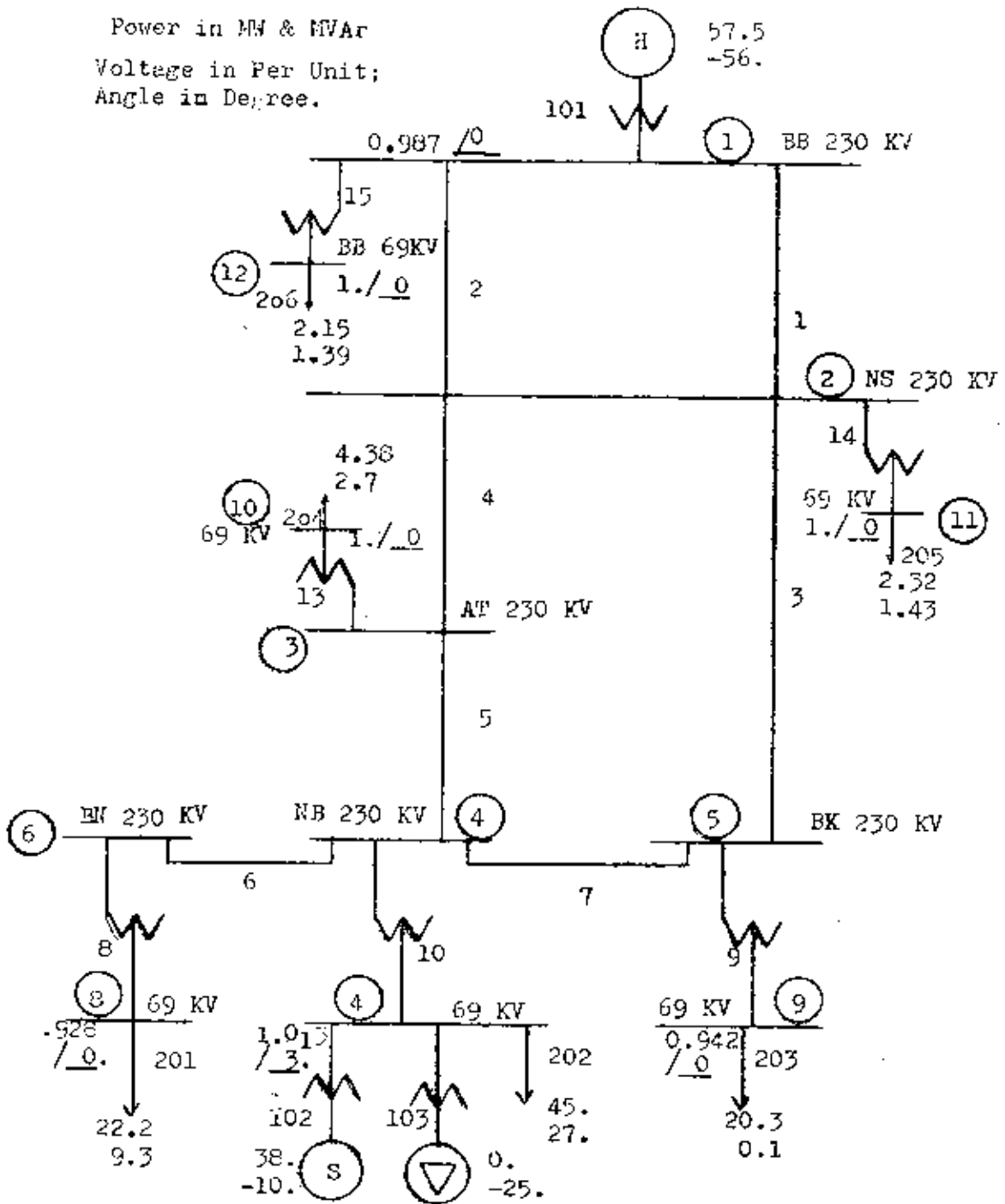


SYSTEM AT CONDITION OF MAXIMUM GENERATION

ON JAN. 30, 1967 AT 7.30 P.M.

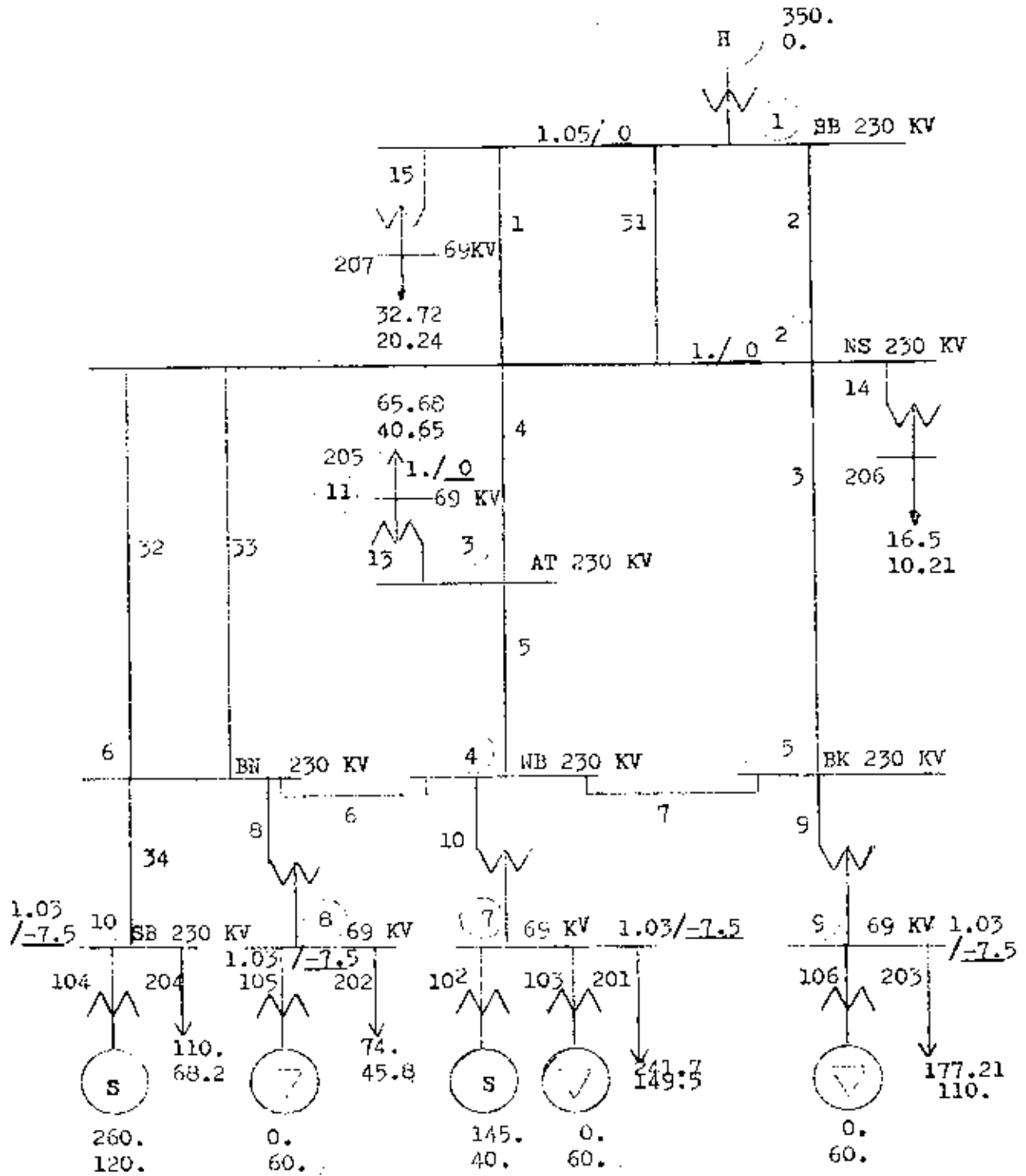
APPENDIX L

Power in MW & MVAR
 Voltage in Per Unit;
 Angle in Degree.



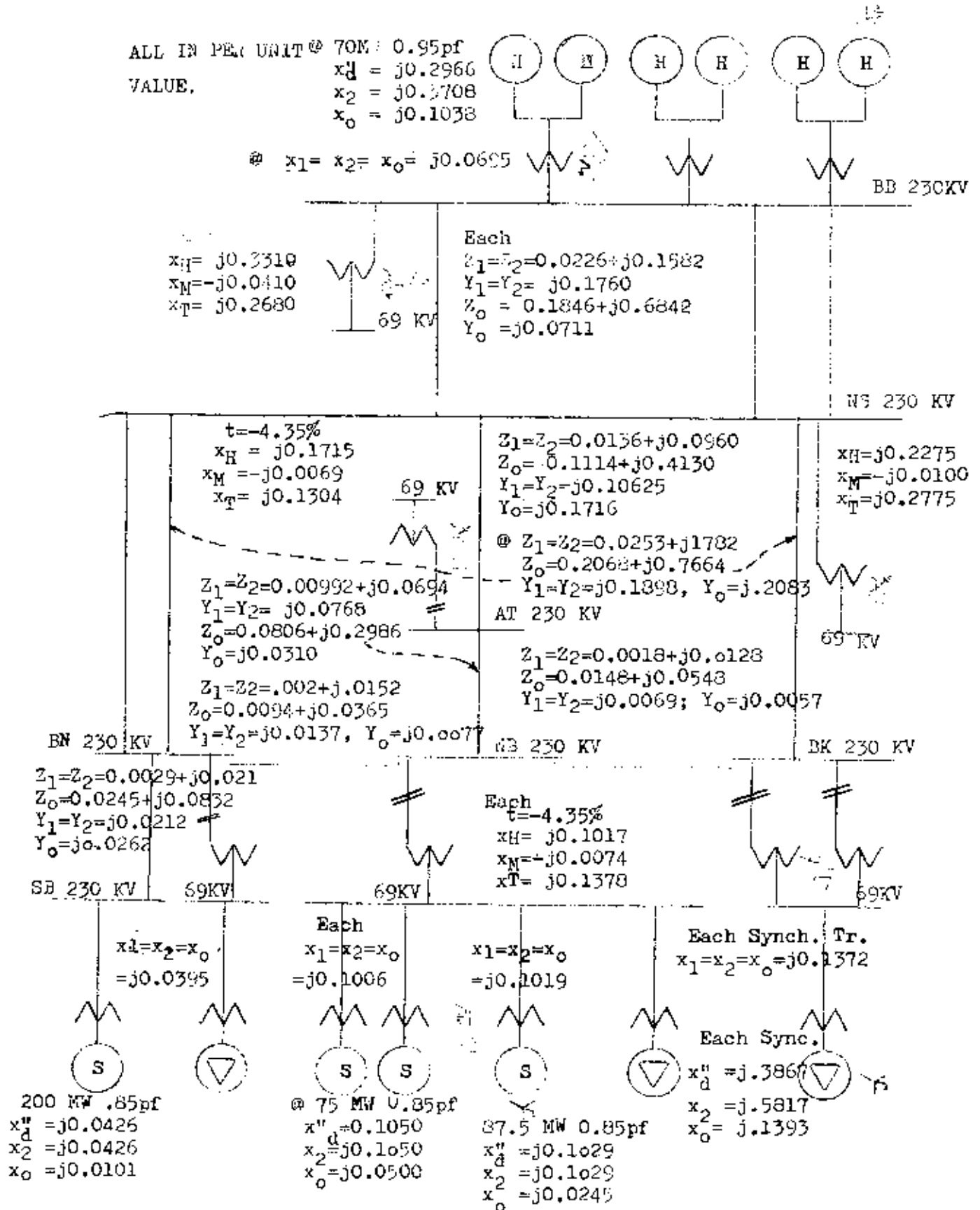
SYSTEM AT MINIMUM GENERATION CONDITION ON JAN. 2, 1967 4.00A.M.

APPENDIX M



SYSTEM CONDITION IN 1970

APPENDIX N



THE IMPEDANCE DIAGRAM OF THE YEA SYSTEM

APPENDIX C

Comparison of Circuit Breaker Interrupting MVA at
230 KV Buses for System at the Given Conditions.

230 KV SUBSTATION	Three-Phase Short Circuit			One-Phase Short Circuit.		
	1967 Min	1967 Max	1970	1967 Min	1967 Max	1970
Bhumiphol(BB)	922.51	1162.28	3099.08	1099.84	1347.61	3597.77
Nakornsawarn (NS)	905.91	1081.42	2753.08	889.37	1009.55	2076.77
Angthong(AT)	851.38	986.94	1846.68	874.55	956.67	1439.93
North Bangkok (NB)	1049.53	1229.03	3424.85	1230.31	1343.79	3295.43
Bangkok Noi (BN)	957.60	1083.76	3610.51	1070.17	1155.23	3425.21
Bangkapi(BK)	983.50	1144.44	2861.12	1101.90	1193.76	2673.92
South Bangkok (SB)	-	-	3532.22	-	-	3695.14

(For 230-KV circuit breakers, the multiplying factor CB is 1.3;
the above C.B. Interrupting MVA = 1.3 x Fault MVA)

APPENDIX P

Comparison of Circuit Breaker Interrupting MVA at
69 KV Substations for System at the Conditions Given.

69 KV	Three-Phase Short Circuit			One-Phase Short Circuit		
	SUBSTATION	1967 Min	1967 Max	1970	1967 Min	1967 Max
NB	1629.72	1994.18	3088.15	2015.92	2345.17	3585.43
BN	528.44	583.04	1325.74	-	-	1547.26
BK	548.93	605.07	1596.33	-	-	1831.76
AT	411.14	455.91	551.18	-	-	647.51
NS	353.71	403.61	517.74	-	-	-
BB	288.21	350.27	355.59	-	-	-

(For 69-KV circuit breakers, the multiplying factor CB is 1.2 ;
the above C.B. Interrupting MVA = 1.2 x Fault MVA)

APPENDIX Q

Maximum and Minimum Fault Currents at the Ends of
Lines Connected to 230 KV Buses at the Condition in 1967

230 KV		Three-Phase S.C		* One-Phase Short Circuit			
SUB.	SUB.	I_{max}	I_{min}	$I_{a max}$	$I_{a min}$	$3I_o max$	$3I_o min$
BB	NS	463.93	97.08	408.16	165.39	325.82	19.50
NS	BB	477.68	153.76	438.31	208.30	304.37	18.22
NS	BK	448.68	43.95	368.90	122.29	238.07	33.80
BK	NS	433.51	44.31	386.40	119.36	299.90	28.79
NS	AT	742.38	130.76	640.09	189.25	389.53	19.82
AT	NS	750.03	89.86	644.04	203.11	448.75	9.90
AT	NB	1043.07	93.49	864.67	249.67	617.15	31.05
NB	AT	1037.51	62.53	851.92	259.74	625.82	31.66
NB	BN	2022.43	1.05	1997.92	48.08	1476.95	18.18
BN	NB	2022.86	1.05	1999.04	47.27	1474.80	18.25
NB	BK	1707.92	23.53	1666.45	37.58	1347.47	26.61
BK	NB	1708.07	24.44	1666.84	36.11	1345.84	26.54
BN	69	1216.90	0.30	-	-	-	-
BK	69	1251.88	0.02	-	-	-	-
NB	69	1543.64	141.01	1591.13	564.45	1143.57	39.63
AT	69	903.26	0.21	-	-	-	-
NS	69	768.49	0.01	-	-	-	-
BB	69	658.49	0.01	-	-	-	-

All currents expressed in ampere unit

*The minimum currents are the minimum of those occurred
when there is a short circuit at a 230 KV busbar.

APPENDIX R

Maximum and Minimum Fault Currents at Ends of Lines
Connected to 69 KV Buses at the Condition in 1967

69 KV		Three-Phase S.C.		* One-Phase Short Circuit			
SUB.	SUB.	I_{max}	I_{min}	$I_{a max}$	$I_{a min}$	$3I_o max$	$3I_o min$
69	BN	3879.90	0.96	-	-	-	-
69	BK	3991.42	0.06	-	-	-	-
69	NB	4921.63	449.61	2776.73	319.04	4947.48	44.29
69	AT	2879.92	0.21	-	-	-	-
69	NS	2561.64	0.05	-	-	-	-
69	BB	2195.79	0.03	-	-	-	-
GEN.AT	BB	1279.60	197.95	1615.31	335.28	1891.55	34.24
GEN.AT	NB	9172.21	835.87	10458.35	1944.35	7582.67	77.94
SYNC.AT	NB	1893.44	68.28	2360.54	133.22	2779.94	28.57

All currents expressed in ampere unit.

* The minimum currents are the minimum of those occurred when there is a short circuit at a 230 KV bus.

APPENDIX-S

MAXIMUM GENERATION ON JAN. 30 , 1990 P.M.:

ONE-PHASE SHORT CIRCUIT ON 230.0 KV-BUS

BUS	AMP+DEG		MVA	CB.MVA
1	2309.13	-84.28	1036.624	1347.611
2	1756.29	-85.57	776.580	1009.554
3	1723.97	-89.03	735.900	956.670
4	2492.74	-92.22	1033.685	1343.790
5	2211.05	-91.37	918.200	1193.764
6	2157.25	-91.95	888.641	1155.234

ONE-PHASE SHORT CIRCUIT ON 69.0 KV-BUS

BUS	AMP+DEG		MVA	CB.MVA
7	15317.36	-92.67	1954.307	2345.160

ONE-PHASE SHORT CIRCUIT ON 230.0 KV-BUS

BUS	AMP+DEG	MVA	CB,MVA
1	2309.13 -84.28	1036.624	1347.611

BRCH	BUS	AMP(A)+DEG	AMP(3I(O))+DEG
1	1	346.69 75.24	101.45 107.92
1	2	327.66 -105.06	114.32 -73.45
2	1	346.69 75.24	101.45 107.92
2	2	327.66 -105.06	114.32 -73.45
3	2	290.95 75.27	47.35 115.00
3	5	251.78 -104.30	59.64 -68.09
4	2	337.26 74.98	77.40 111.90
4	3	310.62 -104.77	89.26 -69.61
5	3	320.09 79.50	34.70 116.94
5	4	300.44 -100.03	35.38 -63.22
6	4	153.27 -33.66	20.32 117.07
6	6	154.41 144.98	20.40 -62.93
7	4	320.91 -83.09	29.74 -67.60
7	5	322.66 95.97	29.66 112.39
8	6	155.23 -35.18	20.56 116.39
8	8	154.27 143.65	.00 .00
9	5	121.31 -39.18	30.27 110.70
9	9	124.48 138.58	.00 .00
10	4	2276.70 98.11	121.74 -64.30
10	7	2175.98 -81.89	121.74 115.69
10	4	708.00 98.75	44.29 114.76
10	7	678.59 -81.22	44.29 -65.23
13	3	24.58 -14.17	54.90 106.14
13	10	35.71 140.78	.00 .00
14	2	26.28 71.14	105.63 98.74
14	11	17.03 144.36	.00 .00
15	1	66.30 83.96	219.47 94.55
15	12	14.56 151.32	.00 .00
101	1	1615.31 -75.17	1891.55 -85.44
102	7	2836.37 -61.75	87.10 -65.05
103	7	522.43 -86.71	31.93 -65.85

BUS	AMP+DEG	MVA	CB,MVA
2	1756.29 -85.57	776.580	1009.554

ONE-PHASE SHORT CIRCUIT ON 69.0 KV-BUS

BUS	AMP+DEG	MVA	CB.MVA
7	15317.36 -92.67	1954.307	2345.168

BRCH	BUS	AMP(A)+DEG		AMP(3I(O))+DEG	
1	1	245.32	-59.36	21.43	-73.90
1	2	292.81	116.73	20.02	106.89
2	1	245.32	-59.36	21.43	-73.90
2	2	292.81	116.73	20.02	106.89
3	2	267.00	-65.13	45.54	-80.94
3	5	298.62	112.49	31.64	103.58
4	2	314.02	-64.44	23.08	-77.05
4	3	333.43	114.23	21.32	106.94
5	3	332.90	-71.09	115.80	-85.54
5	4	344.48	108.27	112.95	94.64
6	4	124.91	2.44	226.94	86.53
6	6	124.80	-178.34	227.86	-93.46
7	4	277.99	93.50	236.89	69.83
7	5	277.16	-86.48	237.54	-90.18
8	6	125.57	1.64	227.14	86.75
8	8	134.86	149.29	.00	.00
9	5	97.03	.85	207.23	87.47
9	9	110.71	144.28	.00	.00
10	4	610.53	-90.03	575.44	-90.53
10	7	592.32	89.96	575.44	89.46
10	4	259.76	76.35	4947.48	88.04
10	7	319.04	-101.03	4947.48	-91.95
13	3	31.50	21.76	95.23	91.53
13	10	34.60	146.34	.00	.00
14	2	15.81	6.98	34.84	93.16
14	11	18.98	149.36	.00	.00
15	1	18.88	-23.39	4.36	105.75
15	12	19.83	153.34	.00	.00
101	1	506.03	-50.13	37.63	-74.24
102	7	10458.75	-88.62	7582.67	-92.99
103	7	2360.54	-94.60	2779.94	-92.99

THREE-PHASE SHORT CIRCUIT STUDY

FAULT ON 230.0 KV-BUS

BUS	AMP+DEG		MVA	CB.MVA
1	1991.56	-81.40	894.059	1162.277
2	1881.30	-82.86	831.857	1081.415
3	1778.53	-84.48	759.188	986.944
4	2279.36	-85.33	945.411	1229.034
5	2119.70	-85.10	880.339	1144.441
6	2023.78	-85.39	833.662	1083.761

FAULT ON 69.0 KV-BUS

BUS	AMP+DEG		MVA	CB.MVA
7	13024.88	-87.35	1661.814	1994.177
8	3880.30	-88.57	485.862	583.035
9	3991.64	-88.82	504.225	605.070
10	2880.33	-89.48	370.921	455.905
11	2561.72	-88.37	336.342	403.610
12	2195.85	-85.21	291.890	350.260

THREE-PHASE SHORT CIRCUIT STUDY

FAULT ON 230.0 KV-BUS

BUS	AMP+DEG		MVA	CB.MVA		
1	1991.56	-81.40	894.059	1162.277		
L	I	J	AMP(I-J)+DEG		AMP(J-I)+DEG	
1	2	1	366.72	-96.45	377.22	83.31
2	2	1	366.72	-96.45	377.22	83.31
3	5	2	309.06	-95.13	342.86	83.93
4	3	2	376.81	-95.80	393.42	83.82
5	4	3	372.85	-93.38	389.64	86.14
6	4	6	93.99	-39.98	95.52	138.18
7	4	5	363.13	-85.97	364.73	93.94
8	8	6	308.14	137.93	96.64	-42.06
9	9	5	240.92	132.44	75.56	-47.55
10	7	4	2547.89	-84.65	799.13	95.34
13	10	3	57.43	133.01	18.01	-46.98
14	2	11	5.28	-48.01	17.61	131.98
15	12	1	.03	-90.67	.01	89.32
101	1	0	1279.60	-72.46		
102	7	0	2834.33	-67.04		
103	7	0	599.74	-91.00		

BUS	VOLT+DEG	
1	.00000	90.00
2	.24015	-14.81
3	.38967	-14.54
4	.49633	-13.94
5	.47787	-14.33
6	.49307	-14.49
7	.81137	-6.84
8	.49958	-18.23
9	.48449	-17.16
10	.40144	-15.90
11	.23768	-15.74
12	.00001	-.63

BUS	AMP+DEG		MVA	CB.MVA
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FAULT ON 69.0 KV BUS

BUS	AMP. DEG		MVA	CB. MVA		
7	13024.88	87.35	1661.814	1994.177		
L	I	J	AMP(I - J)+DEG		AMP(J - I)+DEG	
1	1	2	264.54	-66.87	312.89	111.47
2	1	2	264.54	-66.87	312.89	111.47
3	2	5	282.68	-69.36	315.99	109.75
4	2	3	336.30	-69.10	357.13	110.38
5	3	4	347.41	-71.50	358.08	108.30
6	4	6	44.03	-13.54	44.75	164.65
7	5	4	292.75	-75.96	293.57	104.02
8	8	6	141.97	164.80	44.52	-15.19
9	9	5	123.40	159.35	38.70	-20.64
10	4	7	630.15	-77.08	2009.15	102.91
13	10	3	48.44	158.92	15.19	-21.07
14	2	11	10.24	-20.25	34.16	159.74
15	1	12	13.64	-20.15	45.49	159.84
101	1	0	538.57	-65.81		
102	7	0	9172.21	-88.01		
103	7	0	1893.44	-94.99		

BUS	VOLT+DEG	
1	.64839	12.73
2	.46207	12.23
3	.32746	12.11
4	.22875	12.91
5	.24375	12.48
6	.22722	12.35
7	.00000	5.71
8	.23022	8.61
9	.24711	9.63
10	.33723	10.75
11	.45736	11.29
12	.63996	11.55



BUS	AMP. DEG		MVA	CB. MVA
8	3880.30	-88.57	485.862	583.035