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TOPICAL REPORT **VOLUME 4** APPENDIX

BRUSHLESS ROTATING ELECTRICAL GENERATORS FOR SPACE AUXILIARY POWER SYSTEMS

by

J. N. Ellis and F. A. Collins

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONTRACT NO. NAS 3-2783

LEAR SIEGLER, INC.

POWER EQUIPMENT DIVISION

CLEVELAND 1, OHIO

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Technical Management
Howard A. Shumaker
NASA Lewis Research Center
Space Power System Division
Solar and Chemical Power Branch

LEAR SIEGLER, INC.
Power Equipment Division
Cleveland, Ohio

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GENERATOR THERMAL ANALYSIS
COMPUTER PROGRAM (FORTRAN)

NOMENCLATURE

Variable	Description	Units	Computer Language
r_1	inner radius of shaft	inches	S1
r_2	outer radius of shaft	inches	S2
r_3	outer radius of rotor	inches	S3
r_4	inner radius of stator	inches	S4
r_5	outer radius of stator	inches	S5
r_6	inner radius of end turn	inches	S6
r_7	outer radius of end turn	inches	S7
r_8	inner radius of stator slot	inches	S8
r_9	outer radius of stator slot	inches	S9
u	width of stator slot	inches	U
v	height of stator slot	inches	V
w	distance between stator slots	inches	W
t_i	thickness of slot insulation	inches	TINS
k_s	thermal conductivity of shaft	Btu/hr-ft-°F	AKSH
k_g	thermal conductivity of gas	Btu/hr-ft-°F	AKGAS
k_r	thermal conductivity of rotor (radially)	Btu/hr-ft-°F	AKR
k'_{ri}	thermal conductivity of rotor (axially, inner surface)	Btu/hr-ft-°F	AKRP
k'_{ro}	thermal conductivity of rotor (axially, outer surface)	Btu/hr-ft-°F	AKROP
k_{lam}	thermal conductivity of lamination of stator, radially	Btu/hr-ft-°F	AKL
k'_{lam}	thermal conductivity of lamination of stator, axially	Btu/hr-ft-°F	AKSTL

NOMENCLATURE
(Contd)

Variable	Description	Units	Computer Language
k_{ins}	thermal conductivity of slot insulation	Btu/hr-ft-°F	AKINS
k^*	thermal conductivity of stator winding, radially	Btu/hr-ft-°F	AKSTAR
k_{cop}	thermal conductivity of stator winding, axially	Btu/hr-ft-°F	AKCOP
F_{area}	ratio of copper area/slot area	-------	FAREA
h_e	heat transfer coefficient at end turns	Btu/hr-ft^2-°F	HEND
h_g	heat transfer coefficient in gap	Btu/hr-ft^2-°F	HGAP
h_o	heat transfer coefficient at back iron surface	Btu/hr-ft^2-°F	HOUT
h_w	heat transfer coefficient of ultimate sink at O.D. of stator	Btu/hr-ft^2-°F	HSINK
h_s	heat transfer coefficient of shaft surface	Btu/hr-ft^2-°F	HSH
K_s	number of stator slots	-------	KS
ℓ	stack length	inches	AL
ℓ_e	end ℓ_x tension length	inches	ALE
b	length of bearing	inches	B
d	length of shaft between rotor and bearing	inches	D
t_p	radial clearance of journal bearing	inches	TP
R_{shaft}	thermal resistance between end of shaft and ultimate sink	$\frac{°F\text{-}hr}{BTU}$	RSHAFT
$R_{bearing}$	thermal resistance between bearing and ultimate sink	$\frac{°F\text{-}hr}{BTU}$	RBRG
βr	temperature coefficient of resistivity of rotor material	$°F^{-1}$	BR

NOMENCLATURE
(Contd)

Variable	Description	Units	Computer Language
β_c	temperature coefficient of resistivity of stator windings	$°F^{-1}$	BC
β_ℓ	temperature coefficient of resistivity of rotor lamination	$°F^{-1}$	BL
T*	reference temperature for β_r, β_c, β_ℓ	°F	TSTAR
T64	boundary temperature, see Figure 1	°F	T64
T65	boundary temperature, see Figure 1	°F	T65
T66	boundary temperature, see Figure 1	°F	T66
T52	boundary temperature, see Figure 1	°F	T52
T53	boundary temperature, see Figure 1	°F	T53
T54	boundary temperature, see Figure 1	°F	T54
T55	boundary temperature, see Figure 1	°F	T55
C	specific heat at constant pressure	Btu/lb-°F	C
W_1	flow rate of gas in gap	lbs/hr	W1
W_2	flow rate of gas outside stator	lbs/hr	W2
TINLET	inlet gas temperature	°F	TINLET
Q_i	heat generation at node, See Figure 1	Btu/hr	Q(I)

```
C       PART I   PN0183
        DIMENSION  R(100),A(44,44),X(44),Q(100)
        COMMON A,X,R,Q
        READ 1, S1,S2,S3,S4,S5,S6
        READ 1, S7,S8,S9
        READ 1, AKSH,AKGAS,AKR,AKRP,AKL
        READ 1, AKSTL,AKINS,AKSTAR,AKCOP ,AKROP
        READ 1, FAREA,HEND,HGAP,HOUT,HSINK,HSH
        READ 1, U,V,W,AL,ALE,B,KS
        READ 1, D,TINS,TP,RSHAFT,RBRG
        C1=6./(3.14159*AKSH)
        C2=S2**2-S1**2
        R(1)=(C1/C2)*B+RSHAFT
        C3=36./3.14159
        R(2)=C3*TP/(AKGAS*B*S2)/12.0
        R(3)=R(2)
        R(2)=R(2)+(C1/B)*LOGF(S2/S1)
        R(3)=R(3)+RBRG
        R(4)=(2.*C1/C2)*(B/2.+D/3.)
        R(5)=(3.0*C3)/(S2*D*HSH)
        R(5)=R(5)+(1.5*C1*LOGF(S2/S1))/D
        R(6)=D*C1/C2
        R(7)=2.*R(5)
        R(8)=R(6)/3.
        R(8)=R(8)+(2.0*AL)/(3.14159*AKRP*C2)
        C4=C1*AKSH/AKR
        R(9)=(3.*C4/AL)*LOGF(S2/S1)
        R(10)=(C3/(S3*HGAP*AL))*6.
        R(10)=R(10)+(3.*C4/AL)*LOGF(S3/S2)
```

```
C5=S3**2-S2**2
RRRRR=AL*(C4/C5)*AKR/AKROP
R(11)=RRRRR
R(12)=RRRRR*C5/C2*2./3.*(AKROP/AKRP)
R(13)=R(9)
R(14)=R(12)
R(15)=R(11)
R(16)=R(13)
R(17)=R(8)
R(18)=R(7)
R(19)=R(6)
R(20)=R(5)
R(21)=R(4)
R(22)=R(2)
R(23)=R(1)
R(24)=R(3)
R(26)=R(10)
R(25)=R(10)
R(27)=6.*C3/(S4*AL*HGAP)
C6=C4*AKR/AKL
R(27)=R(27)+(3.*C6/AL)*LOGF((S8+S4)/(2.*S4))
R(28)=R(27)
R(29)=R(27)
R(30)=18.*(S9-S4)
R(30)=R(30)/(AKL*AL*W)
AKS=KS
R(30)=R(30)/AKS
R(31)=R(30)
R(32)=R(30)
```

```
C7=(18./AKL)*(S5-S8)
R(33)=C7/(AL*W*AKS)
R(35)=R(33)
R(37)=R(33)
C8=18./(AKS*U*AL)
R(34)=V/AKSTAR+2.*TINS/AKINS
R(34)=C8*R(34)
CC=2.*S8/(S8+S4)
CCC=18./AKL*AL*3.14159
R(34)=R(34)+CCC*LOGF(CC)
R(36)=R(34)
R(38)=R(34)
CC=(S5+S9)/(2.*S9)
R(43)=V/AKSTAR+2.*TINS/AKINS
R(43)=C8*R(43)
R(43)=R(43)+CCC*LOGF(CC)
R(44)=R(43)
R(45)=R(43)
R(40)=4.*AL/(AKCOP*U*V*AKS*FAREA)
R(41)=R(40)
C9=(S7**2-S6**2)*3.14159*FAREA*AKCOP
R(39)=3.*ALE/C9+0.5*R(40)
R(42)=R(39)
R(46)=144./(3.14159*S6*ALE*HEND)
R(47)=R(46)
R(55)=R(46)
R(56)=R(46)
R(53)=(S6/S7)*R(46)
R(54)=R(53)
```

```
R(61)=R(53)
R(62)=R(53)
R(50)=6.*ALE/C9
R(76)=R(50)
C10=1.+0.5*S7/S6
C11=12./(3.14159*AKSTAR*ALE)
R(48)=C11*LOGF(C10)
R(49)=R(48)
R(57)=R(48)
R(58)=R(48)
C12=2.*S7/(S7+S6)
R(51)=C11*LOGF(C12)
R(52)=R(51)
R(59)=R(51)
R(60)=R(51)
C13=(2.*S5)/(S5+S9)
C14=18./(3.14159*AKL*AL)
R(63)=C14*LOGF(C13)
R(64)=R(63)
R(65)=R(63)
R(66)=216./(3.14159*S5*AL*HOUT)
R(67)=R(66)
R(68)=R(66)
R(69)=R(66)*(1.+HOUT/HSINK)
R(70)=R(69)
R(71)=R(69)
R(72)=4.*AL/(AKSTL*W*V*AKS)
R(73)=R(72)
R(74)=4.0*AL/(AKSTL*AKS*(S5-S9))
```

```
      R(74)=R(74)/(U+W)
      R(75)=R(74)
      C15=18./(V*AL*AKS)
      R(77)=U/AKSTAR+TINS/AKINS+0.5*W/AKSTL
      R(77)=C15*R(77)
      R(78)=R(77)
      R(79)=R(77)
      IF (SENSE SWITCH 1) 10,20
   10 PUNCH 2, (R(I),I=1,79)
   20 STOP
    1 FORMAT(6E10.3,I5)
    2 FORMAT(6E10.3)
      END
```

```
C     PART 2A CALCULATION UP TO A(17,18)
      DIMENSION  R(100),A(44,44),B(44,1),Q(100)
      COMMON A,B,R,Q
      COMMON NR,NQ,BR,BL,BC,TSTAR
      COMMON TIN,T52,T53,T54,T55
      COMMON T64,T65,T66,W1,W2,C
      COMMON BBR,BBL,BBC
      READ 100, NR,NQ,BR,BL,BC,TSTAR
      READ 101, (Q(I),I=1,NQ)
      READ 101, TIN,T52,T53,T54,T55
      READ 101, T64,T65,T66
      READ 101, W1,W2,C
      IF (SENSE SWITCH 1 ) 40,45
   40 READ 101, (R(I),I=1,NR)
   45 N=44
      DO 2 I=1,N
    1 DO 2 J=1,N
    2 A(I,J)=0.0
      DO 3 J=1,N
    3 B(J,1)=0.0
C     CALCULATION OF A(I,J), COEFFICIENTS WHICH
C     ARE NON ZERO
      BBR=1.-BR*TSTAR
      BBL=1.-BL*TSTAR
      BBC=1.-BC*TSTAR
      A(1,1)=1./R(2)+1./R(3)
      A(1,2)=-1./R(2)
      B(1,1)=Q(1)+T53/R(3)
      A(2,1)=A(1,2)
```

k

```
      A(2,2)=1./R(1)+1./R(2)+1./R(4)
      A(2,3)=-1./R(4)
      B(2,1)=T52/R(1)
      A(3,2)=A(2,3)
      A(3,3)=1.0/R(4)+1.0/R(5)+1.0/R(6)
      A(3,4)=-1./R(6)
      A(3,43)=-1.0/R(5)
      B(3,1)=Q(4)
      A(4,3)=A(3,4)
      A(4,4)=1./R(6)+1./R(7)+1./R(8)
      A(4,5)=-1./R(8)
      A(4,44)=-1.0/R(7)
      B(4,1)=Q(6)
      A(5,4)=A(4,5)
      A(5,5)=1./R(8)+1./R(9)+1./R(12)
      A(5,6)=-1./R(9)
      A(5,7)=-1./R(12)
      B(5,1)= Q(7)
      A(6,5)=A(5,6)
      A(6,6)=1.0/R(9)+1./R(10)+1./R(11)-BR*Q(8)
      IF (A(6,6)) 99,99,6
    6 A(6,8)=-1./R(11)
      A(6,15)=-1./R(10)
      B(6,1)=BBR*Q(8)
      A(7,5)=-1./R(12)
      A(7,7)=1./R(12)+1.0/R(13)+1./R(14)
      A(7,8)=-1./R(13)
      A(7,10)=-1./R(14)
      B(7,1) = Q(9)
```

```
      A(8,6)=-1./R(11)
      A(8,7)=A(7,8)
      A(8,8)=1./R(11)+1./R(13)+1./R(15)+1./R(26)-BR*Q(10)
      IF (A(8,8)) 98,98,8
    8 A(8,9)=-1./R(15)
      A(8,16)=-1./R(26)
      B(8,1)=BBR*Q(10)
      A(9,8)=-1./R(15)
      A(9,9)=1./R(25)+1./R(15)+1./R(16)-BR*Q(11)
      IF (A(9,9)) 97,97,9
    9 A(9,10)=-1./R(16)
      A(9,17)=-1./R(25)
      B(9,1)=BBR*Q(11)
      A(10,7)=-1./R(14)
      A(10,9)=A(9,10)
      A(10,10)=1./R(14)+1./R(16)+1./R(17)
      A(10,11)=-1./R(17)
      B(10,1) = Q(12)
      A(11,10)=A(10,11)
      A(11,11)=1./R(17)+1./R(18)+1.0/R(19)
      A(11,12)=-1./R(19)
      A(11,41)=-1./R(18)
      B(11,1)=Q(14)
      A(12,11)=-1./R(19)
      A(12,12)=1.0/R(19)+1./R(20)+1./R(21)
      A(12,13)=-1./R(21)
      A(12,42)=-1./R(20)
      B(12,1)=Q(16)
      A(13,12)=A(12,13)
```

```
      A(13,13)=1./R(21)+1./R(22)+1./R(23)
      A(13,14)=-1./R(22)
      B(13,1)=T54/R(23)
      A(14,13)=A(13,14)
      A(14,14)=1./R(22)+1./R(24)
      B(14,1)=Q(18)+T55/R(24)
      A(15,6)=A(6,15)
      A(15,15)=W1*C+1./R(27)+1./R(10)
      A(15,20)=-1./R(27)
      A(15,44)=-W1*C
      B(15,1)=Q(19)
      A(16,8)=A(8,16)
      A(16,15)=A(15,44)
      A(16,16)=W1*C+1./R(28)+1./R(26)
      A(16,19)=-1./R(28)
      B(16,1)=Q(20)
      A(17,9)=A(9,17)
      A(17,16)=A(16,15)
      A(17,17)=W1*C+1.0/R(29)+1./R(25)
      A(17,18)=-1./R(29)
      B(17,1)=Q(21)
      STOP
   99 PRINT 1000
      LERR=6
      PUNCH 1001, A(6,6),R(9),R(10),R(11),BR,Q(8)
      GO TO 998
   98 PRINT 1000
      LERR=8
      PUNCH 1001, A(8,8),R(11),R(13),R(15),R(26),BR,Q(10)
```

```
      GO TO 998
   97 PRINT 1000
      LERR=9
      PUNCH 1001, A(9,9),R(25),R(15),R(16),BR,Q(11)
      GO TO 998
  998 PUNCH 1002, LERR
      STOP
  100 FORMAT(2I5,4E10.3)
  101 FORMAT(6E10.3)
 1000 FORMAT (19H   UNSTABLE PROBLEM)
 1001 FORMAT(8E10.3)
 1002 FORMAT (10H0  INDEX =I3)
      END
```

```
C       PART 2B CALCULATION UP TO A(28,43)
        DIMENSION  R(100),A(44,44),B(44,1),Q(100)
        COMMON A,B,R,Q
        COMMON NR,NQ,BR,BL,BC,TSTAR
        COMMON TIN,T52,T53,T54,T55
        COMMON T64,T65,T66,W1,W2,C
        COMMON BBR,BBL,BBC
        A(18,17)=A(17,18)
        A(18,18)=1./R(29)+1./R(30)+1./R(34)
        A(18,23)=-1./R(30)
        A(18,24)=-1./R(34)
        B(18,1)=Q(22)
        A(19,16)=A(16,19)
        A(19,19)=1./R(28)+1./R(31)+1./R(36)
        A(19,22)=-1./R(31)
        A(19,25)=-1./R(36)
        B(19,1)=Q(23)
        A(20,15)=-1./R(27)
        A(20,20)=1./R(27)+1./R(32)+1./R(38)
        A(20,21)=-1./R(32)
        A(20,26)=-1./R(38)
        B(20,1)=Q(24)
        A(21,20)=A(20,21)
        A(21,21)=1./R(32)+1./R(37)+1./R(73)-BL*Q(25)+1./R(79)
        IF (A(21,21)) 96,96,21
     21 A(21,22)=-1./R(73)
        A(21,26) = -1./R(79)
        A(21,33)=-1./R(37)
        B(21,1)=BBL*Q(25)
```

```
      A(22,19)=A(19,22)
      A(22,21)=A(21,22)
      A(22,22)=1./R(31)+1./R(35)+1./R(72)+1./R(73)-BL*Q(26)+1./R(78)
      IF (A(22,22)) 95,95,22
   22 A(22,23)=-1./R(72)
      A(22,25) = -1./R(78)
      A(22,32)=-1./R(35)
      B(22,1)=BBL*Q(26)
      A(23,18)=A(18,23)
      A(23,22)=A(22,23)
      A(23,23)=1./R(72)+1./R(33)+1./R(30)-BL*Q(27)+1./R(77)
      A(23,24) = -1./R(77)
      A(23,31)=-1./R(33)
      B(23,1)=BBL*Q(27)
      A(24,18)=A(18,24)
      A(24,24)=1./R(40)+1./R(45)+1./R(39)+1./R(34)-BC*Q(28)+1./R(77)
      A(24,23) = -1./R(77)
      IF (A(24,24)) 94,94,24
   24 A(24,25)=-1./R(40)
      A(24,30)=-1./R(39)
      A(24,31)=-1./R(45)
      B(24,1)=BBC*Q(28)
      A(25,19)=A(19,25)
      A(25,22) = -1./R(78)
      A(25,24)=A(24,25)
      A(25,25)=1./R(36)+1./R(40)+1./R(41)+1./R(44)-BC*Q(29)+1./R(78)
      IF (A(25,25)) 93,93,25
   25 A(25,26)=-1./R(41)
      A(25,32)=-1./R(44)
```

```
      B(25,1)=BBC*Q(29)
      A(26,20)=A(20,26)
      A(26,21) = -1./R(79)
      A(26,25)=A(25,26)
      A(26,26)=1./R(38)+1./R(41)+1./R(42)+1./R(43)-BC*Q(30)+1./R(79)
      IF (A(26,26)) 92,92,26
26    A(26,27)=-1./R(42)
      A(26,33)=-1./R(43)
      B(26,1)=BBC*Q(30)
      A(27,26)=A(26,27)
      A(27,27)=1./R(50)+1./R(42)-BC*Q(33)
      Z=R(51)+R(53)
      ZZ=R(46)+R(48)
      A(27,27)=A(27,27)+1./Z+1./ZZ
      IF (A(27,27)) 91,91,27
27    A(27,28)=-1./R(50)
      A(27,38)=-1./Z
      A(27,44)=-1./ZZ
      B(27,1)=BBC*Q(33)
      A(28,27)=A(27,28)
      Z=R(52)+R(54)
      ZZ=R(47)+R(49)
      A(28,28)=1./R(50)+1./Z+1./ZZ-BC*Q(34)
      IF (A(28,28)) 90,90,28
28    A(28,37)=-1./Z
      A(28,43)=-1./ZZ
      B(28,1)=BBC*Q(34)
      STOP
96    PRINT 1000
```

```
      LERR=21
      PUNCH 1001, A(21,21),R(32),R(37),R(73),BL,Q(25)
      GO TO 998
   95 PRINT 1000
      LERR=22
      PUNCH 1001, A(22,22),R(31),R(72),R(73),BL,Q(26)
      GO TO 998
   94 PRINT 1000
      LERR=24
      PUNCH 1001, A(24,24),R(40),R(45),R(39),R(34),BC,Q(28)
      GO TO 998
   93 PRINT 1000
      LERR=25
      PUNCH 1001, A(25,25),R(36),R(40),R(41),R(44),BC,Q(29)
      GO TO 998
   92 PRINT 1000
      LERR=26
      PUNCH 1001, A(26,26),R(38),R(41),R(42),R(43),BC,Q(30)
      GO TO 998
   91 PRINT 1000
      LERR=27
      PUNCH 1001, A(27,27),Z,ZZ,R(50),R(42),BC,Q(33)
      GO TO 998
   90 PRINT 1000
      LERR=28
      PUNCH 1001, A(28,28),Z,ZZ,R(50),BC,Q(34)
      GO TO 998
  998 PUNCH 1002, LERR
      STOP
```

```
1000 FORMAT(49H  UNSTABLE PROBLEM
1001 FORMAT(8E10.3)
1002 FORMAT (10H0  INDEX =I3)
     END
```

```
C     PART 2C CALCULATION UP TO A(44,44)
      DIMENSION  R(100),A(44,44),B(44,1),Q(100)
      COMMON A,B,R,Q
      COMMON NR,NQ,BR,BL,BC,TSTAR
      COMMON TIN,T52,T53,T54,T55
      COMMON T64,T65,T66,W1,W2,C
      COMMON BBR,BBL,BBC
      N=44
      Z=R(55)+R(57)
      ZZ=R(59)+R(61)
      A(29,29)=1./R(76)+1./Z+1./ZZ-BC*Q(39)
      IF (A(29,29)) 89,89,29
   29 A(29,30)=-1./R(76)
      A(29,42)=-1./Z
      A(29,39)=-1./ZZ
      B(29,1)=BBC*Q(39)
      A(30,24)=A(24,30)
      A(30,29)=A(29,30)
      Z=R(60)+R(62)
      ZZ=R(56)+R(58)
      A(30,30)=1./R(39)+1./R(76)+1./Z+1./ZZ-BC*Q(40)
      IF (A(30,30)) 88,88,30
   30 A(30,41)=-1./ZZ
      A(30,40)=-1./Z
      B(30,1)=BBC*Q(40)
      A(31,23)=A(23,31)
      A(31,24)=A(24,31)
      Z=R(63)+R(66)
      A(31,31)=1./R(33)+1./R(45)+1./R(74)+1./Z-BL*Q(43)
```

```
      IF (A(31,31)) 87,87,31
   31 A(31,32)=-1./R(74)
      A(31,34)=-1./Z
      B(31,1)=BBL*Q(43)
      A(32,22)=A(22,32)
      A(32,25)=A(25,32)
      A(32,31)=A(31,32)
      Z=R(64)+R(67)
      A(32,32)=1./R(35)+1./R(44)+1./R(74)+1./R(75)+1./Z-BL*Q(44)
      IF (A(32,32)) 86,86,32
   32 A(32,33)=-1./R(75)
      A(32,35)=-1./Z
      B(32,1)=BBL*Q(44)
      A(33,21)=A(21,33)
      A(33,26)=A(26,33)
      A(33,32)=A(32,33)
      Z=R(65)+R(68)
      A(33,33)=1./R(75)+1./R(43)+1./R(37)+1./Z-BL*Q(45)
      IF (A(33,33)) 85,85,33
   33 A(33,36)=-1./Z
      B(33,1)=BBL*Q(45)
      A(34,33)=A(33,36)
      A(34,36)=W2*C+1./Z+1./R(71)
      A(34,38)=-W2*C
      B(34,1)=T66/R(71)
      A(35,32)=A(32,35)
      A(35,35)=W2*C+1./R(70)-A(32,35)
      A(35,36)=-W2*C
      B(35,1)=T65/R(70)
```

```
A(36,31)=A(31,34)
A(36,34)=W2*C+1./R(69)-A(31,34)
A(36,35)=-W2*C
B(36,1)=T64/R(69)
A(37,27)=A(27,38)
A(37,37)=-W2*C
A(37,38)=W2*C-A(27,38)
A(38,28)=A(28,37)
A(38,37)=W2*C-A(28,37)
B(38,1)=W2*C*TIN
A(39,30)=A(30,40)
A(39,34)=-W2*C
A(39,40)=-A(39,34)-A(39,30)
A(40,29)=A(29,39)
A(40,40)=A(39,34)
A(40,39)=-A(40,40)-A(40,29)
A(41,11)=A(11,41)
A(41,17)=-W1*C
A(41,30)=A(30,41)
A(41,41)=-A(41,11)-A(41,17)-A(41,30)
A(42,12)=A(12,42)
A(42,29)=A(29,42)
A(42,41)=A(41,17)
A(42,42)=-A(42,41)-A(42,29)-A(42,12)
A(43,3)=A(3,43)
A(43,28)=A(28,43)
A(43,43)=-A(43,3)-A(28,43)+W1*C
B(43,1)=W1*C*TIN
A(44,4)=A(4,44)
```

```
      A(44,27)=A(27,44)
      A(44,43)=-W1*C
      A(44,44)=-A(44,43)-A(44,27)-A(44,4)
      GO TO 999
   89 PRINT 1000
      LERR=29
      PUNCH 1001, A(29,29),Z,ZZ,R(76),BC,Q(39)
      GO TO 998
   88 PRINT 1000
      LERR=30
      PUNCH 1001, A(30,30),Z,ZZ,R(39),R(76),BC,Q(40)
      GO TO 998
   87 PRINT 1000
      LERR=31
      PUNCH 1001, A(31,31),Z,R(33),R(45),R(74),BL,Q(43)
      GO TO 998
   86 PRINT 1000
      LERR=32
      PUNCH 1001, A(32,32),Z,R(35),R(44),R(74),R(75),BL,Q(44)
      GO TO 998
   85 PRINT 1000
      LERR=33
      PUNCH 1001, A(33,33),Z,R(75),R(43),R(37),BL,Q(45)
  998 PUNCH 1002, LERR
      STOP
C     SET UP DATA FOR MATINVERSE
  999 IF(SENSE SWITCH 1) 801,800
  801 DO 802 I=1,N
  802 PUNCH 101, (A(I,J),J=1,N)
```

```
      PUNCH 101, (B(J,1),J=1,N)
  800 STOP
  101 FORMAT(6E10.3)
 1000 FORMAT(49H  UNSTABLE PROBLEM
 1001 FORMAT(8E10.3)
 1002 FORMAT (10HO  INDEX =I3)
      END
```

```
      SUBROUTINE MATINV (A,N,B,M,DETER)
C     THIS VERSION SOLVES SYSTEM OF EQUATIONS WITHOUT
C     GETTING INVERSE OF A MATRIX
      DIMENSION A(44,44),B(44),IPIVO (44),PIVOT(44)
      DETER =1.0
      DO 20 J=1,N
   20 IPIVO(J)=0
      DO 550 I=1,N
C                                                                       F
C     SEARCH FOR PIVOT ELEMENT                                          F
C                                                                       F
      AMAX=0.0
      DO 105 J=1,N
      IF (IPIVO(J)-1) 60,105,60
   60 DO 100 K=1,N
      IF (IPIVO(K) -1) 80, 100, 600
   80 IF (ABSF(AMAX)-ABSF(A(J,K))) 85,100,100
   85 IROW=J
      ICOLU =K
      AMAX=A(J,K)
  100 CONTINUE
  105 CONTINUE
      IPIVO(ICOLU)=IPIVO(ICOLU)+1
C                                                                       F
C     INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL                 F
C                                                                       F
      IF (IROW-ICOLU)  140, 260, 140
  140 DETER =-DETER
      DO 200 L=1,N
```

```
      AMAX=A(IROW,L)
      A(IROW,L)=A(ICOLU,L)
  200 A(ICOLU,L)=AMAX
      AMAX=B(IROW)
      B(IROW)=B(ICOLU)
      B(ICOLU)=AMAX
  260 PIVOT(I)=A(ICOLU,ICOLU)
      DETER =DETER*PIVOT(I)
C                                                                       F
C     DIVIDE PIVOT ROW BY PIVOT ELEMENT                                 F
C                                                                       F
      A(ICOLU,ICOLU)=1.0
      DO 350 L=1,N
  350 A(ICOLU,L)=A(ICOLU,L)/PIVOT(I)
      B(ICOLU)=B(ICOLU)/PIVOT(I)
C                                                                       F
C     REDUCE NON-PIVOT ROWS                                             F
C                                                                       F
  380 DO 550 L1=1,N
      IF(L1-ICOLU)  400, 550, 400
  400 AMAX=A(L1,ICOLU)
      A(L1,ICOLU) =0.0
      DO 450 L=1,N
  450 A(L1,L)=A(L1,L)-A(ICOLU,L)*AMAX
      B(L1)=B(L1)-B(ICOLU)*AMAX
  550 CONTINUE
  600 RETURN
      END
```

```
C     PART III
      DIMENSION  A(44,44),B(44)
      COMMON A,B,R,Q
      NED=1
      READ 100,N
      IF(SENSE SWITCH 1) 5,20
    5 DO 10  I=1,N
   10 READ 130, (A(I,J),J=1,N)
      READ 130, (B(I),I=1,N)
   20 CALL MATINV (A,N,B,NED,DET)
      DO 30 I=1,N
   30 PUNCH 170, I,B(I)
      STOP
  100 FORMAT(I5)
  130 FORMAT(6E10.3)
  170 FORMAT(18H                  X( I2,2H)=E11.3)
      END
```

SALIENT-POLE, WOUND-POLE SYNCHRONOUS A-C GENERATOR COMPUTER PROGRAM AND TEST DATA

SALIENT POLE COMPUTER DESIGN (INPUT)

MODEL ____________________ EWO ____________ DESIGN NO(1) 100000

	No.	Sym.	Item	Value	Value	Item	No.	Sym.	
PARAMETERS	(2)	KVA	GENERATOR KVA	300.0	0.0	FUND/MAX OF FIELD FLUX	(71)	C_1	CONSTANTS
	(3)	E	LINE VOLTS	208.0	0.0	WINDING CONSTANT	(72)	C_w	
	(4)	E_{ph}	PHASE VOLTS	120.0	0.0	POLE CONST.	(73)	C_p	
	(5)	m	PHASES	3.0	0.0	END EXTENSION ONE TURN	(48)	L_E	
	(5a)	f	FREQUENCY	320.0	0.0	DEMAGNETIZATION FACTOR	(74)	C_m	
	(6)	p	POLES	8.0	0.0	CROSS MAGNETIZING FACTOR	(75)	C_q	
	(7)	RPM	RPM	48000	1.975	POLE HEAD WIDTH	(76)	b_h	ROTOR STACK
	(8)	I_{ph}	PHASE CURRENT	83.4	1.100	POLE BODY WIDTH	(76)	b_p	
	(9)	PF	POWER FACTOR	.75	.406	POLE HEAD HEIGHT	(76)	h_h	
	(9a)	K_c	ADJ. FACTOR	1.0	.979	POLE BODY HEIGHT	(76)	h_f	
	(10)		OPTIONAL LOAD POINT	.5	3.0	POLE BODY LENGTH	(76)	ℓ_p	
STATOR STACK	(11)	d	STATOR I.D.	7.25	3.0	POLE HEAD LENGTH	(76)	ℓ_n	
	(12)	D	STATOR O.D.	9.25	.71	POLE EMBRACE	(77)	α	
	(13)	ℓ	GROSS CORE LENGTH	3.0	7.18	ROTOR DIAMETER	(11a)	d_r	
	(14)	n_v	NO. OF DUCTS	0.0	.97	STACKING FACTOR (ROTOR)	(16)	K_i	
	(15)	b_v	WIDTH OF DUCT	0.0	0.0	WEIGHT OF ROTOR IRON	(157)	(-)	
	(16)	K_i	STACKING FACTOR (STATOR)	.92	1.17	POLE FACE LOSS FACTOR	(187)	(K_1)	
	(19)	k	WATTS/LB.	15.0	0.0	WIDTH OF SLOT OPENING	(135)	b_{bo}	DAMPER BAR
	(20)	B	DENSITY	77.4	0.0	HEIGHT OF SLOT OPENING	(135)	h_{bo}	
STATOR SLOT	(21)		TYPE OF SLOT	2.0	0.0	DAMPER BAR DIA. OR WIDTH	(136)	( )	
	(22)	b_o	SLOT OPENING	.06	0.0	RECTANGULAR BAR THICKNESS	(137)	h_{bl}	
	(22)	b_1	SLOT WIDTH TOP	0.0	0.0	RECTANGULAR SLOT WIDTH	(135)	b_{bl}	
	(22)	b_2		0.0	0.0	NO. OF DAMPER BARS	(138)	n_b	
	(22)	b_3		0.0	0.0	DAMPER BAR LENGTH	(139)	ℓ_b	
	(22)	b_s	SLOT WIDTH	.122	0.0	DAMPER BAR PITCH	(140)	τ_b	
	(22)	h_o		.020	0.0	RESISTIVITY OF DAMP. BAR @ 20°	(141)	ρ_b	
	(22)	h_1		.344	0.0	DAMPER BAR TEMP °C	(142)	X_a °C	
	(22)	h_2		0.0	68	NO. OF FIELD TURNS	(146a)	N_p	FIELD
	(22)	h_3		0.0	10.13	MEAN LENGTH OF FLD. TURN	(147)	ℓ_{tr}	
	(22)	h_s	SLOT DEPTH	.434	.0641	FLD. COND. DIA. OR WIDTH	(148)		
	(22)	h_t		0.0	0.0	FLD. COND. THICKNESS	(149)		
	(22)	h_w		.030	150	FLD. TEMP IN °C	(150)	X_f °C	
	(22)	Q	NO. OF SLOTS	96.0	.694	RESISTIVITY OF FIELD COND @ 20°	(151)	ρ_f	
STATOR WINDING	(28)		TYPE OF WDG.	1.0	1.0	NO LOAD SAT.	(87)		
	(29)		TYPE OF COIL	1.0	0	FRICTION & WINDAGE	(183)	(F&W)	
	(30)	n_s	CONDUCTORS/SLOT	2.0	M-36	ROTOR LAM. MTR'L	(18)		MATR'L
	(31)	y	SLOTS SPANNED	10.0	M-22	STATOR LAM. MTR'L (CURVE)	(18)		
	(32)	c	PARALLEL CIRCUITS	1.0					
	(33)		STRAND DIA. OR WIDTH	.075					
	(34)	N_{st}	STRANDS/CONDUCTOR	1.0					
	(34a)	N'_{st}	STRANDS/CONDUCTOR	1.0					
	(39)		STATOR STRAND T'KNS	.162					
	(35)	d_b	DIA. OF PIN	.25					
	(36)	ℓ_{e2}	COIL EXT. STR. PORT	.25					
	(37)	h_{st}	UNINS. STRD. HT.	.162					
	(38)	h'_{st}	DIST. BTWN. CL OF STD.	.192					
	(42a)		PHASE BELT/ANGLE	60.0					
	(40)	τ_{sk}	STATOR SLOT SKEW	0.0					
	(50)	X_s °C	STATOR TEMP °C	150.0					
	(51)	ρ_s	RES'TVY STA. COND. @ 20° C	.694					
GAP	(59)	g_{min}	MINIMUM AIR GAP	.035					
	(59a)	g_{max}	MAXIMUM AIR GAP	.047					

STATOR SLOT	POLE
DAMPER SLOT	REMARKS

DESIGNER ____________________ DATE ____________

REV

SUMMARY OF DESIGN CALCULATIONS - SALIENT POLE (OUTPUT)

	(24) (D_s)	DEPTH BELOW SLOT	[illegible]
	(26) (τ_s)	SLOT PITCH	.33720
	(27) (τ_s 1/3)	SLOT PITCH 1/3 DIST. UP	.24670
	(42) (K_{sk})	SKEW FACTOR	1.00000
	(43) (K_d)	DIST. FACTOR	.95705
	(44) (K_p)	PITCH FACTOR	.9659[illegible]
	(45) (n_e)	EFF. CONDUCTORS	165.60000
STATOR	(46) (a_c)	COND. AREA	.011[illegible]5
	(47) (S_s)	CURRENT DENSITY (STA.)	7343.00000
	(49) (ℓ_t)	1/2 MEAN TURN LENGTH	7.59[illegible]
	(53) (R_{ph})	COLD STA. RES. 20° C	.029[illegible]
	(54) (R_{ph})	HOT STA. RES. X° C	.044[illegible]
	(55) (EF_{top})	EDDY FACTOR TOP	1.10[illegible]
	(56) (EF_{bot})	EDDY FACTOR BOT	1.0[illegible]
	(62) (λ_i)	STATOR COND. PERM.	2.48[illegible]
	(64) (λ_e)	END PERM.	5.6[illegible]1[illegible]
	(65) ( )	WT. OF STA COPPER	5.[illegible]14
	(66) ( )	WT. OF STA IRON	16.[illegible]75[illegible]
	(41) (τ_p)	POLE PITCH	2.847[illegible]
	(79) (a_p)	POLE AREA	[illegible].201[illegible]
	(82b) ($\lambda_{e\ell}$)	POLE END LEAK PERM.	[illegible]18[illegible]
	(81b) ($\lambda_{t\ell}$)	POLE TIP LEAK PERM.	[illegible]48[illegible]
	(80b) ($\lambda_{s\ell}$)	POLE SIDE LEAK PERM.	.8[illegible]
ROTOR	(153) (a_{CF})	FLD. COND. AREA	.009[illegible]
	(154) (R_F)	COLD FLD RES 20° C	1.15572
	(155) (R_F)	HOT FLD RES X° C	1.79620
	(156) ( )	WT OF FLD COPPER	5.70550
	(157) ( )	WT OF ROTOR IRON	.00000
	(145) (V_r)	PERIPHERAL SPEED	9029.50000
	(176) (T_{do})	OPEN CIR. TIME CONST.	.15551
	(177) (T_a)	ARM TIME CONST.	.00709
TIME CONSTANTS	(178) (T'_d)	TRANS TIME CONST.	.02474
	(179) (T''_d)	SUB TRANS TIME CONST.	.00500
	(180) (F_{sc})	SHORT CIR NI	747.[illegible]000
	(181) (SCR)	SHORT CIR RATIO	1.0[illegible]7

[illegible]	AIR GAP AREA	(68) ( )	GAP
157.[illegible]1[illegible]	AIR GAP PERM	(70c) (λ_a)	
.0[illegible]78[illegible]	EFFECTIVE AIR GAP	(69) (g_e)	
1.[illegible]	FUND MAX OF FLD. FLUX	(71) (C_1)	CONSTANTS
[illegible]	WINDING CONST.	(72) (C_w)	
.[illegible]5[illegible]	POLE CONST.	(73) (C_p)	
[illegible]1	END. EXT. ONE TURN	(48) (L_E)	
.[illegible]	DEMAGNETIZING FACTOR	(74) (C_M)	
.[illegible]	CROSS MAGNETIZING FACTOR	(75) (C_q)	
[illegible]7[illegible].[illegible]	AMP COND/IN	(128) (A)	REACTANCE
.07[illegible]	REACTANCE FACTOR	(129) (X)	
7.7[illegible]7[illegible]	LEAKAGE REACTANCE	(130) (X_ℓ)	
11[illegible]	REACTANCE OF	(131) (X_{ad})	
6[illegible].[illegible]85	ARMATURE REACTION	(132) (X_{aq})	
1[illegible]7[illegible]	SYN REACT DIRECT AXIS	(133) (X_d)	
77.[illegible]7[illegible]7[illegible]	SYN REACT QUAD AXIS	(134) (X_q)	
1[illegible]	FIELD LEAKAGE REACT	(160) (X_f)	
.18[illegible]	FIELD SELF INDUCTANCE	(161) (L_f)	
.00000	DAMPER	(163) (X_{Dd})	
.00000	LEAKAGE REACT	(165) (X_{Dq})	
[illegible]	UNSAT. TRANS. REACT	(166) (X'_{du})	
1[illegible].[illegible]4710	SAT. TRANS. REACT	(167) (X'_d)	
1[illegible].[illegible]4710	SUB.TRANS.REACT DIRECT AX.	(168) (X''_d)	
77.[illegible]70	SUB.TRANS.REACT QUAD AX.	(169) (X''_q)	
4[illegible].[illegible]1040	NEG SEQUENCE REACT	(170) (X_2)	
[illegible].[illegible]51	ZERO SEQUENCE REACT	(172) (X_0)	
[illegible]0.00000	TOTAL FLUX	(88) (ϕ_t)	MAGNETIZATION
[illegible].[illegible]000	FLUX PER POLE	(92) (ϕ_p)	
[illegible]1.[illegible]1[illegible]0	GAP DENSITY	(95) (B_g)	
1[illegible].[illegible]000	TOOTH DENSITY	(91) (B_t)	
[illegible]1.[illegible]000	CORE DENSITY	(94) (B_c)	
[illegible].10[illegible]	TOOTH AMPERE TURNS	(97) (F_t)	
[illegible]	CORE AMPERE TURNS	(98) (F_c)	
[illegible]11.[illegible]	GAP AMPERE TURNS	(96) (F_g)	

	PERCENT LOAD	0		100	150	200	OPTIONAL
VARIABLE LOAD	(ϕ_ℓ) (100a) LEAK FLUX	25.174	($\phi_{\ell t}$) (197a)	[illegible].[illegible]77	[illegible]1.[illegible]21	74.87	[illegible]
	(ϕ_{pt}) (102a) POLE FLUX	311.204	(ϕ_{pil}) (213a)	[illegible].[illegible]17	[illegible]1.[illegible]1	[illegible]	[illegible]
	(B_p) (103a) POLE DENSITY	97.[illegible]21	(B_{pl}) (213b)	11[illegible]	119.115	127.[illegible]	[illegible]
	(F_p) (104a) POLE NI	[illegible]	(F_{pl}) (213c)	[illegible]	[illegible].[illegible]67	9[illegible].90[illegible]	.000
	(F_{nl}) (127) TOTAL NI	765.0[illegible]0	(F_{fl}) (236)	1[illegible]27.51[illegible]	[illegible]1[illegible].[illegible]59	3007.846	.00
	(I_{fnl}) (127a) FIELD AMPS	11.250	(I_{fl}) (237)	[illegible]	[illegible].[illegible]27	44.233	.00
	(S_F) (127c) CUR.DENS.(FLD)	3488.0[illegible]0	(S_{fl}) (239)	74[illegible]0.[illegible]	1[illegible].737	1371[illegible].[illegible]70	.000
	(E_F) (127b) FIELD VOLTS	1[illegible].[illegible]	(E_{fl}) (238)	[illegible]2.[illegible]90	58.066	79.451	.00
	(I^2R_r) (182) ROTOR LOSS	150.065	(I^2R_r) (241)	1[illegible].[illegible]	1877.091	[illegible]514.[illegible]7	.00
	(F&W) (183) F&W LOSS	[illegible]47.290	(F&W) (183)	[illegible]47.[illegible]	[illegible]47.290	347.29[illegible]	[illegible]47.290
	(W_{tnl}) (184) STA TOOTH LOSS	184.55[illegible]	(W_{tnl}) (242)	23[illegible].[illegible]5	288.611	359.217	.000
	(W_c) (185) STA CORE LOSS	404.250	(W_c) (185)	404.250	404.250	404.25[illegible]	404.[illegible]5
	(W_{pnl}) (186) POLE FACE LOSS	105.020	(W_{pfl}) (243)	[illegible]7.[illegible]8	154.989	193.85[illegible]	.000
	(W_{dnl}) (193) DAMPER LOSS	.000	(W_{dfl}) (244)	.000	.000	.00[illegible]	.000
	(I^2R_s) (194) STATOR CU LOSS	.000	(I^2R_s) (245)	[illegible]	2111.895	3754.[illegible]	.00
	(–) (195) EDDY LOSS	.000	(–) (246)	[illegible]	198.518	352.921	.00
	(–) (196) TOTAL LOSSES	1191.155	(–) (247)	[illegible]	5[illegible].645	89[illegible].[illegible]	.000
	(–) (–) RATING (KW)	.000	(–) (248)	22.[illegible]4	33.801	45.06[illegible]	.00[illegible]
	(–) (–) RATING & LOSSES	1.191	(–) (249)	25.703	39.183	53.99[illegible]	.00
	(–) (–) PERCENT LOSSES	100.000	(–) (250)	1[illegible].[illegible]0	13.736	16.5[illegible]	[illegible]
	(–) (–) PERCENT EFF.	.000	(–) (251)	87.[illegible]	86.263	83.467	.00[illegible]

REMARKS

GA-2

DESIGNER

DATE

ORIGINAL PAGE IS OF POOR QUALITY

REV.

ITEMS / VOLTS	(3) (E) VOLTS (98a) (F_s) STATOR A.T.	(96) (F_g) AIR GAP A.T. (100a) (ϕ) LEAKAGE FLUX	(91) (B_t) TOOTH DENSITY (102a) (ϕ_{pt}) TOTAL FLUX/POLE	(97) (F_t) TOOTH A.T. (103A) (B_p) POLE DENSITY	(94) (B_c) CORE DENSITY (104a) (F_p) POLE A.T.	(98) (F_c) (127) (F_{nl}) TOTAL A.T. (N.L.)
80%	[illegible] [illegible]	[illegible]9.17600 18.0[illegible]	85.1[illegible] [illegible]	7.[illegible] 77.1[illegible]	7[illegible] 1[illegible]	7.[illegible] [illegible]
90%	187.05600 30.59950	550.[illegible]00 20.80150	95.06100 278.[illegible]0850	1[illegible].16591 [illegible]	82.[illegible] 26.06550	11.[illegible] [illegible]07.[illegible]
100%	207.84000 69.65541	611.[illegible]7000 2[illegible].17448	106.[illegible] 311.[illegible]	[illegible] 7[illegible].[illegible]101	91.[illegible] [illegible]	[illegible] [illegible]
110%	[illegible] [illegible]	672.61700 32.19[illegible]25	117.1[illegible] 34[illegible]	15[illegible] 108.[illegible]	100.70[illegible] 120.36[illegible]7[illegible]	[illegible] 1[illegible]
120%	249.40800 5[illegible]5.81114	73[illegible].76400 45.[illegible]	127.78800 [illegible]88.40800	354.56272 131.[illegible]5851	109.85380 56[illegible]	171.[illegible] 1[illegible]
130%	[illegible] SATURATED					
140%						
150%						
160%						

ORIGINAL PAGE IS OF POOR QUALITY

30.	208.	120.	3.	320.	8.	4800.	83.4	.75	1.
.5	7.25	9.25	3.	0.	0.	.92	15.	77.4	2.
.06	0.	0.	0.	.122	.02	.344	0.	0.	.434
0.	.03	96.	1.	1.	2.	10.	1.	.075	1.
1.	.162	.25	.25	.162	.192	60.	0.	150.	.694
.035	.047	0.	0.	0.	0.	0.	0.	1.975	1.1
.406	.979	3.	3.	.71	7.18	.97	0.	1.17	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	68.
10.13	.0641	0.	150.	.694	1.	0.			

SATURATION CURVE (STATOR MATERIAL)

132.	18.	1.	40.	2.	66.
5.	76.	8.	85.	14.5	102.
101.	114.	300.	132.	1000.	

SATURATION CURVE (ROTOR MATERIAL)

134.	20.	1.7	30.	2.1	56.
4.	64.	5.	73.	7.	82.
13.	89.	20.	106.	130.	116.
300.	134.	1000.			

ORIGINAL PAGE IS
OF POOR QUALITY

TEST AND CALCULATED SATURATION FOR AN 8-POLE SYNCHRONOUS GENERATOR OPERATING AT 4800 RPM

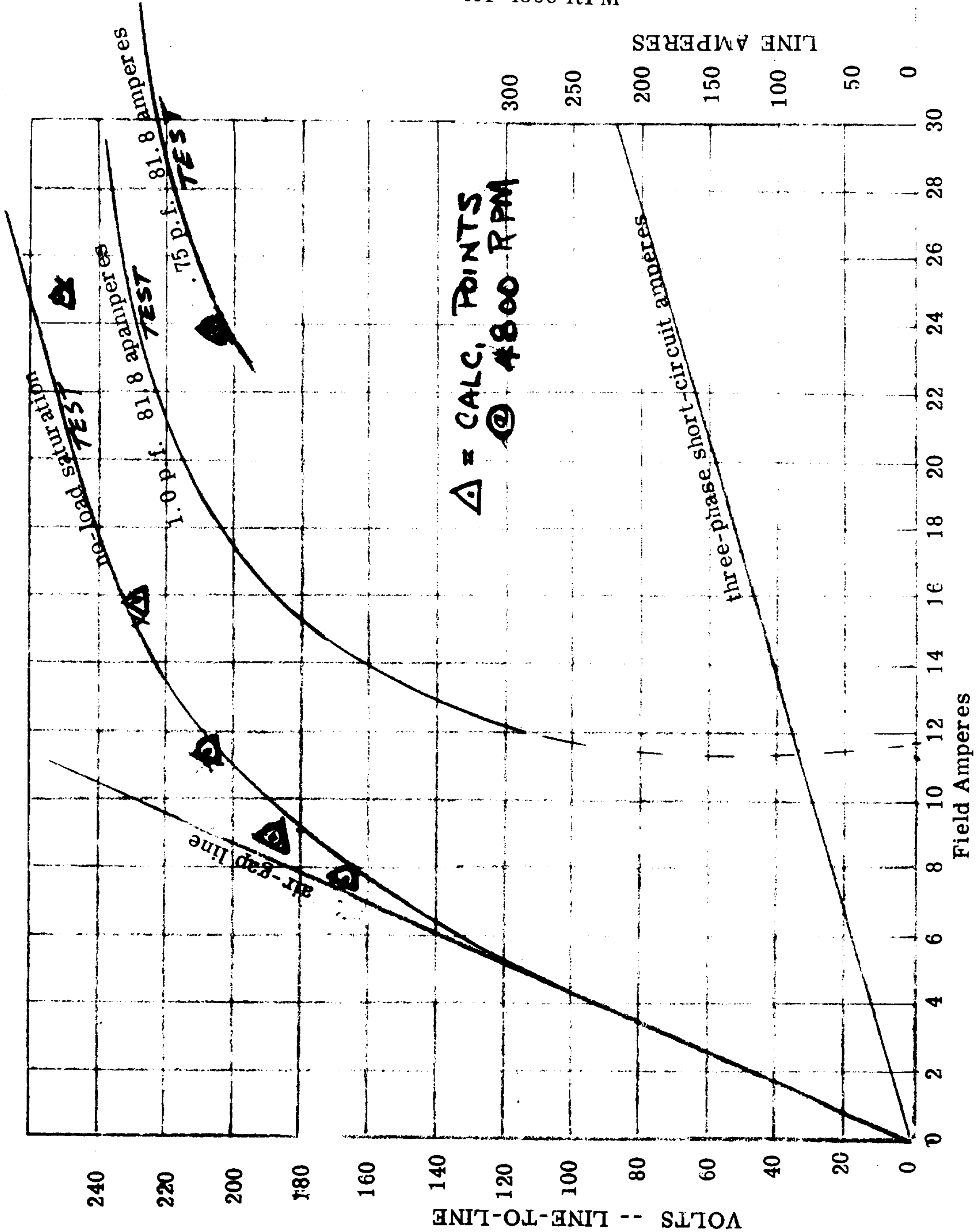


PHOTO NO. 66355-6

E.W.O. 53326

SHOWING:

LOAD REMOVAL AT 6000 RPM

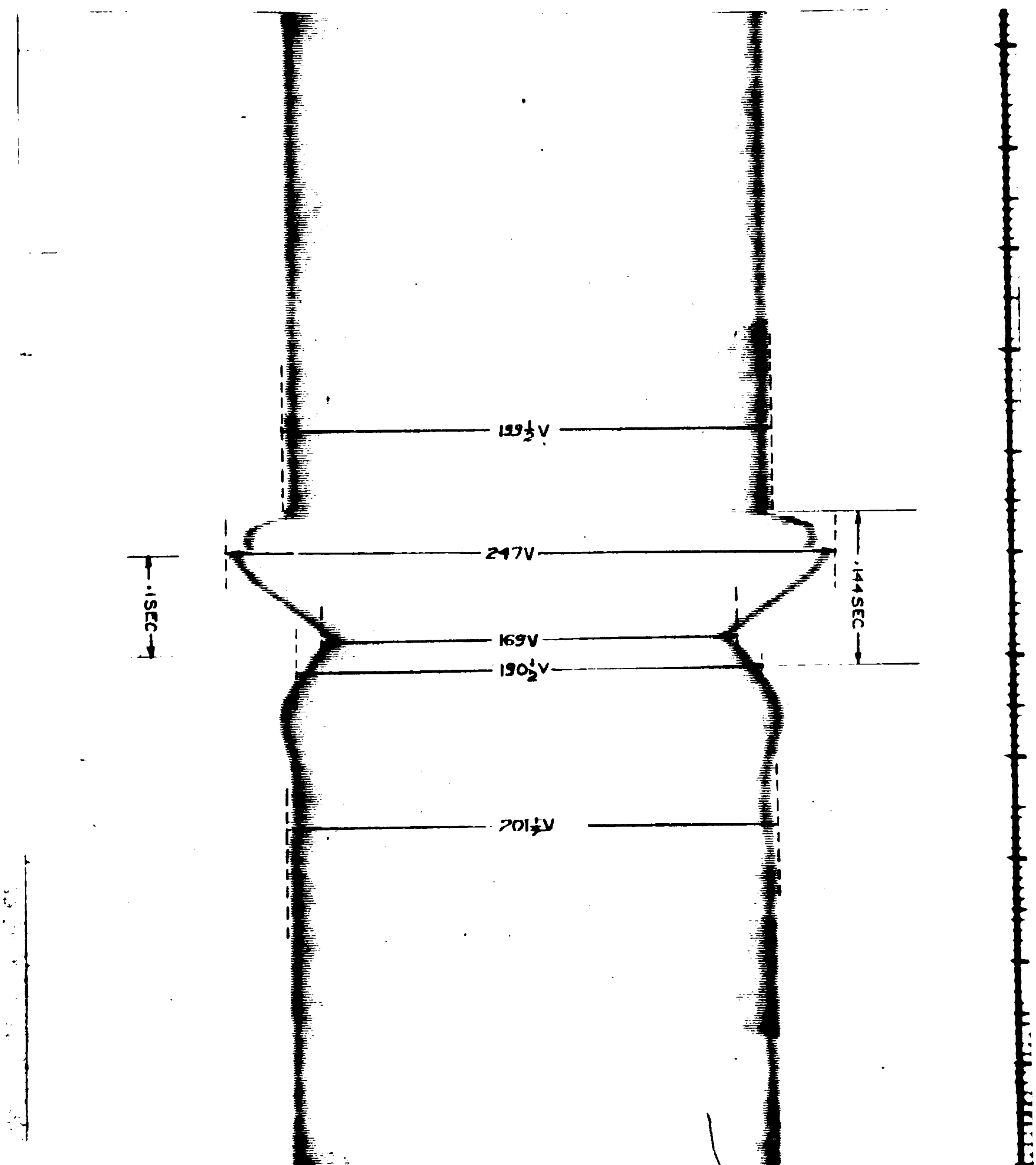


PHOTO NO. 60355-5

E.W.O. 53326

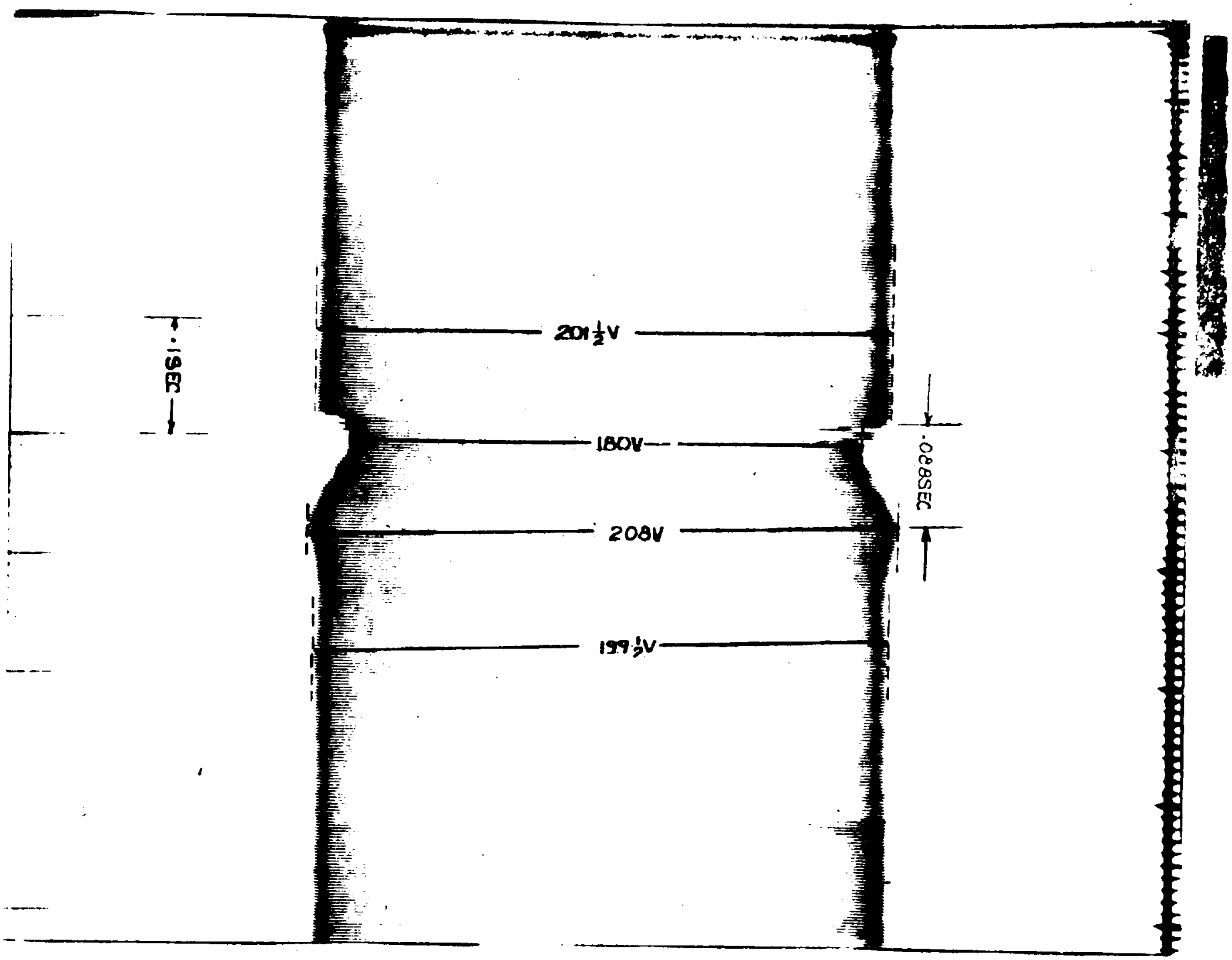
SHOWING:

GR181, XL102 REGULATOR

LOAD APPLICATION AT 6000 RPM

DATE

PHOT



[illegible]

% VOLTAGE UNBALANCE

KVA 30

RPM	% 1Φ 100% PF LOAD	CONNECTED BETWEEN	[illegible] LOAD	LINE-LINE % UNBALANCE	TEST PAGE NO.	LINE-NEUT. % UNBALANCE
7200	31.5	L-N	0	4.1	21994	3.76
4800	32.6	L-N	0	1.92	"	1.95
4800	63.9	L-N	0	3.74	"	4.08
7200	60.4	L-N	0	7.5	"	7.51
4800	33.4	L-N	33.6	2.36	"	1.84
7200	30.7	L-N	31.4	3.12	"	3.01
4800	62.9	L-N	32.6	3.4	"	3.84
7200	53.5	L-N	30.5	6.25	"	5.8
4800	31.9	L-N	67.2	1.89	"	1.47
7200	30.7	L-N	63.6	3.45	"	2.71
4800	10.8	L-L	32.2	0.49	"	0.57
7200	10.3	L-L	31.7	1.33	"	1.16

ORIGINAL PAGE IS
OF POOR QUALITY

HARMONIC	3		5		7		9				13		15		17		19		21		23	
CONDITION	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N
RPM 4800, AMPS 0, %P.F. —	0	0	1.3	1.3	.66	.66	0	0	—	—	—	—	0	0	—	—	—	—	0	0	.17	.18
RPM 4800, AMPS 43.4, %P.F. 100	0	0	.57	.56	.30	.29	0	0	—	—	—	—	0	0	—	—	—	—	0	0	—	—
RPM 4800, AMPS 86.6, %P.F. 100	0	0	.74	.72	.16	.17	0	0	.09	.09	—	—	0	0	—	—	—	—	0	0	—	—
RPM 4800, AMPS 43.4, %P.F. 75	0	0	.74	.74	.38	.39	0	0	—	—	.09	.10	0	0	.08	.08	—	—	0	0	.08	.08
RPM 4800, AMPS 86.6, %P.F. 75	0	0	.39	.40	.28	.28	0	0	—	—	.14	.14	0	0	.10	.10	—	—	0	0	—	—
RPM 7200, AMPS 0, %P.F. —	0	0	1.2	1.2	.93	.92	0	0	—	—	—	—	0	0	—	—	—	—	0	0	—	—
RPM 7200, AMPS 43.4, %P.F. 100	0	0	.42	.42	.30	.31	0	0	—	—	.12	.12	0	0	—	—	—	—	0	0	—	—
RPM 7200, AMPS 86.6, %P.F. 100	0	0	.42	.40	.38	.38	0	0	—	—	.19	.18	0	0	.10	.10	—	—	0	0	—	—
RPM 7200, AMPS 43.4, %P.F. 75	0	0	.96	.98	.38	.38	0	0	—	—	.17	.17	0	0	.09	.09	—	—	0	0	—	—
RPM 7200, AMPS 86.6, %P.F. 75	0	0	1.1	1.0	.30	.29	0	0	—	—	.25	.25	0	0	.13	.13	—	—	0	0	—	—

TEST DATA - A.C. SYNCHRONOUS GENERATOR

% HARMONIC CONTENT

G_

HARMONIC	3		5		7		9		11		13		15	
CONDITION	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-
RPM 4800 AMPS 0 Load % P.F	0	1.5	.34	.34	.13	.13	0	.36	.04	.05	-	-	0	.1
RPM 4800 AMPS 41.7 % P.F 100%	.02	3.2	.22	.12	.11	.11	-	.40	-	-	.05	.03	-	.2
RPM 4800 AMPS 83.4 % P.F 100%	.02	5.5	.06	.15	.06	.05	-	.44	-	-	.12	.10	-	.16
RPM 4800 AMPS 41.7 % P.F 75%	[illegible]	2.6	.54	.50	.15	.14		.40	-	-	.04	-	-	[illegible]
RPM 4800 AMPS 83.4 % P.F 75%	.15	5.2	.5	.86	.11	.02	.06	.40	-	-	.13	.15	-	.2
RPM 7200 AMPS 0 Load % P.F	0	1.2	.34	.3	.17	.18	-	.4	-	-	-	-	-	.34
RPM 7200 AMPS 41.7 % P.F 100%	.04	9.6	.19	.2	.12	.04	-	.55	-	-	.15	.15	.04	.36
RPM 7200 AMPS 83.4 % P.F 100%	.05	15.0	.05	-	-	.05	-	.56	-	-	.2	.22	-	.52
RPM 7200 AMPS 41.7 % P.F 75%	.14	8.0	.4	.4	.11	.08	-	.6	.04	-	.25	.22	-	.54
RPM 7200 AMPS 83.4 [illegible]P.F 75%	.13	12.0	.25	.2	-	.08	-	.64	.08	-	.3	.32	-	.68

G. KVA 30

RPM	% 1 φ 100% PF LOAD	CONNECTED BETWEEN	% 3 φ 100% PF BALANCED LOAD	% UNBALANCE	TEST LETTER
7200	60	L-L	0	3.85	3389
7200	53	L-N	0	3.45	3389
7200	67	L-N	0	4.3	3389
7200	67	L-N	0	3.42	3389
7200	10	L-L	29	0	3389
7200	67	L-N	0	3.32	3647
7200	10	L-L	34	0.96	3647
6300	88	L-N	0	3.83	3647
6300	38	L-N	0	1.78	3647
6300	13	L-L	44	1.35	3647

TEST DATA - A.C. SYNCHRONOUS GENERATOR
SATURATION POINTS

KVA 30

RPM	% LOAD	VOLTS	% P.F.	FIELD AMPS. TEST	FIELD AMPS. CALC.	% DEVIATION	TEST LETTER	MACHINE NO.
4800	0	208	-	12.0	11.6	3.3	2181	1
4800	0	208	-	11.6	11.6	0	3389	1
4800	0	208	-	13.0	11.6	10.8	3453	1
5520	0	312	-	35.0	168	-	3500	1
6000	0	208	-	8.0	7.72	3.5	2181	1
6300	0	208	-	7.05	7.3	3.6	3647	1
7200	0	208	-	6.0	6.25	4.2	3647	1
7200	0	208	-	6.1	6.25	2.5	2181	1
7200	0	208	-	6.3	6.25	0.8	3389	1
7200	0	208	-	6.75	6.25	7.4	3453	1
4800	25	208	76	14.3	14.8	3.5	3647	1
4800	25	208	75	14.5	14.8	2.1	3647	1
4800	27	208	65	15.5	15.4	0.7	3438	1
4800	50	208	100	14.5	13.8	4.8	3453	1
4800	50	208	75	17.3	17.8	2.9	3453	1
4800	100	208	74	25.2	24.6	2.4	3389	1
4800	100	208	78.5	21.7	24.6	13.4	3409	1
4800	100	208	76	22.3	24.6	10.3	3438	1
4800	100	208	100	18.2	17.1	6.1	3453	1
4800	100	208	73	22.1	24.6	11.3	3453	1
5520	200	208	73	32.	33.7	5.3	3409	1
5700	34	208	73	12	11.3	8.3	3647	1
5700	34	208	70.5	11.8	11.3	4.2	3647	1
5700	132	208	76	22.8	22.0	3.5	3647	1
5700	132	208	73	22.8	22.0	3.5	3647	1
5700	187	208	72.5	28.5	31.0	8.8	3647	1
5700	194	208	77.5	29.8	31.0	4.0	3647	1
6000	132	208	77	21.8	21.2	2.8	3647	1
7200	0	208	-	6.0	6.25	4.2	3389	1
7200	50	208	100	8.75	8.2	6.3	3453	1
7200	50	208	71.5	10.5	10.7	1.9	3453	1
7200	100	208	73	16.0	16.0	0	3453	1
7200	100	208	100	13.6	12.5	8.1	3453	1
7200	100	208	76	16.6	16.0	3.8	3438	1
7200	100	208	80.7	17.0	16.3	4.1	3389	1

TEST DATA - A.C. SYNCHRONOUS GENERATOR

G _____ KVA 30

SPEC MIL-G-6099; DWG E-1822

EXCITATION FROM Integral Exciter

	CALC VALUE	TEST VALUE	TEST LETTER
(1.) DIELECTRIC STRENGTH FOR ONE MINUTE / SECOND			
(a) STATOR		1500 V.	3389
(b) ROTOR		500 V.	3389
(2) RPM OVERSPEED FOR 5 MINUTES		10,000	3389
(3) WEIGHT (ROTOR ONLY)		34.22#	PG. 9622
(4) WR^2		204.3#in²	PG. 9622
(5) OVERHUNG MOMENT			
(6) STATOR RESIS./PHASE AT 73 °F	0262	0255	3389
(7) FIELD RESISTANCE AT 73 °	1.202	1.186	3389
(8) SHORT CIRCUIT RATIO AT 4800 RPM	1.055	1.043	3500
(9) % SHORT CIRCUIT CURRENT CAPACITY			
(10) F & W LOSS AT ____ RPM			
(11) CORE LOSS AT ____ CYCLES/SEC.			
(12) % EFFICIENCIES WITH STABILIZED TEMPS.			
(a) AT 100 % LOAD 4800 RPM 75 % PF		87.4	3438
(b) AT 100 % LOAD 7200 RPM 75 % PF		87.1	3438
(c) AT ____ % LOAD ____ RPM ____ % PF			
(d) AT ____ % LOAD ____ RPM ____ % PF			
(e) AT ____ % LOAD ____ RPM ____ % PF			
(13) FIELD CURRENTS AT 208 VOLTS			
(a) AT 0 % LOAD 4800 RPM - % PF	11.6	11.6	3389
(b) AT 100 % LOAD 4800 RPM 75 % PF	24.6	25.2	3389
(c) AT 0 % LOAD 7200 RPM - % PF	6.25	6.0	3389
(d) AT 100 % LOAD 7200 RPM 75 % PF	16.0	16.0	3453
(e) AT ____ % LOAD ____ RPM ____ % PF			
(14) REACTANCES AT 320 CYCLES/SEC.			
(a) SYNCHRONOUS	121	124	3500
(b) TRANSIENT			
(c) SUBTRANSIENT			
(d) NEGATIVE SEQUENCE			
(e) ZERO SEQUENCE			

ALL INPUT PARAMETERS ARE IN FORMAT F7.0 (FIG. 1)

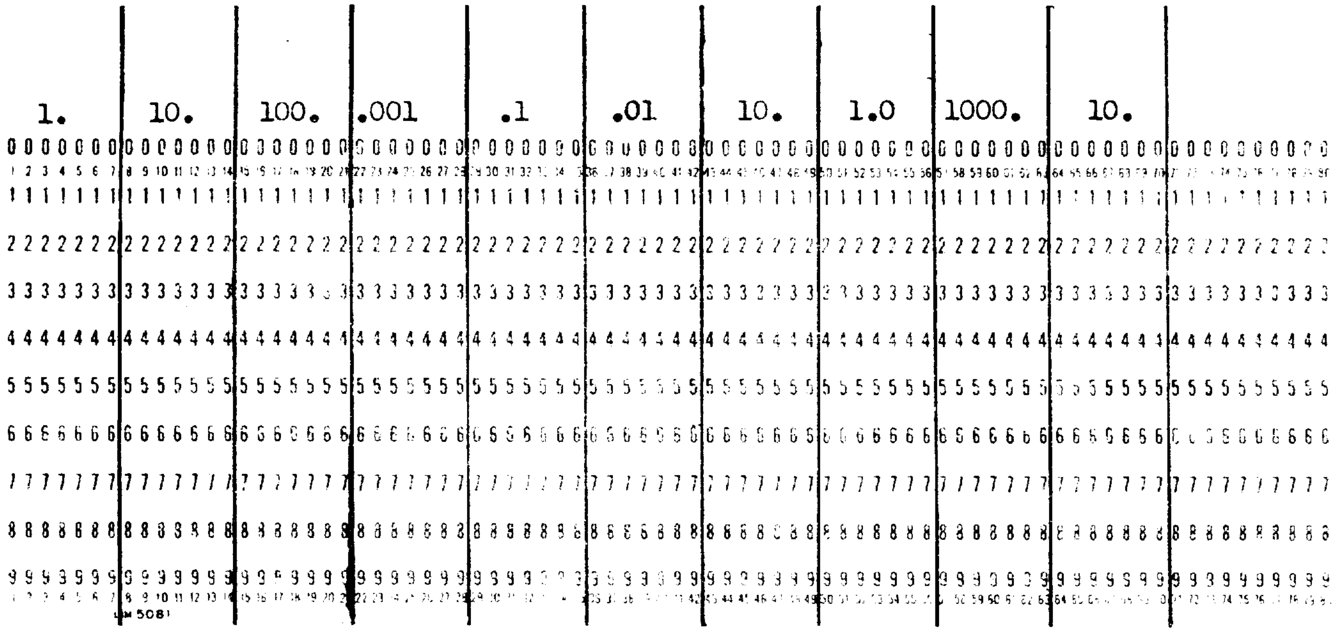


FIG. 1

ALL SATURATION CURVE VALUES ARE IN FORMAT F10.0 (FIG. 2)
(ALL SATURATION CURVES MUST HAVE 5 CARDS)

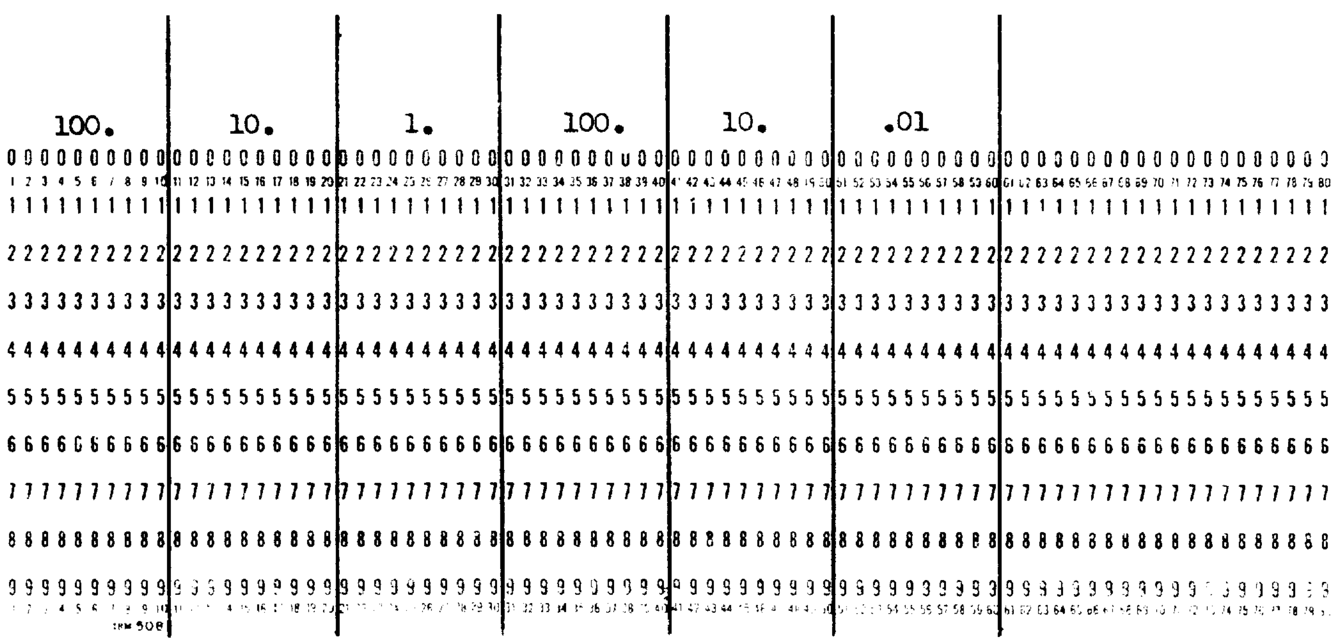


FIG. 2

SALIENT POLE GENERATOR

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
	A, a	
(46)	A_c	AC
(68)	A_g	GA
(79)	A_p	AP
(128)	A	A
(144)	A_{cd}	AB
(153)	A_{cf}	AS
	B, b	
(15)	b_v	BV
(20)	B	BK
(22)	b_o	BO
(22)	b_1	B1
(22)	b_2	B2
(22)	b_3	B3
(22)	b_s	BS
(57)	b_{tm}	TM
(57a)	$b_{t1/3}$	SM
(76)	b_p	BP
(91)	B_t	TE

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
(94)	B_c	BX
(95)	B_g	BG
(103a)	B_p	PD
(135)	b_{bo}	WO
(135)	b_{b1}	B
(213b)	B_{PL}	FD
(76)	b_h	BH

C, c

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
(32)	C	C
(60)	C_x	CX
(71)	C_1	C1
(72)	C_w	CW
(73)	C_p	CP
(74)	C_m	CM
(75)	C_q	CQ

D, d

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
(11)	d	DI
(11a)	d_r	DR
(12)	D	DU
(35)	d_b	DB

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
	E, e	
(3)	E	EE
(4)	E_{PH}	EP
(55)	E_F (top)	ET
(56)	E_F (bot)	EB
(127)	E_f	EFNL
(198)	e_d	ED
(238)	E_{FFL}	EF
	F, f	
(5a)	f	F
(96)	F_g	FH
(97)	F_T	FT
(98)	F_c	AT
(104a)	F_p	FA
(127)	F_{NL}	FN
(180)	F_{sc}	FSC
(183)	F & W	WF
(213c)	F_{PL}	FX
	G, g	
(69)	g_e	GE
(59)	g_{min}	GC

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
(59g)	g_{max}	GP
	H, h	
(22)	h_o	HO
(22)	h_1	HX
(22)	h_2	HY
(22)	h_3	HZ
(22)	h_s	HS
(22)	h_t	HT
(22)	h_w	HW
(24)	h_c	HC
(37)	h_{st}	SH
(38)	h'_{st}	SD
(135)	h_{bo}	HO
(135)	h_b	DD
(137)	h_{b1}	H
(76)	h_h	HH
(76)	h_f	HF
	I, i	
(8)	I_{PH}	PI
(127a)	I_{FNL}	FI
(182)	I^2R_R	PR

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
(237)	I_{FFL}	FI
(241)	I^2R_R	PR
(245)	I^2R_L	PS
(194)	I^2R	PS
	K, k	
(2)	K_{VA}	VA
(9a)	K_c	CK
(16)	K_i	RK
(19)	k	WL
(42)	K_{sk}	FS
(43)	K_d	DF
(44)	K_p	CF
(61)	K_x	FF
(63)	K_E	EK
(67)	K_s	CC
	L, l	
(13)	l	L
(17)	l_s	SS
(36)	l_{e2}	CE
(48)	L_E	EL

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
(49)	l_t	HM
(76)	l_p	PL
(139)	l_b	SB
(161)	L_F	SI
	M, m	
(5)	m	PN
	N, n	
(14)	n_v	HV
(30)	n_s	SC
(34)	N_{st}	SN
(34a)	N'_{st}	SN1
(45)	n_e	EC
(138)	n_b	BN
(146a)	N_p	PT
	P, p	
(6)	p	PX
(9)	P_F	PF

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
	Q, q	
(23)	Q	QQ
(25)	q	QN
	R, r	
(7)	R_{pm}	RPM
(53)	R_{SPH}	RG
(54)	R_{SPH} (Hot)	RP
(154)	R_f (Cold)	FK
(155)	R_f (Hot)	FR
	S, s	
(127c)	S_F	CONL
(181)	S_{CR}	SCR
(239)	S_{FL}	CD
	T, t	
(176)	T'_{do}	TC
(177)	T_a	TA
(178)	T'_d	T5
(179)	T''_d	T4

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
	V, v	
(145)	v_r	VR
	W, w	
(184)	W_{TNL}	ST
(185)	W_c	WQ
(186)	W_{NPL}	WN
(193)	W_{DNL}	WD
(242)	W_{TFL}	ST
(243)	W_{PFL}	PP
(244)	W_{DFL}	DL
	X, x	
(50)	$X_s {}^oC$	T1
(129)	X	XR
(130)	X_1	XL
(131)	X_{ad}	XD
(132)	X_{aq}	XQ
(133)	X_d	XA
(134)	X_q	XB
(142)	$X_D {}^o{}_C$	T3
(150)	$X_c {}^o{}_c$	T2

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
(160)	X_F	XF
(163)	X_{Dd}	X1
(165)	X_{Dq}	X2
(166)	$X'D_u$	XU
(167)	X'_d	XS
(168)	X''_d	XX
(169)	X''_q	XY
(170)	X_2	XN
(172)	X_o	XO
	Y, y	
(31)	y	YY
	τ	
(26)	τ_s	TS
(27)	$\tau_{s1/3}$	TT
(40)	τ_{sk}	SK
(41)	τ_p	TP
(140)	τ_b	TB
	λ	
(62)	λ_i	PC

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
(64)	λ_E	EW
(70c)	λ_a	AG
(80b)	λ_{sL}	SL
(81b)	λ_{tL}	TL
(82b)	λ_{eL}	ES
	$\underline{\phi}$	
(88)	ϕ_T	TG
(92)	ϕ_p	FQ
(100a)	ϕ_L	UX
(102a)	ϕ_{PT}	TF
(197a)	ϕ_{11}	GZ
(213a)	ϕ_{PTL}	GL
	$\underline{\rho}$	
(51)	ρ_s	RS
(141)	ρ_D	RE
(151)	ρ_F	RR
	$\underline{\alpha}$	
(77)	α	PE

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
	$\underline{\theta}$	
(198a)	θ	AN
	$\underline{K}$	
(187)	K_1	D1
(188)	K_2	D2
(189)	K_3	D3
(190)	K_4	D4
(191)	K_5	D5
(192)	K_6	D6

```
C       PASS 1  SALIENT POLE GENERATOR
        DIMENSION DA(8),DX(6),DY(8),DZ(8)
      1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      2 FORMAT(F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0)
     33 READ2,VA,EE,EP,PN,F,PX,RPM,PI,PF,CK
        READ2,POL,DI,DU,CL,HV,BV,SF,WL,BK,ZZ
        READ2,BO,B1,B2,B3,BS,HO,HX,HY,HZ,HS
        READ2,HT,HW,QQ,W,RF,SC,YY,C,DW,SN
        READ2,SN1,DW1,DB,CE,SH,SD,PBA,SK,T1,RS
        READ2,GC,GP,C1,CW,CP,EL,CM,CQ,BH,BP
        READ2,HH,HF,SQ,PL,PE,DR,RK,WR,D1,WO
        READ2,HD,DD,H,B,BN,SB,TB,RE,T3,PT
        READ2,FE,RD,RT,T2,RR,SNL,WF
        SS=SF*(CL-HV*BV)
        HC=(DU-DI-2.0*HS)*0.5
        IF(HC-.7*HS)33,5,5
      5 QN=QQ/(PX*PN)
        TS=3.142*DI/QQ
        IF(ZZ-4.0)29,30,29
     29 TT=(0.667*HS+DI)*3.142/QQ
        GO TO 31
     30 TT=3.1416*(DI+2.*HO+1.32*BS)/QQ
     31 IF(ZZ-1.0)6,6,7
      6 BO=BS
        CC=(5.0*GC+BS)*TS/((5.0*GC+BS)*TS-BS*BS)
        GO TO 8
      7 QC=(4.44*GC+0.75*BO)*TS
        CC=QC/(QC-BO*BO)
      8 CS=YY/(PN*QN)
```

```
      TP=3.142*DI/PX
      IF(SK)32,32,92
   32 FS=1.0
      GO TO 34
   92 FS=SIN(1.571*SK/TP)*TP/(1.571*SK)
   34 IF(PBA-60.)9,9,10
    9 D=1.0
      GO TO 95
   10 D=2.0
   95 I=QN
      U=I
      IF(QN-U)36,36,35
   35 U=PX*PN
      XX=U
      N=U
      DO 11 K=1,N
      Z=U/XX
      I=Z
      Z1=I
      IF(Z-Z1)12,12,11
   12 ZY=QQ/XX
      I=ZY
      Z1=I
      IF(ZY-Z1)37,37,11
   11 XX=XX-1.
   36 ZY=QN
   37 DF=SIN(1.571*D/PN)/(ZY*D*SIN(1.571/(PN*ZY)))
      CF=SIN(YY*1.571/(PN*QN))
      EC=QQ*SC*CF*FS/C
```

```
      DT=DW1
      IF(DT) 13,13,14
   13 AC=0.785*DW*DW*SN1
      GO TO 24
   14 ZY=0.0
      DA(1)=0.05
      DA(2)=0.072
      DA(3)=0.125
      DA(4)=0.165
      DA(5)=0.225
      DA(6)=0.438
      DA(7)=0.688
      DA(8)=1.5
      DX(1)=0.000124
      DX(2)=0.00021
      DX(3)=0.00021
      DX(4)=0.00084
      DX(5)=0.00189
      DX(6)=0.00189
      DY(1)=0.000124
      DY(2)=0.000124
      DY(3)=0.00084
      DY(4)=0.00084
      DY(5)=0.00189
      DY(6)=0.00335
      DY(7)=0.00754
      DY(8)=0.03020
      DZ(1)=0.000124
      DZ(2)=0.000124
```

```
      DZ(3)=0.000124
      DZ(4)=0.00335
      DZ(5)=0.00335
      DZ(6)=0.00754
      DZ(7)=0.0134
      DZ(8)=0.0302
   93 IF(DT-.05)94,94,15
   15 JA=0
      JB=0
      JC=0
      JD=0
   16 JA=JA+1
      JB=JB+1
      JC=JC+1
      JD=JD+1
      IF(DT-DA(JA))17,17,16
   94 D=0
      IF(ZY)23,23,27
   17 IF(DW-0.188)18,18,19
   18 CY=DX(JB-1)
      CZ=DX(JB)
      GO TO 22
   19 IF(DW-0.75)20,20,21
   20 CY=DY(JC-1)
      CZ=DY(JC)
      GO TO 22
   21 CY=DZ(JD-1)
      CZ=DZ(JD)
   22 D=CY+(CZ-CY)*(DT-DA(JA-1))/(DA(JA)-DA(JA-1))
```

```
      IF(ZY)23,23,27
   23 AC=(DT*DW-D)*SN1
   24 IF(RT)25,25,26
   25 AS=0.785*RD*RD
      GO TO 28
   26 ZY=1.0
      DT=RT
      DW=RD
      GO TO 93
   27 AS=RT*RD-D
   28 S=PI/(C*AC)
      PUNCH1,VA,EE,EP,PN,F,PX
      PUNCH1,RPM,PI,PF,CK,POL,DI
      PUNCH1,DU,CL,SS,HC,SF,QN
      PUNCH1,WL,BK,ZZ,BO,B1,B2
      PUNCH1,B3,BS,HO,HX,HY,HZ
      PUNCH1,HS,HT,HW,QQ,W,RF
      PUNCH1,SC,YY,C,TS,SN,DB
      PUNCH1,CE,SH,SD,TT,SK,T1
      PUNCH1,RS,GC,GP,C1,CW,CP
      PUNCH1,EL,CM,CQ,BH,BP,HH
      PUNCH1,HF,SQ,PL,PE,DR,RK
      PUNCH1,CC,WR,D1,WO,HD,DD
      PUNCH1,H,B,BN,SB,TB,RE
      PUNCH1,T3,PT,FE,RD,RT,T2
      PUNCH1,RR,SNL,WF,CS,AS,FS
      PUNCH1,TP,DF,CF,EC,AC,S
      PUNCH1,PBA
      PAUSE
```

END

```
C     PASS 2  SALIENT POLE GENERATOR
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
    3 FORMAT(9X F12.5,2X F12.5)
      READ1, VA,EE,EP,PN,F,PX
      READ1, RPM,PI,PF,CK,POL,DI
      READ1, DU,CL,SS,HC,SF,QN
      READ1, WL,BK,ZZ,BO,B1,B2
      READ1, B3,BS,HO,HX,HY,HZ
      READ1, HS,HT,HW,QQ,W,RF
      READ1, SC,YY,C,TS,SN,DB
      READ1, CE,SH,SD,TT,SK,T1
      READ1, RS,GC,GP,C1,CW,CP
      READ1, EL,CM,CQ,BH,BP,HH
      READ1, HF,SQ,PL,PE,DR,RK
      READ1, CC,WR,D1,WO,HD,DD
      READ1, H,B,BN,SB,TB,RE
      READ1, T3,PT,FE,RD,RT,T2
      READ1, RR,SNL,WF,CS,AS,FS
      READ1, TP,DF,CF,EC,AC,S
      READ1,PBA
      GA=3.142*DI*CL
      AG=6.38*DI/(PX*GC*CC)
      GE=CC*GC
      IF(C1) 44,43,44
   43 C1=(0.649*LOG(PE)+1.359)*((GC/GP)**0.352)
   44 IF(CW)45,45,46
   45 CW=0.707*EE*C1*DF/(EP*PN)
   46 TG=6000000.0*EE/(CW*EC*RPM)
      BG=TG/GA
```

```
      IF(CP)47,47,48
   47 CP=(GC/GP)**0.41*PE*(LOG(GC/TP)*.0378+1.191)
   48 FQ=TG*CP/PX
      IF(ZZ-3.0)49,50,51
   49 SM=TT-BS
      GO TO 53
   50 SM=(3.1416*(DI+2.*HS)/QQ)-B3
      GO TO 53
   51 IF(ZZ-4.0)50,52,49
   52 SM=TT-.94*BS
   53 TE=TG/(QQ*SS*SM)
      BX=0.5*FQ/(HC*SS)
      IF(EL) 54,54,62
   54 IF(RF) 55,55,61
   55 IF(PX-2.0) 56,56,57
   56 U=1.3
      GO TO 60
   57 IF(PX-4.0) 58,58,59
   58 U=1.5
      GO TO 60
   59 U=1.7
   60 EL=3.142*U*YY*(DI+HS)/QQ+0.5
      GO TO 62
   61 EL=2.0*CE+(3.142*(0.5*HX+DB))+(YY*TS*TS/(SQRT(TS*TS-BS*BS)))
   62 HM=CL+EL
      RY=SC*QQ*HM/(PN*AC*C*C)
      RX=RS*0.000001
      RB=(T1+234.5)*0.00394*RX
      RG=RX*RY
```

```
      RP=RB*RY
      IF(SH)37,38,40
   38 ET=1
      EB=1
      GO TO 39
   40 AA=0.584+(SN*SN-1.0)*0.0625*(SD*CL/(SH*HM))*2.0
      AB=(SH*SC*F*AC/(BS*RB*1000000.0))**2.0
      ET=AA*AB*0.00335+1.0
      EB=ET-0.00168*AB
   39 IF(CM)63,63,64
   63 AA=SIN(3.142*PE)
      AB=SIN(1.571*PE)*4.0
      CM=(3.142*PE+AA)/AB
   64 A=PI*SC*CF/(C*TS)
      PRINT3,SS,CC,HC,GA,TS,AG,TT,GE,FS,C1,DF,CW,CF,CP,EC,EL,AC,CM
      PUNCH1,VA,EE,EP,PN,F,PX
      PUNCH1,RPM,PI,PF,CK,POL,DI
      PUNCH1,DU,CL,SS,HC,SF,QN
      PUNCH1,WL,BK,ZZ,BO,B1,B2
      PUNCH1,B3,BS,HO,HX,HY,HZ
      PUNCH1,HS,HT,HW,QQ,W,GE
      PUNCH1,SC,YY,C,TS,BG,TG
      PUNCH1,FQ,TE,BX,TT,HM,SM
      PUNCH1,RG,GC,RP,C1,CW,CP
      PUNCH1,EL,CM,CQ,BH,BP,HH
      PUNCH1,HF,SQ,PL,PE,DR,RK
      PUNCH1,CC,WR,D1,WO,HD,DD
      PUNCH1,H,B,BN,SB,TB,RE
      PUNCH1,T3,PT,FE,RD,RT,T2
```

```
PUNCH1,RR,SNL,WF,CS,AS,ET
PUNCH1,TP,DF,CF,EB,AC,S
PUNCH1,AG,A,SM,PBA
PAUSE
END
```

```
C     PASS 3  SALIENT POLE GENERATOR
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
    3 FORMAT(9X F12.5,2X F12.5)
      READ1, VA,EE,EP,PN,F,PX
      READ1, RPM,PI,PF,CK,POL,DI
      READ1, DU,CL,SS,HC,SF,QN
      READ1, WL,BK,ZZ,BO,B1,B2
      READ1, B3,BS,HO,HX,HY,HZ
      READ1, HS,HT,HW,QQ,W,GE
      READ1, SC,YY,C,TS,BG,TG
      READ1, FQ,TE,BX,TT,HM,SM
      READ1, RG,GC,RP,C1,CW,CP
      READ1, EL,CM,CQ,BH,BP,HH
      READ1, HF,SQ,PL,PE,DR,RK
      READ1, CC,WR,D1,WO,HD,DD
      READ1, H,B,BN,SB,TB,RE
      READ1, T3,PT,FE,RD,RT,T2
      READ1, RR,SNL,WF,CS,AS,ET
      READ1, TP,DF,CF,EB,AC,S
      READ1,AG,A,SM,PBA
      IF(CQ)69,69,70
   69 AA=1.571*PE
      AB=3.1416*PE
      CQ=(0.5*COS(AA)+AB-SIN(AB))/(4.0*SIN(AA))
   70 XR=.0707*A*DF/(C1*BG)
      IF(ZZ-5.)350,351,350
  351 FF=1.0
      GO TO 75
  350 IF(PBA-60.)352,353,352
```

```
353 IF(CS-.667)354,355,355
355 D=.75
    Z=.25
    GO TO 74
354 D=1.5
    Z=-.25
    GO TO 74
352 IF(CS-.667)356,357,357
357 FF=.75
    GO TO 75
356 D=1.2
    Z=-.05
 74 FF=D*CS+Z
 75 CX=FF/(CF*CF*DF*DF)
    Z=CX*20.0/(PN*QN)
    BT=3.142*DI/00-BO
    ZA=BT*BT/(16.0*TS*GC)
    ZB=0.35*BT/TS
    ZC=HO/BO
    ZD=HX*0.333/BS
    ZE=HY/BS
    IF(ZZ-2.0) 76,77,78
 76 PC=Z*(ZE+ZD+ZA+ZB)
    GO TO 82
 77 PC=Z*(ZC+(2.0*HT/(BO+BS))+(HW/BS)+ZD+ZA+ZB)
    GO TO 82
 78 IF(ZZ-4.0) 79,80,81
 79 PC=Z*(ZC+(2.0*HT/(BO+B1))+(2.0*HW/(B1+B2))+(HX*0.333/B2)+ZA+ZB)
    GO TO 82
```

```
80 PC=Z*(ZC+0.62)
   GO TO 82
81 PC=Z*(ZE+ZD+(0.5*GC/TS)+(0.25*TS/GC)+0.6)
82 EK=EL/(10.0**(0.103*YY*TS+0.402))
   IF(DI-8.0) 83,83,84
83 EK=SQRT(EK)
84 ZF=.612*LOG(10.0*CS)
   EW=6.28*EK*ZF*(TP**(0.62-(0.228*LOG(ZF))))/(CL*DF*DF)
   IF(PN-3.0)85,86,86
85 ZC=0.1*DI*SIN(3.0*YY/(PN*QN))*1.57/(PX*GE*CF)
   GO TO 87
86 ZC=0.0
87 XL=(PC+EW+ZC)*XR
   XD=XR*AG*C1*CM
   XQ=XR*CQ*AG
   WC=0.321*SC*QQ*AC*HM
   PRINT3,S,CO,HM,A,RG,XR,RP,XL,ET,XD,EB,XQ
   PUNCH1,VA,EE,EP,PN,F,PX
   PUNCH1,RPM,PI,PF,CK,POL,DI
   PUNCH1,DU,CL,SS,HC,PC,QN
   PUNCH1,WL,BK,ZZ,BO,XD,XQ
   PUNCH1,XR,BS,XL,HX,HY,HZ
   PUNCH1,HS,WC,AC,QQ,W,GE
   PUNCH1,SC,YY,C,TS,BG,TG
   PUNCH1,FQ,TE,BX,TT,EW,AG
   PUNCH1,RG,GC,RP,C1,TP,CP
   PUNCH1,DF,CM,CF,BH,BP,HH
   PUNCH1,HF,SQ,PL,EB,DR,RK
   PUNCH1,CC,WR,D1,WO,HD,DD
```

```
PUNCH1,H,B,BN,SB,TB,RE
PUNCH1,T3,PT,FE,RD,RT,T2
PUNCH1,RR,SNL,WF,CS,AS,ET
PUNCH1,SM
PAUSE
END
```

```
C     PASS 4  SALIENT POLE GENERATOR
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
    3 FORMAT(9X F12.5,2X F12.5)
      READ1, VA,EE,EP,PN,F,PX
      READ1, RPM,PI,PF,CK,POL,DI
      READ1, DU,CL,SS,HC,PC,QN
      READ1, WL,BK,ZZ,BO,XD,XQ
      READ1, XR,BS,XL,HX,HY,HZ
      READ1, HS,WC,AC,QQ,W,GE
      READ1, SC,YY,C,TS,BG,TG
      READ1, FQ,TE,BX,TT,EW,AG
      READ1, RG,GC,RP,C1,TP,CP
      READ1, DF,CM,CF,BH,BP,HH
      READ1, HF,SQ,PL,EB,DR,RK
      READ1, CC,WR,D1,WO,HD,DD
      READ1, H,B,BN,SB,TB,RE
      READ1, T3,PT,FE,RD,RT,T2
      READ1, RR,SNL,WF,CS,AS,ET
      READ1,SM
      ZA=3.1416*(DI+HS)/QQ
      IF(ZZ-3.0) 88,89,88
   88 TM=ZA-BS
      GO TO 90
   89 TM=(3.1416*(DI+2.*HS)/QQ)-B3
   90 WI=(TM*QQ*SS*HS+(DU-HC)*3.142*HC*SS)*0.283
      AN=0.0
  100 AN=AN+0.005
      AL=COS(AN)
      IF(PF-AL) 100,100,101
```

```
101 VR=0.262*DR*RPM
    AP=BP*SQ*RK
    SL=HF/((DR-2.0*HH-0.5*HF)*3.142/PX-BP)
    ES=((PL-CL)*2.0+HF+0.25*BP)/CL
    TL=(HH+GC-TP/18.0)*2.0/(TP-BH)
    FH=BG*GE/0.00319
    ZG=PT*PX*FE*0.000001/AS
    FK=RR*ZG
    FR=(T2+234.5)*FK*0.00394
    RC=0.321*PT*PX*FE*AS
    RL=(1.5*TL+SL)*4.25+6.38*ES
    XF=(1.0-C1/((1.273*RL/AG+2.0*CP)*CM))*XD
    SI=(1.571*CP*AG+RL)*PT*PT*PX*SQ*0.00000001
    IF(BN)307,306,307
306 X1=0
    P2=0
    X2=0
    GO TO 308
307 IF(DD)103,103,102
102 ZG=0.62
    GO TO 104
103 ZG=0.333*H/B
104 BD=(HD/WO+ZG+0.5)*6.38
    BE=(BH-(BN-1.0)*TB)*2.127/GE
    P1=(BD+BE)*RL*COS((BN-1.0)*TB*1.572/TP)/(BD+BE+RL)
    X1=XR*P1
    P2=(HD/WO+ZG+0.5+GC/TB)*20.0*TB/TP
    X2=XR*P2
308 XA=XL+XD
```

```
      XB=XL+XQ
      XU=XL+XF
      XS=0.88*XU
      IF(BN)105,105,106
  105 XX=XS
      XY=XB
      GO TO 107
  106 XX=XL+X1
      XY=XL+X2
  107 XN=(XX+XY)*0.5
      TC=SI/FK
      RA=PN*PI*PI*RP*0.001/VA
      TA=XN/(628.4*F*RA)
      T5=XS*TC/XA
      IF(F-60.0)108,108,109
  108 T4=0.035
      GO TO 110
  109 T4=0.005
  110 IF(WF)111,111,112
  111 WF=DR**2.5*(RPM**1.5)*PL*0.00000252
  112 WQ=(DU-HC)*1.42*HC*SS*(BX/BK)**2.0*WL
      WT=(SM)*QO*SS*HS*0.453*(TE/BK)**2.0*WL
      PRINT3,PC,XA,EW,XB,WC,XF,WI,SI,TP,X1,AP,X2,ES,XU,TL,XS,SL,XX,AS,XY
      PRINT3,FK,XN
      PUNCH1,VA,EE,EP,PN,F,PX
      PUNCH1,RPM,PI,PF,CK,POL,DI
      PUNCH1,DU,CL,SS,HC,PC,QN
      PUNCH1,WL,BK,ZZ,BO,XD,XQ
      PUNCH1,XR,BS,TL,HX,HY,HZ
```

```
PUNCH1,HS,ES,AC,QQ,W,GE
PUNCH1,SC,YY,C,TS,BG,TG
PUNCH1,FQ,TE,BX,TT,EW,AG
PUNCH1,RG,GC,RP,C1,AP,P2
PUNCH1,DF,SL,CF,FH,BP,HH
PUNCH1,HF,SQ,PL,EB,DR,RK
PUNCH1,CC,WR,D1,WO,TC,DD
PUNCH1,H,B,BN,SB,TB,RE
PUNCH1,T3,PT,VR,RD,RT,WT
PUNCH1,WQ,SNL,WF,CS,AS,ET
PUNCH1,FK,FR,XA,XB,T5,T4
PUNCH1,AN,AL,RC,TA,HD
PAUSE
END
```

```
C       PASS 5  SALIENT POLE GENERATOR
      1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      3 FORMAT(9X F12.5,2X F12.5)
        READ1, VA,EE,EP,PN,F,PX
        READ1, RPM,PI,PF,CK,POL,DI
        READ1, DU,CL,SS,HC,PC,QN
        READ1, WL,BK,ZZ,BO,XD,XQ
        READ1, XR,BS,TL,HX,HY,HZ
        READ1, HS,ES,AC,QQ,W,GE
        READ1, SC,YY,C,TS,BG,TG
        READ1, FQ,TE,BX,TT,EW,AG
        READ1, RG,GC,RP,C1,AP,P2
        READ1, DF,SL,CF,FH,BP,HH
        READ1, HF,SQ,PL,EB,DR,RK
        READ1, CC,WR,D1,WO,TC,DD
        READ1, H,B,BN,SB,TB,RE
        READ1, T3,PT,VR,RD,RT,WT
        READ1, WQ,SNL,WF,CS,AS,ET
        READ1, FK,FR,XA,XB,T5,T4
        READ1, AN,AL,RC,TA,HD
        GT=BO/GC
        IF(GT-1.0)304,304,303
    304 AA=2.6
        GO TO 115
    303 IF(GT-3.75)113,114,114
    113 AA=10.0**0.178/((GT-1.0)**0.334)
        GO TO 115
    114 AA=10.0**0.11/((GT-1.0)**0.174)
    115 GF=AA*PI*SC/(C*FH)
```

```
305 IF(SC-1.0)121,121,122
120 A5=0.0
    GO TO 129
121 AX=1.0
    AY=1.0
    GO TO 125
122 AX=3.0*YY/(PN*QN)-2.0
    IF(CS-0.667)123,124,124
123 AY=1.5*YY/(PN*QN)-0.25
    GO TO 125
124 AY=.75*YY/(PN*QN)+0.25
125 A3=AX*P2/AY
    A4=0.07*AX*AG/(CF*CF)
    IF(AX)120,120,126
126 IF(BN)127,127,128
127 A5=A4
    GO TO 129
128 A5=(A4+A3)/(A3*A4)
129 IF(W)130,130,131
130 XO=0.0
    GO TO 132
131 AA=(3.0*HZ+HX)*1.667/(PN*QN*CF*CF*DF*DF*BS)
    XO=((PC+A5)*AX/AY+AA+0.2*EW)*XR
132 D2=BG**2.5*0.000061
    D3=(0.0167*QQ*RPM)**1.65*0.000015147
    IF(TS-0.9) 133,133,134
133 D4=TS**1.285*0.81
    GO TO 137
134 IF(TS-2.0) 135,135,136
```

```
135 D4=TS**1.145*0.79
    GO TO 137
136 D4=TS**0.79*0.92
137 D7=BO/GC
    IF(D7-1.7) 138,138,139
138 D5=D7**2.31*0.3
    GO TO 144
139 IF(D7-3.0) 140,140,141
140 D5=D7**2.0*0.35
    GO TO 144
141 IF(D7-5.0) 142,142,143
142 D5=D7**1.4*0.625
    GO TO 144
143 D5=D7**0.965*1.38
144 D6=10.0**(0.932*C1-1.606)
    BA=3.142*DI*CL
    WN=D1*D2*D3*D4*D5*D6*BA
    UY=(SL+ES+TL)*SQ*0.00638
    AA=WO/(GC*CC)
    VT=0
    IF(AA)148,147,148
148 IF(AA-.65)145,145,146
145 VT=LOG(10.0*AA)*(-0.242)+0.59
    GO TO 147
146 VT=0.327-(AA*0.266)
147 UZ=(DU-HC)*0.7850/PX
    EZ=(ET+EB)*0.5-1.0
    AA=PN*PI*PI
    PU=AA*RG
```

```
PV=AA*RP
VV=EP*PI*PF*.003
FSC=XA*FH*0.01
PRINT3,FR,XO,RC,TG,WR,FQ,VR,BG,TC,TE,TA,BX
PUNCH1,VA,EE,EP,PN,F,PX
PUNCH1,RPM,PI,PF,CK,POL,TB
PUNCH1,BO,GC,HH,HF,SQ,DR
PUNCH1,SB,RE,T3,PT,T5,T4
PUNCH1,WO,DD,H,BN,GF,VT
PUNCH1,SNL,TS,CC,BG,FK,AP
PUNCH1,FQ,TE,BX,FR,XD,FH
PUNCH1,WQ,WT,AN,AL,XA,WF
PUNCH1,AS,HS,B,GE,BP,XB
PUNCH1,WN,UY,UZ,EZ,PU,VV
PUNCH1,FSC,PV,HD,ON
PAUSE
END
```

```
C     PASS 5A SALIENT POLE GENERATOR
      DIMENSION GX(4),YA(4),ED(4)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      READ1,VA,EE,EP,PN,F,PX
      READ1,RPM,PI,PF,CK,POL,TB
      READ1,BO,GC,HH,HF,SQ,DR
      READ1,SB,RE,T3,PT,T5,T4
      READ1,WO,DD,H,BN,GF,VT
      READ1,SNL,TS,CC,BG,FK,AP
      READ1,FQ,TE,BX,FR,XD,FH
      READ1,WQ,WT,AN,AL,XA,WF
      READ1,AS,HS,B,GE,BP,XB
      READ1,WN,UY,UZ,EZ,PU,VV
      READ1,FSC,PV,HD,QN
      YA(1)=100.
      YA(2)=66.66667
      YA(3)=50.
      IF(POL)310,320,310
  320 ED(4)=0
      GX(4)=0
      JA=3
      GO TO 330
  310 YA(4)=100./POL
      JA=4
  330 DO 99 K=1,JA
      AA=ATAN((XB/YA(K)+SIN(AN))/AL)
      BB=AA-AN
      ED(K)=XA*SIN(AA)/YA(K)+COS(BB)
      IF(PF-.95)213,213,212
```

```
212 GX(K)=FQ*CK
    GO TO 99
213 GX(K)=(ED(K)-(.93*XD*SIN(AA)/YA(K)))*FQ
 99 CONTINUE
    IF(POL)820,821,820
820 AJ=4
    GO TO822
821 AJ=3
822 PUNCH1,GX(1),GX(2),GX(3),GX(4),AJ
    PUNCH1,ED(1),ED(2),ED(3),ED(4)
    PUNCH1,VA,EE,EP,PN,F,PX
    PUNCH1,RPM,PI,PF,POL,TB
    PUNCH1,BO,GC,HH,HF,SQ,DR
    PUNCH1,SB,RE,T3,PT,T5,T4
    PUNCH1,WO,DD,H,BN,GF,VT
    PUNCH1,SNL,TS,CC,BG,FK,AP
    PUNCH1,FQ,TE,BX,FR,XD,FH
    PUNCH1,WQ,WT,AN,XA,WF
    PUNCH1,AS,HS,B,GE,BP,XB
    PUNCH1,WN,UY,UZ,EZ,PU,VV
    PUNCH1,FSC,PV,HD,QN
    PAUSE
    END
```

```
C     PASS 6  SALIENT POLE GENERATOR
      DIMENSION GX(4),GZ(4),GL(4),FD(4),FX(4),FB(4),ED(4)
      DIMENSION FI(5),EF(4),CD(4),AI(60)
    4 FORMAT (F11.3,8X F11.3,F11.3,F11.3,F11.3)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
  888 FORMAT(F10.0,F10.0,F10.0,F10.0,F10.0,F10.0)
    3 FORMAT(9X F12.5,2X F12.5)
      K=1
  823 READ888,AI(K),AI(K+1),AI(K+2),AI(K+3),AI(K+4),AI(K+5)
      K=K+6
      IF(K-59)823,199,199
  199 READ1,GX(1),GX(2),GX(3),GX(4),AJ
      READ1,ED(1),ED(2),ED(3),ED(4)
      READ1,VA,EE,EP,PN,F,PX
      READ1,RPM,PI,PF,POL,TB
      READ1, BO,GC,HH,HF,SQ,DR
      READ1, SB,RE,T3,PT,T5,T4
      READ1, WO,DD,H,BN,GF,VT
      READ1, SNL,TS,CC,BG,FK,AP
      READ1, FQ,TE,BX,FR,XD,FH
      READ1,WQ,WT,AN,XA,WF
      READ1, AS,HS,B,GE,BP,XB
      READ1, WN,UY,UZ,EZ,PU,VV
      READ1, FSC,PV,HD,QN
      LA=1
      DO 950 K=1,4
      GZ(K)=0
      GL(K)=0
      FD(K)=0
```

```
      FX(K)=0
      FB(K)=0
      FI(K)=0
      CD(K)=0
  950 EF(K)=0
      FI(5)=0
      LOAD=1.
      NA=1
      K=1
      X=BX
      GO TO 802
  803 AT=UZ*Y
      NA=1
      K=2
      X=TE
      GO TO 802
  804 FT=HS*Y
      SA=FT+AT
      UX=(SA+FH)*UY
      TF=FQ+UX
      PD=TF/AP
      NA=31
      K=3
      X=PD
      GO TO 802
  805 FA=(HF+HH)*Y
      FN=SA+FA+FH
      SCR=FN/FSC
      PRINT3,T5,FT,T4,AT,FSC,FH
```

```
221 FORMAT(9X F12.5/)
    PRINT221,SCR
    JA=AJ
    LA=2
    DO 840 M=1,JA
    GZ(M)=((1.0+PF)*FT+AT+(FH*ED(M)))*UX/(FH+SA)
    GL(M)=GX(M)+GZ(M)
    FD(M)=GL(M)/AP
    K=4
    NA=31
    X=FD(M)
    GO TO 802
806 FX(M)=(HF+HH)*Y
    FB(M)=(1.0+PF)*FT+AT+FX(M)+ED(M)*FH
    FI(M+1)=FB(M)/PT
    EF(M)=FI(M+1)*FR
    CD(M)=FI(M+1)/AS
840 CONTINUE
    FI(1)=FN/PT
    CDNL=FI(1)/AS
    EFNL=FI(1)*FK
    Z=FQ+UX
    PRINT4,UX,GZ(1),GZ(2),GZ(3),GZ(4)
    PRINT4,Z,GL(1),GL(2),GL(3),GL(4)
    PRINT4,PD,FD(1),FD(2),FD(3),FD(4)
    PRINT4,FA,FX(1),FX(2),FX(3),FX(4)
    PRINT4,FN,FB(1),FB(2),FB(3),FB(4)
    PRINT4,FI(1),FI(2),FI(3),FI(4),FI(5)
    PRINT4,CDNL,CD(1),CD(2),CD(3),CD(4)
```

```
      PRINT4,EFNL,EF(1),EF(2),EF(3),EF(4)
      PUNCH1,FI(1),FI(2),FI(3),FI(4),FI(5)
      PUNCH1,EP,PN,F,PX,WQ,WT
      PUNCH1,BO,GC,HH,HF,POL,TB
      PUNCH1,SB,RE,T3,HS,FK,FR
      PUNCH1,WO,DD,H,BN,GF,VT
      PUNCH1,SNL,TS,CC,BG,AP,B
      PUNCH1,FQ,TE,BX,FH,XA,WF
      PUNCH1,WN,UY,UZ,EZ,PU,VV
      PUNCH1,PV,HD,QN
      PAUSE
  802 IF(AI(NA)-X)830,831,831
  831 NA=NA+3
  835 IF(AI(NA)-X)833,834,834
  833 NA=NA+2
      GO TO 835
  834 AA=AI(NA)
      BB1=AI(NA-2)
      DC=AI(NA+1)
      D=AI(NA-1)
      XX=(AA-BB1)/(.4343*(LOG(DC)-LOG(D+.0001)))
      Y=AA-XX*.4343*LOG(DC)
      Y=EXP(2.306*(X-Y)/XX)
      GO TO (838,839),LOAD
  838 GO TO (803,804,805,806),K
  839 GO TO (236,237,238),K
  830 GO TO (836,840),LA
  836 PRINT850
  850 FORMAT(17HMACHINE SATURATED)
```

```
PAUSE
END
```

```
C     PASS 7  SALIENT POLE GENERATOR
      DIMENSION PR(5),FI(5),PS(5),G(5),DL(5),PP(5),EX(5),ST(5),VA(5)
      DIMENSION P(5),E(5),PM(5),SP(5)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
    4 FORMAT (F11.3,8X F11.3,F11.3,F11.3,F11.3)
      READ1, FI(1),FI(2),FI(3),FI(4),FI(5)
      READ1, EP,PN,F,PX,WQ,WT
      READ1, BO,GC,HH,HF,POL,TB
      READ1, SB,RE,T3,HS,FK,FR
      READ1, WO,DD,H,BN,GF,VT
      READ1, SNL,TS,CC,BG,AP,B
      READ1, FQ,TE,BX,FH,XA,WF
      READ1, WN,UY,UZ,EZ,PU,VV
      READ1, PV,HD,QN
      IF(RE)309,309,311
  309 WD=0.0
      WU=0.0
      GO TO 178
  311 FS1=2.0*QN*PN*F
      FS2=2.0*FS1
      M=0
  150 IF(M-1)151,152,178
  151 RM=RE
      GO TO 153
  152 RM=RE*(T3+234.5)/254.5
  153 AA=(FS1/RM)**0.5*DD*0.32
      AB=(FS2/RM)**0.5*DD*0.32
      IF(AA-2.5) 160,160,161
  160 V1=1.0-0.15*AA+0.3*AA*AA
```

```
      GO TO 162
  161 V1=AA
  162 IF(AB-2.5) 163,163,164
  163 V2=1.0-0.15*AB+0.3*AB*AB
      GO TO 165
  164 V2=AB
  165 IF(H-B) 167,166,167
  166 VC=0.75/V1
      GO TO 169
  167 IF(DD) 166,168,166
  168 VC=H/(3.0*B*V1)
  169 VS=HD/WO+VT+VC
      VG=TB/(CC*GC)
      Q1=1.0-(1.0/(((BO*0.5/GC)**2.0+1.0)**0.5))
      QZ=BO/TS
      Q2=1.05*SIN(QZ*2.844)
      IF(QZ-0.37)170,170,171
  170 Q3=0.46
      GO TO 172
  171 Q3=0.23*SIN(10.46*QZ-2.1)+0.23
  172 Q4=SIN(6.283*TB/TS-1.571)+1.0
      Q5=SIN(12.566*TB/TS-1.571)+1.0
      IF(H)173,173,174
  173 AB=0.785*DD*DD
      GO TO 175
  174 AB=H*DD
  175 W2=PX*BN*SB*RM*1.246/(AB*1000.)
      W3=(Q2/(2.0*VS+(VG/Q4)))**2.0*V1
      W5=(Q3/(2.0*VS+(VG/Q5)))**2.0*V2
```

```
      WD=(TS*BG*Q1*CC)**2.0*W2*(W3+W5)
      M=M+1
      IF(M-1)176,176,177
  176 WU=WD
  177 GO TO 150
  178 G(1)=0
      G(2)=1
      G(3)=1.5
      G(4)=2.
      G(5)=POL
      PW=PU
      FW=FK
      WW=WU
      DO 183 M=1,5
      UA=G(M)
      PR(M)=FI(M)*FI(M)*FW
      IF(FI(M))198,197,198
  198 PS(M)=PW*UA*UA
      X=WF+WQ
      GM  =(GF*UA)**2.0+1.0
      ST(M)=(2.0*(0.0027*XA*UA)**1.8+1.0)*WT
      VA(M)=VV*UA
  181 DL(M)=GM  *WW
      PP(M)=GM  *WN
      EX(M)=EZ*PS(M)
      SP(M)=PP(M)+DL(M)+PR(M)+PS(M)+EX(M)+ST(M)+X
      P(M)=(SP(M)/1000.)+VA(M)
      IF(GM)185,184,185
  184 PM(M)=0
```

```
      E(M)=0
      GO TO 186
  185 PM(M)=(SP(M)/P(M))*.1
      E(M)=100.0-PM(M)
  186 FW=FR
      WW=WD
  183 PW=PV
      PRINT4, PR(1),PR(2),PR(3),PR(4),PR(5)
      PRINT4, WF,WF,WF,WF,WF
      PRINT4, ST(1),ST(2),ST(3),ST(4),ST(5)
      PRINT4, WQ,WQ,WQ,WQ,WQ
      PRINT4, PP(1),PP(2),PP(3),PP(4),PP(5)
      PRINT4, DL(1),DL(2),DL(3),DL(4),DL(5)
      PRINT4, PS(1),PS(2),PS(3),PS(4),PS(5)
      PRINT4, EX(1),EX(2),EX(3),EX(4),EX(5)
      PRINT4, SP(1),SP(2),SP(3),SP(4),SP(5)
      PRINT4, VA(1),VA(2),VA(3),VA(4),VA(5)
      PRINT4, P(1),P(2),P(3),P(4),P(5)
      PRINT4,PM(1),PM(2),PM(3),PM(4),PM(5)
      PRINT4, E(1),E(2),E(3),E(4),E(5)
      IF(SNL)191,191,190
  190 PUNCH1,FH,TE,BX,UZ,UY,FQ
      PUNCH1,AP,HF,HH,HS,EP
  191 PAUSE
  197 PS(M)=0
      GM=0
      ST(M)=0
      X=0
      VA(M)=0
```

```
GO TO 181
END
```

```
C       PASS 8  SALIENT POLE GENERATOR
        DIMENSION AI(60)
      1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
    888 FORMAT(F10.0,F10.0,F10.0,F10.0,F10.0,F10.0)
        K=1
    823 READ888,AI(K),AI(K+1),AI(K+2),AI(K+3),AI(K+4),AI(K+5)
        K=K+6
        IF(K-59)823,234,234
    234 READ1, FH,TE,BX,UZ,UY,FQ
        READ1, AP,HF,HH,HS,EP
        LOAD=2.
        LA=1
        UB=0.7
    235 UB=UB+0.1
        V=1.732*EP*UB
        FG=FH*UB
        TD=TE*UB
        BC=BX*UB
        K=1
        NA=1
        X=BC
        GO TO 802
    236 AT=UZ*Y
        K=2
        NA=1
        X=TD
        GO TO 802
    237 FT=Y*HS
        SA=FT+AT
```

```
      UX=(FG+SA)*UY
      TF=FO*UB+UX
      PD=TF/AP
      K=3
      NA=31
      X=PD
      GO TO 802
  238 FA=(HF+HH)*Y
      FN=SA+FA+FG
  246 FORMAT(F12.5,F12.5,F12.5,F12.5,F12.5,F12.5//)
  247 FORMAT(F12.5,F12.5,F12.5,F12.5,F12.5,F12.5)
      PRINT247,V,FG,TD,FT,BC,AT
      PRINT246,SA,UX,TF,PD,FA,FN
      IF(UB-1.6) 235,245,245
  245 PAUSE
  802 IF(AI(NA)-X)830,831,831
  831 NA=NA+3
  835 IF(AI(NA)-X)833,834,834
  833 NA=NA+2
      GO TO 835
  834 AA=AI(NA)
      BB1=AI(NA-2)
      DC=AI(NA+1)
      D=AI(NA-1)
      XX=(AA-BB1)/(.4343*(LOG(DC)-LOG(D+.0001)))
      Y=AA-XX*.4343*LOG(DC)
      Y=EXP(2.306*(X-Y)/XX)
      GO TO (838,839),LOAD
  838 GO TO (803,804,805,806),K
```

```
839 GO TO (236,237,238),K
830 GO TO (836,840),LA
836 PRINT850
850 FORMAT(17HMACHINE SATURATED)
    PAUSE
    END
```

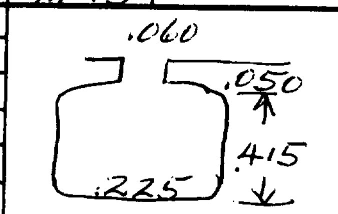
NON-SALIENT-POLE, WOUND-ROTOR, SYNCHRONOUS GENERATOR COMPUTER PROGRAM AND TEST DATA

NON-SALIENT-POLE DESIGN (INPUT)

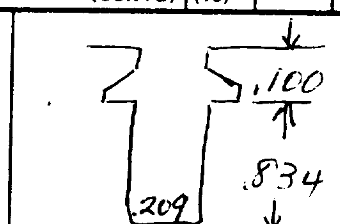
MODEL 125 KVA 12000 RPM EWO ____ DESIGN NO.(1) ____ BY ____

Section	Ref.	Symbol	Item	Value
PARAMETERS	(2)	KVA	GENERATOR KVA	125
	(3)	E	LINE VOLTS	208
	(4)	E_{ph}	PHASE VOLTS	120
	(5)	m	PHASES	3
	(5a)	f	FREQUENCY	400
	(6)	p	POLES	4
	(7)	RPM	RPM	12000
	(8)	I_{ph}	PHASE CURRENT	347
	(9)	PF	POWER FACTOR	0.8
	(10)		OPTIONAL LOAD POINT	1.75
STATOR STACK	(11)	d	STATOR I.D.	7.13
	(12)	D	STATOR O.D.	9.72
	(13)	ℓ	GROSS CORE LENGTH	6.09
	(14)	n_v	NO. OF DUCTS	0
	(15)	b_v	WIDTH OF DUCT	0
	(16)	K_i	STACKING FACTOR (STATOR)	.92
	(19)	k	WATTS/LB.	12.
	(20)	B	DENSITY	77.4
STATOR SLOT	(21)		TYPE OF SLOT	2
	(22)	b_o	SLOT OPENING	.060
	(22)	b_1	SLOT WIDTH TOP	0
	(22)	b_2		0
	(22)	b_3		0
	(22)	b_s	SLOT WIDTH	.225
	(22)	h_o		.050
	(22)	h_1		.333
	(22)	h_2		0
	(22)	h_3		0
	(22)	h_s	SLOT DEPTH	.462
	(22)	h_t		0
	(22)	h_w		.050
	(23)	Q	NO. OF SLOTS	54
STATOR WINDING	(28)		TYPE OF WDG.	1
	(29)		TYPE OF COIL	1
	(30)	n_s	CONDUCTORS/SLOT	2
	(31)	y	SLOTS SPANNED	10
	(32)	c	PARALLEL CIRCUITS	2
	(33)		STRAND DIA. OR WIDTH	.170
	(34)	N_{st}	STRANDS/CONDUCTOR	1
	(34a)	N'_{st}	STRANDS/CONDUCTOR	1
	(39)		STATOR STRAND T'KNS	.150
	(35)	db	DIA. OF PIN	.25
	(36)	ℓ_{e2}	COIL EXT. STR. PORT	.25
	(37)	h_{st}	UNINS. STRD. HT.	.150
	(38)	h'_{st}	DIST. BTWN. CL OF STD.	.165
	(42a)		PHASE BELT/ANGLE	60
	(40)	τ_{sk}	STATOR SLOT SKEW	.415
	(50)	X_s °C	STATOR TEMP °C	200
	(51)	ρ_s	RES'TVY STA. COND. @ 20° C	.694
	(59)	g min	MINIMUM AIR GAP	.065

Value	Item	Ref.	Symbol	Section
0	FUND/MAX OF FIELD FLUX	(71)	C1	CONSTANTS
0	WINDING CONSTANT	(72)	C_w	
0	POLE CONST.	(73)	C_p	
0	END EXTENSION ONE TURN	(48)	L_E	
0	DEMAGNETIZATION FACTOR	(74)	C_n	
1	TYPE ROTOR 1, 2	*		ROTOR
48	SLOTS PUNCHED	(300)	Q'_r	
40	SLOTS WOUND	(301)	Q'_r	
0	SLOTS IN POLE CENTER	(302a)	N_{rc}	
.209	WIDTH OF SLOT OPENING	(303)	b_{rc}	
.100	HEIGHT OF SLOT OPENING	(303)	h_{r2}	
.834	SLOT DEPTH BELOW WEDGE	(303)	h_{r1}	
.209	SLOT WIDTH	(303)	b_r	
.934	SLOT DEPTH	(303)	h_r	
.459	SLOT PITCH	(304)	τ_{rs}	
6.47	ROTOR STACK LENGTH	(305)	ℓ_r	
.93	ROTOR STACKING FACTOR	(16)	K_i	
7.00	ROTOR DIAMETER	(11a)	d_r	
3.235	ROTOR I.D. (PCHGS.)	(314a)	d_s	
0	HEIGHT VENT HOLES	(314b)	b_{rh}	
0	WEIGHT OF ROTOR IRON	(157)	(–)	
1.2	POLE FACE LOSS FACTOR	(187)	(K1)	
55	NO. OF FIELD TURNS/POLE	(146a)	N_p	FIELD
22.4	MEAN LENGTH OF FLD. TURN	(147)	ℓ_{tr}	
.159	FLD. COND. DIA. OR WIDTH	(148)		
.056	FLD. COND. THICKNESS	(149)		
200	FLD. TEMP IN C	(150)	X_f °C	
.694	RESISTIVITY OF FIELD COND @20°	(151)	ρ_f	
1	NO LOAD SAT.	(87)		
0	FRICTION & WINDAGE	(183)	(F&W)	
M-15	ROTOR LAM. MTR'L	(18)		MTR'L
M-15	STATOR LAM. MTR'L (CURVE)	(18)		



STATOR SLOT



ROTOR SLOT

* SLOTTED POLE-CENTER 2
SOLID POLE-CENTER 1

REMARKS :

REV. A

INPUT PARAMETERS FOR NON-SALIENT POLE DESIGN

125.	208.	120.	3.	400.	4.	12000.	347.	.8	1.75
7.13	9.72	6.09	0.	0.	.92	12.	77.4	2.	.06
0.	0.	0.	.225	.05	.333	0.	0.	.462	0.
.05	54.	1.	1.	2.	10.	2.	.17	1.	1.
.15	.25	.25	.15	.165	60.	.415	200.	.694	.065
0.	0.	0.	0.	0.	1.	48.	40.	0.	.209
.100	.834	.209	.934	.459	6.47	.93	7.	3.235	0.
0.	1.2	55.	22.4	.159	.056	200.	.694	1.	0.

SATURATION CURVE (STATOR MATERIAL)

128.	34.	1.	50.	2.	60.
3.1	70.	5.2	76.	8.	86.
20.	96.	70.	104.	150.	128.
870.					

SATURATION CURVE (ROTOR MATERIAL)

128.	34.	1.	50.	2.	60.
3.1	70.	5.2	76.	8.	86.
20.	96.	70.	104.	150.	128.
870.					

SUMMARY OF DESIGN CALCULATIONS – NON-SALIENT – POLE (OUTPUT)

MODEL ____________________ EWO ____________ DESIGN NO. ____________

Section	No.	Item	Value
STATOR	(17) (ℓ_s)	SOLID CORE LENGTH	5.60280
STATOR	(24) (h_c)	DEPTH BELOW SLOT	.83300
STATOR	(26) (τ_s)	SLOT PITCH	.41486
STATOR	(27) (τ_s1/3)	SLOT PITCH 1/3 DIST. UP	.43279
STATOR	(42) (K_{sk})	SKEW FACTOR	.99774
STATOR	(43) (K_d)	DIST. FACTOR	.95493
STATOR	(44) (K_p)	PITCH FACTOR	.91827
STATOR	(45) (e)	EFF. CONDUCTORS	49.47400
STATOR	(46) (a_c)	COND. AREA	.02489
STATOR	(47) (S_s)	CURRENT DENSITY (STA.)	6968.90000
STATOR	(49) (ℓ_t)	1/2 MEAN TURN LENGTH	12.83600
STATOR	(53) (R_{ph})	COLD STA. RES. @ 20° C	.00322
STATOR	(54) (R_{ph})	HOT STA. RES. @ X °C	.00551
STATOR	(55) (EF_{top})	EDDY FACTOR TOP	1.24430
STATOR	(56) (EF_{bot})	EDDY FACTOR BOT.	1.03450
STATOR	(62) (λ_{i1})	STATOR COND. PERM.	3.32080
STATOR	(64) (λe)	END PERM.	3.72230
STATOR	(65) ( )	WT. OF STA COPPER	11.07800
STATOR	(66) ( )	WT. OF STA IRON	45.45188
ROTOR	(212a) (rs)	ROTOR SLOT LEAK PER	3.49001
ROTOR	(153) (a_{CF})	FLD. COND. AREA	.00875
ROTOR	(154) (R_F)	COLD FLD RES @ 20° C	.39057
ROTOR	(155) (R_F)	HOT FLD RES. @ X° C	.66862
ROTOR	(156) ( )	WT OF FLD COPPER	13.85100
ROTOR	(157) ( )	WT OF ROTOR IRON	35.55751
ROTOR	(145) (V_r)	PERIPHERAL SPEED	22008.00000
TIME CONSTANTS	(176) (T_{do})	OPEN CIR. TIME CONST.	.22429
TIME CONSTANTS	(177) (T_a)	ARM TIME CONST.	.00268
TIME CONSTANTS	(178) (T'_d)	TRANS TIME CONST.	.01936
TIME CONSTANTS	(179) (T''_d)	SUB TRANS TIME CONST.	.00500
TIME CONSTANTS	(180) (F_{sc})	SHORT CIR NI	2053.30000
TIME CONSTANTS	(181) (SCR)	SHORT CIR RATIO	.54356

Value	Item	No.	Section
1.02670	CARTER COEFFICIENT	(67) (K_s)	GAP
136.43098	AIR GAP AREA	(68) (–)	GAP
170.40930	AIR GAP PERM	(70c) (Λ_a)	GAP
.06673	EFFECTIVE AIR GAP	(69) (g_e)	GAP
.82869	FUND/MAX OF FLD. FLUX	(71) (C_1)	CONSTANTS
.32325	WINDING CONST.	(72) (C_w)	CONSTANTS
.50907	POLE CONST.	(73) (C_p)	CONSTANTS
6.74656	END. EXT. ONE TURN	(48) (LE)	CONSTANTS
1.06115	DEMAGNETIZING FACTOR	(74) (C_M)	CONSTANTS
768.06000	AMP COND/IN	(128) (A)	REACTANCE
1.31270	REACTANCE FACTOR	(129) (X)	REACTANCE
9.24560	LEAKAGE REACTANCE	(130) (X_q)	REACTANCE
196.69055	REACTANCE OF ARMATURE REACTION	(131) (X_{ad})	REACTANCE
205.93560	SYN REACT DIRECT AXIS	(133) (X_d)	REACTANCE
11.61018	FIELD LEAKAGE REACT	(160) (X_f)	REACTANCE
.08760	FIELD SELF INDUCTANCE	(161) (L_f)	REACTANCE
20.20865	UNSAT. TRANS. REACT	(166) (X'_{du})	REACTANCE
17.78361	SAT. TRANS. REACT	(167) (X'_d)	REACTANCE
10.73736	SUB. TRANS. REACT	(168) (X''_d)	REACTANCE
10.73736	NEG SEQUENCE REACT	(170) (X_2)	REACTANCE
3.01942	ZERO SEQUENCE REACT	(172) (X_o)	REACTANCE
6502.90000	TOTAL FLUX	(88) (ϕ_t)	MAGNETIZATION
827.62000	FLUX PER POLE	(92) (ϕ_p)	MAGNETIZATION
47.66400	GAP DENSITY	(95) (B_g)	MAGNETIZATION
103.43000	TOOTH DENSITY	(91) (B_t)	MAGNETIZATION
88.66500	CORE DENSITY	(94) (B_c)	MAGNETIZATION
66.12557	TOOTH AMPERE TURNS	(97) (F_t)	MAGNETIZATION
48.94801	CORE AMPERE TURNS	(98) (F_c)	MAGNETIZATION
997.13000	GAP AMPERE TURNS	(96) (F_g)	MAGNETIZATION

VARIABLE LOAD

PERCENT LOAD	0		100	150	200	OPTIONAL
(ϕ_{ls}) (312) LEAK FLUX	23.355	(ϕ_{lls}) (312a)	61.692	82.583	103.758	93.149
(ϕ_{rc}) (313) FLUX IN P.C.	429.785	(ϕ_{rcl}) (318)	468.122	489.013	510.188	499.579
(B_{pd}) (314) POLE DENSITY	58.534	(B_{pcl}) (319)	63.756	66.601	69.485	68.040
(B_{rc}) (315) ROTOR CORE DENSITY	37.654	(B_{pcl}) (321)	41.013	42.843	44.698	43.768
(F_{nl}) (127) TOTAL NI	1116.103	(F_{fl}) (236)	2942.790	3938.299	4947.479	4441.828
(I_{fnl}) (127a) FIELD AMPS	20.292	(I_{ffl}) (237)	53.505	71.605	89.954	80.760
(S_F) (127c) CUR.DENS.(FLD)	2317.455	(S_{fl}) (239)	6110.350	8177.405	10272.844	9222.921
(E_F) (127b) FIELD VOLTS	7.925	(E_{fl}) (238)	35.774	47.876	60.145	53.998
(I^2R_r) (182) ROTOR LOSS	160.823	(I^2R_r) (241)	1914.115	3428.199	5410.287	4360.858
(F&W) (183) F&W LOSS	2778.500	(F&W) (183)	2778.500	2778.500	2778.500	2778.500
(W_{tnl}) (184) STA TOOTH LOSS	281.930	(W_{tnl}) (242)	477.959	688.640	964.544	818.702
(W_c) (185) STA CORE LOSS	927.460	(W_c) (185)	927.460	927.460	927.460	927.460
(W_{pnl}) (186) POLE FACE LOSS	102.900	(W_{pfl}) (243)	187.138	292.436	439.854	360.880
(I^2R_s) (194) STATOR CU LOSS	.000	(I^2R_s) (245)	1991.500	4480.875	7966.000	6098.968
(–) (195) EDDY LOSS	.000	(–) (246)	277.615	624.633	1110.460	850.196
(–) (196) TOTAL LOSSES	4251.613	(–) (247)	8554.288	13220.745	19597.105	16195.565
(–) (–) RATING (KW)	.000	(–) (248)	100.000	150.000	200.000	175.000
(–) (–) RATING&LOSSES	4.251	(–) (249)	108.554	163.220	219.597	191.195
(–) (–) PERCENT LOSSES	100.000	(–) (250)	7.880	8.099	8.924	8.470
(–) (–) PERCENT EFF.	.000	(–) (251)	92.119	91.900	91.075	91.529

DESIGNER ____________________

DATE ____________________

REV. A

NO LOAD SATURATION OUTPUT SHEET

ITEMS / VOLTS	(3) (E) VOLTS (98a) (F_s) STATOR A.T.	(96) (F_g) AIR GAP A.T. (312) $\phi_{\ell s}$ LEAKAGE FLUX	(91) (B_t) TOOTH DENSITY (313) Φ_{PC} TOTAL FLUX POLE	(97) (F_t) TOOTH A.T. (314) B_{PC} POLE DENSITY	(94) (B_c) CORE DENSITY (316) (F_{pl}) POLE A.T.	(98) (F_c) (127) (F_{nl}) TOTAL A.T. (N.L.)
80%	166.27200 16.60572	797.70400 17.09969	82.74400 423.52969	6.88425 57.68273	70.93200 37.10615	9.7214 1019.0954
90%	187.05600 42.41508	897.41700 19.73553	93.08700 426.16553	22.58272 58.04172	79.79850 37.33708	19.8323 1044.96600
100%	207.84000 115.07358	997.13000 23.35516	103.43000 429.78516	66.12557 58.53469	88.66500 37.65421	48.9480 1117.71000
110%	228.62400 285.18549	1096.84300 29.02121	113.77300 435.45121	142.99718 59.30638	97.53150 38.15062	142.18831 1287.9585
120%	249.40800 619.62697	1196.55600 38.13802	124.11600 444.56802	305.36916 60.54805	106.39800 38.94936	314.25781 1622.6275
130%	MACHINE SATURATED					
140%						
150%						
160%						

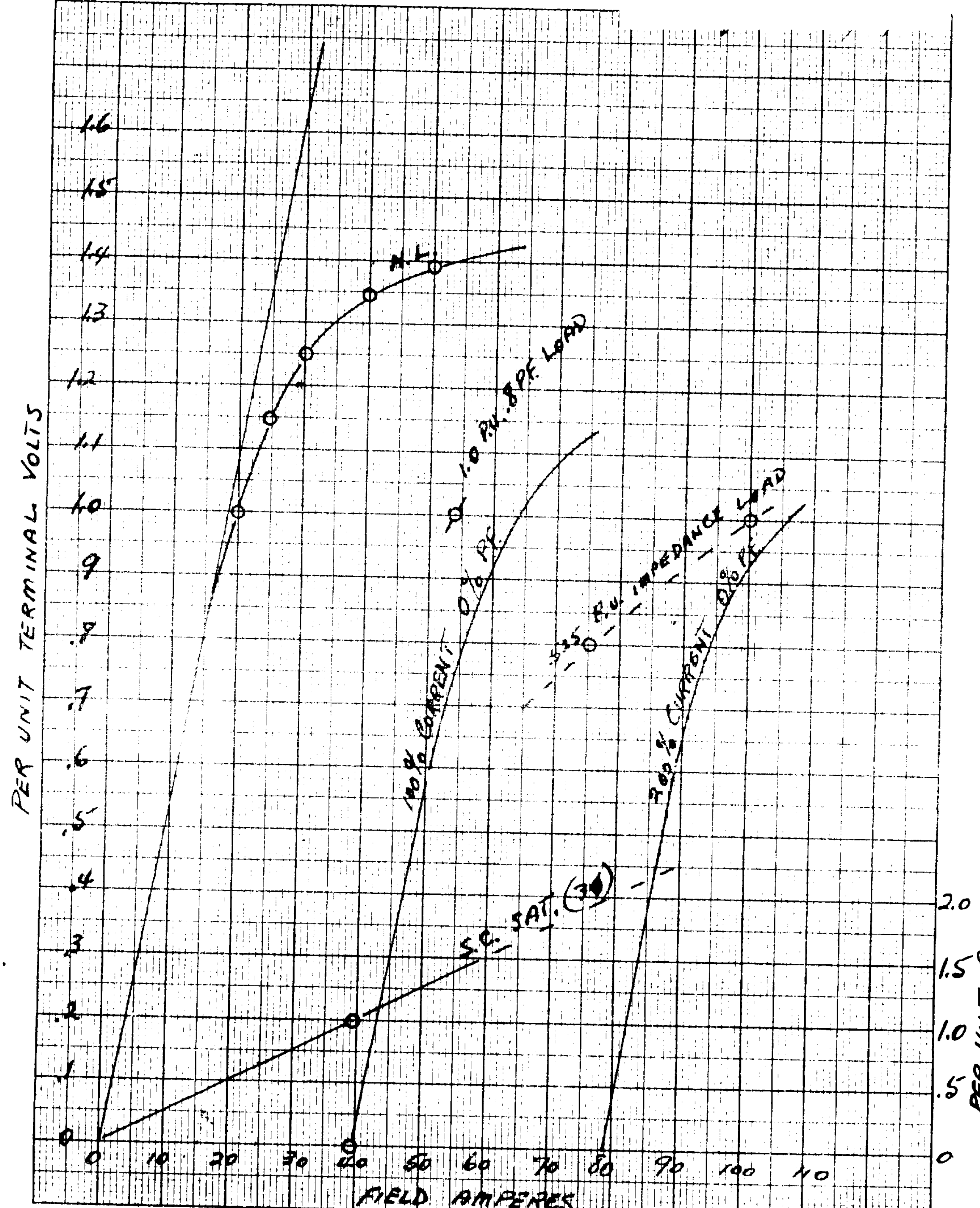
REV A

GRAPH NO.

E. W. O. REP'T NO.

SHOWING TEST SATURATION OF 125 KVA 416/208 VOLT 175/350 AMPERE 400 CYCLE 12000 RPM GENERATOR

DATE



FORM 281

TEST DATA - A. C. SYNC. GENERATOR

125

EXCITATION - SELF

	SPEC. VALUE	CALC. VALUE	TEST VALUE	TEST LETTER
(1) DIELECTRIC STRENGTH FOR 1 MINUTE / SECOND				
(a) STATOR	1832			
(b) ROTOR	1500			
(2) RPM OVERSPEED FOR 5 MIN.	13800			
(3) WEIGHT	178#			
(4) WR^2				
(5) OVERHUNG MOMENT				
(6) STATOR RES. / PH. AT 75 °F		.0128	.010 Ω	
(7) FIELD RES. AT 75 °F		.397	.373 Ω	
(8) SHORT CIRC. RATIO AT 6000 RPM		.545	.547	
(9) % SHORT CIRC. CURRENT CAPACITY				
(10) F & W LOSS AT ___ RPM				
(11) CORE LOSS AT ___ CYCLES / SEC.				
(12) % EFFICIENCIES - TEMPS. STABLE				
(a) AT ___ % LOAD ___ RPM ___ % PF				
(b) AT ___ % LOAD ___ RPM ___ % PF				
(c) AT ___ % LOAD ___ RPM ___ % PF				
(d) AT ___ % LOAD ___ RPM ___ % PF				
(e) AT ___ % LOAD ___ RPM ___ % PF				
(13) FIELD CURRENTS AT ___ VOLTS				
(a) AT ___ % LOAD ___ RPM ___ % PF				
(b) AT ___ % LOAD ___ RPM ___ % PF				
(c) AT ___ % LOAD ___ RPM ___ % PF				
(d) AT ___ % LOAD ___ RPM ___ % PF				
(e) AT ___ % LOAD ___ RPM ___ % PF				
(14) REACTANCES AT 400 CYCLES / SEC. IN %				
(a) SYNCHRONOUS		206	200	
(b) TRANSIENT SATURATED VALUE		17.3	24.2	
(c) SUBTRANSIENT		10.6	7.3	
(d) NEGATIVE SEQUENCE		10.6		
(e) ZERO SEQUENCE		3.1		

TEST DATA - A. C. SYN. GENERATOR

% VOLTAGE UNBALANCE

KVA 125

RPM	% 1φ CURRENT & P.F.	CONNECTED BETWEEN	% 3φ BALANCED LOAD & P.F.	% UNBALANCE	TEST LETTER
12000	38.5 @ .76 P.F.	T_1 & N.	50 @ .78 P.F.	1.45	3675
				1.27	
				1.27	
				1.27	
				1.32	
				1.27	
				1.27	
				1.27	
12000	30 1.00	T_1 & N	0	1.42	4/28/54

ABOVE DATA TAKEN FROM HEAT RUN WITHOUT REGULATOR. MACHINE WAS SELF VENTILATED. DATA WAS TAKEN FOR 30 MIN. AT END OF THE 30 MINUTES HEAT RUN TEMPERATURES WERE AS FOLLOWS.

AIR IN	BY THERMOCOUPLE		92°F
AIR OUT	"	"	144°F
DRIVE END BRG.	"	"	137°F
EXCITER END BRG	"	"	91°F
BRUSH BODY	"	"	223°F
FIELD BY RES.			242°F
STATOR END TURN	BY THERMOCOUPLE		215°F

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TEST DATA - A. C. SYNCHRONOUS GENERATOR

TYPE COOLING SELF — AIR

KVA 125

TEST LETTER & DURATION	ALTITUDE & AMBIENT	AIR PRESS.	RPM	% LOAD	% PF AND FIELD I²R	TEMPERATURES °F				
						FIELD	STATOR	FRAME	AIR IN	AIR OUT
3675	SEA LEVEL	SELF VENT.	12000	100	78	372	325		98	185
						FLANGE END BRG				174°F
						EXCITER END BRG.				109°F
						INBOARD BRUSH BODY				277°F
						OUTBOARD BRUSH BODY				285°F

① AMBIENT WAS MEASURED OUTSIDE TEST ROOM 78°F AND IS MEANINGLESS.

② STATOR END TURN, BEARINGS, BRUSH BODIES, AIR IN & AIR OUT TEMPERATURES WERE MEASURED WITH THERMOCOUPLES.

③ FIELD TEMP. BASED ON A FIELD RES. OF .373 Ω @ 75°F

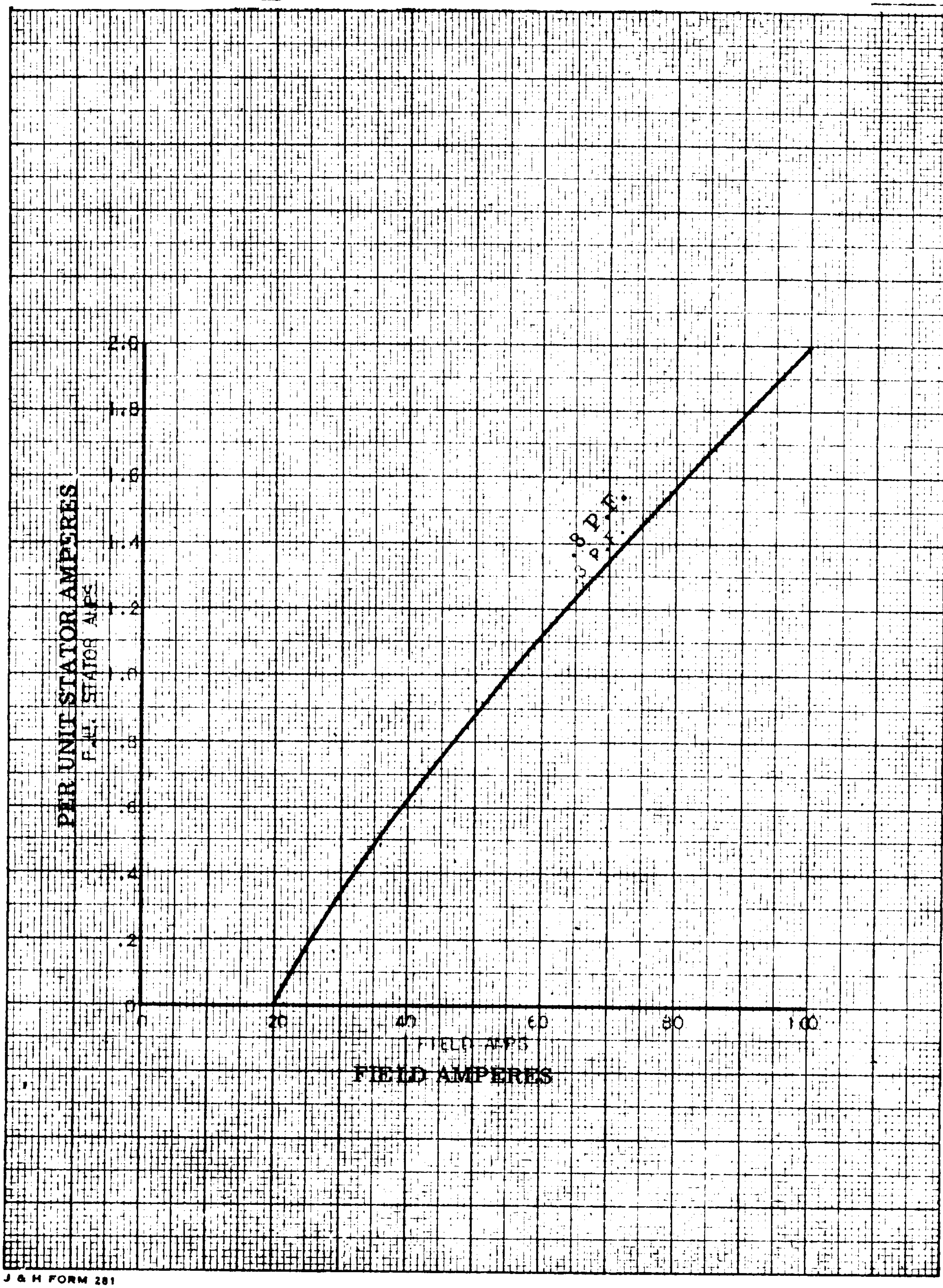
④ THIS HEAT RUN WAS FOR 45 MINUTES DURATION.

GRAPH NO. 1-2476

E. W. O. REP'T NO.

SHOWING EXCITATION REQUIRED VS. LOAD AT RATED VOLTS

(FROM TEST DATA)



J & H FORM 281

GRAPH NO. T-2475

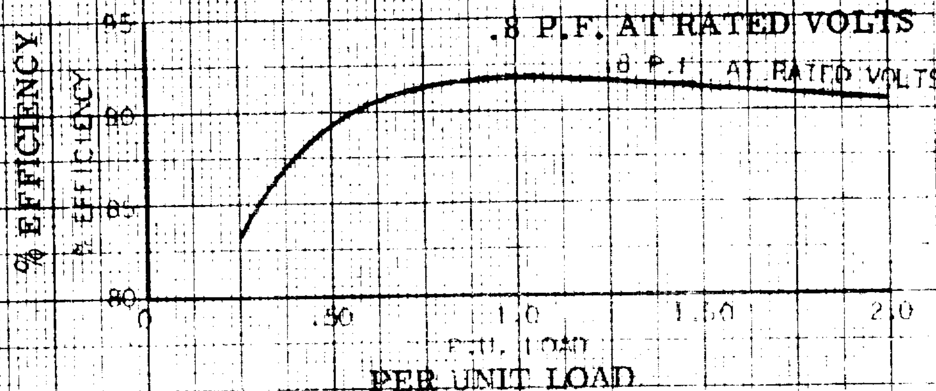
JACK & HEINTZ, INC.

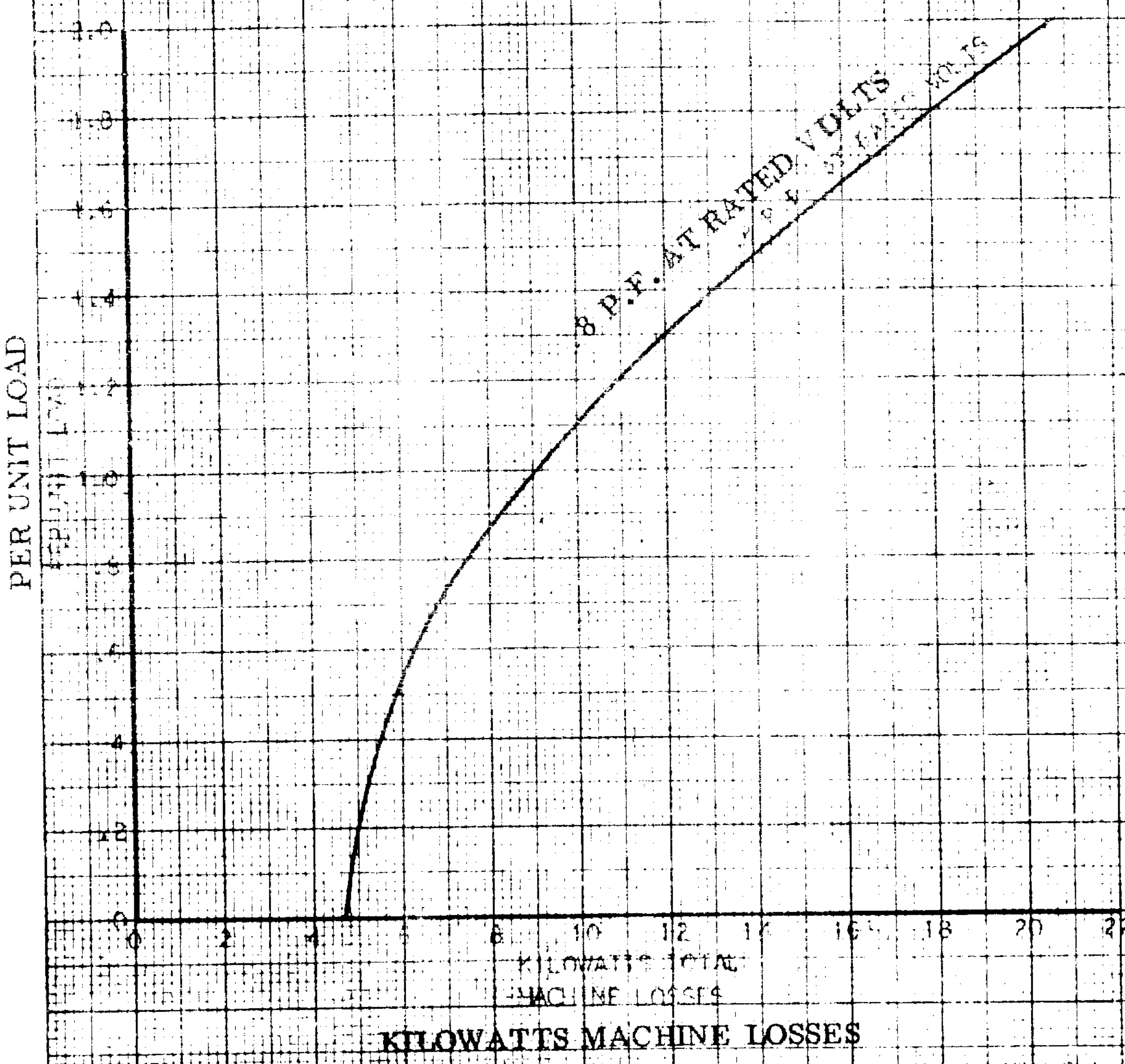
E. W. O. REP'T NO.

SHOWING CALCULATED LOSSES AND EFFICIENCY FOR

(REGULATOR LOSSES ARE NOT INCLUDED)

DATE





J & H FORM 281

TEST DATA - A. C. SYNCHRONOUS GENERATOR

% HARMONIC CONTENT

G 125 KVA NON-SALIENT POLE

HARMONIC	3		5		7		9		11		13		15		17		19		21		23	
CONDITION	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N	L-L	L-N
RPM 12000 AMPS 0 % P. F.	0	4	.55	.10	.40	.10	.01	.05	0	0	.02	.01	.01	.04	.01	.01	.02	0	0	.01	.07	.02
RPM 12000 AMPS 347 % P. F. 1.0	0	6	.5	.28	.10	.10	.01	.40	.01	.02	.01	.01	0	.15	.01	.01	0	0	0	0	.02	.02
RPM 6000 AMPS 0 % P. F.	0	3.2	.6	.6	.6	.5	0	.07	0	.06												
RPM 6000 AMPS 178 % P. F. 1.0	.56	5.5	.20	.22	1.0	1.1	.05	.40	.08	.10												
RPM AMPS % P. F.																						
RPM AMPS % P. F.																						
RPM AMPS % P. F.																						
RPM AMPS % P. F.																						
RPM AMPS % P. F.																						
RPM AMPS % P. F.																						

EWO 531 74 MODEL NO. 6183 & 6R183 SERI NO. XL 101 ROTOR NO. —

DATE OF TEST 6/28/54 TEST LETTER: NO. — TESTED BY REINER & TIRADO STATOR NO. —

TITLE PRESHIPMENT CHECK

UNBALANCED LOAD 30% Current 1.0 PF APPLIED ON ONE PHASE

~~30% Load~~ 37.5 KVA @ 100% PF

$E_{T_1T_2}$ - 208 VOLTS E_{T_1N} - 120 VOLTS I_1 - 116 AMPS

$E_{T_1T_3}$ - 212 VOLTS E_{T_2N} - 124 VOLTS I_2 - 0

$E_{T_2T_3}$ - 213 VOLTS E_{T_3N} - 124 VOLTS I_3 - 0

WAVE FORM

OSCILLOGRAMS TAKEN AT 6000 RPM

LOAD CONNECTED TO 416 VOLT TERMINALS

E_{LL} - 208 VOLTS I_1 - 176 AMPS I_F - 45.4 AMPS

E_{LN} - 119 VOLTS I_2 - 173 AMPS V_F - 23 VOLTS

I_3 - 176 AMPS

HARMONIC ANALYSIS

NO LOAD 6000 RPM 200 CPS

HARMONIC	1ST	3RD	5TH	7TH	9TH	11TH	22ND
LINE TO LINE (%)	100		.6	.6			.15
LINE TO NEUTRAL (%)	100	3.2	.60	.50	.07	.06	.15

FULL LOAD 6000 RPM 200 CPS

EL - 208 VOLTS I_1 - 176 AMPS I_2 - 166 AMPS I_3 - 170 AMPS

HARMONIC	1ST	3RD	5TH	7TH	9TH	11TH	22ND
LINE TO LINE (%)	100	.56	.20	1.0	.05	.08	.08
LINE TO NEUTRAL (%)	100	5.5	.22	1.1	.40	.10	.08

HA-11

FIGURE 4a

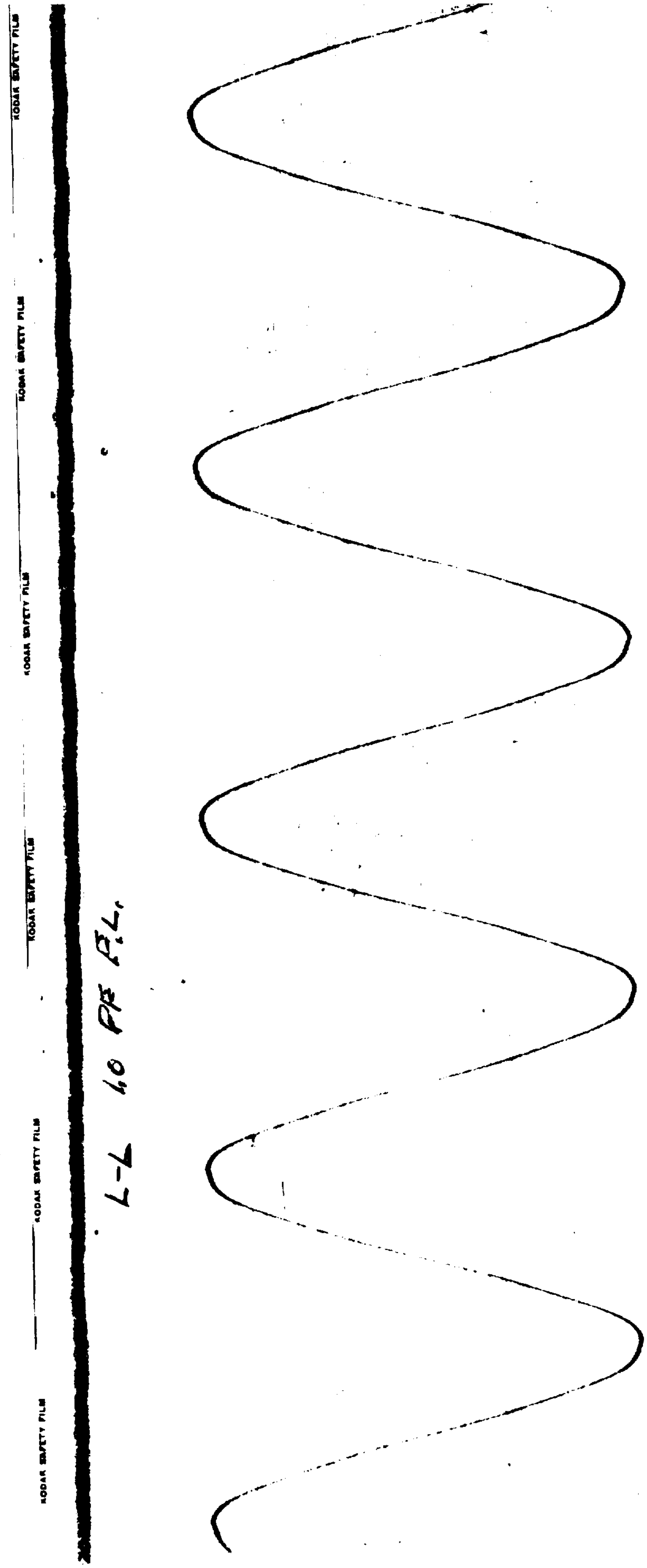
TEST DATA - A. C. SYNCHR[illegible]

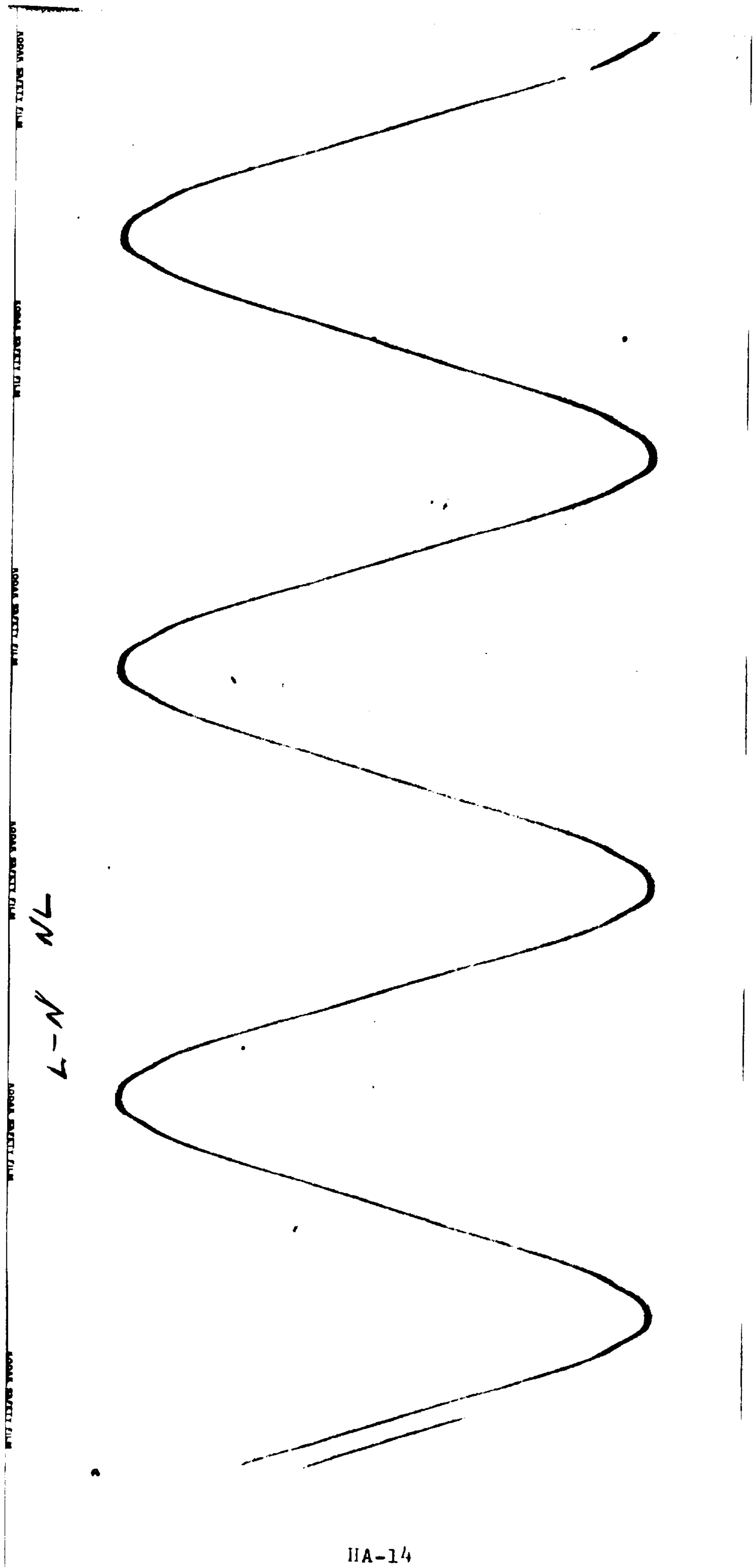
TYPE COOLING AIR

G 183 & G183-1 KVA 125 [illegible]

TEST LETTER & DURATION	ALTITUDE ~~& AMBIENT~~	AIR PRESS.	RPM	% LOAD	% PF AND ~~FIELD~~	TEMPERATURES °F FIELD	STATOR	FRAME	GEN. AIR IN	AIR OUT	
3675 45 MIN	SEA LEVEL	SELF VENT.	12000	100	78	372	325		98	185	G183
6/25/54 60 MIN	" "	"	"	"	71	375	355	230	92	176	G183-1

ORIGINAL PAGE IS OF POOR QUALITY


KODAK SAFETY FILM
L-L 1.0 PF P.L.


L-N NL

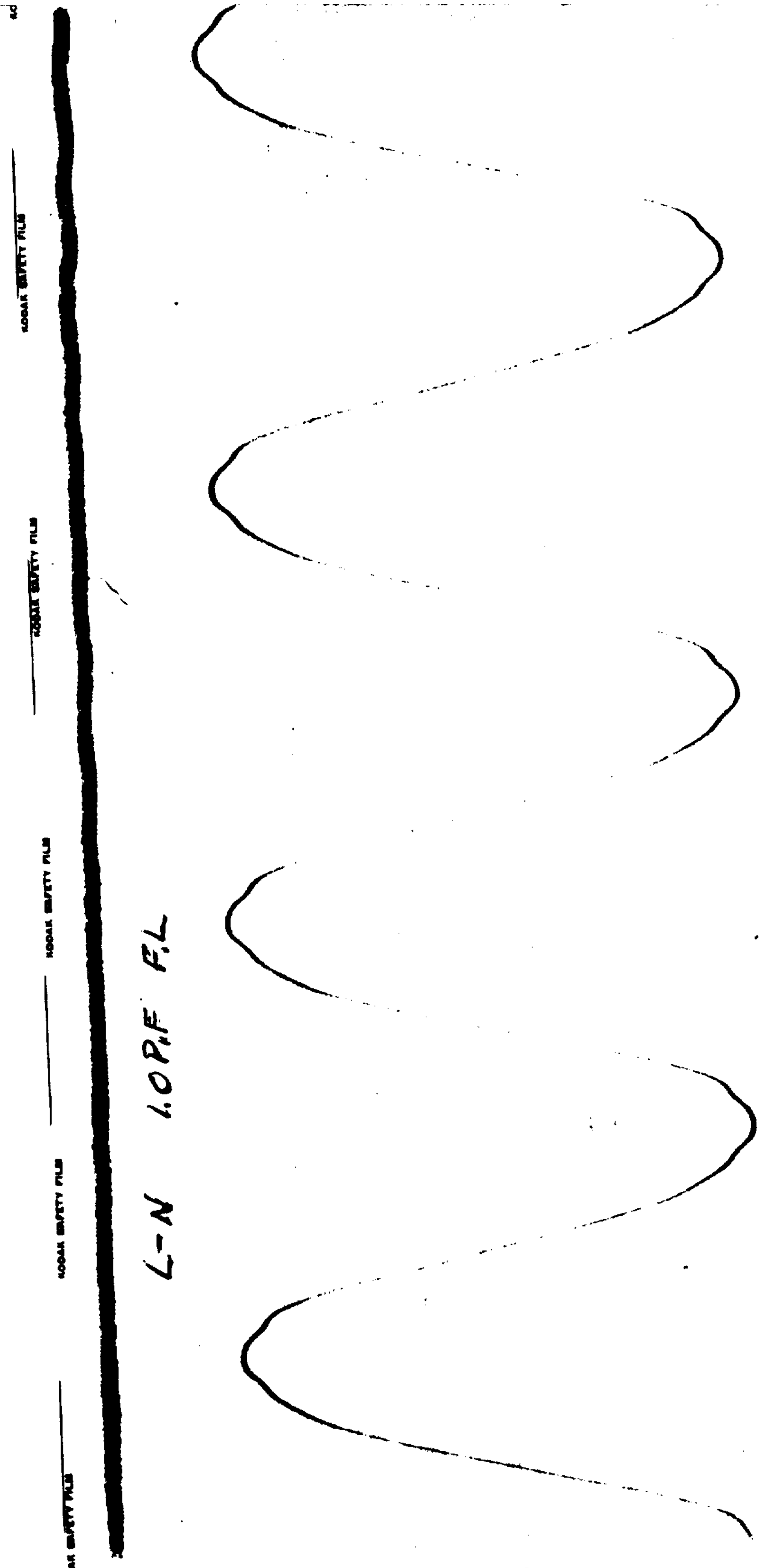
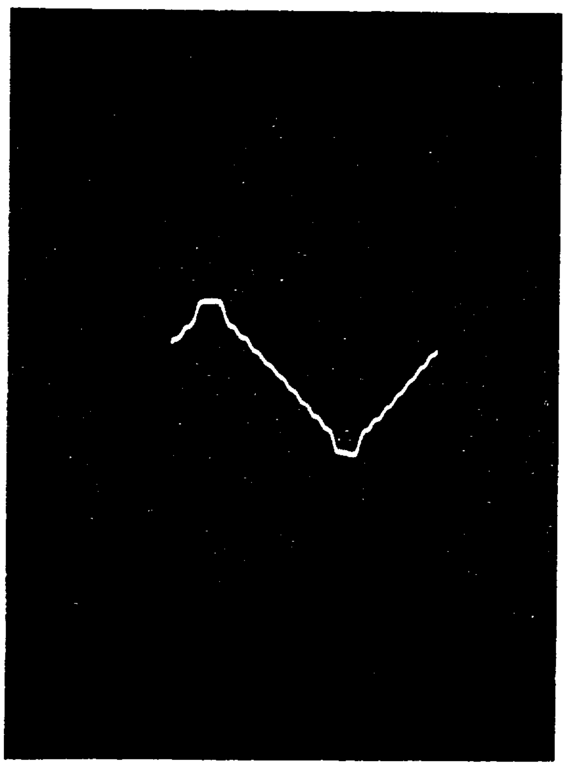

L-N 1.0P.F F.L
KODAK SAFETY FILM

PHOTO NO. 40555

E.W.O. 53193

SHOWING:

VOLTAGE WAVES OBTAINED FROM FULL PITCH SEARCH COIL AND 1/2 TURN SEARCH COIL



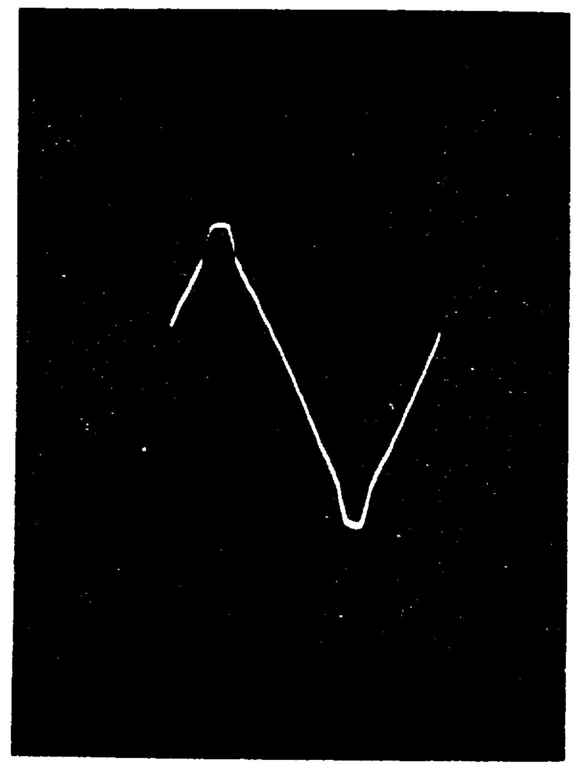


PHOTO NO. 10255-9

E.W.O. 53193

SHOWING:

ONE PHASE OF A THREE-PHASE
SHORT CIRCUIT DECREMENT
SHORT CIRCUIT FROM NO LOAD - FULL VOLTAGE

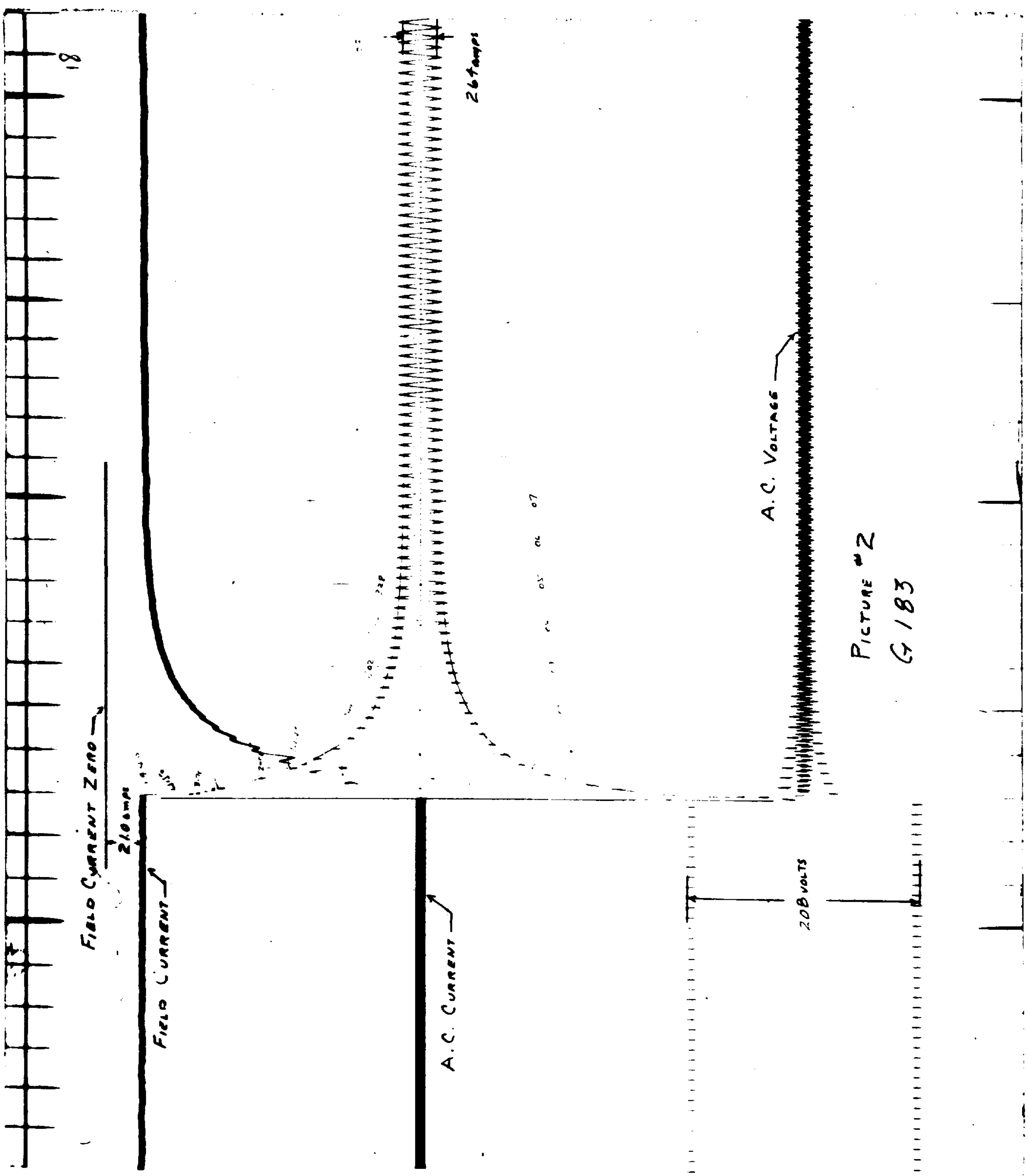
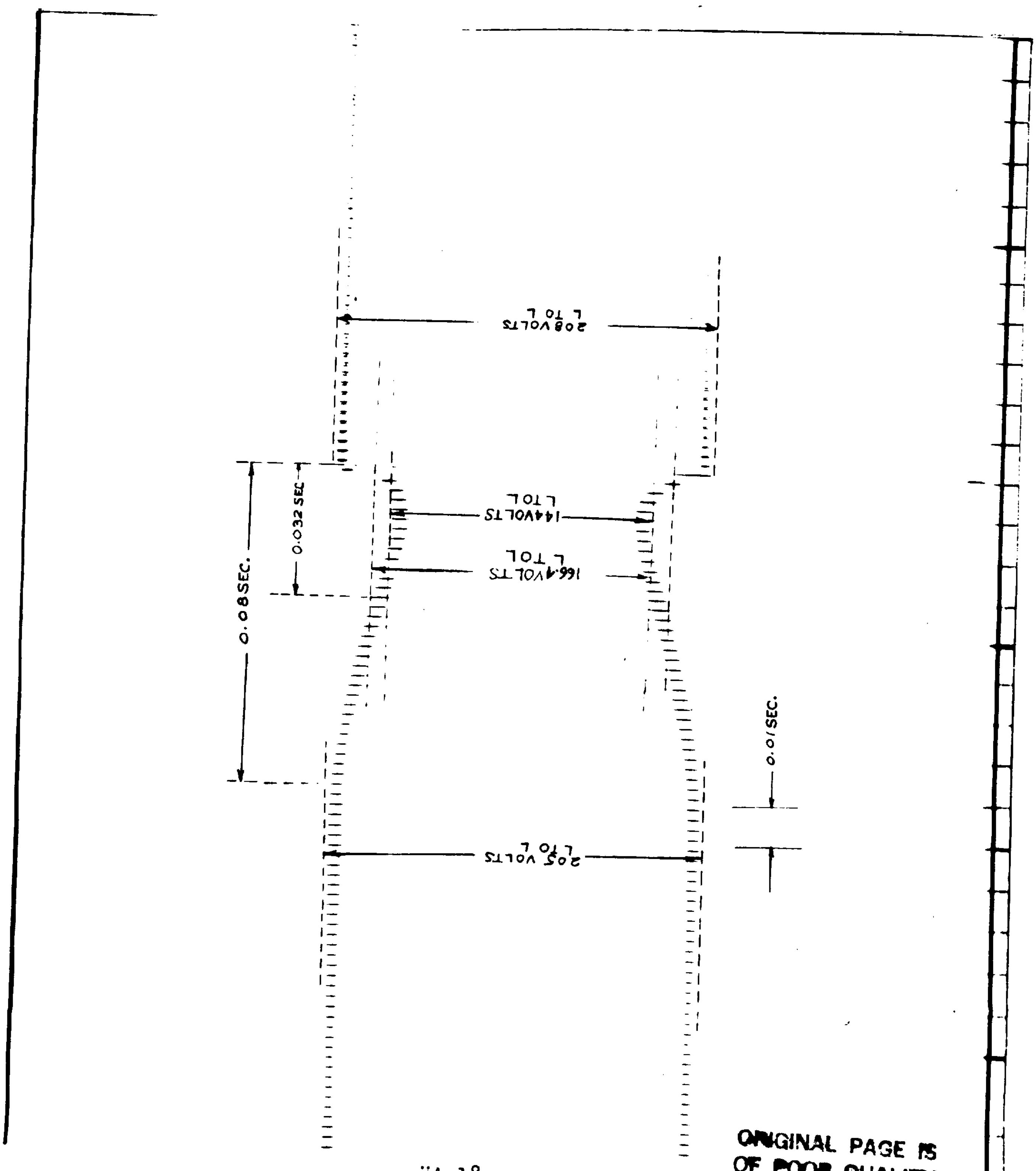


PHOTO NO. 40255-10

W.O. 53193

SHOWING:

TRANSIENT VOLTAGE REGULATION
WITH THREE-PHASE, 0.40 POWER FACTOR,
0.5 PER UNIT IMPEDANCE



COMPUTER PROCEDURE FOR

NON SALIENT POLE DESIGN CALCULATIONS

1. Clear core (no switch control).
2. Insert output Form #1 into typewriter, set margin for correct output, and set typewriter for single space.
3. Load pass #1 followed by input parameters (output punched cards).
4. Load pass #2 followed by output from pass #1 (output printed plus punched cards).
5. Load pass #3 followed by output from pass #2 (output printed plus punched cards).
6. Load pass #4 followed by output from pass #3 (output printed plus punched cards).
7. Load pass #5 followed by output from pass #4 (output printed plus punched cards).
8. Load pass #5A followed by output from pass #5 (output punched cards).
9. Load pass #6 followed by Saturation curve values* and output from pass #5A (output printed plus punched cards).
10. Load pass #7 followed by output from pass #6 (output printed plus punched cards if no load saturation curve required).
11. If there is card output from pass #7 a no load saturation curve is required. Insert output Form #2 in typewriter and set margin. Load pass #8 followed by saturation curve values* and output from pass #7 (output printed).

* Saturation curves are loaded in order shown on Input Form #1.

ALL INPUT PARAMETERS ARE IN FORMAT F7.0 (FIG. 1)

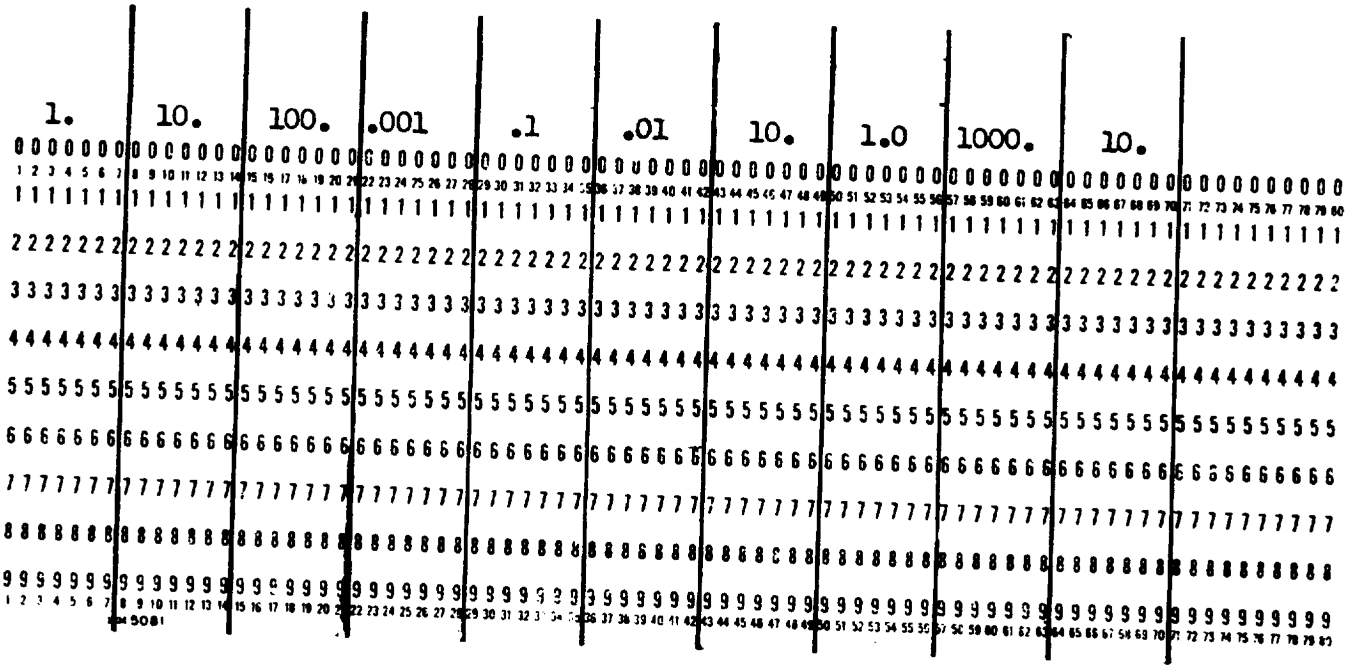


FIG. 1

ALL SATURATION CURVE VALUES ARE IN FORMAT F10.0 (FIG. 2)
(ALL SATURATION CURVES MUST HAVE 5 CARDS)

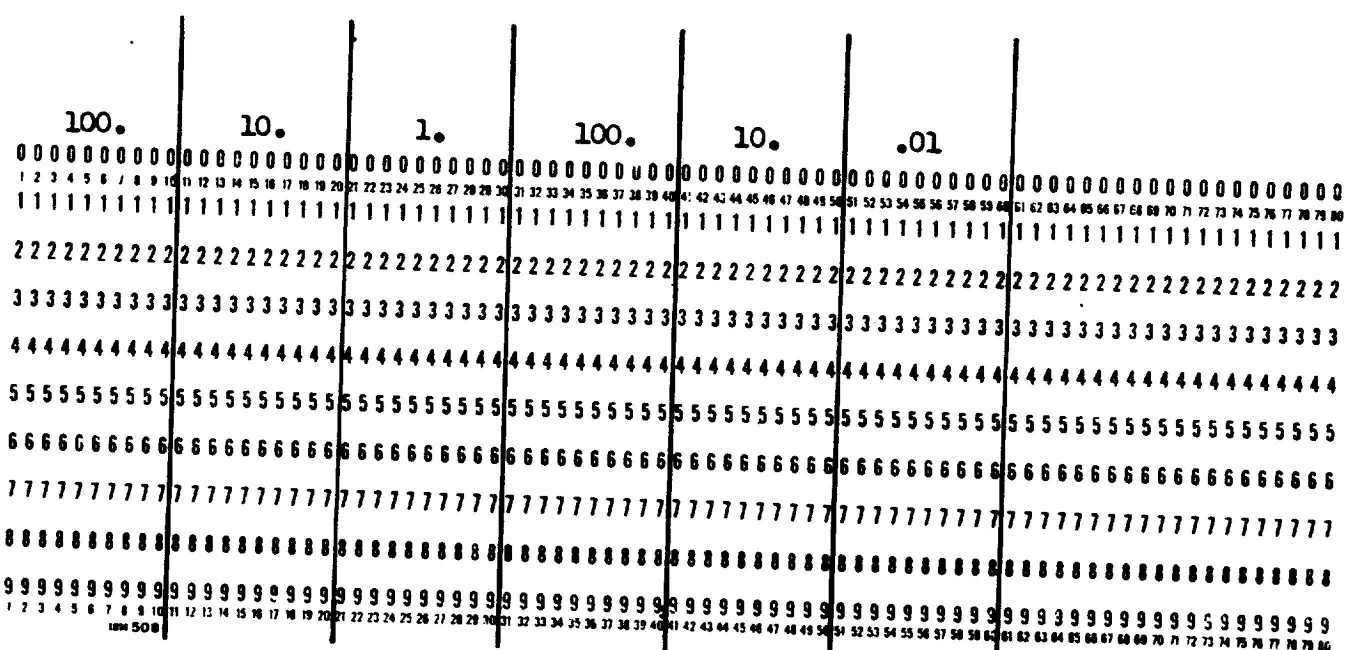


FIG. 2

NON-SALIENT WOUND-POLE GENERATOR

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
	A, a	
(46)	A_c	AC
(68)	A_g	GA
(128)	A	A
(153)	A_{cf}	AS
	B, b	
(15)	b_v	BV
(20)	B	BK
(22)	b_o	BO
(22)	b_1	B1
(22)	b_2	B2
(22)	b_3	B3
(22)	b_s	BS
(57)	b_{tm}	TM
(57a)	$b_{t1/3}$	SM
(91)	B_t	TE
(303)	b_r	BR
(321)	B_{rcL}	FDD
(314)	B_{pc}	PD
(314b)	b_{rh}	BRH

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
(315)	B_{rc}	PDD
(319)	B_{PCL}	FD
	C, c	
(32)	C	CC
(60)	C_x	CX
(71)	C_1	C1
(72)	C_w	CW
(73)	C_p	CP
(74)	C_m	CM
	D, d	
(11)	d	DI
(11a)	d_r	DR
(12)	D	DU
(35)	d_b	DB
(314a)	d_s	DRS
	E, e	
(3)	E	EE
(4)	E_{PH}	EP
(55)	EF_{top}	ET

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
(56)	E_{FBot}	EB
(127)	E_f	EFNL
(198)	e_d	ED
(228)	E_{FFL}	EF
	F, f	
(5a)	f	F
(96)	F_g	FH
(97)	F_T	FT
(98)	F_c	AT
(127)	F_{NL}	FN
(180)	F_{sc}	FSC
(183)	F & W	WF
(316)	F_{pc}	FA
(317)	F_{rc}	FA1
(320)	F_{PCL}	FX
(322)	F_{rcL}	FX1
	G, g	
(59)	g	GC
(69)	g_e	GE

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
	H, h	
(22)	h_o	HO
(22)	h_1	HX
(22)	h_2	HY
(22)	h_3	HZ
(22)	h_s	HS
(22)	h_t	HT
(22)	h_w	HW
(24)	h_c	HC
(37)	h_{st}	SH
(38)	h'_{st}	SD
(303)	h_r	HR
(303)	h_{r1}	HR1
(303)	h_{r2}	HD
	I, i	
(8)	I_{PH}	PI
(127a)	I_{FNL}	FI
(182)	I^2R_F	PR
(237)	I_{FFL}	FI
(241)	I^2R_F	PR

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
	K, k	
(2)	K_{VA}	VA
(9a)	K_c	CK
(16)	K_i	RK
(19)	k	WL
(42)	K_{sk}	FS
(43)	K_d	DF
(44)	K_p	CF
(61)	K_x	FF
(63)	K_E	EK
(67)	K_s	CC
(308)	K_r	RCC
	L, l	
(13)	l	l
(17)	l_s	SS
(36)	l_{e2}	CE
(48)	L_E	EL
(49)	l_t	HM
(147)	l_{tr}	FE
(161)	L_F	SI
(305)	l_r	ALR
(305a)	l_{rs}	ALRS

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
	M, m	
(5)	m	PN
	N, n	
(14)	n_v	HV
(30)	n_s	SC
(34)	N_{st}	SN
(34a)	N'_{st}	SN1
(45)	n_e	EC
(302a)	N_{rc}	ANRC
	P, p	
(6)	P	PX
(9)	P_F	PF
	Q, q	
(23)	Q	QQ
(25)	q	QN
(300)	Q'_r	Q1R
(301)	Q_r	QR

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
	R, r	
(7)	R_{pm}	RPM
(53)	R_{sph}	RG
(54)	R_{sph} (hot)	RP
(154)	R_f (cold)	FK
(155)	R_f (hot)	FR
	S, s	
(47)	S_s	S
(127c)	S_F	CDD
(181)	S_{cr}	SCR
	T, t	
(176)	T'_{do}	TC
(177)	T_a	TA
(178)	T'_d	T5
(179)	T''_d	T4
(304)	t_{rs}	TRS
	V, v	
(145)	V_r	VR

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
	W, w	
(184)	W_{TNL}	ST
(185)	W_c	WQ
(186)	W_{NPL}	WN
(242)	W_{TFL}	ST
(243)	W_{PFL}	PP
(244)	W_{DFL}	DL
	X, x	
(50)	$X_s\,{}^{o}C$	T1
(129)	X	XR
(130)	X_L	XL
(131)	X_{ad}	XD
(132)	X_{aq}	XQ
(133)	X_d	XA
(150)	$X_C\,{}^{o}C$	TZ
(160)	X_F	XF
(163)	X_{Dd}	X1
(166)	X'_{Du}	XU
(167)	X'_d	XS
(168)	X''_d	XX

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
(170)	X_2	XN
(172)	X_o	XO
	Y, y	
(31)	y	YY
	Υ	
(26)	Υ_s	TS
(27)	$\Upsilon_{s1/3}$	TT
(40)	Υ_{sk}	SK
(41)	Υ_p	TP
	λ	
(62)	λ_i	PC
(64)	λ_E	EW
(70c)	λ_a	AG
(312b)	λ_{rs}	XRS
(332)	λ_F	XF
(333)	λ_{FE}	XF1

CALCULATION NUMBER	ELECTRICAL SYMBOL	FORTRAN SYMBOL
	ϕ	
(88)	ϕ_T	TG
(92)	ϕ_p	FQ
(311)	ϕ_{gp}	PGP
(312)	ϕ_{LS}	UX
(312a)	ϕ_{LLS}	GZ
(313)	ϕ_{rc}	TF
(318)	ϕ_{PCL}	GL
	ρ	
(51)	ρ_s	RS
(151)	ρ_f	RR
	θ	
(198a)	θ	AN
	K	
(187)	K_1	D1
(188)	K_2	D2
(189)	K_3	D3
(190)	K_4	D4
(191)	K_5	D5
(192)	K_6	D6

```
C     PASS 1  NON-SALIENT WOUND-POLE GENERATOR
      DIMENSION DA(8),DX(6),DY(8),DZ(8)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
    2 FORMAT(F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0)
   33 READ2,VA,EE,EP,PN,F,PX,RPM,PI,PF,POL
      READ2,DI,DU,CL,HV,BV,SF,WL,BK,ZZ,BO
      READ2,B1,B2,B3,BS,HO,HX,HY,HZ,HS,HT
      READ2,HW,QQ,W,RF,SC,YY,C,DW,SN,SN1
      READ2,DW1,DB,CE,SH,SD,PBA,SK,T1,RS,GC
      READ2,C1,CW,CP,EL,CM,TPR,Q1R,QR,ANRC,WO
      READ2,HD,HR1,BR,HR,TRS,ALR,RK,DR,DRS,BRH
      READ2,WR,D1,PT,FE,RD,RT,T2,RR,SNL,WF
      SS=SF*(CL-HV*BV)
      HC=(DU-DI-2.0*HS)*0.5
      IF(HC-.7*HS)33,5,5
    5 QN=QQ/(PX*PN)
      TS=3.142*DI/QQ
      IF(ZZ-4.0)29,30,29
   29 TT=(0.667*HS+DI)*3.142/QQ
      GO TO 31
   30 TT=3.1416*(DI+2.*HO+1.32*BS)/QQ
   31 IF(ZZ-1.0)6,6,7
    6 BO=BS
      CC=(5.0*GC+BS)*TS/((5.0*GC+BS)*TS-BS*BS)
      GO TO 8
    7 QC=(4.44*GC+0.75*BO)*TS
      CC=QC/(QC-BO*BO)
    8 CS=YY/(PN*QN)
      TP=3.142*DI/PX
```

```
      IF(SK)32,32,92
   32 FS=1.0
      GO TO 34
   92 FS=SIN(1.571*SK/TP)*TP/(1.571*SK)
   34 IF(PBA-60.)9,9,10
    9 D=1.0
      GO TO 95
   10 D=20.
   95 I=QN
      U=I
      IF(QN-U)36,36,35
   35 U=PX*PN
      XX=U
      N=U
      DO 11 K=1,N
      Z=U/XX
      I=Z
      Z1=I
      IF(Z-Z1)12,12,11
   12 ZY=QQ/XX
      I=ZY
      Z1=I
      IF(ZY-Z1)37,37,11
   11 XX=XX-1.
   36 ZY=QN
   37 DF=SIN(1.571*D/PN)/(ZY*D*SIN(1.571/(PN*ZY)))
      CF=SIN(YY*1.571/(PN*QN))
      EC=QQ*SC*CF*FS/C
      DT=DW1
```

```
      IF(DT) 13,13,14
   13 AC=0.785*DW*DW*SN1
      GO TO 24
   14 ZY=0.0
      DA(1)=0.05
      DA(2)=0.072
      DA(3)=0.125
      DA(4)=0.165
      DA(5)=0.225
      DA(6)=0.438
      DA(7)=0.688
      DA(8)=1.5
      DX(1)=0.000124
      DX(2)=0.00021
      DX(3)=0.00021
      DX(4)=0.00084
      DX(5)=0.00189
      DX(6)=0.00189
      DY(1)=0.000124
      DY(2)=0.000124
      DY(3)=0.00084
      DY(4)=0.00084
      DY(5)=0.00189
      DY(6)=0.00335
      DY(7)=0.00754
      DY(8)=0.03020
      DZ(1)=0.000124
      DZ(2)=0.000124
      DZ(3)=0.000124
```

```
      DZ(4)=0.00335
      DZ(5)=0.00335
      DZ(6)=0.00754
      DZ(7)=0.0134
      DZ(8)=0.0302
   93 IF(DT-.05)94,94,15
   15 JA=0
      JB=0
      JC=0
      JD=0
   16 JA=JA+1
      JB=JB+1
      JC=JC+1
      JD=JD+1
      IF(DT-DA(JA))17,17,16
   94 D=0
      IF(ZY)23,23,27
   17 IF(DW-0.188)18,18,19
   18 CY=DX(JB-1)
      CZ=DX(JB)
      GO TO 22
   19 IF(DW-0.75)20,20,21
   20 CY=DY(JC-1)
      CZ=DY(JC)
      GO TO 22
   21 CY=DZ(JD-1)
      CZ=DZ(JD)
   22 D=CY+(CZ-CY)*(DT-DA(JA-1))/(DA(JA)-DA(JA-1))
      IF(ZY)23,23,27
```

```
23 AC=(DT*DW-D)*SN1
24 IF(RT)25,25,26
25 AS=0.785*RD*RD
   GO TO 28
26 ZY=1.0
   DT=RT
   DW=RD
   GO TO 93
27 AS=RT*RD-D
28 S=PI/(C*AC)
   PUNCH1,VA,EE,EP,PN,F,PX
   PUNCH1,RPM,PI,PF,POL,DI
   PUNCH1,DU,CL,SS,HC,SF,QN
   PUNCH1,WL,BK,ZZ,BO,B1,B2
   PUNCH1,B3,BS,HO,HX,HY,HZ
   PUNCH1,HS,HT,HW,QQ,W,RF
   PUNCH1,SC,YY,C,TS,SN,DB
   PUNCH1,CE,SH,SD,TT,SK,T1
   PUNCH1,RS,GC,C1,CW,CP,EL
   PUNCH1,CM,TPR,Q1R,QR,BR,HR
   PUNCH1,TRS,ALR,DR,RK,CC,WR
   PUNCH1,D1,WO,HD,HR1,ANRC,DRS
   PUNCH1,BRH,PT,FE,RD,RT,T2
   PUNCH1,RR,SNL,WF,CS,AS,FS
   PUNCH1,TP,DF,CF,EC,AC,S
   PUNCH1,PBA
   PAUSE
   END
```

```
C       PASS 2  NON-SALIENT WOUND-POLE GENERATOR
      1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      3 FORMAT(9X F12.5,2X F12.5)
        READ1, VA,EE,EP,PN,F,PX
        READ1,RPM,PI,PF,POL,DI
        READ1, DU,CL,SS,HC,SF,QN
        READ1, WL,BK,ZZ,BO,B1,B2
        READ1, B3,BS,HO,HX,HY,HZ
        READ1, HS,HT,HW,QQ,W,RF
        READ1, SC,YY,C,TS,SN,DB
        READ1, CE,SH,SD,TT,SK,T1
        READ1,RS,GC,C1,CW,CP,EL
        READ1,CM,TPR,Q1R,QR,BR,HR
        READ1,TRS,ALR,DR,RK,CC,WR
        READ1,D1,WO,HD,HR1,ANRC,DRS
        READ1,BRH,PT,FE,RD,RT,T2
        READ1, RR,SNL,WF,CS,AS,FS
        READ1, TP,DF,CF,EC,AC,S
        READ1,PBA
        GA=3.142*DI*CL
        AG=6.38*DI/(PX*GC*CC)
        ALP=QR/Q1R
        X=BR**2
        IF(BR-WO)41,42,41
     42 RCC=TRS*(5.*GC+BR)
        RCC=RCC/(RCC-X)
        GO TO 43
     41 RCC=TRS*(4.44*GC+.75*BR)
        RCC=RCC/(RCC-X)
```

```
43  X=1.5708*ALP
    IF(TPR-1.)47,48,47
48  GE=CC*GC
    C1=(COS(X)*((RCC-1.)/RCC)+(.6366/(RCC*ALP))*SIN(X))*1.27
    CP=1.-ALP+ALP/(2.*RCC)
    CFA=1.-ALP+ALP/(3.*RCC)
    GO TO 63
47  GE=RCC*CC*GC
    C1=(.8105/ALP)*SIN(X)
    CP=1.-ALP/2.
    CFA=1.-2.*ALP/3.
63  CM=1.23*ALP/SIN(X)
44  IF(CW)45,45,46
45  CW=0.707*EE*C1*DF/(EP*PN)
46  TG=6000000.0*EE/(CW*EC*RPM)
    BG=TG/GA
    FQ=TG*CP/PX
    IF(ZZ-3.0)49,50,51
49  SM=TT-BS
    GO TO 53
50  SM=(3.1416*(DI+2.*HS)/QQ)-B3
    GO TO 53
51  IF(ZZ-4.0)50,52,49
52  SM=TT-.94*BS
53  TE=TG/(QQ*SS*SM)
    BX=0.5*FQ/(HC*SS)
    IF(EL) 54,54,62
54  IF(RF) 55,55,61
55  IF(PX-2.0) 56,56,57
```

```
56 U=1.3
   GO TO 60
57 IF(PX-4.0) 58,58,59
58 U=1.5
   GO TO 60
59 U=1.7
60 EL=3.142*U*YY*(DI+HS)/QQ+0.5
   GO TO 62
61 EL=2.0*CE+(3.142*(0.5*HX+DB))+(YY*TS*TS/(SQRT(TS*TS-BS*BS)))
62 HM=CL+EL
   RY=SC*QQ*HM/(PN*AC*C*C)
   RX=RS*0.000001
   RB=(T1+234.5)*0.00394*RX
   RG=RX*RY
   RP=RB*RY
   A=PI*SC*CF/(C*TS)
   XR=.0707*A*DF/(C1*BG)
   PRINT3,SS,CC,HC,GA,TS,AG,TT,GE,FS,C1,DF,CW,CF,CP,EC,EL,AC,CM
   PUNCH1,VA,EE,EP,PN,F,PX
   PUNCH1,RPM,PI,PF,POL,DI
   PUNCH1,DU,CL,SS,HC,SF,QN
   PUNCH1,WL,BK,ZZ,BO,B1,B2
   PUNCH1,B3,BS,HO,HX,HY,HZ
   PUNCH1,HS,HT,HW,QQ,W,GE
   PUNCH1,SC,YY,C,TS,BG,TG
   PUNCH1,FQ,TE,BX,TT,HM,SM
   PUNCH1,RG,GC,RP,C1,CW,CP
   PUNCH1,EL,CM,TPR,Q1R,QR,BR
   PUNCH1,HR,TRS,ALR,DR,RK,CC
```

```
PUNCH1,WR,D1,WO,HD,HR1,ANRC
PUNCH1,DRS,BRH,CFA,PT,FE,RD
PUNCH1,RT,T2,RR,SNL,WF,CS
PUNCH1,AS,SH,TP,DF,CF,SN
PUNCH1,AC,S,AG,A,SM,SD
PUNCH1,RB,XR,PBA
PAUSE
END
```

```
C       PASS 3  NON-SALIENT WOUND-POLE GENERATOR
      1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      3 FORMAT(9X F12.5,2X F12.5)
        READ1, VA,EE,EP,PN,F,PX
        READ1,RPM,PI,PF,POL,DI
        READ1, DU,CL,SS,HC,SF,QN
        READ1, WL,BK,ZZ,BO,B1,B2
        READ1, B3,BS,HO,HX,HY,HZ
        READ1, HS,HT,HW,QQ,W,GE
        READ1, SC,YY,C,TS,BG,TG
        READ1, FQ,TE,BX,TT,HM,SM
        READ1, RG,GC,RP,C1,CW,CP
        READ 1,EL,CM,TPR,Q1R,QR,BR
        READ 1,HR,TRS,ALR,DR,RK,CC
        READ 1,WR,D1,WO,HD,HR1,ANRC
        READ 1,DRS,BRH,CFA,PT,FE,RD
        READ 1,RT,T2,RR,SNL,WF,CS
        READ 1,AS,SH,TP,DF,CF,SN
        READ 1,AC,S,AG,A,SM,SD
        READ1,RB,XR,PBA
        IF(SH)37,38,40
     38 ET=1
        EB=1
        GO TO 39
     40 AA=0.584+(SN*SN-1.0)*0.0625*(SD*CL/(SH*HM))*2.0
        AB=(SH*SC*F*AC/(BS*RB*1000000.0))**2.0
        ET=AA*AB*0.00335+1.0
        EB=ET-0.00168*AB
        IF(ZZ-5.)350,351,350
```

```
351 FF=1.0
    GO TO 75
350 IF(PBA-60.)352,353,352
353 IF(CS-.667)354,355,355
355 D=.75
    Z=.25
    GO TO 74
354 D=1.5
    Z=-.25
    GO TO 74
352 IF(CS-.667)356,357,357
357 FF=.75
    GO TO 75
356 D=1.2
    Z=-.05
 74 FF=D*CS+Z
 75 CX=FF/(CF*CF*DF*DF)
    Z=CX*20.0/(PN*QN)
    BT=3.142*DI/QQ-BO
    ZA=BT*BT/(16.0*TS*GC)
    ZB=0.35*BT/TS
    ZC=HO/BO
    ZD=HX*0.333/BS
    ZE=HY/BS
    IF(ZZ-2.0) 76,77,78
 76 PC=Z*(ZE+ZD+ZA+ZB)
    GO TO 82
 77 PC=Z*(ZC+(2.0*HT/(BO+BS))+(HW/BS)+ZD+ZA+ZB)
    GO TO 82
```

```
78 IF(ZZ-4.0) 79,80,81
79 PC=Z*(ZC+(2.0*HT/(BO+B1))+(2.0*HW/(B1+B2))+(HX*0.333/B2)+ZA+ZB)
   GO TO 82
80 PC=Z*(ZC+0.62)
   GO TO 82
81 PC=Z*(ZE+ZD+(0.5*GC/TS)+(0.25*TS/GC)+0.6)
82 EK=EL/(10.0**(0.103*YY*TS+0.402))
   IF(DI-8.0) 83,83,84
83 EK=SQRT(EK)
84 ZF=.612*LOG(10.0*CS)
   EW=6.28*EK*ZF*(TP**(0.62-(0.228*LOG(ZF))))/(CL*DF*DF)
   XL=(PC+EW)*XR
   XD=XR*AG*C1*CM
   WC=0.321*SC*QQ*AC*HM
   PRINT3,S,A,HM,XR,RG,XL,RP,XD
   PUNCH1,VA,EE,EP,PN,F,PX
   PUNCH1,RPM,PI,PF,POL,DI
   PUNCH1,DU,CL,SS,HC,PC,QN
   PUNCH1,WL,BK,ZZ,BO,XD
   PUNCH1,XR,BS,XL,HX,HY,HZ
   PUNCH1,HS,WC,AC,QQ,W,GE
   PUNCH1,SC,YY,C,TS,BG,TG
   PUNCH1,FQ,TE,BX,TT,EW,AG
   PUNCH1,RG,GC,RP,C1,TP,CP
   PUNCH1,DF,CM,CFA,TPR,Q1R,QR
   PUNCH1,HR,TRS,ALR,EB,DR,RK
   PUNCH1,CC,WR,D1,WO,HD,HR1
   PUNCH1,ANRC,DRS,BRH,PT,FE,RD
   PUNCH1,RT,T2,RR,SNL,WF,CS
```

```
PUNCH1,AS,ET,SM,BR,CF
PAUSE
END
```

```
C       PASS 4  NON-SALIENT WOUND-POLE GENERATOR
      1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      3 FORMAT(9X F12.5,2X F12.5)
        READ1, VA,EE,EP,PN,F,PX
        READ1,RPM,PI,PF,POL,DI
        READ1, DU,CL,SS,HC,PC,QN
        READ1, WL,BK,ZZ,BO,XD
        READ1, XR,BS,XL,HX,HY,HZ
        READ1, HS,WC,AC,QQ,W,GE
        READ1, SC,YY,C,TS,BG,TG
        READ1, FQ,TE,BX,TT,EW,AG
        READ1, RG,GC,RP,C1,TP,CP
        READ 1,DF,CM,CFA,TPR,Q1R,QR
        READ 1,HR,TRS,ALR,EB,DR,RK
        READ 1,CC,WR,D1,WO,HD,HR1
        READ 1,ANRC,DRS,BRH,PT,FE,RD
        READ 1,RT,T2,RR,SNL,WF,CS
        READ1,AS,ET,SM,BR,CF
        ZA=3.1416*(DI+HS)/QQ
        IF(ZZ-3.0) 88,89,88
     88 TM=ZA-BS
        GO TO 90
     89 TM=(3.1416*(DI+2.*HS)/QQ)-B3
     90 WI=(TM*QQ*SS*HS+(DU-HC)*3.142*HC*SS)*0.283
        AN=0.0
    100 AN=AN+0.005
        AL=COS(AN)
        IF(PF-AL) 100,100,101
    101 VR=0.262*DR*RPM
```

```
      FH=BG*GE/0.00319
      ZG=PT*PX*FE*0.000001/AS
      FK=RR*ZG
      FR=(T2+234.5)*FK*0.00394
      RC=0.321*PT*PX*FE*AS
      XA=XL+XD
      X=12.76*PX/QR
      Y=.35*(TRS-WO)/TRS+GC/(2.*TRS)
      IF(WO-BR)102,103,102
  103 XRS=(HD/BR+HR1/(2.*BR)+Y)*X
      GO TO 104
  102 XRS=(HD/WO+2.*(HR-HR1-HD)/(WO+BR)+HR1/(2.*BR)+Y)*X
  104 EWR=TP*(TP*(6.6756187E-4*TP-3.0560938E-2)+.66201215)-.10576361
      EWR=EWR*6.28/ALR
      XF1=EWR+XRS
      XF=XR*CM*CM*XF1*4./3.1416
      SI=(PT*PT*PX*ALR/1.E+8)*((CFA*3.19*TP/GE)+XF1)
      XZ=(3.19*PX/DI)*(GC+.47*SQRT(400./F)+HD)*XR
      XU=XL+XF*(XD/(XD+XF))
      XS=0.88*XU
      XX=XL+XZ
      XN=XX
      XB=XA
      TC=SI/FK
      RA=PN*PI*PI*RP*0.001/VA
      TA=XN/(628.4*F*RA)
      T5=XS*TC/XA
      IF(F-60.0)108,108,109
  108 T4=0.035
```

```
      GO TO 110
  109 T4=0.005
  110 IF(WF)111,111,112
  111 WF=DR**2.5*(RPM**1.5)*ALR*0.00000252
  112 WQ=(DU-HC)*1.42*HC*SS*(BX/BK)**2.0*WL
      WT=(SM)*QQ*SS*HS*0.453*(TE/BK)**2.0*WL
      PRINT3,ET
      PRINT3,EB,XA,PC,XF,EW,SI,WC,XU,WI,XS
      PRINT3,XRS,XX,AS,XN
      PUNCH1,VA,EE,EP,PN,F,PX
      PUNCH1,RPM,PI,PF,POL,DI
      PUNCH1,DU,CL,SS,HC,PC,QN
      PUNCH1,WL,BK,ZZ,BO,XD,XR
      PUNCH1,BS,XRS,HX,HY,HZ,HS
      PUNCH1,BR,AC,QQ,W,GE,SC
      PUNCH1,YY,C,TS,BG,TG,FQ
      PUNCH1,TE,BX,TT,EW,AG,RG
      PUNCH1,GC,RP,C1,TPR,Q1R,QR
      PUNCH1,HR,TRS,ALR,DF,CF
      PUNCH1,FH,HR1,ANRC,DRS,BRH,XZ
      PUNCH1,EB,DR,RK,CC,WR,D1
      PUNCH1,WO,TC,PT,VR,RD,RT
      PUNCH1,WT,WQ,SNL,WF,CS,AS
      PUNCH1,ET,FK,FR,XA,XB,T5
      PUNCH1,T4,AN,AL,RC,TA,HD
      PAUSE
      END
```

```
C     PASS 5  NON-SALIENT WOUND-POLE GENERATOR
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
    3 FORMAT(9X F12.5,2X F12.5)
      READ1, VA,EE,EP,PN,F,PX
      READ1,RPM,PI,PF,POL,DI
      READ1, DU,CL,SS,HC,PC,QN
      READ 1,WL,BK,ZZ,BO,XD,XR
      READ 1,BS,XRS,HX,HY,HZ,HS
      READ 1,BR,AC,QQ,W,GE,SC
      READ 1,YY,C,TS,BG,TG,FQ
      READ 1,TE,BX,TT,EW,AG,RG
      READ 1,GC,RP,C1,TPR,Q1R,QR
      READ 1,HR,TRS,ALR,DF,CF
      READ 1,FH,HR1,ANRC,DRS,BRH,XZ
      READ 1,EB,DR,RK,CC,WR,D1
      READ 1,WO,TC,PT,VR,RD,RT
      READ 1,WT,WQ,SNL,WF,CS,AS
      READ 1,ET,FK,FR,XA,XB,T5
      READ 1,T4,AN,AL,RC,TA,HD
      GT=BO/GC
      IF(GT-1.0)304,304,303
  304 AA=2.6
      GO TO 115
  303 IF(GT-3.75)113,114,114
  113 AA=10.0**0.178/((GT-1.0)**0.334)
      GO TO 115
  114 AA=10.0**0.11/((GT-1.0)**0.174)
  115 GF=AA*PI*SC/(C*FH)
  305 IF(SC-1.0)121,121,122
```

```
121 AX=1.0
    AY=1.0
    GO TO 125
122 AX=3.0*YY/(PN*QN)-2.0
    IF(CS-0.667)123,124,124
123 AY=1.5*YY/(PN*QN)-0.25
    GO TO 125
124 AY=.75*YY/(PN*QN)+0.25
125 IF(WR)126,127,126
127 IF(TPR-1.)85,86,85
 85 X=Q1R
    GO TO 87
 86 X=QR
 87 WR=.238*(3.1416*(DR-HR)-X*BR)*ALR*HR*RK
    HRC1=(DR-2.*HR-DRS)/2.
    WR=WR+.89*(DRS+HRC1)*HRC1*ALR*RK
126 IF(W)130,130,131
130 XO=0.0
    GO TO 132
131 AA=(2.0*HZ+HX)*1.6/(PN*QN*CF*CF*DF*DF*BS)
    XO=((PC+XZ)*AX/AY+AA+0.2*EW)*XR
132 D2=BG**2.5*0.000061
    D3=(0.0167*QQ*RPM)**1.65*0.000015147
    IF(TS-0.9) 133,133,134
133 D4=TS**1.285*0.81
    GO TO 137
134 IF(TS-2.0) 135,135,136
135 D4=TS**1.145*0.79
    GO TO 137
```

```
136 D4=TS**0.79*0.92
137 D7=BO/GC
    IF(D7-1.7) 138,138,139
138 D5=D7**2.31*0.3
    GO TO 144
139 IF(D7-3.0) 140,140,141
140 D5=D7**2.0*0.35
    GO TO 144
141 IF(D7-5.0) 142,142,143
142 D5=D7**1.4*0.625
    GO TO 144
143 D5=D7**0.965*1.38
144 D6=10.0**(0.932*C1-1.606)
    BA=3.142*DI*CL
    WN=D1*D2*D3*D4*D5*D6*BA
    UY=XRS*ALR*RK/1000.
    AA=WO/(GC*CC)
    VT=0
    IF(AA)148,147,148
148 IF(AA-.65)145,145,146
145 VT=LOG(10.0*AA)*(-0.242)+0.59
    GO TO 147
146 VT=0.327-(AA*0.266)
147 UZ=(DU-HC)*0.7850/PX
    EZ=(ET+EB)*0.5-1.0
    AA=PN*PI*PI
    PU=AA*RG
    PV=AA*RP
    VV=EP*PI*PF*.003
```

```
FSC=XA*FH*0.01
PRINT3,FK,XO,FR,TG,RC,FQ,WR,BG,VR,TE,TC,BX
PUNCH1,VA,EE,EP,PN,F,PX
PUNCH1,RPM,PH,PF,POL,BO
PUNCH1,GC,DR,PT,T5,T4,WO
PUNCH1,GF,VT,SNL,TS,CC
PUNCH1,BG,FK,TPR,Q1R,QR,HR
PUNCH1,TRS,ALR,TG,TE,BX,FR
PUNCH1,XD,FH,HR1,ANRC,DRS,BRH
PUNCH1,WQ,WT,AN,AL,XA,WF
PUNCH1,AS,HS,  GE,XB,WN
PUNCH1,UY,UZ,EZ,PU,VV,FSC
PUNCH1,PV,HD,XRS,BR,RK,TA
PAUSE
END
```

```
C     PASS 5A NON-SALIENT WOUND-POLE GENERATOR
      DIMENSION GX(4),YA(4),ED(4)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      READ1,VA,EE,EP,PN,F,PX
      READ 1,RPM,PI,PF,POL,BO
      READ 1,GC,DR,PT,T5,T4,WO
      READ 1,GF,VT,SNL,TS,CC
      READ 1,BG,FK,TPR,Q1R,QR,HR
      READ1,TRS,ALR,TG,TE,BX,FR
      READ 1,XD,FH,HR1,ANRC,DRS,BRH
      READ 1,WQ,WT,AN,AL,XA,WF
      READ 1,AS,HS,  GE,XB,WN
      READ 1,UY,UZ,EZ,PU,VV,FSC
      READ 1,PV,HD,XRS,BR,RK,TA
      BP=(3.1416*(DR-HR)/PX)
      Y=Q1R-QR+PX
      IF(TPR-1.)890,891,890
  891 BP=BP*(Y/QR)-BR
      GO TO 893
  890 BP=BP*(Y/Q1R)-(ANRC+1.)*BR
  893 ALRS=ALR*RK
      AP1=BP*ALRS
      AP2=(DR-2.*HR-DRS-2.*BRH)*ALRS
      PGP=((Q1R-QR+PX)/Q1R)*TG/PX
      ALRCL=(3.1416*(DRS+(DR-2.*HR-DRS-2.*BRH)))/(4.*PX)
      YA(1)=100.
      YA(2)=66.66667
      YA(3)=50.
      IF(POL)310,320,310
```

```
320 ED(4)=0
    GX(4)=0
    JA=3
    GO TO 330
310 YA(4)=100./POL
    JA=4
330 DO 99 K=1,JA
    AA=ATAN((XB/YA(K)+SIN(AN))/AL)
    BB=AA-AN
    ED(K)=XA*SIN(AA)/YA(K)+COS(BB)
 99 GX(K)=PGP
213 IF(POL)820,821,820
820 AJ=4
    GO TO822
821 AJ=3
822 PUNCH1,GX(1),GX(2),GX(3),GX(4),AJ
    PUNCH1,ED(1),ED(2),ED(3),ED(4)
    PUNCH1,VA,EE,EP,PN,F,PX
    PUNCH1,RPM,PI,PF,POL
    PUNCH1,BO,GC,DR,PT
    PUNCH1,T5,T4,WO,GF,VT,SNL
    PUNCH1,TS,CC,BG,FK,TE,BX
    PUNCH1,FR,XD,FH,ALRS,AP1,AP2
    PUNCH1,PGP,ALRCL,XRS,HR,WQ,WT
    PUNCH1,AN,XA,WF,AS,HS,GE
    PUNCH1,XB,WN,UY,UZ,EZ,PU
    PUNCH1,VV,FSC,PV,HD,TA
    PAUSE
    END
```

```
C     PASS 6  NON-SALIENT WOUND-POLE GENERATOR
      DIMENSION GX(4),GZ(4),GL(4),FD(4),FDD(4),FB(4),ED(4)
      DIMENSION FI(5),EF(4),CD(4),AI(60)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
  888 FORMAT(F10.0,F10.0,F10.0,F10.0,F10.0,F10.0)
    3 FORMAT(9X F12.5,2X F12.5)
    4 FORMAT (F11.3,8X F11.3,F11.3,F11.3,F11.3)
      K=1
  823 READ888,AI(K),AI(K+1),AI(K+2),AI(K+3),AI(K+4),AI(K+5)
      K=K+6
      IF(K-59)823,199,199
  199 READ1,GX(1),GX(2),GX(3),GX(4),AJ
      READ1,ED(1),ED(2),ED(3),ED(4)
      READ1,VA,EE,EP,PN,F,PX
      READ1,RPM,PI,PF,POL
      READ 1,BO,GC,DR,PT
      READ 1,T5,T4,WO,GF,VT,SNL
      READ 1,TS,CC,BG,FK,TE,BX
      READ 1,FR,XD,FH,ALRS,AP1,AP2
      READ 1,PGP,ALRCL,XRS,HR,WQ,WT
      READ 1,AN,XA,WF,AS,HS,GE
      READ 1,XB,WN,UY,UZ,EZ,PU
      READ 1,VV,FSC,PV,HD,TA
      LA=1
      DO 950 K=1,4
      GZ(K)=0
      GL(K)=0
      FD(K)=0
      FDD(K)=0
```

```
      FB(K)=0
      FI(K)=0
      CD(K)=0
  950 EF(K)=0
      FI(5)=0
      LOAD=1.
      NA=1
      K=1
      X=BX
      GO TO 802
  803 AT=UZ*Y
      NA=1
      K=2
      X=TE
      GO TO 802
  804 FT=HS*Y
      SA=FT+AT
      UX=(SA+FH)*UY
      TF=PGP+UX
      PD=TF/AP1
      NA=31
      K=3
      X=PD
      GO TO 802
  805 FA=HR*Y
      PDD=TF/AP2
      X=PDD
      NA=31
      K=4
```

```
      GO TO 802
  806 FA1=ALRCL*Y
      FN=SA+FA+FH+FA1
      SCR=FN/FSC
      PRINT3,TA,FT,T5,AT,T4,FH,FSC
  221 FORMAT(9X F12.5/)
      PRINT221,SCR
      JA=AJ
      LA=2
      DO 840 M=1,JA
      GZ(M)=((1.0+PF)*FT+AT+(FH*ED(M)))*UX/(FH+SA)
      GL(M)=GX(M)+GZ(M)
      FD(M)=GL(M)/AP1
      K=5
      NA=31
      X=FD(M)
      GO TO 802
  807 FX=HR*Y
      K=6
      NA=31
      FDD(M)=GL(M)/AP2
      X=FDD(M)
      GO TO 802
  808 FX1=ALRCL*Y
      FB(M)=(1.0+PF)*FT+AT+FX+ED(M)*FH+FX1
      FI(M+1)=FB(M)/PT
      EF(M)=FI(M+1)*FR
      CD(M)=FI(M+1)/AS
  840 CONTINUE
```

```
      FI(1)=FN/PT
      CDNL=FI(1)/AS
      EFNL=FI(1)*FK
      PRINT4,UX,GZ(1),GZ(2),GZ(3),GZ(4)
      PRINT4,TF,GL(1),GL(2),GL(3),GL(4)
      PRINT4,PD,FD(1),FD(2),FD(3),FD(4)
      PRINT4,PDD,FDD(1),FDD(2),FDD(3),FDD(4)
      PRINT4,FN,FB(1),FB(2),FB(3),FB(4)
      PRINT4,FI(1),FI(2),FI(3),FI(4),FI(5)
      PRINT4,CDNL,CD(1),CD(2),CD(3),CD(4)
      PRINT4,EFNL,EF(1),EF(2),EF(3),EF(4)
      PUNCH1,FI(1),FI(2),FI(3),FI(4),FI(5)
      PUNCH1,EP,PN,F,PX,WQ,WT
      PUNCH1,BO,GC,POL,HS,PGP
      PUNCH1,FK,FR,WO,GF,VT,SNL
      PUNCH1,TS,CC,BG,AP1,AP2,HR
      PUNCH1,ALRCL,TE,BX,FH,XA
      PUNCH1,WF,WN,UY,UZ,EZ,PU
      PUNCH1,VV,PV,HD
      PAUSE
  802 IF(AI(NA)-X)830,831,831
  831 NA=NA+3
  835 IF(AI(NA)-X)833,834,834
  833 NA=NA+2
      GO TO 835
  834 AA=AI(NA)
      BB1=AI(NA-2)
      DC=AI(NA+1)
      D=AI(NA-1)
```

```
    XX=(AA-BB1)/(.4343*(LOG(DC)-LOG(D+.0001)))
    Y=AA-XX*.4343*LOG(DC)
    Y=EXP(2.306*(X-Y)/XX)
    GO TO (838,839),LOAD
838 GO TO (803,804,805,806,807,808),K
839 GO TO (236,237,238),K
830 GO TO (836,840),LA
836 PRINT850
850 FORMAT(17HMACHINE SATURATED)
    PAUSE
    END
```

```
C       PASS 7  NON-SALIENT WOUND-POLE GENERATOR
        DIMENSIONPR(5),FI(5),PS(5),G(5),PP(5),EX(5),ST(5),VA(5)
        DIMENSION P(5),E(5),PM(5),SP(5)
      1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      4 FORMAT (F11.3,8X F11.3,F11.3,F11.3,F11.3)
        READ 1,FI(1),FI(2),FI(3),FI(4),FI(5)
        READ 1,EP,PN,F,PX,WQ,WT
        READ 1,BO,GC,POL,HS,PGP
        READ 1,FK,FR,WO,GF,VT,SNL
        READ 1,TS,CC,BG,AP1,AP2,HR
        READ 1,ALRCL,TE,BX,FH,XA
        READ 1,WF,WN,UY,UZ,EZ,PU
        READ 1,VV,PV,HD
    178 G(1)=0
        G(2)=1
        G(3)=1.5
        G(4)=2.
        G(5)=POL
        PW=PU
        FW=FK
        DO 183 M=1,5
        UA=G(M)
        PR(M)=FI(M)*FI(M)*FW
        IF(FI(M))198,197,198
    198 PS(M)=PW*UA*UA
        X=WF+WQ
        GM  =(GF*UA)**2.0+1.0
        ST(M)=(2.0*(0.0027*XA*UA)**1.8+1.0)*WT
        VA(M)=VV*UA
```

```
181 PP(M)=GM *WN
    EX(M)=EZ*PS(M)
    SP(M)=PP(M)        +PR(M)+PS(M)+EX(M)+ST(M)+X
    P(M)=(SP(M)/1000.)+VA(M)
    IF(GM)185,184,185
184 PM(M)=0
    E(M)=0
    GO TO 186
185 PM(M)=(SP(M)/P(M))*.1
    E(M)=100.0-PM(M)
186 FW=FR
183 PW=PV
    PRINT4, PR(1),PR(2),PR(3),PR(4),PR(5)
    PRINT4, WF,WF,WF,WF,WF
    PRINT4, ST(1),ST(2),ST(3),ST(4),ST(5)
    PRINT4, WQ,WQ,WQ,WQ,WQ
    PRINT4, PP(1),PP(2),PP(3),PP(4),PP(5)
    PRINT4, PS(1),PS(2),PS(3),PS(4),PS(5)
    PRINT4, EX(1),EX(2),EX(3),EX(4),EX(5)
    PRINT4, SP(1),SP(2),SP(3),SP(4),SP(5)
    PRINT4, VA(1),VA(2),VA(3),VA(4),VA(5)
    PRINT4, P(1),P(2),P(3),P(4),P(5)
    PRINT4,PM(1),PM(2),PM(3),PM(4),PM(5)
    PRINT4, E(1),E(2),E(3),E(4),E(5)
    IF(SNL)191,191,190
190 PUNCH1,FH,TE,BX,UZ,UY,AP1
    PUNCH1,AP2,ALRCL,HR,PGP,HS,EP
191 PAUSE
197 PS(M)=0
```

```
GM=0
ST(M)=0
X=0
VA(M)=0
GO TO 181
END
```

```
C     PASS 8  NON-SALIENT WOUND-POLE GENERATOR
      DIMENSION AI(60)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
  888 FORMAT(F10.0,F10.0,F10.0,F10.0,F10.0,F10.0)
      K=1
  823 READ888,AI(K),AI(K+1),AI(K+2),AI(K+3),AI(K+4),AI(K+5)
      K=K+6
      IF(K-59)823,234,234
  234 READ 1,FH,TE,BX,UZ,UY,AP1
      READ 1,AP2,ALRCL,HR,PGP,HS,EP
      LOAD=2.
      LA=1
      UB=0.7
  235 UB=UB+0.1
      V=1.732*EP*UB
      FG=FH*UB
      TD=TE*UB
      BC=BX*UB
      K=1
      NA=1
      X=BC
      GO TO 802
  236 AT=UZ*Y
      K=2
      NA=1
      X=TD
      GO TO 802
  237 FT=Y*HS
      SA=FT+AT
```

```
      UX=(FG+SA)*UY
      TF=PGP+UX
      PD=TF/AP1
      NA=31
      K=3
      X=PD
      GO TO 802
  238 FA=HR*Y
      PDD=TF/AP2
      X=PDD
      NA=31
      K=4
      GO TO 802
  239 FA1=ALRCL*Y
      FN=SA+FA+FH+FA1
  246 FORMAT(F12.5,F12.5,F12.5,F12.5,F12.5,F12.5//)
  247 FORMAT(F12.5,F12.5,F12.5,F12.5,F12.5,F12.5)
      PRINT247,V,FG,TD,FT,BC,AT
      PRINT246,SA,UX,TF,PD,PDD,FN
      IF(UB-1.6) 235,245,245
  245 PAUSE
  802 IF(AI(NA)-X)830,831,831
  831 NA=NA+3
  835 IF(AI(NA)-X)833,834,834
  833 NA=NA+2
      GO TO 835
  834 AA=AI(NA)
      BB1=AI(NA-2)
      DC=AI(NA+1)
```

```
      D=AI(NA-1)
      XX=(AA-BB1)/(.4343*(LOG(DC)-LOG(D+.0001)))
      Y=AA-XX*.4343*LOG(DC)
      Y=EXP(2.306*(X-Y)/XX)
      GO TO (838,839),LOAD
  838 GO TO (803,804,805,806),K
  839 GO TO (236,237,238,239),K
  830 GO TO (836,840),LA
  836 PRINT850
  850 FORMAT(17HMACHINE SATURATED)
      PAUSE
      END
```

ROTATING-COIL, LUNDELL-TYPE A-C GENERATOR COMPUTER PROGRAM AND TEST DATA

ROTATING COIL LUNDELL

5-4-65

COMPUTER DESIGN -- -- -- -- -- -- -- (INPUT)

MODEL ______ EWO ______ DESIGN NO(1) ______

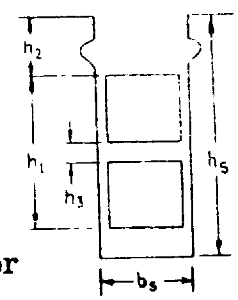
No.	Symbol	Item	Value	Value	Item	No.	Symbol	Group
(2)	KVA	GENERATOR KVA	1.04	0	FUND/MAX OF FLD FLUX	(71)	C_1	CONSTANTS
(3)	E	LINE VOLTS	15	0	WINDING CONSTANT	(72)	C_w	
(4)	E_{ph}	PHASE VOLTS	8.7	0	POLE CONSTANT	(73)	C_p	
(5)	m	PHASES	3	0	END EXTENSION ONE TURN	(48)	LE	
(5a)	f	FREQUENCY	200	0	DEMAGNETIZATION FACTOR	(74)	C_m	
(6)	p	POLES	12	0	CROSS MAGNETIZING FACTOR	(75)	C_q	
(7)	RPM	RPM	2000	.64	POLE EMBRACE	(77)	α	
(8)	I_{ph}	PHASE CURRENT	50	.45	WIDTH OF POLE (NARROW END)	(76)	b_{p1}	POLE AND ROTOR
(9)	PF	POWER FACTOR	.95	1.15	WIDTH OF POLE (WIDE END)	(76)	b_{p2}	
(9a)	K_c	ADJ. FACTOR	1.05	.20	POLE THICKNESS (NARROW END)	(76)	t_{p1}	
(10)		OPTIONAL LOAD POINT	.8	.40	POLE THICKNESS (WIDE END)	(76)	t_{p2}	
(11)	d	STATOR I.D.	4.8	1.15	POLE LENGTH	(76)	ℓ_p	
(12)	D	STATOR O.D.	6.63	4.764	ROTOR DIAMETER	(11a)	d_r	
(13)	ℓ	GROSS CORE LENGTH	1.0	0	WEIGHT OF ROTOR IRON	(157)	(–)	
(14)	n_v	NO. OF DUCTS	0	7	POLE FACE LOSS FACTOR	(187)	(K_1)	
(15)	b_v	WIDTH OF DUCT	0	.5	FLUX PLATE THICKNESS	(78)	(t_{fp})	
(16)	K_i	STACKING FACTOR (STATOR)	.92	3.2	FLUX PLATE DIAMETER	(78)	(d_{fp})	
(19)	k	WATTS/LB.	.5	2.0	SHAFT O.D.(FLUX CARRYING PORT.)	(78)	(d_s)	SHAFT
(20)	B	DENSITY	77.2	1.25	SHAFT LENGTH(FLUX CARRYING PORT)	(78)	(ℓ_{SH})	
(21)		TYPE OF SLOT	3	0	PERM OF LEAKAGE PATH 1	(80)	P_1	PERMEANCE
(22)	b_o	SLOT OPENING	.12	0	PERM OF LEAKAGE PATH 2	(81)	P_2	
(22)	b_1	SLOT WIDTH TOP	.16	0	PERM OF LEAKAGE PATH 3	(82)	P_3	
(22)	b_2		.16	0	PERM OF LEAKAGE PATH 4	(83)	P_4	
(22)	b_3		.25	0	PERM OF LEAKAGE PATH 5	(84)	P_5	
(22)	b_s	SLOT WIDTH	.205	0	PERM OF LEAKAGE PATH 7	(86)	P_7	
(22)	h_o		.02	3.9	OUTSIDE DIAMETER OF FLD COIL	(78)	d_{oc}	FIELD
(22)	h_1		.5	1.25	LENGTH OF FIELD COIL	(76)	ℓ_{oc}	
(22)	h_2		0	650	NO. OF FIELD TURNS/COIL	(146)	N_f	
(22)	h_3		0	8.6	MEAN LENGTH OF FLD. TURN	(147)	ℓ_f	
(22)	h_s	SLOT DEPTH	.55	.0360	FLD. COND. DIA. OR WIDTH	(148)		
(22)	h_t		.03	0	FLD. COND. THICKNESS	(149)		
(22)	h_w		.001	100	FLD. TEMP IN °C	(150)	X_f °C	
(23)	Q	NO. OF SLOTS	36	.694	RESISTIVITY OF FIELD COND @ 20°	(151)	ρ_f	
(28)		TYPE OF WDG.	1	1	NO LOAD SAT.	(87)		
(29)		TYPE OF COIL	0	0	FRICTION & WINDAGE	(183)	(F&W)	
(30)	n_s	CONDUCTORS/SLOT	14	38.3	SPECIAL PERMEANCE	64a	λ_z	
(31)	y	SLOTS SPANNED	3	118	STATOR LAM MATERIAL	(18)		MATERIAL
(32)	c	PARALLEL CIRCUITS	2	12	POLE MATERIAL	(18)		
(33)		STRAND DIA. OR WIDTH	.0508	12	SHAFT MATERIAL	(18)		
(34)	N_{st}	STRANDS/CONDUCTOR IN DEPTH	1					
(34a)	N'_{st}	STRANDS/CONDUCTOR	1.0					
39)		STATOR STRAND T'KNS.	0					
(35)	d_b	DIA. OF PIN	.25					
(36)	ℓ_{e2}	COIL EXT. STR. PORT	.20					
37)	h_{st}	UNINS. STRD. HT.	.0508					
(38)	h''_{st}	DIST. BTWN. C_L OF STD.	.0508					
(42a)		PHASE BELT ANGLE	60					
40)	τ_{sk}	STATOR SLOT SKEW	0					
(50)	X °C	STATOR TEMP °C	100					
(51)	ρ_s	RES'TVY STA. COND. @ 20°C	.694					
59)	g	MAIN GAP	.018					

STATOR SLOT	POLE
DAMPER SLOT	REMARKS

DESIGNER ______ DATE ______

JA-1

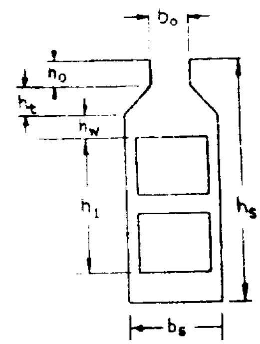
(a) Open Slots



TYPE 1

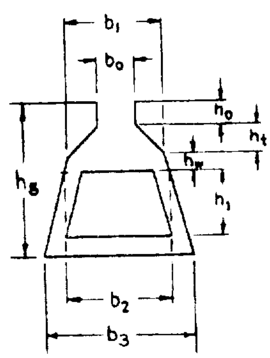
(Type 5 is an open slot with 1 conductor per slot)

(b) Constant Slot Width



TYPE 2

(c) Constant Tooth Width

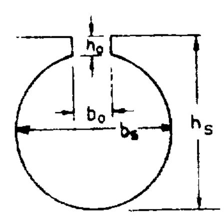


TYPE 3

b_s for type 3 is

$$b_s = \left(\frac{b_1 + b_3}{2}\right)$$

(d) Round Slots

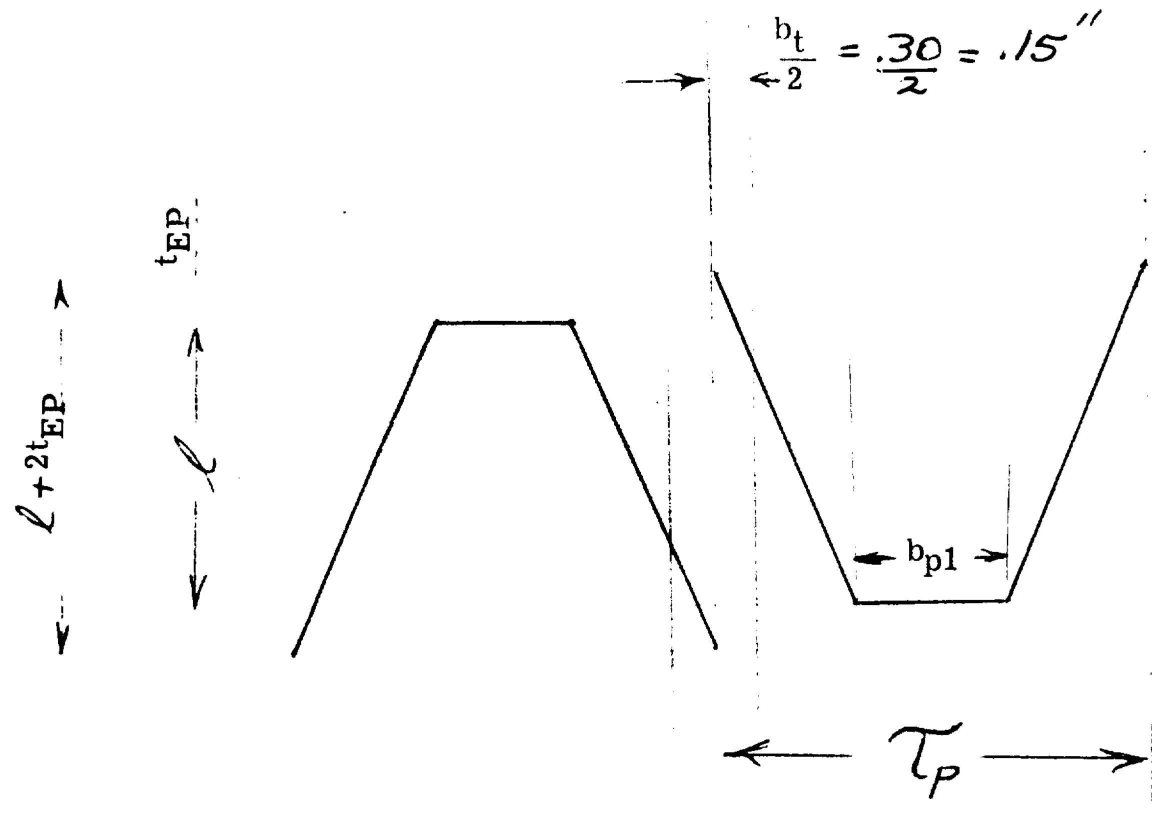


TYPE 4

λ_z <u>SPECIAL LEAKAGE PERMEANCE</u> - For machines having a section of the pole that is approximately a full pole-pitch wide, an additional leakage permeance must be added to the slot and end-turn leakage permeances. This permeance is that of the leakage path from one pole into a tooth top and from tooth top back into the adjacent pole. The leakage is similar to Zig Zag leakage and by increasing the stator leakage reactance, can reduce the output of the generator significantly.

This same leakage can be used to purposely limit the output of the generator and make it current limited. The presence of this additional leakage can be good or bad depending upon what is wanted from the generator. The important thing is for the designer to be aware that it is there.

In many cases, the designer should estimate the specific permeances λ_z since the pole base will be more or less than a full pole pitch wide and the following formula will not suffice.



$$\rho_z = \frac{\text{area of pole over tooth when tooth is on centerline between poles}}{2\,\ell\, g}$$

$$= \frac{b_t\,(\tau_p - b_{p1})\,(\ell + 2\,t_{EP})\,\dfrac{(\tau_p - b_{p1})}{\tau_p}}{2\,\ell\,g}$$

$$\rho_z = \frac{.30\,(1.245 - .45)(1.0 + .375)\dfrac{(1.245 - .45)}{1.245}}{2(1.0).018}$$

$$\rho_z = 5.8$$

$$\lambda_z = \frac{c_x\,(20)}{mq}\,\rho_z = \frac{22}{3}(5.8) = 38.3$$

ROTATING COIL LUNDELL

SUMMARY OF DESIGN CALCULATIONS – – – – – – – – (OUTPUT)

5-11-65

MODEL NO. ______________ EWO ______________ DESIGN NO. ______________

Group	No.	Symbol	Item	Value	Value	Item	No.	Symbol	Group
STATOR	(17)	(ℓ_s)	SOLID CORE LENGTH	.92000	1.25358	CARTER COEFFICIENT	(67)	(K_s)	
STATOR	(24)	(h_c)	DEPTH BELOW SLOT	.36500	.02256	EFFECTIVE AIR GAP	(69)	(g_e)	
STATOR	(26)	(τ_s)	SLOT PITCH	.41893	1.06935	FUND/MAX OF FLD FLUX	(71)	(C_1)	CONSTANTS
STATOR	(27)	($\tau_s 1/3$)	SLOT PITCH 1/3 DIST. UP	.45095	.43450	WINDING CONST.	(72)	(C_w)	CONSTANTS
STATOR	(42)	(K_{sk})	SKEW FACTOR	1.00000	.65952	POLE CONST.	(73)	(C_p)	CONSTANTS
STATOR	(43)	(K_d)	DIST. FACTOR	1.00000	2.88137	END. EXT. ONE TURN	(48)	(L_E)	CONSTANTS
STATOR	(44)	(K_p)	PITCH FACTOR	.99999	.86321	DEMAGNETIZING FACTOR	(74)	(C_M)	CONSTANTS
STATOR	(45)	(n_e)	EFF. CONDUCTORS	251.99999	.40680	CROSSMAGNETIZING FACTOR	(75)	(C_q)	CONSTANTS
STATOR	(46)	(a_c)	COND. AREA	.00202	835.45000	AMP COND/IN	(128)	(A)	REACTANCE
STATOR	(47)	(S_s)	CURRENT DENSITY (STA.)	12340.00000	2.02671	REACTANCE FACTOR	(129)	(X)	REACTANCE
STATOR	(49)	(ℓ_t)	1/2 MEAN TURN LENGTH	3.88130	128.98268	LEAKAGE REACTANCE	(130)	(X_ℓ)	REACTANCE
STATOR	(53)	(R_{ph})	COLD STA. RES. @ 20° C	.05584	211.57952	REACTANCES OF ARMATURE REACTION	(131)	(X_{ad})	REACTANCE
STATOR	(54)	(R_{ph})	HOT STA. RES. @ X° C	.07360	93.24778		(132)	(X_{aq})	REACTANCE
STATOR	(55)	(EF_{top})	EDDY FACTOR TOP	1.00460	340.56220	SYN REACT DIRECT AXIS	(133)	(X_d)	REACTANCE
STATOR	(56)	(EF_{bot})	EDDY FACTOR BOT	1.00060	222.23046	SYN REACT QUAD AXIS	(134)	(X_q)	REACTANCE
STATOR	(62)	(λ_i)	STATOR COND. PERM.	16.12100	88.85927	FIELD LEAKAGE REACT	(160)	(X'_f)	REACTANCE
STATOR	(64)	(λ_e)	END PERM.	9.22020	9.61539	FIELD SELF INDUCTANCE	(161)	(L_f)	REACTANCE
STATOR	(65)	(–)	WT. OF STA COPPER	1.27200	217.84195	UNSAT. TRANS. REACT	(166)	(X'_{du})	REACTANCE
STATOR	(66)	(–)	WT. OF STA. IRON	3.23610	191.70092	SAT. TRANS. REACT	(167)	(X'_d)	REACTANCE
	(41)	(τ_p)	POLE PITCH	1.25660	206.96569	NEG SEQUENCE REACT	(170)	(X_2)	REACTANCE
	(157)	(–)	WT. OF ROTOR IRON	.00000	55.20278	ZERO SEQUENCE REACT	(172)	(X_o)	REACTANCE
	(145)	(V_r)	PERIPHERAL SPEED	2494.43030	2.52160	OPEN CIR. TIME CONST.	(176)	(T_{do})	TIME CONST.
FIELD	(153)	(a_{cf})	FLD COND. AREA	.00101	.00408	ARM TIME CONST.	(177)	(T_a)	TIME CONST.
FIELD	(154)	(R_f)	COLD FLD RES. @ 20° C	3.81320	1.41940	TRANS. TOME CONST.	(178)	(T'_d)	TIME CONST.
FIELD	(155)	(R_f)	HOT FLD RES. @ X° C	5.02560	.00500	SUB TRAN TIME CONST.	(179)	(T''_d)	TIME CONST.
FIELD	(156)	(–)	WT. OF FLD COPPER	1.82550	410.99771	TOTAL FLUX	(88)	(ϕ_T)	MAGNETIZATION
PERMEANCE	(80)	(P_1)	PERM OF LEAKAGE PATH 1	.20496	22.58843	FLUX PER POLE	(92)	(ϕ_p)	MAGNETIZATION
PERMEANCE	(81)	(P_2)	PERM OF LEAKAGE PATH 2	2.41031	27.25506	GAP DENSITY (MAIN)	(95)	(B_g)	MAGNETIZATION
PERMEANCE	(82)	(P_3)	PERM OF LEAKAGE PATH 3	.58503	46.85072	TOOTH DENSITY	(91)	(B_t)	MAGNETIZATION
PERMEANCE	(83)	(P_4)	PERM OF LEAKAGE PATH 4	1.18214	33.63376	CORE DENSITY	(94)	(B_c)	MAGNETIZATION
PERMEANCE	(84)	(P_5)	PERM OF LEAKAGE PATH 5	19.95300	1.35937	TOOTH AMPERE TURNS	(97)	(F_t)	MAGNETIZATION
PERMEANCE	(85)	(P_7)	PERM OF LEAKAGE PATH 7	13.10000	.66466	CORE AMPERE TURNS	(98)	(F_c)	MAGNETIZATION
	(180)	(F_{SC})	SHORT CIR NI	1313.10000	192.78000	GAP AMPERE TURNS (MAIN)	(96)	(F_g)	MAGNETIZATION
	(181)	(S_{CR})	SHORT AIR RATIO	.31462					

PERCENT LOAD	0		100	150	200	OPTIONAL
(ϕ_ℓ) (100a) LEAKAGE FLUX	20.454	($\phi_{\ell\ell}$) (197a)	77.563	.000	.000	.000
(ϕPT) (102a) TOTAL FLUX/POLE	56.515	(ϕP_{fl}) (213a)	124.950	.000	.000	.000
(B_p) (103a) POLE DENSITY	25.997	(B_{pl}) (213b)	57.477	.000	.000	.000
(B_{sh}) (113) SHAFT DENSITY	52.209	(B_{shl}) (232)	114.800	.000	.000	.000
(F_{nl}) (127) TOTAL NI	413.130	(F_{fl}) (236)	2639.400	.000	.000	.000
(I_{fnl}) (127a) FIELD AMPERES	.635	(I_{ffl}) (237)	4.060	.000	.000	.000
(S_f) (127c) CUR. DEN. FLD.	624.780	( ) (239)	3991.600	.000	.000	.000
(E_{fnl}) (127b) FIELD VOLTS	2.423	(E_{ffl}) (238)	20.407	.000	.000	.000
(W_c) (185) STA CORE LOSS	2.835	(W_c) (185)	2.835	2.835	2.835	2.835
(W_{tnl}) (184) STA TOOTH LOSS	4.024	(W_{tfl}) (242)	10.830	.000	.000	.000
(I^2R_s) (194) STATOR CU LOSS	.000	(I^2R_s) (245)	552.000	.000	.000	.000
(–) (195) EDDY LOSS	.000	(–) (246)	1.435	.000	.000	.000
(W_{pnl}) (186) POLE FACE LOSS	25.607	(W_{pfl}) (243)	102.201	.000	.000	.000
(I^2R_f) (182) FIELD COIL LOSS	1.540	(I^2R_{fl}) (241)	82.864	.000	.000	.000
(F&W) (183) F&W LOSS	12.840	(F&W) (183)	12.840	12.840	12.840	12.840
(–) (196) TOTAL LOSSES	46.847	(–) (247)	765.007	.000	.000	.000
(–) (–) PERCENT EFF.	.000	(–) (251)	61.839	.000	.000	.000

REV. A

5-11-65

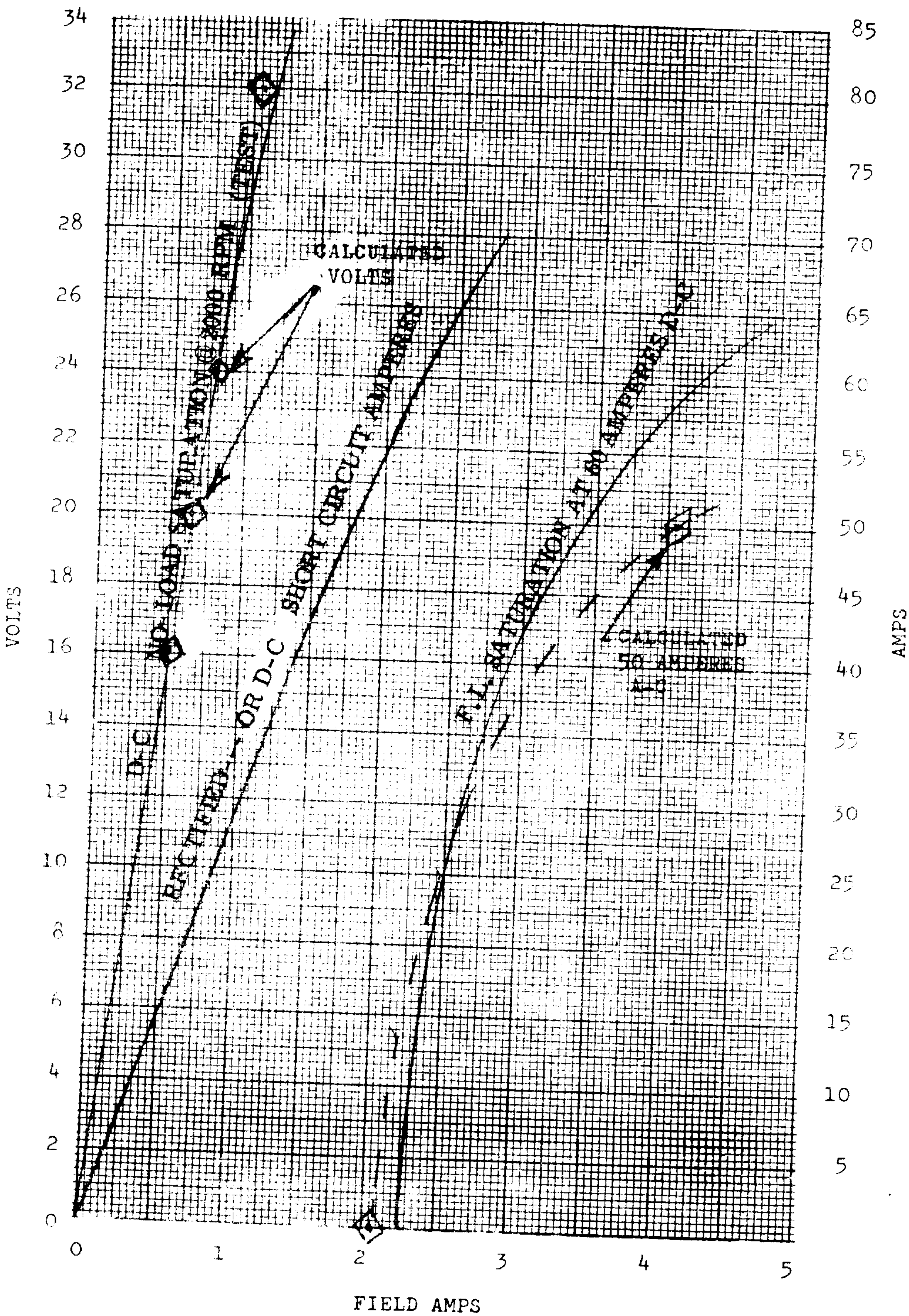
ROTATING COIL LUNDELL

NO LOAD SATURATION OUTPUT SHEET

ITEMS / % VOLTS	(3) (E) VOLTS	(91) B_t STA. TOOTH DENSITY	(97) F_t STATOR TOOTH N.I.	(94) B_c STA. CORE DENSITY	(98) F_c STA. CORE N.I.	(96) F_g GAP N.I.
	(100a) ϕ_ℓ LEAKAGE FLUX	(102a) ϕ_{pt} TOTAL FLUX/POLE	(103a) B_p POLE DENSITY	(104a) F_p POLE N.I.	(113) B_{sh} SHAFT DENSITY	(127) F_{nl} TOTAL N.I.
80%	12.00000	37.48000	1.00402	26.90640	.53995	154.22400
	16.35496	20.79622	45.20919	6.43277	40.39412	330.83579
90%	13.50000	42.16500	1.16037	30.26970	.59906	173.50200
	18.40214	23.39622	50.86135	7.09223	45.44377	371.72786
100%	15.00000	46.85000	1.35937	33.63300	.66465	192.78000
	20.45414	25.99702	56.51526	7.81953	50.49544	412.90751
110%	16.50000	51.53500	1.62574	36.99630	.73742	212.05800
	22.51360	28.59906	62.17188	8.81807	55.55094	454.83762
120%	18.00000	56.22000	1.94432	40.35960	.81816	231.33600
	24.57898	31.20209	67.83064	10.31000	60.61062	497.99724
130%	19.50000	60.90500	2.32532	43.72290	.90774	250.61400
	26.65138	33.80629	73.49195	12.05521	65.67389	542.36293
140%	21.00000	65.59000	2.78098	47.08620	1.02263	269.89200
	28.73297	36.41202	79.15658	14.09712	70.74173	587.73036
150%	22.50000	70.27500	3.32593	50.44950	1.16281	289.17000
	30.82528	39.01954	84.82510	19.11187	75.82587	639.51731
160%	24.00000	74.96000	4.31285	53.81280	1.32221	308.44800
	32.96509	41.63498	90.51083	26.61487	80.93742	697.96028

REV. A

TEST CURVE AND CALCULATED POINTS FOR A
60 AMPERE D-C ROTATING-COIL LUNDELL GENERATOR



INPUT PARAMETERS ROTATING COIL LUNDELL

1.04	15.	8.7	3.	200.	12.	2000.	50.	.95	1.05
.8	4.8	6.63	1.	0.	0.	.92	5.	77.2	3.
.12	.16	.16	.25	.205	.02	.5	0.	0.	.55
.03	.001	36.	1.	0.	14.	3.	2.	.0508	1.
1.	0.	.1	.2	.0508	.0508	60.	0.	100.	.694
.018	0.	0.	0.	0.	0.	0.	.64	.45	1.15
.20	.40	1.15	4.764	0.	7.	.5	3.2	2.	1.25
0.	0.	0.	0.	0.	13.1	3.9	1.25	650.	8.6
.036	0.	100.	.694	1.	0.	38.3			

SATURATION CURVE (STATOR MATERIAL)

132.	0.	0.	18.	1.	45.
2.3	71.	6.2	80.	10.5	87.
18.5	99.	82.	110.	220.	132.
1000.					

SATURATION CURVE (POLE MATERIAL)

140.	0.	1.4	20.	3.3	40.
5.1	60.	7.2	80.	12.5	100.
40.	120.	300.	140.	1000.	

SATURATION CURVE (SHAFT MATERIAL)

140.	0.	1.6	10.	2.3	20.
3.3	30.	4.2	60.	7.3	70.
9.2	80.	12.5	85.	15.	90.
20.	100.	40.	108.	100.	112.
160.	126.	500.	140.	1000.	

ALL INPUT PARAMETERS ARE IN FORMAT F7.0 (FIG. 1)

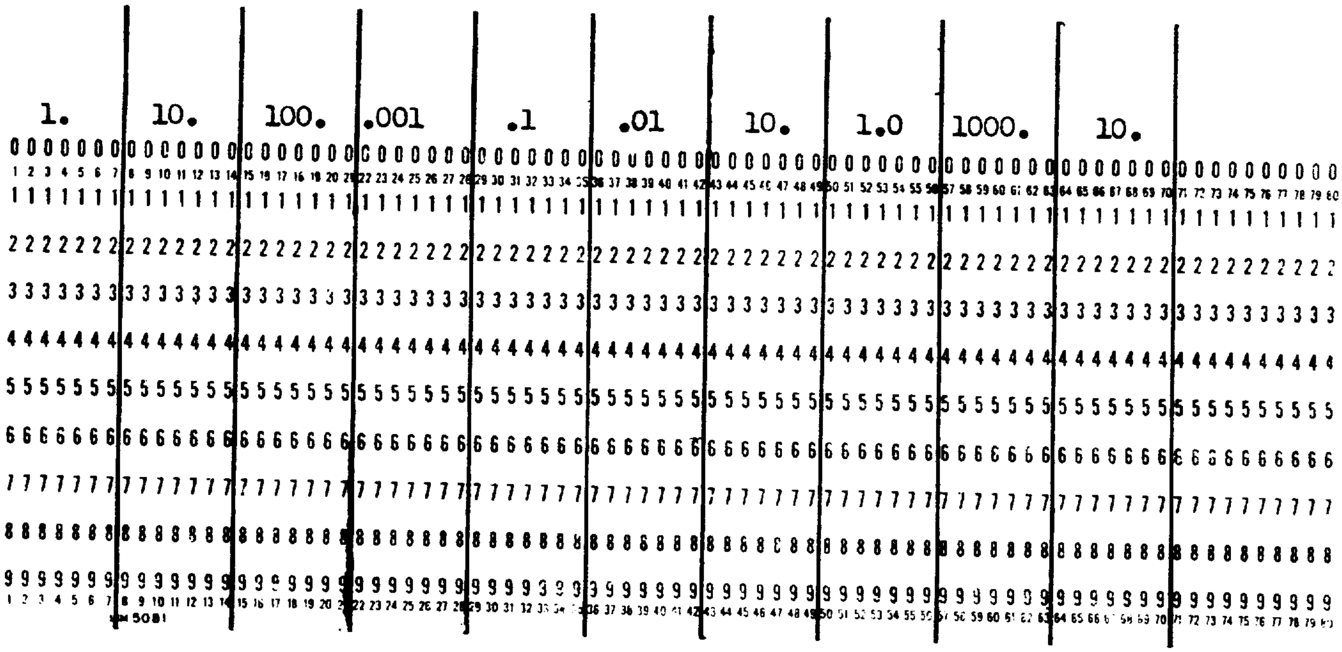


FIG. 1

ALL SATURATION CURVE VALUES ARE IN FORMAT F10.0 (FIG. 2)
(ALL SATURATION CURVES MUST HAVE 5 CARDS)

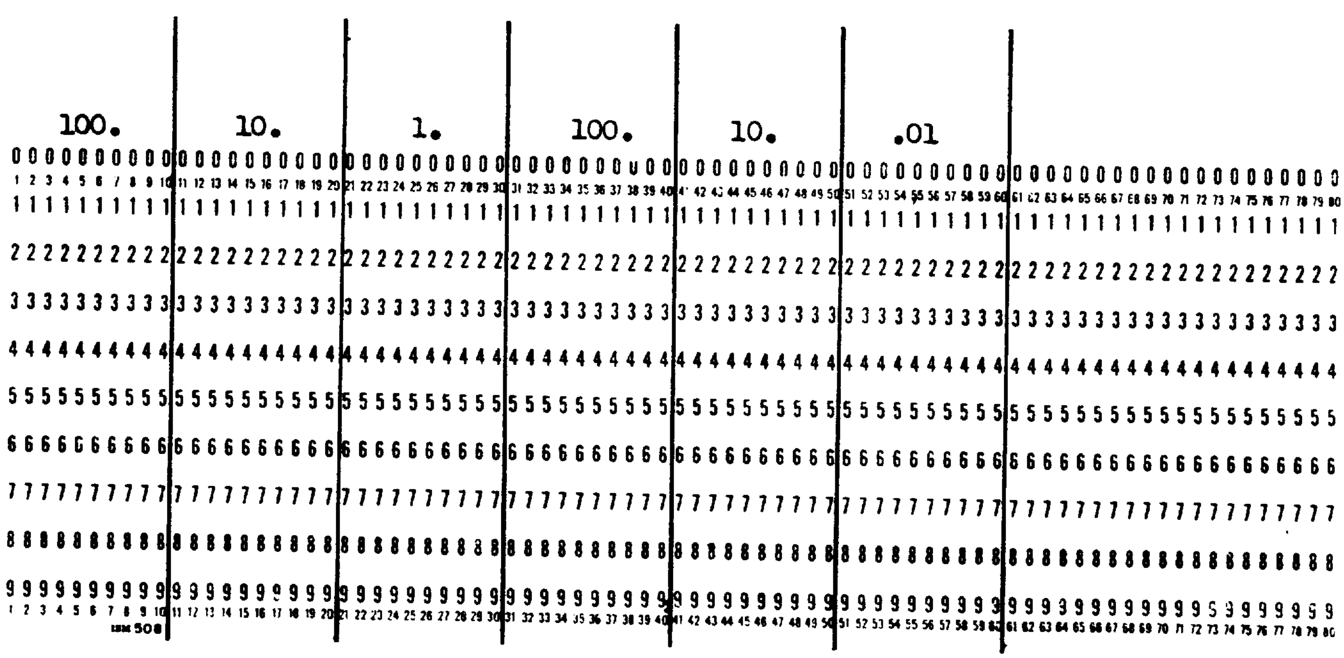


FIG. 2

COMPUTER PROCEDURE FOR ROTATING COIL LUNDELL DESIGN CALCULATIONS

1. Clear core (no switch control).
2. Insert output Form #1 into typewriter, set margin for correct output, and set typewriter for single space.
3. Load pass #1 followed by input parameters (output punch cards).
4. Reset and load pass #2 followed by output from pass #1 (output punched cards).
5. Reset and load pass #3 followed by output from pass #2 (output punched cards).
6. Reset and load pass #4 followed by output from pass #3 (output printed plus punched cards).
7. Reset and load pass #5 followed by output from pass #4 (output punched cards).
8. Reset and load pass #6 followed by saturation curve values* and output from pass #5 (output printed plus punched cards).
9. Reset and load pass #7 followed by output from pass #6 (output printed plus punched cards if no load saturation curve required).

---

* Saturation curve values are loaded in order shown on Input Form #1.

10. If there is punch card output from pass #7, a no load saturation curve is required. Insert output Form #2 into typewriter and reset margin. Load pass #8 followed by saturation curve values* and output from pass #7 (output printed).

NOTE: Pages JA-13 and JA-14 are nonexistent.

Calculation Number	Electrical Symbol	Fortran Symbol
	A, a	
(128)	A	A
(46)	a_c	AC
(79)	a_p	AP
	B, b	
(20)	B	BK
(22)	b_o	BO
(94)	$B_{c'}$	BC1
(95)	$B_{g'}$	BG1
(76)	b_{p1}	BP1
(76)	b_{p2}	BP2
(103)	B_p	BP
(113b)	B_{pl}	BPL
(22)	b_s	BS
(113)	B_{SH}	BSH
(232)	B_{SHL}	B_{SHL}
(57a)	$b_{t\ 1/3}$	SM
(91)	$B_{T'}$	BT1
(57)	b_{tm}	TM

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Calculation Number	Electrical Symbol	Fortran Symbol
(15)	b_v	BV
	C, c	
(32)	c	C
(71)	c_1	C1
(74)	c_M	CM
(73)	c_P	CP
(75)	c_q	CQ
(72)	c_W	CW
	D, d	
(12)	D	DU
(11)	d	DI
(35)	d_b	DB
(78)	d_{fp}	DFP
(78)	d_{oc}	DC1
(11a)	d_r	DR
(78)	d_s	DS1

Calculation Number	Electrical Symbol	Fortran Symbol
	E, e	
(3)	E	EE
(55)	EF_{TOP}	ET
(56)	EF_{BOT}	EB
(238)	E_{FFL}	EPFL
(127b)	E_{FNL}	EPNL
(4)	E_{PH}	EP
	F, f	
(5a)	f	F
(98)	F_c	FC
(236)	F_{FL}	FFL
(96)	F_g	FG
(127)	F_{NL}	FNL
(104)	F_p	FP
(98a)	F_s	FS
(180)	F_{SC}	FSC
(233)	F_{SHL}	FSHL
(97)	F_T	FT
(183)	F & W	WF

Calculation Number	Electrical Symbol	Fortran Symbol
	G, g	
(59)	g	GC
(69)	g_e	GE
	H, h	
(24)	h_c	HC
(38)	h_{ST}	SD
(39)	h_{ST}	SH
	I, i	
(237)	I_{FFL}	AIFL
(127a)	I_{FNL}	AINL
(8)	I_{PH}	PI
(182)	$I^2 R_F$	FEL
(241)	$I^2 R_{FL}$	FCUL
(194)	$I^2 R$	PS
(245)	$I^2 R_L$	SCUL
	K, k	
(19)	k	WL
(9a)	K_c	CK
(43)	K_d	DF

Calculation Number	Electrical Symbol	Fortran Symbol
(63)	K_e	EK
(16)	K_i	SF
(44)	K_p	CF
(67)	K_s	CC
(42)	K_{SK}	FS
(2)	K_{VA}	VA
(61)	K_X	FF

L, l

(13)	ℓ	CL
(76)	ℓ_{co}	ALCO
(48)	L_E	EL
(36)	ℓ_{e2}	CE
(161)	L_F	SI
(76)	ℓ_p	ALP
(17)	ℓ_s	SS
(78)	ℓ_{SH}	ALSH
(49)	ℓ_t	HM
(147)	ℓ_{tf}	FE

Calculation Number	Electrical Symbol	Fortran Symbol
	M, m	
(5)	m	PN
	N, n	
(146)	N_F	PT
(45)	n_e	EC
(30)	n_s	SC
(34)	N_{ST}	SN
(34a)	N'_{ST}	SN1
(14)	n_v	HV
	P, p	
(6)	p	PX
(9)	PF	PF
(80)	P_1	P1
(81)	P_2	P2
(82)	P_3	P3
(83)	P_4	P4
(84)	P_5	P5
(86)	P_7	P7

Calculation Number	Electrical Symbol	Fortran Symbol
	Q, q	
(23)	Q	QQ
(25)	q	QN
	R, r	
(154)	$R_{f(cold)}$	FK
(155)	$R_{f(hot)}$	FR
(7)	RPM	RPM
(53)	$R_{SPH(cold)}$	RG
(54)	$R_{SPH(hot)}$	RP
	S, s	
(181)	SCR	SCR
(127c)	S_P	CD
(47)	S_S	S
	T, t	
(177)	T_a	TA
(178)	T'_d	T5
(176)	T'_{do}	TC
(178a)	T''_d	T4
(78)	t_{fp}	TFP
(76)	t_{p1}	TP1
(76)	t_{p2}	TP2

Calculation Number	Electrical Symbol	Fortran Symbol
	V, v	
(145)	V_r	VR
	W, w	
(185)	W_C	WQ
(186)	W_{NPL}	WN
(243)	W_{PFL}	WNL
(242)	W_{TFL}	WTFL
(184)	W_{TNL}	WT
	X, x	
(129)	X	XR
(131)	X_{ad}	XD
(132)	X_{aq}	XQ
(167)	X_d'	XS
(133)	X_d	XA
(166)	X_{du}'	XU
(160)	X_F	XF
(150)	X_f °C	T2
(130)	X_ℓ	XL
(134)	X_q	XB

Calculation Number	Electrical Symbol	Fortran Symbol
(50)	X_s °C	TI
(170)	X_2	XN
(172)	X_o	XO

<u>Y, y</u>

(31)	y	YY
(207)	ϕ_{7L}	PL7
(92)	ϕ_p	FQ
(213)	ϕ_{PL}	FQL
(88)	ϕ_T	TG

<u>Υ</u>

(41)	Υ_p	TP
(26)	Υ_s	TS
(40)	Υ_{SK}	SK
(27)	$\Upsilon_{S\ 1/3}$	TT

<u>λ</u>

(64)	λ_E	EW
(160c)	λ_F	FL

Calculation Number	Electrical Symbol	Fortran Symbol
	$\underline{\rho}$	
(151)	ρ_f	RR
(152)	$\rho_{f\ (hot)}$	
(51)	ρ_s	RS

```
C      PASS 1  ROTATING COIL LUNDELL
     1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
     2 FORMAT(F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0)
     3 FORMAT(9X F12.5,2X F12.5)
     7 READ2,VA,EE,EP,PN,F,PX,RPM,PI,PF,CK
       READ2,POL,DI,DU,CL,HV,BV,SF,WL,BK,ZZ
       READ2,BO,B1,B2,B3,BS,HO,HX,HY,HZ,HS
       READ2,HT,HW,QQ,W,RF,SC,YY,C,DW,SN
       READ2,SN1,DW1,DB,CE,SH,SD,PBA,SK,T1,RS
       READ2,GC,C1,CW,CP,EL,CM,CQ,PE,BP1,BP2
       READ2,TP1,TP2,ALP,DR,WR,D1,TFP,DFP,DS1,ALSH
       READ2,P1,P2,P3,P4,P5,P7,DC1,ALCO,PT,FE
       READ2,RD,RT,T2,RR,SNL,WF,ALZ
       SS=SF*(CL-HV*BV)
       HC=(DU-DI-2.0*HS)*0.5
       QN=QQ/(PX*PN)
       TS=3.142*DI/QQ
       IF(ZZ-4.0)9,10,9
     9 TT=(0.667*HS+DI)*3.142/QQ
       GO TO 11
    10 TT=3.1416*(DI+2.*HO+1.32*BS)/QQ
    11 IF(ZZ-1.0)12,12,13
    12 BO=BS
       CC=(5.*GC+BS)*TS/((5.*GC+BS)*TS-BS*BS)
       GO TO 14
    13 QC=(4.44*GC+0.75*BO)*TS
       CC=QC/(QC-BO*BO)
    14 CS=YY/(PN*QN)
       TP=3.1416*DI/PX
```

```
      IF(SK)18,18,19
   18 FS=1.0
      GO TO 20
   19 FS=SIN(1.571*SK/TP)*TP/(1.571*SK)
   20 IF(PBA-60.)21,21,22
   21 D=1.0
      GO TO 95
   22 D=2.0
   95 I=QN
      U=I
      IF(QN-U)23,23,24
   24 U=PX*PN
      XX=U
      N=U
      DO 25 K=1,N
      Z=U/XX
      I=Z
      Z1=I
      IF(Z-Z1)26,26,25
   26 ZY=QQ/XX
      I=ZY
      Z1=I
      IF(ZY-Z1)27,27,25
   25 XX=XX-1.
   23 ZY=QN
   27 DF=SIN(.5236*D)/(ZY*D*SIN(.5236/ZY))
      CF=SIN(YY*1.571/(PN*QN))
      EC=QQ*SC*CF*FS/C
      GE=CC*GC
```

```
      IF(C1)29,28,29
   28 C1=0.649*LOG(PE)+1.359
   29 IF(CW)30,30,31
   30 CW=0.707*EE*C1*DF/(EP*PN)
   31 IF(CP)32,32,33
   32 CP=PE*(LOG(GC/TP)*.0378+1.191)
   33 IF(EL)34,34,42
   34 IF(RF)35,35,41
   35 IF(PX-2.0)36,36,37
   36 U=1.3
      GO TO 40
   37 IF(PX-4.0)38,38,39
   38 U=1.5
      GO TO 40
   39 U=1.7
   40 EL=3.142*U*YY*(DI+HS)/QQ+0.5
      GO TO 42
   41 EL=2.0*CE+3.142*(0.5*HX+DB)+YY*TS*TS/SQRT(TS*TS-BS*BS)
   42 AA=1.571*PE
      AB=3.142*PE
      IF(CM)43,43,44
   43 CM=(AB+SIN(AB))/(SIN(AA)*4.)
   44 IF(CQ)45,45,46
   45 CQ=(0.5*COS(AA)+AB-SIN(AB))/(4.0*SIN(AA))
   46 RB=(T1+234.5)*0.00394*RS
      PRINT3,SS,CC,HC,GE,TS,C1,TT,CW,FS,CP,DF,EL,CF,CM,EC,CQ
      PUNCH1,VA,EE,EP,PN,F,PX
      PUNCH1,RPM,PI,PF,CK,POL,DI
      PUNCH1,DU,CL,SS,HC,SF,QN
```

```
PUNCH1,WL,BK,ZZ,BO,B1,B2
PUNCH1,B3,BS,HO,HX,HY,HZ
PUNCH1,HS,HT,HW,QQ,W,RF
PUNCH1,SC,YY,C,TS,SN,DB
PUNCH1,CE,SH,SD,TT,SK,RB
PUNCH 1, ALCO,TP,D1,FE,RD,RT
PUNCH1,T2,RR,SNL,WF,PE,SN1
PUNCH1,DW1,BP1,BP2,TP1,TP2,ALP
PUNCH1,DR,WR,TFP,DFP,DS1,ALSH
PUNCH1,P1,P2,P3,P4,P5,P7
PUNCH 1,RS,GC,PT,C1,CW,CP
PUNCH 1,EL,CM,CQ,DW,CC,PBA
PUNCH 1,GE,CS,CF,FS,EC,DF
PUNCH1,DC1,ALZ
PAUSE
END
```

```
C     PASS 2  ROTATING COIL LUNDELL
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      DIMENSION DA(8),DX(6),DY(8),DZ(8)
      READ1,VA,EE,EP,PN,F,PX
      READ1 ,RPM,PI,PF,CK,POL,DI
      READ1,DU,CL,SS,HC,SF,QN
      READ1,WL,BK,ZZ,BO,B1,B2
      READ1,B3,BS,HO,HX,HY,HZ
      READ1,HS,HT,HW,QQ,W,RF
      READ1,SC,YY,C,TS,SN,DB
      READ1,CE,SH,SD,TT,SK,RB
      READ1,ALCO,TP,D1,FE,RD,RT
      READ1,T2,RR,SNL,WF,PE,SN1
      READ1,DW1,BP1,BP2,TP1,TP2,ALP
      READ1,DR,WR,TFP,DFP,DS1,ALSH
      READ1,P1,P2,P3,P4,P5,P7
      READ1,RS,GC,PT,C1,CW,CP
      READ1,EL,CM,CQ,DW,CC,PBA
      READ1,GE,CS,CF,FS,EC,DF
      READ1,DC1,ALZ
      DT=DW1
      IF(ZZ-3.0)49,50,51
   49 SM=TT-BS
      GO TO 53
   50 SM=(3.1416*(DI+2.*HS)/QQ)-B3
      GO TO 53
   51 IF(ZZ-4.0)50,52,49
   52 SM=TT-.94*BS
   53 HM=CL+EL
```

```
      IF(DT) 61,61,62
   61 AC=0.785*DW*DW*SN1
      GO TO 72
   62 ZY=0.0
      DA(1)=0.05
      DA(2)=0.072
      DA(3)=0.125
      DA(4)=0.165
      DA(5)=0.225
      DA(6)=0.438
      DA(7)=0.688
      DA(8)=1.5
      DX(1)=0.000124
      DX(2)=0.00021
      DX(3)=0.00021
      DX(4)=0.00084
      DX(5)=0.00189
      DX(6)=0.00189
      DY(1)=0.000124
      DY(2)=0.000124
      DY(3)=0.00084
      DY(4)=0.00084
      DY(5)=0.00189
      DY(6)=0.00335
      DY(7)=0.00754
      DY(8)=0.03020
      DZ(1)=0.000124
      DZ(2)=0.000124
      DZ(3)=0.000124
```

```
      DZ(4)=0.00335
      DZ(5)=0.00335
      DZ(6)=0.00754
      DZ(7)=0.0134
      DZ(8)=0.0302
   63 IF(DT-.05)201,201,200
  200 JA=0
      JB=0
      JC=0
      JD=0
   64 JA=JA+1
      JB=JB+1
      JC=JC+1
      JD=JD+1
      IF(DT-DA(JA))65,65,64
  201 D=0
      IF(ZY)71,71,54
   65 IF(DW-0.188)66,66,67
   66 CY=DX(JB-1)
      CZ=DX(JB)
      GO TO 70
   67 IF(DW-0.75)68,68,69
   68 CY=DY(JC-1)
      CZ=DY(JC)
      GO TO 70
   69 CY=DZ(JD-1)
      CZ=DZ(JD)
   70 D=CY+(CZ-CY)*(DT-DA(JA-1))/(DA(JA)-DA(JA-1))
      IF(ZY)71,71,54
```

```
 71 AC=(DT*DW-D)*SN1
 72 IF(RT)73,73,74
 73 AS=0.785*RD*RD
    GO TO 55
 74 ZY=1.0
    DT=RT
    DW=RD
    GO TO 63
 54 AS=RT*RD-D
 55 S=PI/(C*AC)
    CY=PT    *FE*0.000001/AS
    FK=RR*CY
    FR=(T2+234.5)*FK*0.00394
    RC=0.321*PT    *FE*AS
    IF(SH)202,203,202
203 ET=1
    EB=1
    GO TO 204
202 AA=0.584+(SN*SN-1.0)*0.0625*(SD*CL/(SH*HM))**2.0
    AB=(SH*SC*F*AC/(BS*RB))**2.0
    ET=AA*AB*0.00335+1.0
    EB=ET-0.00168*AB
204 RY=SC*QQ*0.000001*HM/(PN*AC*C*C)
    RG=RS*RY
    RP=RB*RY
    A=PI*SC*CF/(C*TS)
    PUNCH1,VA,EE,EP,PN,F,PX
    PUNCH1,RPM,PI,PF,CK,POL,DI
    PUNCH1,DU,CL,SS,HC,SF,QN
```

```
PUNCH1,WL,BK,ZZ,BO,B1,B2
PUNCH1,B3,BS,HO,HX,HY,HZ
PUNCH1,HS,HT,HW,QQ,W,RF
PUNCH1,SC,YY,C,TS,SN,DB
PUNCH1,CE,SH,SD,TT,SK,RB
PUNCH 1, ALCO,TP,D1,FE,RD,RT
PUNCH1,T2,RR,SNL,WF,PE,SN1
PUNCH1,DW1,BP1,BP2,TP1,TP2,ALP
PUNCH1,DR,WR,TFP,DFP,DS1,ALSH
PUNCH1,P1,P2,P3,P4,P5,P7
PUNCH 1,RS,GC,PT,C1,CW,CP
PUNCH 1,EL,CM,CQ,DW,CC,PBA
PUNCH 1,GE,CS,CF,FS,EC,DF
PUNCH1,HM,SM,AS,AC,ET,EB
PUNCH1,S,FK,FR,RC,RG,RP
PUNCH1,A,DC1,ALZ
PAUSE
END
```

```
C     PASS 3  ROTATING COIL LUNDELL
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      READ1 ,VA,EE,EP,PN,F,PX
      READ1 ,RPM,PI,PF,CK,POL,DI
      READ1 ,DU,CL,SS,HC,SF,QN
      READ1 ,WL,BK,ZZ,BO,B1,B2
      READ1 ,B3,BS,HO,HX,HY,HZ
      READ1 ,HS,HT,HW,QQ,W,RF
      READ1 ,SC,YY,C,TS,SN,DB
      READ1 ,CE,SH,SD,TT,SK,RB
      READ1 ,  ALCO,TP,D1,FE,RD,RT
      READ1 ,T2,RR,SNL,WF,PE,SN1
      READ1 ,DW1,BP1,BP2,TP1,TP2,ALP
      READ1 ,DR,WR,TFP,DFP,DS1,ALSH
      READ1 ,P1,P2,P3,P4,P5,P7
      READ1 , RS,GC,PT,C1,CW,CP
      READ1  ,EL,CM,CQ,DW,CC,PBA
      READ1  ,GE,CS,CF,FS,EC,DF
      READ1 ,HM,SM,AS,AC,ET,EB
      READ1 ,S,FK,FR,RC,RG,RP
      READ1,A,DC1,ALZ
      IF(PBA-60.0)105,105,108
  105 IF(CS-0.667)106,106,107
  106 FF=0.25*(6.0*CS-1.0)
  107 FF=0.25*(3.*CS+1.0)
      GO TO 75
  108 IF(CF-0.667)109,109,110
  109 FF=0.05*(24.0*CS-1.0)
      GO TO 75
```

```
110 FF=0.75
 75 CX=FF/(CF*CF*DF*DF)
    Z=CX*20.0/(PN*QN)
    BT=3.142*DI/QQ-BO
    ZA=BT*BT/(16.0*TS*GC)
    ZB=0.35*BT/TS
    ZC=HO/BO
    ZD=HX*0.333/BS
    ZE=HY/BS
    IF(ZZ-2.0) 76,77,78
 76 PC=Z*(ZE+ZD+ZA+ZB)
       GO TO 82
 77 PC=Z*(ZC+(2.0*HT/(BO+BS))+(HW/BS)+ZD+ZA+ZB)
    GO TO 82
 78 IF(ZZ-4.0) 79,80,81
 79 PC=Z*(ZC+(2.0*HT/(BO+B1))+(2.0*HW/(B1+B2))+(HX*0.333/B2)+ZA+ZB)
    GO TO 82
 80 PC=Z*(ZC+0.62)
    GO TO 82
 81 PC=Z*(ZE+ZD+(0.5*GC/TS)+(0.25*TS/GC)+0.6)
 82 EK=EL/(10.0**(0.103*YY*TS+0.402))
    IF(DI-8.0) 83,83,84
 83 EK=SQRT(EK)
 84 ZF=.612*LOG(10.0*CS)
    EW=6.28*EK*ZF*(TP**(0.62-(0.228*LOG(ZF))))/(CL*DF*DF)
 87 ZA=3.1416*(DI+HS)/QQ
    IF(ZZ-3.0) 88,89,88
 88 TM=ZA-BS
    GO TO 90
```

```
 89 TM=(3.1416*(DI+2.*HS)/QQ)-B3
 90 WI=(TM*QQ*SS*HS+(DU-HC)*3.142*HC*SS)*0.283
    IF(WF)445,446,445
446 WF=2.52E-6*(DR**2.5)*ALP*RPM**1.5
445 WC=.321*HM*QQ*AC*SC
    PUNCH1,VA,EE,EP,PN,F,PX
    PUNCH1,RPM,PI,PF,CK,POL,DI
    PUNCH1,DU,CL,SS,HC,SF,QN
    PUNCH1,WL,BK,ZZ,BO,B1,B2
    PUNCH1,B3,BS,HO,HX,HY,HZ
    PUNCH1,HS,HT,HW,QQ,W,RF
    PUNCH1,SC,YY,C,TS,SN,DB
    PUNCH1,CE,SH,SD,TT,SK,RB
    PUNCH 1, ALCO,TP,D1,FE,RD,RT
    PUNCH1,T2,RR,SNL,WF,PE,SN1
    PUNCH1,DW1,BP1,BP2,TP1,TP2,ALP
    PUNCH1,DR,WR,TFP,DFP,DS1,ALSH
    PUNCH1,P1,P2,P3,P4,P5,P7
    PUNCH 1,RS,GC,PT,C1,CW,CP
    PUNCH 1,EL,CM,CQ,DW,CC,PBA
    PUNCH 1,GE,CS,CF,FS,EC,DF
    PUNCH1,HM,SM,AS,AC,ET,EB
    PUNCH1,S,FK,FR,RC,RG,RP
    PUNCH1,FF,CX,PC,EK,EW,TM
    PUNCH1,A,DC1,WI,WC,ALZ
    PAUSE
    END
```

```
C     PASS 4  ROTATING COIL LUNDELL
    3 FORMAT(9X F12.5,2X F12.5)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      READ1 ,VA,EE,EP,PN,F,PX
      READ1 ,RPM,PI,PF,CK,POL,DI
      READ1 ,DU,CL,SS,HC,SF,QN
      READ1 ,WL,BK,ZZ,BO,B1,B2
      READ1 ,B3,BS,HO,HX,HY,HZ
      READ1 ,HS,HT,HW,QQ,W,RF
      READ1 ,SC,YY,C,TS,SN,DB
      READ1 ,CE,SH,SD,TT,SK,RB
      READ1  , ALCO,TP,D1,FE,RD,RT
      READ1 ,T2,RR,SNL,WF,PE,SN1
      READ1 ,DW1,BP1,BP2,TP1,TP2,ALP
      READ1 ,DR,WR,TFP,DFP,DS1,ALSH
      READ1 ,P1,P2,P3,P4,P5,P7
      READ1  ,RS,GC,PT,C1,CW,CP
      READ1  ,EL,CM,CQ,DW,CC,PBA
      READ1  ,GE,CS,CF,FS,EC,DF
      READ1 ,HM,SM,AS,AC,ET,EB
      READ1 ,S,FK,FR,RC,RG,RP
      READ1 ,FF,CX,PC,EK,EW,TM
      READ1,A,DC1,WI,WC,ALZ
      AP=BP2*TP2
      IF(P1)400,401,400
  401 R2=(DR-DFP)/2.
      R1=R2+TP1
      P1=2.*BP1*LOG(R1/R2)
  400 IF(P2)402,403,402
```

```
403 AL2=TP-(BP1+BP2)/2.
    P2=3.19*ALP*((TP2+TP1)/2.)/AL2
402 IF(P3)404,405,404
405 R3=R1+ALP/2.
    R4=R1
    P3=(6.38*((3.*BP1+BP2)/4.)/3.1416)*LOG(R3/R4)
404 IF(P4)406,407,406
407 P4=(3.19*ALP/3.1416)*LOG(1.+(BP1+BP2)/(2.*AL2))
    IF(PX-4.)408,408,406
408 P4=1.5*P4
406 IF(P5)410,411,410
411 P5=(6.675/ALCO)*(DC1**2.-DS1**2.)/3.
410 IF(P7)412,413,412
413 P7=2.5*(DU+DFP)*(DU-DI)/(DU-DFP)
412 TG=6.E6*EE/(CW*EC*RPM)
    BT1=TG/(QQ*SS*SM)
    FQ=TG*CP/PX
    BC1=FQ/(2.*HC*SS)
    BG1=TG/(3.1416*DI*CL)
    FG=BG1*GE/.00319
    ALA=6.38*DI/(PX*GE)
    PGE=PX*(P1+P2+P3+P4)
    ALF=(PGE+P5)/CL
    XR=.0707*A*DF/(BG1*C1)
    XL=XR*(PC+EW+ALZ)
    XD=XR*C1*CM*ALA
    XQ=XR*CQ*ALA
    XA=XL+XD
    XB=XL+XQ
```

```
      VR=3.1416*DR*RPM/12.
      XF=XD*(1.-((C1/CM)/(2.*CP+(4.*ALF/(3.1416*ALA)))))
      SI=PT*PT*CL*PX*(CP*ALA*1.57+ALF)*1.E-8
      XU=XL+XF
      XS=.88*XU
      XX=XS
      XY=XB
      XN=.5*(XX+XY)
      IF(W)414,415,414
  415 XO=0.
      GO TO 422
  414 IF(CS-1.)417,418,417
  418 AKX=1.
      AKX1=1.
      GO TO 419
  417 AA=(3.*YY/(PN*QN))
      AKX=AA-2.
      IF(AA/3.-.667)420,420,421
  420 AKX1=.75*AA-.25
      GO TO 419
  421 AKX1=.75*AA+.25
  419 ABL=(AKX/(CF**2))*.07*ALA
      XO=AKX*(ABL+PC)/AKX1
      XO=XR*(XO+(1.667*(HX+3.*HZ))/(PN*QN*CF**2*DF**2*BS)+.2*EW)
  422 TC=SI/FK
      RA=PN*PI*PI*RG/(VA*1000.)
      TA=XN/(628.32*F*RA)
      T5=XS*TC/XA
      IF(F-60.)425,426,425
```

```
425 T4=.005
    GO TO 427
426 T4=.035
427 FSC=XA*FG*.02
    PRINT3,AC,A,S,XR,HM,XL,RG,XD,RP,XQ,ET,XA,EB,XB,PC,XF,EW,SI,WC,XU
    PRINT3,WI,XS,TP,XN,WR,XO,VR,TC,AS,TA,FK,T5,FR,T4,RC,TG,P1,FQ
    PRINT3,P2,BG1,P3,BT1,P4,BC1
    PUNCH1, BK,WL,QQ,SM,BS,RPM
    PUNCH1,TS,BO,GC,C1,DI,CL
    PUNCH1,ET,EB,C,SC,PN,PI
    PUNCH1,HS,BT1,BC1,DU,HC,PX
    PUNCH1,PGE,FQ,AP,ALP,P7,FG
    PUNCH1,DS1,ALSH,PT,FR,AS,PF
    PUNCH1,XB,XA,CK,XD,POL,SNL
    PUNCH1,FK,RP,RG,EP,BG1,SS
    PUNCH1,D1,FSC,P5,WF,EP,EE
    PAUSE
    END
```

```
C      PASS 5  ROTATING COIL LUNDELL
     1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
       DIMENSION GB(4),AE(4),DX(4)
       READ1 , BK,WL,QQ,SM,BS,RPM
       READ1, TS,BO,GC,C1,DI,CL
       READ1 ,ET,EB,C,SC,PN,PI
       READ1 ,HS,BT1,BC1,DU,HC,PX
       READ1 ,PGE,FQ,AP,ALP,P7,FG
       READ1 ,DS1,ALSH,PT,FR,AS,PF
       READ1 ,XB,XA,CK,XD,POL,SNL
       READ1 ,FK,RP,RG,EP,BG1,SS
       READ1 ,D1,FSC,P5,W ,EP,EE
       WQ=(DU-HC)*1.42*HC*SS*(BC1/BK)**2.0*WL
       WT= SM    *QQ*SS*HS*0.453*(BT1/BK)**2.0*WL
   132 D2=BG1**2.5*0.000061
       D3=(0.0167*QQ*RPM)**1.65*0.000015147
       IF(TS-0.9)133,133,134
   133 D4=TS**1.285*0.81
       GO TO 137
   134 IF(TS-2.0)135,135,136
   135 D4=TS**1.145*0.79
       GO TO 137
   136 D4=TS**0.79*0.92
   137 D7=BO/GC
       IF(D7-1.7)138,138,139
   138 D5=D7**2.31*0.3
       GO TO 144
   139 IF(D7-3.0)140,140,141
   140 D5=D7**2.0*0.35
```

```
      GO TO 144
141   IF(D7-5.0)142,142,143
142   D5=D7**1.4*0.625
      GO TO 144
143   D5=D7**0.965*1.38
144   D6=10.0**(0.932*C1-1.606)
      BA=3.142*D1*CL
      WN=D1*D2*D3*D4*D5*D6*BA
      AXX=B0/GC
      IF(AXX-1.)964,965,964
965   AKSC=2.6
      GO TO 957
964   IF(AXX-3.75)955,955,956
955   AKSC=10.**.178/((AXX-1.)**.334)
      GO TO957
956   AKSC=10.**.11/((AXX-1.)**.174)
957   XX1=PI*PI*PN
      XX3=3.*EP*PI*PF
      XX2=(ET+EB)/2.-1.
      XX4=AKSC*PI*SC/(C*FG)
      GB(1)=1.
      GB(2)=1.5
      GB(3)=2.
      GB(4)=POL
      AN=ATAN(SQRT(1.-PF*PF)/PF)
      AN1=SIN(AN)
      DO 777 K=1,4
      YB=GB(K)
      AA    =ATAN((AN1+XB*YB/100.)/PF)
```

```
      AE(K)=COS(AA-AN)+XA*SIN(AA)*YB/100.
  777 DX(K)=.93*XD*YB*SIN(AA)/100.
      PUNCH1,AE(1),AE(2),AE(3),AE(4)
      PUNCH1,DX(1),DX(2),DX(3),DX(4)
      PUNCH1,HS,BT1,BC1,DU,HC,PX
      PUNCH1,PGE,FQ,AP,ALP,P7,FG
      PUNCH1,DS1,ALSH,PT,FR,AS,PF
      PUNCH1,XB,XA,CK,XD,POL,SNL
      PUNCH1,WQ,WN,WF,XX1,XX2,XX3
      PUNCH1,FK,RP,RG,XX4,FSC,P5
      PUNCH1,WT,EE
      PAUSE
      END
```

```
C     PASS 6  ROTATING COIL LUNDELL
      DIMENSIONBSHL(4),BPL(4),FFL(4),CDD(4),AIFL(4),EPFL(4)
      DIMENSION AE(4),DX(4),AI(90),PTL(4),PLL(4)
  700 FORMAT (I3)
    3 FORMAT(9X F12.5,2X F12.5)
    4 FORMAT (9X F12.5/)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
  888 FORMAT(F10.0,F10.0,F10.0,F10.0,F10.0,F10.0)
      K=1
  823 READ888,AI(K),AI(K+1),AI(K+2),AI(K+3),AI(K+4),AI(K+5)
      K=K+6
      IF(K-89)823,824,824
  824 READ1,AE(1),AE(2),AE(3),AE(4)
      READ1,DX(1),DX(2),DX(3),DX(4)
      READ1 ,HS,BT1,BC1,DU,HC,PX
      READ1 ,PGE,FQ,AP,ALP,P7,FG
      READ1 ,DS1,ALSH,PT,FR,AS,PF
      READ1 ,XB,XA,CK,XD,POL,SNL
      READ1 ,WQ,WN,WF,XX1,XX2,XX3
      READ1 ,FK,RP,RG,XX4,FSC,P5
      READ1 ,WT,EE
      ASH=.7854*DS1*DS1
      COREL=(.7854*(DU-HC)/PX)
      LOAD=1
      X=BT1
      NA=1
      K=1
      GO TO 802
  806 FT=HS*AT
```

```
      X=BC1
      K=2
      NA=1
      GO TO 802
  807 FC=COREL*AT
      FS=FT+FC
      PL=PGE*(2.*FG+2.*FT+FC)*.001
      PLT=FQ+(PL*2./PX)
      BP=PLT/AP
      X=BP
      NA=31
      K=3
      GO TO 802
  808 FP=AT*ALP
      PL7=P7*(FP+FG+FS)*.001
      PL5=P5*(2.*(FG+FT+FP)+FC)*.000667
      PSH=(PLT*PX/2.)+PL7+PL5
      BSH=PSH/ASH
      X=BSH
      NA=61
      K=4
      GO TO 802
  809 FSH=ALSH*AT
      FNL=2.*(FG+FS+FP)+FSH
      AINL=FNL/PT
      EPNL=AINL*FK
      CD=AINL/AS
      SCR=FNL/FSC
      PRINT3,P5,FT,P7,FC,FSC,FG
```

```
      PRINT4,SCR
      LOAD=2
      DO 899 J=1,4
      AED=AE(J)
      PLL(J)=PL*((AED*FG+(1.+PF)*FT+FC)/(FG+FS))
      IF(PF-.95)825,825,826
  825 PPL=FQ*(AED-DX(J))
      GO TO 827
  826 PPL=FQ*CK
  827 PTL(J)=PPL+(PLL(J)*2./PX)
      PPTL=PTL(J)
      X=PPTL/AP
      BPL(J)=X
      NA=31
      K=1
      GO TO 802
  841 FPL=AT*ALP
      AA=(AED*FG+FPL+FT*(1.+PF)+FC)
      PL7L=.001*P7*AA
      PL5=P5*(2.*(AED*FG+FPL+FT*(1.+PF))+FC)*.000667
      PSHL=PPTL*PX/2.+PL7L+PL5
      PSHL=PPTL*PX/2.+PL7L
      X=PSHL/ASH
      BSHL(J)=X
      NA=61
      K=2
      GO TO 802
  842 FSHL=ALSH*AT
      FFL(J)=2.*(AED*FG+(1.+PF)*FT+FPL)+FC+FSHL
```

```
      FFL(J)=AA*2.+FSHL
      AIFL(J)=FFL(J)/PT
      CDD(J)=AIFL(J)/AS
  899 EPFL(J)=AIFL(J)*FR
  837 JA=JA/2
      PUNCH700,JA
      IF(JA)891,892,891
  891 DO 890 K=1,JA
      PUNCH1,BPL(K),BSHL(K),FFL(K),AIFL(K),CDD(K),EPFL(K)
  890 PUNCH1,PTL(K),PLL(K)
  892 PUNCH1,XX1,XX2,XX3,XX4,WT,WQ
      PUNCH1,WF,WN,RP,RG,FK,FR
      PUNCH1,BP,BSH,FNL,AINL,CD,EPNL
      PUNCH1,SNL,FP,BT1,FQ,BC1
      PUNCH1,FG,AT,HS,COREL,P7,PGE
      PUNCH1,AP,ALP,PX,ALSH,ASH
      PUNCH 1,PL,PLT,POL,XA,EE
      PAUSE
  802 IF(AI(NA)-X)830,831,831
  831 NA=NA+3
  835 IF(AI(NA)-X)833,834,834
  833 NA=NA+2
      GO TO 835
  834 AX=AI(NA)
      BB1=AI(NA-2)
      DC=AI(NA+1)
      D=AI(NA-1)
      XX= (AX-BB1)/(.4343*(LOG(DC)-LOG(D+.0001)))
      Y=AX-XX*.4343*LOG(DC)
```

```
      AT=EXP(2.306*(X-Y)/XX)
    GO TO (838,839),LOAD
838 GO TO (806,807,808,809,810),K
839 JA=JA+1
    GO TO (841,842),K
830 GO TO (836,837),LOAD
836 PRINT 850,
850 FORMAT (17HMACHINE SATURATED)
    PAUSE
    END
```

```
C      PASS 7  ROTATING COIL LUNDELL
       DIMENSION BPL(4),BSHL(4),FFL(4),AIFL(4),CDD(4),EPFL(4),FCUL(4)
       DIMENSION  WNL(4),STTL(4),SCUL(4),EDDL(4),TOTL(4),PEFF(4),GB(4)
       DIMENSION PLL(4),PTL(4)
  961 FORMAT(F11.3,8X F11.3,F11.3,F11.3,F11.3)
  700 FORMAT (I3)
    1 FORMAT (E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      DO 705  N=1,4
      PLL(N)=0
      PTL(N)=0
      BPL(N)=0
      BSHL(N)=0
      FFL(N)=0
      AIFL(N)=0
      CDD(N)=0
      EPFL(N)=0
      FCUL(N)=0
      WNL(N)=0
      STTL(N)=0
      SCUL(N)=0
      EDDL(N)=0
      TOTL(N)=0
  705 PEFF(N)=0
      READ700,JA
      IF(JA)702,703,702
  702 DO 704 K=1,JA
      READ1,BPL(K),BSHL(K),FFL(K),AIFL(K),CDD(K),EPFL(K)
  704 READ1 ,PTL(K),PLL(K)
  703 READ1 ,XX1,XX2,XX3,XX4,WT,WQ
```

```
      READ1 ,WF,WN,RP,RG,FK,FR
      READ1 ,BP,BSH,FNL,AINL,CD,EPNL
      READ1,SNL,FP,BT1,FQ,BC1
      READ1,FG,AT,HS,COREL,P7,PGE
      READ1 ,AP,ALP,PX,ALSH,ASH
      READ  1,PL,PLT,POL,XA,EE
      IF(SNL)707,706,707
  707 PUNCH1,SNL,BT1,FQ,BC1,EE
      PUNCH1,FG,HS,COREL,P7,PGE
      PUNCH1,AP,ALP,PX,ALSH,ASH
  706 FEL=AINL*AINL*FK
      TL=FEL+WT+WQ+WN +WF
      ABX=0
      IF(JA)714,712,714
  714 IF(JA-4) 708,709,708
  709 IF(POL)708,710,708
  710 JA=JA-1
  708 GB(1)=1.
      GB(2)=1.5
      GB(3)=2.
      GB(4)=POL
      DO 711 K=1,JA
      YB=GB(K)
      FCUL(K)=AIFL(K)**2*FR
      STTL(K)=((.0027*XA*YB)**2*2.+1.)*WT
      WNL(K)=((XX4*YB)**2+1.)*WN
      SCUL(K)=XX1*RP*YB
      EDDL(K)=SCUL(K)*XX2
      TOTL(K)=EDDL(K)+SCUL(K)+WNL(K)+STTL(K)+FCUL(K)+WQ+WF
```

```
711 PEFF(K)=XX3*YB*100./(XX3*YB+TOTL(K))
712 IF(POL)958,959,958
958 PRINT961,PL,PLL(1),PLL(2),PLL(3),PLL(4)
    PRINT961,BP,BPL(1),BPL(2),BPL(3),BPL(4)
    PRINT961,PLT,PTL(1),PTL(2),PTL(3),PTL(4)
    PRINT961,BSH,BSHL(1),BSHL(2),BSHL(3),BSHL(4)
    PRINT961,FNL,FFL(1),FFL(2),FFL(3),FFL(4)
    PRINT961,AINL,AIFL(1),AIFL(2),AIFL(3),AIFL(4)
    PRINT961,CD,CDD(1),CDD(2),CDD(3),CDD(4)
    PRINT961,EPNL,EPFL(1),EPFL(2),EPFL(3),EPFL(4)
    PRINT961,WQ,WQ,WQ,WQ,WQ
    PRINT961,WT,STTL(1),STTL(2),STTL(3),STTL(4)
    PRINT961,ABX,SCUL(1),SCUL(2),SCUL(3),SCUL(4)
    PRINT961,ABX,EDDL(1),EDDL(2),EDDL(3),EDDL(4)
    PRINT961,WN,WNL(1),WNL(2),WNL(3),WNL(4)
    PRINT961,FEL,FCUL(1),FCUL(2),FCUL(3),FCUL(4)
    PRINT961,WF,WF,WF,WF,WF
    PRINT961,TL,TOTL(1),TOTL(2),TOTL(3),TOTL(4)
    PRINT961,ABX,PEFF(1),PEFF(2),PEFF(3),PEFF(4)
    PAUSE
959 PRINT961,PL,PLL(1),PLL(2),PLL(3)
    PRINT961,PLT,PTL(1),PTL(2),PTL(3)
    PRINT961,BP,BPL(1),BPL(2),BPL(3)
    PRINT961,BSH,BSHL(1),BSHL(2),BSHL(3)
    PRINT961,FNL,FFL(1),FFL(2),FFL(3)
    PRINT961,AINL,AIFL(1),AIFL(2),AIFL(3)
    PRINT961,CD,CDD(1),CDD(2),CDD(3)
    PRINT961,EPNL,EPFL(1),EPFL(2),EPFL(3)
    PRINT961,WQ,WQ,WQ,WQ
```

```
PRINT961,WT,STTL(1),STTL(2),STTL(3)
PRINT961,ABX,SCUL(1),SCUL(2),SCUL(3)
PRINT961,ABX,EDDL(1),EDDL(2),EDDL(3)
PRINT961,WN,WNL(1),WNL(2),WNL(3)
PRINT961,FEL,FCUL(1),FCUL(2),FCUL(3)
PRINT961,WF,WF,WF,WF
PRINT961,TL,TOTL(1),TOTL(2),TOTL(3)
PRINT961,ABX,PEFF(1),PEFF(2),PEFF(3)
PAUSE
END
```

```
C     PASS 8  ROTATING COIL LUNDELL
      DIMENSION AI(90)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
  888 FORMAT(F10.0,F10.0,F10.0,F10.0,F10.0,F10.0)
  878 FORMAT(F12.5,F12.5,F12.5,F12.5,F12.5,F12.5)
  879 FORMAT(F12.5,F12.5,F12.5,F12.5,F12.5,F12.5//)
      K=1
  823 READ888,AI(K),AI(K+1),AI(K+2),AI(K+3),AI(K+4),AI(K+5)
      K=K+6
      IF(K-89)823,824,824
  824 READ 1,SNL,BT1,FQ,BC1,EE
      READ 1,FG,HS,COREL,P7,PGE
      READ 1,AP,ALP,PX,ALSH,ASH
      YB=.8
      LOAD=1
      DO 800 N=1,9
      R1=BT1*YB
      R2=FQ*YB
      R3=BC1*YB
      R4=FG*YB
      R5=EE*YB
      X=R1
      NA=1
      K=1
      GO TO 802
  806 FT=HS*AT
      X=R3
      K=2
      NA=1
```

```
      GO TO 802
  807 FC=COREL*AT
      FS=FT+FC
      PL=PGE*(2.*(R4+FT)+FC)*.001
      PLT=R2+PL*2./PX
      BP=PLT/AP
      X=BP
      NA=31
      K=3
      GO TO 802
      PL5=P5*(2.*(R4+FT+FP)+FC)*.000667
  808 FP=AT*ALP
      PL7=P7*.001*(FP+FS+R4)
      PSH=(PLT*PX/2.)+PL7
      BSH=PSH/ASH
      X=BSH
      NA=61
      K=4
      GO TO 802
  809 FSH=ALSH*AT
      FNL=2.*(R4+FS+FP)+FSH
      PRINT878,R5,R1,FT,R3,FC,R4
      PRINT879,PL,PLT,BP,FP,BSH,FNL
  800 YB=YB+.1
      PAUSE
  802 IF(AI(NA)-X)830,831,831
  831 NA=NA+3
  835 IF(AI(NA)-X)833,834,834
  833 NA=NA+2
```

```
      GO TO 835
  834 AX=AI(NA)
      BB1=AI(NA-2)
      DC=AI(NA+1)
      D=AI(NA-1)
      XX= (AX-BB1)/(.4343*(LOG(DC)-LOG(D+.0001)))
      Y=AX-XX*.4343*LOG(DC)
         AT=EXP(2.306*(X-Y)/XX)
      GO TO (838,839),LOAD
  838 GO TO (806,807,808,809,810),K
  839 JA=JA+1
      GO TO (841,842),K
  830 GO TO (836,837),LOAD
  836 PRINT 850,
  850 FORMAT (17HMACHINE SATURATED)
      PAUSE
      END
```

INSIDE, SINGLE-COIL, STATIONARY-COIL
LUNDELL-TYPE A-C GENERATOR
COMPUTER PROGRAM AND TEST DATA

INSIDE-COIL, STATIONARY-COIL LUNDELL GENERATOR

COMPUTER DESIGN - - - - - - - (INPUT)

5-18-65

MODEL ______ EWO ______ DESIGN NO (1) ______

Group	No.	Symbol	Item	Value
PARAMETERS	(2)	KVA	GENERATOR KVA	3.46
	(3)	E	LINE VOLTS	10.0
	(4)	E_{ph}	PHASE VOLTS	5.78
	(5)	m	PHASES	3.0
	(5a)	f	FREQUENCY	120
	(6)	p	POLES	12
	(7)	RPM	RPM	1360
	(8)	I_{ph}	PHASE CURRENT	140
	(9)	PF	POWER FACTOR	.95
	(9a)	K_c	ADJ. FACTOR	1.0
	(10)		OPTIONAL LOAD POINT	1.6
STATOR STACK	(11)	d	STATOR I.D.	6.462
	(12)	D	STATOR O.D.	8.475
	(13)		GROSS CORE LENGTH	2.45
	(14)	n_v	NO. OF DUCTS	0.0
	(15)	b_v	WIDTH OF DUCT	0.0
	(16)	K	STACKING FACTOR(STATOR)	.97
			WATTS LB.	3.0
			DENSITY	774
STATOR SLOT			TYPE OF SLOT	2
			OPENING	.040
			WIDTH TOP	0
				0
				0
			SLOT WIDTH	.150
	(22)	h_0		.015
	(22)	h_1		.335
	(22)	h_2		0
	(22)	h_3		0
	(22)	h_s	SLOT DEPTH	.400
	(22)	h_t		0
	(22)	h_w		.020
	(23)	Q	NO. OF SLOTS	72
STATOR WINDING	(28)		TYPE OF WDG.	1
	(29)		TYPE OF COIL	1
	(30)	n_s	CONDUCTORS SLOT	2
	(31)	y	SLOTS SPANNED	6
	(32)	c	PARALLEL CIRCUITS	1
	(33)		STRAND DIA. OR WIDTH	.150
	(34)	N_{st}	STRANDS CONDUCTOR IN DEPTH	1
	(34a)	N'_{st}	STRANDS/CONDUCTOR	1
	(39)		STATOR STRAND T'KNS.	.100
	(35)	d_b	DIA. OF PIN	.25
	(36)	ℓ_{e2}	COIL EXT. STR. PORT	.25
	(37)	h_{st}	UNINS. STRD. HT.	.150
	(38)	h'_{st}	DIST. BTWN. C_L OF STD.	.185
	(42a)		PHASE BELT ANGLE	60
	(40)	τ_{sk}	STATOR SLOT SKEW	0
	(50)	X °C	STATOR TEMP °C	75
	(51)	ρ_s	RES'TVY STA. COND. - 20° C	.694
GAP	(78)	ℓ_{g3}	AXIAL LENGTH OF GAP (g3)	1.6
	(78)	d_{g3}	DIAMETER AT GAP (g3)	4.55
	(78)	d_{g2}	DIAMETER AT GAP (g2)	5.36
	(59)	g	MAIN AIR GAP	.022
	(59a)	g2	AUXILIARY GAP (g2)	.020
	(59b)	g3	AUXILIARY GAP (g3)	.020

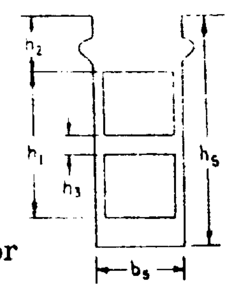
Group	Value	Item	No.	Symbol
CONSTANTS	0	FUND/MAX OF FIELD FLUX	(71)	C1
	0	WINDING CONSTANT	(72)	C_w
	0	POLE CONSTANT	(73)	C_p
	0	END EXTENSION ONE TURN	(48)	LE
	0	DEMAGNETIZATION FACTOR	(74)	C_m
	0	CROSS MAGNETIZING FACTOR	(75)	C_q
	.635	POLE EMBRACE	(77)	α_c
POLE & ROTOR	.84	WIDTH OF POLE (NARROW END)	(76)	b_{P1}
	1.40	WIDTH OF POLE (WIDE END)	(76)	b_{P2}
	.10	POLE THICKNESS (NARROW END)	(76)	t_{P1}
	.8	POLE THICKNESS (WIDE END)	(76)	t_{P2}
	2.45	POLE LENGTH	(76)	ℓ_p
	6.419	ROTOR DIAMETER	(11a)	d_r
	0	WEIGTH OF ROTOR IRON	(157)	(–)
	7.0	POLE FACE LOSS FACTOR	(187)	K_i
SHAFT	3.2	SHAFT O.D.(FLUX CARRYING PART	(78)	d_s
	4.0	SHAFT LENGTH " " "	(78)	ℓ_{sh}
	0	PERM OF LEAKAGE PATH 1	(80)	P1
	0	PERM OF LEAKAGE PATH 2	(81)	P2
	0	PERM OF LEAKAGE PATH 3	(82)	
	0	PERM OF LEAKAGE PATH 4	(83)	P4
	0	PERM OF LEAKAGE PATH 5	(84)	P5
	0	PERM OF LEAKAGE PATH 7		P
	0.7	LENGTH OF PERM PATH 1	(80a)	
	0.5	LENGTH OF PERM PATH 2	(81a)	
	0.6	LENGTH OF PERM PATH 3	(82a)	ℓ_3
FIELD	4.30	OUTSIDE DIA. OF FIELD COIL	(78)	d_{co}
	1.6	LENGTH OF FIELD COIL	(76)	ℓ_{co}
	355	NO. OF FIELD TURNS COIL	(146)	NF
	12.1	MEAN LENGTH OF FLD. TURN	(147)	λ_{tf}
	.0508	FLD. COND. DIA. OR WIDTH	(148)	
	0	FLD. COND. THICKNESS	(149)	
	75	FLD. TEMP IN °C	(150)	X_f °C
	.694	RESISTIVITY OF FLD. COND.	(151)	ρ_f
	1	NO LOAD SAT.	(87)	
	0	FRICTION & WINDAGE	(183)	(F&W)
	18.2	SPECIAL PERM	644	λ
	11C	STATOR LAM MATERIAL M22		
	12	POLE MATERIAL 1010	(18)	
	12	SHAFT MATERIAL 1010	(18)	

STATOR SLOT	POLE
DAMPER SLOT	REMARKS

DESIGNER ______ DATE ______

REV. A

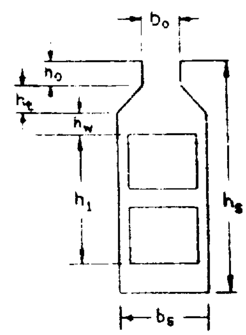
(a) Open Slots



TYPE 1

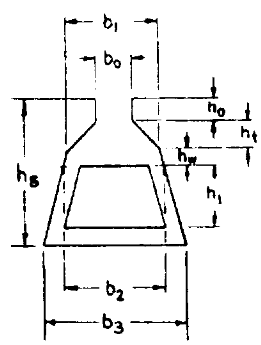
(Type 5 is an open slot with 1 conductor per slot)

(b) Constant Slot Width



TYPE 2

(c) Constant Tooth Width

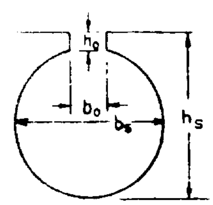


TYPE 3

b_s for type 3 is

$$b_s = \left(\frac{b_1 + b_3}{2}\right)$$

(d) Round Slots



TYPE 4

5-18-65

INSIDE-COIL, STATIONARY-COIL LUNDELL GENERATOR
SUMMARY OF DESIGN CALCULATIONS - - - - - - - (OUTPUT)

MODEL NO. ______ EWO ______ DESIGN NO ______

Group	No. (Symbol)	Item	Value
STATOR	(17) (ℓ_s)	SOLID CORE LENGTH	2.37650
	(24) (h_c)	DEPTH BELOW SLOT	.60650
	(26) (τ_s)	SLOT PITCH	.28199
	(27) (τ_s 1/3)	SLOT PITCH 1/3 DIST. UP	.29363
	(42) (K_{sk})	SKEW FACTOR	1.00000
	(43) (K_d)	DIST. FACTOR	.96592
	(44) (K_p)	PITCH FACTOR	1.00000
	(45) (n_e)	EFF. CONDUCTORS	144.00000
	(46) (a_c)	COND. AREA	.01479
	(47) (S_s)	CURRENT DENSITY (STA.)	9465.80000
	(49) (ℓ_t)	1/2 MEAN TURN LENGTH	6.25980
	(53) (R_{ph})	COLD STA. RES. ~ 20° C	.01409
	(54) (R_{ph})	HOT STA. RES. @ X° C	.01719
	(55) (EF_{top})	EDDY FACTOR TOP	1.03440
	(56) (EF_{bot})	EDDY FACTOR BOT	1.00480
	(62) (λ_i)	STATOR COND. PERM.	7.65400
	(63) (λ_e)	END PERM.	5.17480
	(65) ( )	WT. OF STA COPPER	4.27950
	(66) ( )	WT. OF STA. IRON	12.97800
	(41) (τ_p)	POLE PITCH	1.69170
	(157) (-)	WT. OF ROTOR IRON	.00000
	(115) (V_r)	PERIPHERAL SPEED	2205.47200
FIELD	(153) [illegible]	FLD. COND. AREA	.00[illegible]
	[illegible]	COLD FLD. RES. ~ 20° C	[illegible].47150
	[illegible]	[illegible]	[illegible]9740
	[illegible]	WT. OF FLD. COPPER	.7[illegible]70
PERMEANCE	(80) (P1)	PERM OF LEAKAGE PATH 1	.58[illegible]86
	(81) (P2)	PERM OF LEAKAGE PATH 2	7.0[illegible]90
	(82) (P3)	PERM OF LEAKAGE PATH 3	6.38260
	(83) (P4)	PERM OF LEAKAGE PATH 4	[illegible].36[illegible]30
	(84) (P5)	PERM OF LEAKAGE PATH 5	8.50000
	(86) (P7)	PERM OF LEAKAGE PATH 7	37.20000
	(180) (FSC)	SHORT CIR NI	1762.57800
	(181) (SCR)	SHORT CIR RATIO	.23694

Value	Item	No.	Symbol	Group
1.04650	CARTER COEFFICIENT	(67)	(K_s)	CONSTANTS
.02302	EFFECTIVE AIR GAP	(69)	(g_e)	
1.06426	FUND/MAX OF FLD. FLUX	(71)	(C_1)	
.41913	WINDING CONST.	(72)	(C_w)	
.65205	POLE CONST.	(73)	(C_p)	
3.80987	END. EXT. ONE TURN	(48)	(LE)	
.86485	DEMAGNETIZING FACTOR	(74)	(C_M)	
.40320	CROSS MAGNETIZING FACTOR	(75)	(C_q)	
992.94000	AMP COND IN	(128)	(A)	REACTANCE
4.33571	REACTANCE FACTOR	(129)	(X)	
134.53218	LEAKAGE REACTANCE	(130)	(X_ℓ)	
340.19923	REACTANCE OF ARMATURE REACTION	(131)	(X_{ad})	
149.03552		(132)	(X_{aq})	
474.73141	SYN REACT DIRECT AXIS	(133)	(X_d)	
283.56770	SYN REACT QUAD AXIS	(134)	(X_q)	
329.29340	FIELD LEAKAGE REACT	(160)	(X_f)	
.27932	FIELD SELF INDUCTANCE	(161)	(L_f)	
463.82558	UNSAT. TRANS. REACT	(166)	(X'_{du})	
408.16651	SAT. TRANS. REACT	(167)	(X'_d)	
408.16651	SUB. TRANS. REACT DIRECT AX.	(168)	(X''_d)	
283.56770	SUB. TRANS REACT QUAD AX.	(169)	(X''_q)	
345.86711	NEG SEQUENCE REACT	(170)	(X_2)	
66.43164	ZERO SEQUENCE REACT	(171)	(X_0)	
.19[illegible]8[illegible]	OPEN CIR. TIME CONS	(176)	(T'_{do})	TIME CONST.
.0191[illegible]	ARM TIME CONST.	(177)	(T_a)	
.16[illegible]	TRANS TIME CONST	(178)	(T'_d)	
.[illegible]16[illegible]	SUB TRAN TIME CONST	(179)	(T''_d)	
[illegible]50.97000	TOTAL FLUX	(90)	[illegible]	MAGNETIZATION
59.71900	FLUX PER POLE	(93)	(ϕ_p)	
14.69600	GAP DENSITY (MAIN)	(95)	(B_g)	
29.74500	TOOTH DENSITY	(91)	(B_T)	
13.77800	CORE DENSITY	(94)	(B_c)	
.57943	TOOTH AMPERE TURNS	(97)	(F_t)	
.45081	CORE AMPERE TURNS	(98)	(F_c)	
106.06000	GAP AMPERE TURNS (MAIN)	(96)	(F_g)	

VARIABLE LOAD — PERCENT LOAD	0		100	150	200	OPTIONAL
(ϕ_ℓ) (100a) LEAKAGE FLUX	45.555	($\phi_{\ell f}$) (197a)	[illegible]1.5[illegible]	.000	.000	.000
(ϕ_{pt}) (102a) TOTAL FLUX/POLE	[illegible].[illegible]11	(ϕ_{ptf}) (213a)	121.58[illegible]	.000	.000	.000
(B_p) (103a) POLE DENSITY	42.[illegible]	(B_{pf}) (213b)	108.550	.000	.000	.000
(B_{g2}) (122) AUX GAP (g2) DENSITY	12.778	(B_{g2fl}) (224)	[illegible].66[illegible]	.000	.000	.000
(B_{g3}) (119) AUX GAP (g3) DENSITY	12.607	(B_{g3fl}) (230)	[illegible].21[illegible]	.000	.000	.000
(B_{sh}) (113) SHAFT DENSITY	30.[illegible]	(B_{shl}) (232)	36.5[illegible]	.000	.000	.000
(F_{nl}) (127) TOTAL NI	417.[illegible]	(F_{fl}) (236)	2161.600	.000	.000	.000
(I_{fnl}) (127a) FIELD AMPERES	1.176	(I_{ffl}) (237)	6.089	.000	.000	.000
(S_f) (127c) CUR. DEN. FLD.	58[illegible].7[illegible]	( ) (239)	3005.800	.000	.000	.000
(E_{fnl}) (127b) FIELD VOLTS	1.7[illegible]1	(E_{ffl}) (238)	10.926	.000	.000	.000
(W_c) (185) STA CORE LOSS	1.531	(W_c) (185)	1.531	1.531	1.531	1.531
(W_{tnl}) (184) STA TOOTH LOSS	1.972	(W_{tfl}) (242)	8.455	.000	.000	.000
(I^2R_s) (194) STATOR CU LOSS	.000	(I^2R_s) (245)	1010.889	.000	.000	.000
(-) (195) EDDY LOSS	.000	(-) (246)	19.813	.000	.000	.000
(W_{pnl}) (186) POLE FACE LOSS	2.394	(W_{pfl}) (243)	45.702	.000	.000	.000
(I^2R_f) (182) FIELD COIL LOSS	2.036	(I^2R_f) (241)	66.533	.000	.000	.000
(F&W) (183) F&W LOSS	32.325	(F&W) (183)	32.325	32.325	32.325	32.325
(-) (196) TOTAL LOSSES	40.259	(-) (247)	1185.250	.000	.000	.000
(-) (-) PERCENT EFF.	.000	(-) (251)	66.052	.000	.000	.000

DESIGNER ______ DATE ______ REV. A

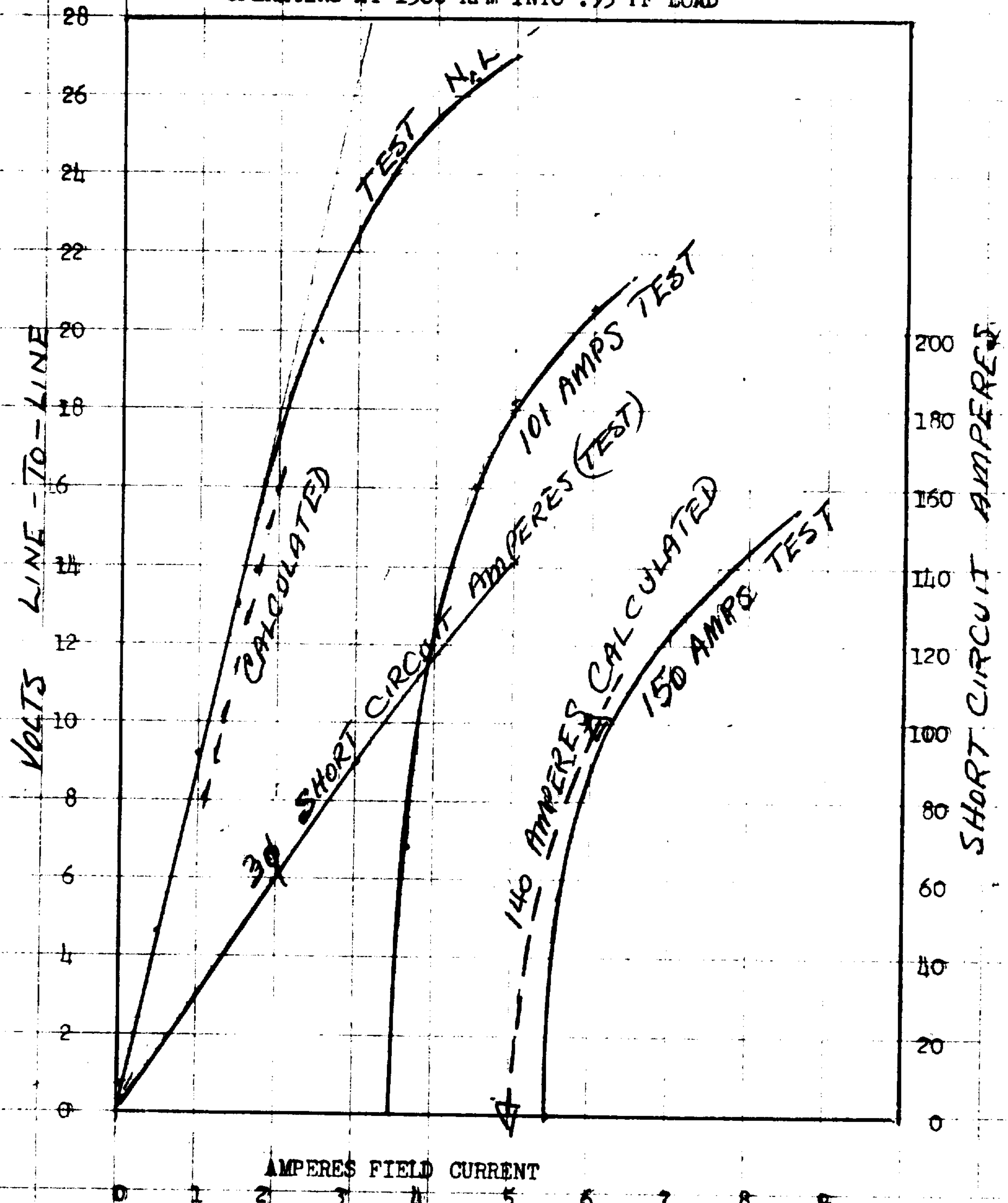
ORIGINAL PAGE IS OF POOR QUALITY

INSIDE-COIL, STATIONARY-COIL LUNDELL

NO LOAD SATURATION OUTPUT SHEET

ITEMS % VOLTS	(3) (E) VOLTS (102a) ϕ_{pt} TOTAL FLUX/POLE	(96) F_g GAP N.I. (103a) B_p POLE DENSITY	(91) B_t STA. TOOTH DENSITY (122) B_{g2} DENSITY g2	(97) F_t STATOR TOOTH N.I. (119) B_{g3} DENSITY g3	(94) (B_c) STA CORE DENSITY (113) B_{sh} SHAFT DENSITY	(98) F_c STA. CORE N.I. (127) F_{nl} TOTAL N.I.
80%	8.00000 37.85231	84.84800 33.79671	23.79440 10.22491	.48028 10.08810	11.02240 29.02610	.4132 336.9904
90%	9.00000 42.58176	95.45400 38.01943	26.76870 11.50159	.52753 11.34770	12.40020 32.64924	.43163 377.2471
100%	10.00000 47.31157	106.06000 42.24247	29.74300 12.77849	.57943 12.60752	13.77800 36.27317	.45081 417.64480
110%	11.00000 52.04177	116.66600 46.46587	32.71730 14.05564	.63643 13.86758	15.15580 39.89796	.47063 458.30107
120%	12.00000 56.77240	127.27200 50.68964	35.69160 15.33306	.69904 15.12790	16.53360 43.52370	.49175 499.2336
130%	13.00000 61.50350	137.87800 54.91384	38.66590 16.61076	.76782 16.38851	17.91140 47.15045	.5136 540.4642
140%	14.00000 66.23549	148.48400 59.13883	41.64020 17.88888	.84659 17.64953	19.28920 50.77863	.5364 582.028
150%	15.00000 70.96845	159.09000 63.36469	44.61450 19.16797	.94251 18.91150	20.66700 54.41043	.560 624.57019
160%	16.00000 75.70219	169.69600 67.59124	47.58880 20.44771	1.04683 20.17412	22.04480 58.04462	.585 667.77725

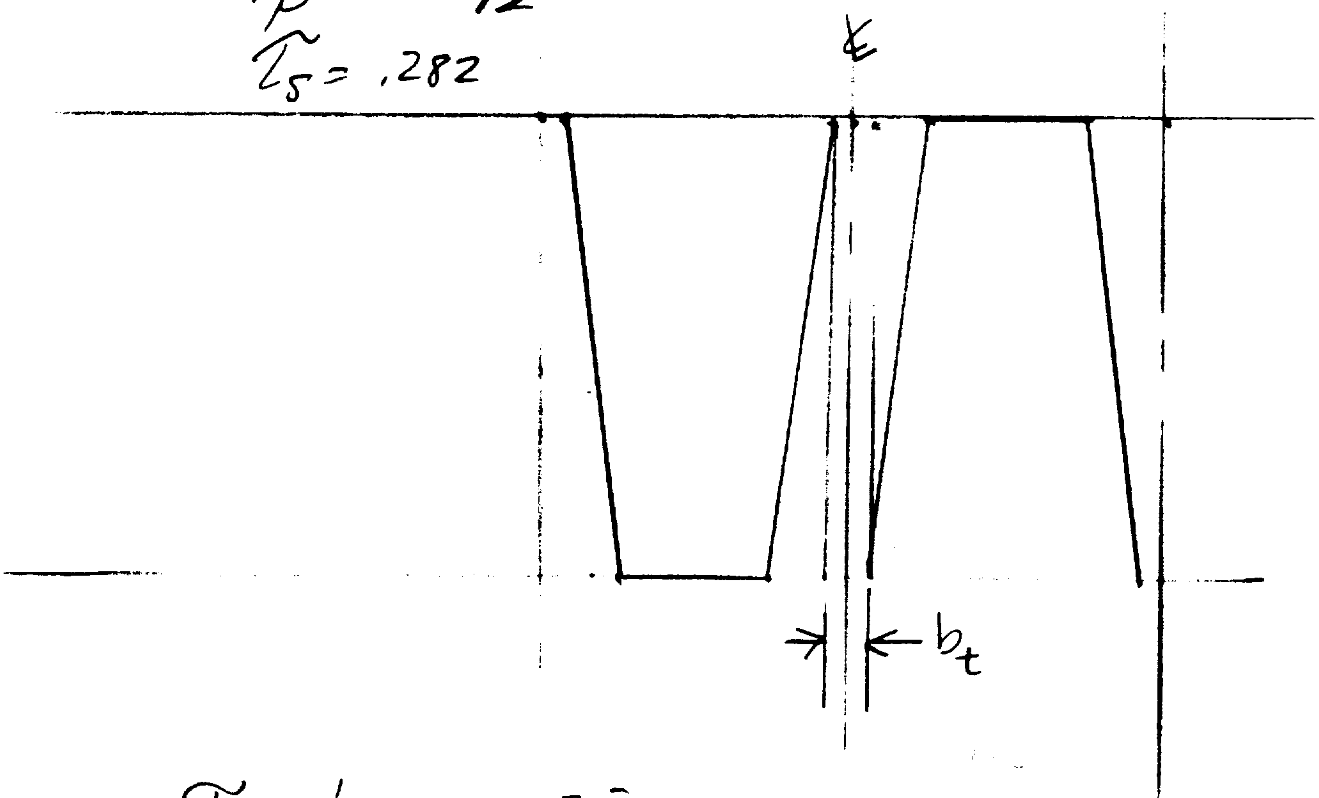
TEST SATURATION AND CALCULATED SATURATION
FOR AN INSIDE-COIL, STATIONARY-COIL LUNDELL
OPERATING AT 1360 RPM INTO .95 PF LOAD



$b_p = 1.45$

$\tau_p = \dfrac{6.42"}{12} = 1.68$

$\tau_s = .282$



$\tau_p - b_p = .23$

$b_t = .282 - .04 = .242$

IN THIS DESIGN, THE TOOTH TOP JUST BARELY BRIDGES THE GAP AND THE LEAKAGE PERMEANCE, ITEM (64a) SHOULD BE ESTIMATED

$\sigma_Z = \text{APPROX.} \dfrac{(.1 \times 1.0)}{.02} = 5$

$\lambda_Z = \dfrac{22}{6}(5) = 18.2$

COMPUTER PROCEDURE FOR

INSIDE COIL LUNDELL DESIGN CALCULATIONS

1. Clear core (no switch control).
2. Insert output Form #1 into typewriter, set margin for correct output.
3. Load pass #1 followed by input #1 (output printed plus punched cards).
4. Reset and load pass #2 followed by output from pass #1 (output punched cards).
5. Reset and load pass #3 followed by output from pass #2 (output punched cards).
6. Reset and load pass #4 followed by output from pass #3(output punched cards).
7. Reset and load pass #5 followed by saturation curve values* and output from pass #4 (output punched cards).
8. Reset and load pass #6 followed by output from pass #5 (output printed plus punch cards).
9. Reset and load pass #7 followed by output from pass #6 (output punched cards).
10. Reset and load pass #8 followed by saturation curve values* and output from pass #7 (output punched cards).
11. Reset and load pass #9 followed by output from pass #8 (output printed plus punched cards if no load saturation curve required).
12. If there is punch card output from pass #9 a no load saturation curve is required. Insert output Form #2 into typewriter and reset margin. Load pass #10 followed by saturation curve values and output from pass #9 (output printed).

* Saturation curves are loaded in order shown on Input Form #1.

INPUT PARAMETERS INSIDE STATIONARY COIL

3.46	10.0	5.78	3.0	120.	12.	1360.	150.	1.0	1.1
1.6	6.462	8.475	2.45	0.	0.	.97	3.	77.4	2.
.040	0.	0.	0.	.15	.015	.335	0.	0.	.4
0.	.02	72.	1.	.1.	2.	6.	1.	.15	1.
1.	.1	.25	.25	.15	.185	60.	0.	75.	.694
1.6	4.55	5.36	.022	.02	.02	0.	0.	0.	0.
0.	0.	.635	.84	1.4	.1	.8	2.45	6.419	0.
7.	3.2	4.	0.	0.	0.	0.	8.5	37.2	.7
.5	.6	4.3	1.6	355.	12.1	.0508	0.	75.	.694
1.	0.	18.2							

SATURATION CURVE (STATOR LAM. MATERIAL)

132.	18.	1.	40.	2.	66.
5.	76.	8.	85.	14.5	102.
101.	114.	300.	132.	1000.	

SATURATION CURVE (POLE MATERIAL)

140.	0.	1.6	10.	2.3	20.
3.3	30.	4.2	60.	7.3	70.
9.2	80.	12.5	85.	15.	90.
20.	100.	40.	108.	100.	112.
160.	126.	500.	140.	1000.	

SATURATION CURVE (SHAFT MATERIAL)

140.	0.	1.6	10.	2.3	20.
3.3	30.	4.2	60.	7.3	70.
9.2	80.	12.5	85.	15.	90.
20.	100.	40.	108.	100.	112.
160.	126.	500.	140.	1000.	

ALL INPUT PARAMETERS ARE IN FORMAT F7.0 (FIG. 1)

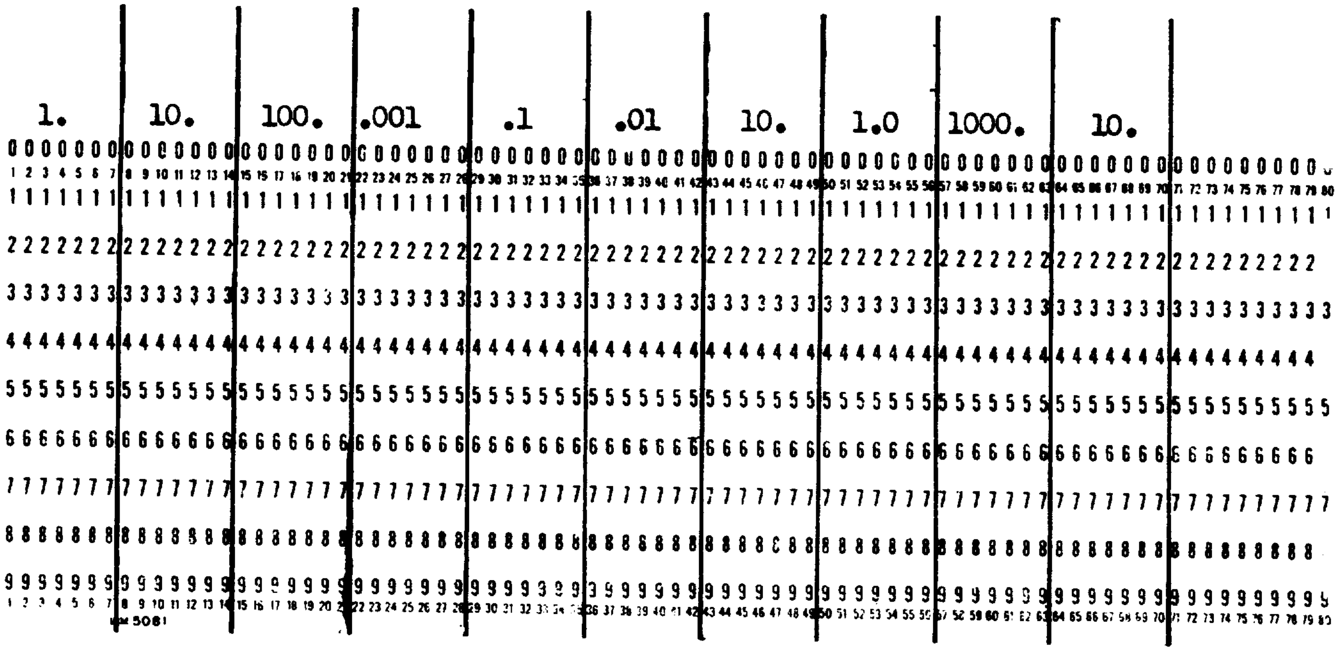


FIG. 1

ALL SATURATION CURVE VALUES ARE IN FORMAT F10.0 (FIG. 2)
(ALL SATURATION CURVES MUST HAVE 5 CARDS)

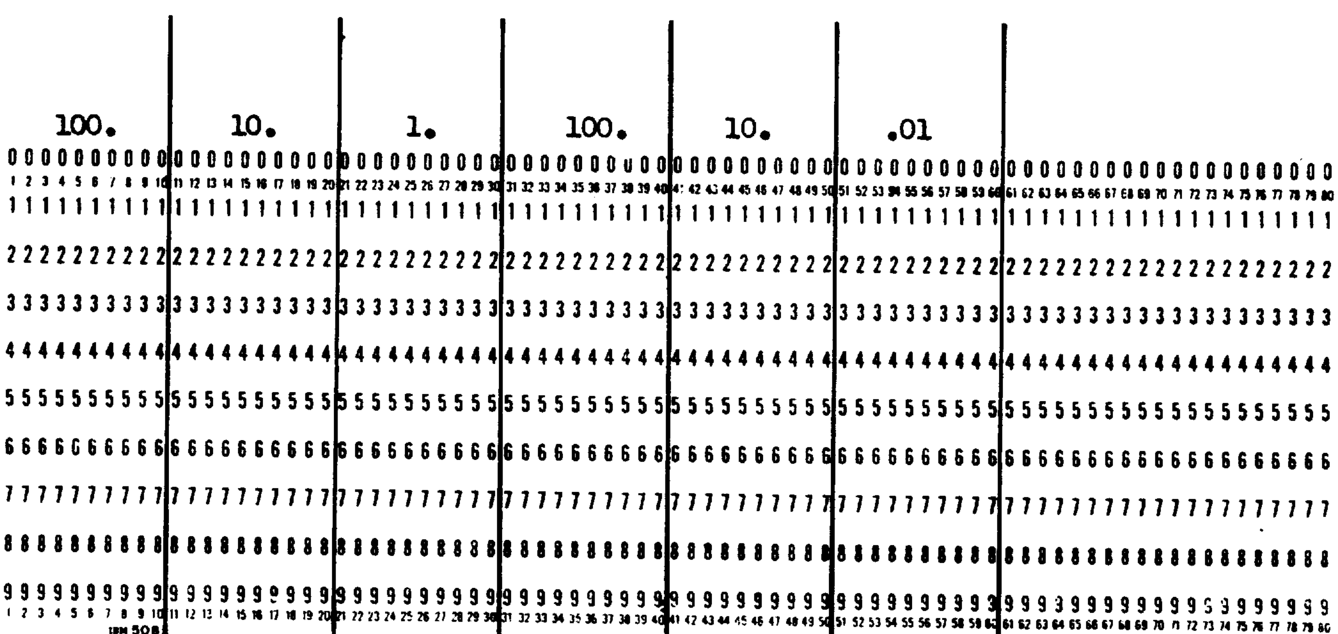


FIG. 2

INSIDE-COIL, STATIONARY-COIL LUNDELL

Calculation Number	Electrical Symbol	Fortran Symbol
	A, a	
(128)	A	A
(46)	a_c	AC
(153)	a_{cf}	AS
(68)	A_g	GA
(70)	A_{g2}	A2
(70a)	A_{g3}	A3
(79)	a_p	AP
(112)	a_s	AS
	B, b	
(20)	B	BK
(22)	b_o	BO
(94)	$B_{c'}$	BC1
(76)	b_{p1}	BP1
(76)	b_{p2}	BP2
(95)	$B_{g'}$	BG1
(122)	B_{g2}	BG2
(119)	B_{g3}	BG3
(224)	B_{g2FL}	BG2L

Calculation Number	Electrical Symbol	Fortran Symbol
(230)	B_{g3FL}	BG3L
(103)	B_p	BP
(213a)	B_{pl}	BPL
(22)	b_s	BS
(57a)	$b_{t\ 1/3}$	SM
(91)	B_T	BT1
(57)	b_{tm}	TM
(15)	b_v	BV
(113)	B_{SH}	BSH
(232)	B_{SHL}	BSHL

C, c

Calculation Number	Electrical Symbol	Fortran Symbol
(32)	c	C
(71)	C_1	C1
(74)	C_M	CM
(73)	C_P	CP
(75)	C_q	CQ
(72)	C_W	CW

Calculation Number	Electrical Symbol	Fortran Symbol
		D, d
(12)	D	DU
(11)	d	DI
(35)	d_b	DB
(78)	d_{g2}	DG2
(78)	d_{g3}	DG3
(78)	d_{oc}	DC1
(11a)	d_r	DR
(78)	d_s	DS1
		E, e
(3)	E	EE
(55)	EF_{TOP}	ET
(56)	EF_{BOT}	EB
(238)	E_{FFL}	EPFL
(127b)	E_{FNL}	EPNL
(4)	E_{PH}	EP
		F, f
(5a)	f	F
(98)	F_c	FC
(236)	F_{FL}	FFL

Calculation Number	Electrical Symbol	Fortran Symbol
(96)	F_g	FG
(123)	F_{g2}	FG2
(225)	$F_{g2\,FL}$	FG2 L
(120)	F_{g3}	FG3
(231)	$F_{g3\,FL}$	FG3 L
(127)	F_{NL}	FNL
(104)	F_p	FP
(213c)	F_{pl}	FPL
(180)	F_{SC}	FSC
(97)	F_T	FT
(183)	F & W	WF
(114)	F_{SH}	FSH
(233)	F_{SHL}	FSHL
		G, g
(59)	g	GC
(59a)	g_2	G2
(59c)	g_3	G3
(69)	g_e	GE

Calculation Number	Electrical Symbol	Fortran Symbol
	H, h	
(24)	h_c	HC
(38)	h'_{ST}	SD
(39)	h_{ST}	SH
	I, i	
(237)	I_{FFL}	AIFL
(127a)	I_{FNL}	AINL
(8)	I_{PH}	PI
(132)	I^2R_F	FEL
(241)	I^2R_{FL}	FCUL
(194)	I^2R	PS
(245)	I^2R_S	SCUL
	K, k	
(19)	k	WL
(9a)	K_c	CK
(43)	K_d	DF
(63)	K_e	EK
(16)	K_i	SF
(44)	K_p	CF

Calculation Number	Electrical Symbol	Fortran Symbol
(67)	K_S	CC
(42)	K_{SK}	FS
(2)	K_{VA}	VA
(61)	K_X	FF
	L, l	
(13)	ℓ	CL
(80a)	ℓ_1	AL1
(81a)	ℓ_2	AL2
(82a)	ℓ_3	AL3
(76)	ℓ_{co}	ALCO
(48)	L_E	EL
(36)	ℓ_{e2}	CE
(161)	L_F	SI
(78)	ℓ_{g3}	ALG3
(17)	ℓ_g	SS
(49)	ℓ_t	HM
(147)	ℓ_{tf}	FE
(78)	ℓ_{SH}	ALSH

Calculation Number	Electrical Symbol	Fortran Symbol
	M, m	
(5)	m	PN
	N, n	
(146)	n_f	PT
(45)	n_e	EC
(30)	n_s	SC
(34)	N_{ST}	SN
(34a)	N'_{ST}	SN1
(14)	n_v	HV
	P, p	
(6)	p	PX
(9)	PF	PF
(80)	P_1	P1
(81)	P_2	P2
(82)	P_3	P3
(83)	P_4	P4
(84)	P_5	P5
(86)	P_7	P7
	Q, q	
(23)	Q	QQ
(25)	q	QN

Calculation Number	Electrical Symbol	Fortran Symbol
(154)	R_f (cold)	FK
(155)	R_f (hot)	FR
(7)	RPM	RPM
(53)	R_{SPH} (cold)	RG
(54)	R_{SPH} (hot)	RP
	S, s	
(181)	SCR	SCR
(127c)	S_F	CD
(47)	S_S	S
	T, t	
(177)	T_a	TA
(178)	T'_d	T5
(176)	T'_{do}	TC
(76)	t_{p1}	TP1
(76)	t_{p2}	TP2
	V, v	
(145)	V_r	VR
	W, w	
(185)	W_C	WQ
(186)	W_{NPL}	WN

Calculation Number	Electrical Symbol	Fortran Symbol
(243)	W_{PFL}	WNL
(242)	W_{TFL}	WTFL
(184)	W_{TNL}	WT

X, x

Calculation Number	Electrical Symbol	Fortran Symbol
(129)	X	XR
(131)	X_{ad}	XD
(132)	X_{aq}	XQ
(133)	X_d	XA
(167)	X_d'	XS
(168)	X_d''	XX
(166)	X_{du}'	XU
(160)	X_F'	XF
(150)	X_f °C	T2
(130)	X_ℓ	XL
(169)	X_q''	XY
(134)	X_q	XB
(50)	X_s °C	TI
(170)	X_2	XN
(172)	X_o	XO

Calculation Number	Electrical Symbol	Fortran Symbol
		Y, y
(31)	y	YY
(108)	ϕ_{g2}	PG2
(100)	ϕ_{ℓ}	PL
(221)	ϕ_{g2}	PG2 L
(118)	$\phi_{\ell 5}$	PL5
(99)	$\phi_{\ell 7}$	PL7
(193a)	$\phi_{\ell\ell}$	PLL
(226)	ϕ_{5L}	PL5 L
(207)	ϕ_{7L}	PL7 L
(92)	ϕ_{p}	FQ
(213)	ϕ_{PL}	FQ L
(102)	ϕ_{PT}	
(213a)	ϕ_{PTL}	PTLL
(111)	ϕ_{SH}	PSH
(88)	ϕ_{T}	TG
		τ
(41)	τ_{p}	TP
(26)	τ_{s}	TS
(40)	τ_{SK}	SK
(27)	$\tau_{S\ 1/3}$	TT

Calculation Number	Electrical Symbol	Fortran Symbol
	λ	
(64)	λ_E	EW
(159)	λ_{pt}	BE
(62)	λ_i	PC
(64a)	λ_z	ALZ
	φ	
(151)	φ_f	RR
(152)	$\varphi_{f\,(hot)}$	
(51)	φ_s	RS
(52)	$\varphi_{s\,(hot)}$	
	α	
(77)	α	PE

```
C      PASS 1  INSIDE COIL
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
    2 FORMAT(F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0)
    3 FORMAT(9X F12.5,2X F12.5)
    7 READ2,VA,EE,EP,PN,F,PX,RPM,PI,PF,CK
      READ2,POL,DI,DU,CL,HV,BV,SF,WL,BK,ZZ
      READ2,BO,B1,B2,B3,BS,HO,HX,HY,HZ,HS
      READ2,HT,HW,QQ,W,RF,SC,YY,C,DW,SN
      READ2,SN1,DW1,DB,CE,SH,SD,PBA,SK,T1,RS
      READ2,ALG3,DG3,DG2,GC,G2,G3,C1,CW,CP,EL
      READ2,CM,CQ,PE,BP1,BP2,TP1,TP2,ALP,DR,WR
      READ2,D1,DS1,ALSH,P1,P2,P3,P4,P5,P7,AL1
      READ2,AL2,AL3,DC1,ALCO,PT,FE,RD,RT,T2,RR
      READ2,SNL,WF,ALZ
      SS=SF*(CL-HV*BV)
      HC=(DU-DI-2.0*HS)*0.5
      QN=QQ/(PX*PN)
      TS=3.142*DI/QQ
      IF(ZZ-4.0)9,10,9
    9 TT=(0.667*HS+DI)*3.142/QQ
      GO TO 11
   10 TT=3.1416*(DI+2.*HO+1.32*BS)/QQ
   11 IF(ZZ-1.0)12,12,13
   12 BO=BS
      CC=(5.*GC+BS)*TS/((5.*GC+BS)*TS-BS*BS)
      GO TO 14
   13 QC=(4.44*GC+0.75*BO)*TS
      CC=QC/(QC-BO*BO)
   14 CS=YY/(PN*QN)
```

```
      TP=3.1416*DI/PX
      IF(SK)18,18,19
   18 FS=1.0
      GO TO 20
   19 FS=SIN(1.571*SK/TP)*TP/(1.571*SK)
   20 IF(PBA-60.)21,21,22
   21 D=1.0
      GO TO 95
   22 D=2.0
   95 I=QN
      U=I
      IF(QN-U)23,23,24
   24 U=PX*PN
      XX=U
      N=U
      DO 25 K=1,N
      Z=U/XX
      I=Z
      Z1=I
      IF(Z-Z1)26,26,25
   26 ZY=QQ/XX
      I=ZY
      Z1=I
      IF(ZY-Z1)27,27,25
   25 XX=XX-1.
   23 ZY=QN
   27 DF=SIN(.5236*D)/(ZY*D*SIN(.5236/ZY))
      CF=SIN(YY*.5236/QN)
      EC=QQ*SC*CF*FS/C
```

```
      GE=CC*GC
      IF(C1)29,28,29
28    C1=0.649*LOG(PE)+1.359
29    IF(CW)30,30,31
30    CW=.23566*EE*C1*DF/EP
31    IF(CP)32,32,33
32    CP=PE*(LOG(GC/TP)*.0378+1.191)
33    IF(EL)34,34,42
34    IF(RF)35,35,41
35    IF(PX-2.0)36,36,37
36    U=1.3
      GO TO 40
37    IF(PX-4.0)38,38,39
38    U=1.5
      GO TO 40
39    U=1.7
40    EL=3.142*U*YY*(DI+HS)/QQ+0.5
      GO TO 42
41    EL=2.0*CE+3.142*(0.5*HX+DB)+YY*TS*TS/SQRT(TS*TS-BS*BS)
42    AA=1.571*PE
      AB=3.142*PE
      IF(CM)43,43,44
43    CM=(AB+SIN(AB))/(SIN(AA)*4.)
44    IF(CQ)45,45,46
45    CQ=(0.5*COS(AA)+AB-SIN(AB))/(4.0*SIN(AA))
46    RB=(T1+234.5)*0.00394*RS
      PRINT3,SS,CC,HC,GE,TS,C1,TT,CW,FS,CP,DF,EL,CF,CM,EC,CQ
      PUNCH1,VA,EE,EP,PN,F,PX
      PUNCH1,RPM,PI,PF,CK,POL,DI
```

```
PUNCH1,DU,CL,SS,HC,SF,QN
PUNCH1,WL,BK,ZZ,BO,B1,B2
PUNCH1,B3,BS,HO,HX,HY,HZ
PUNCH1,HS,HT,HW,QQ,W,RF
PUNCH1,SC,YY,C,TS,SN,DB
PUNCH1,CE,SH,SD,TT,SK,RB
PUNCH 1, ALCO,TP,D1,FE,RD,RT
PUNCH1,T2,RR,SNL,WF,PE,SN1
PUNCH1,DW1,BP1,BP2,TP1,TP2,ALP
PUNCH1,DR,WR,DS1,ALSH
PUNCH1,P1,P2,P3,P4,P5,P7
PUNCH1,RS,GC,PT,C1,CW,CP
PUNCH1,EL,CM,CQ,DW,CC,PBA
PUNCH1,GE,CS,CF,FS,EC,DF
PUNCH1,ALG3,DC1,DG3,DG2,AL1,AL2
PUNCH1,AL3,ALCO,G2,G3,ALZ
PAUSE
END
```

```
C     PASS 2  INSIDE COIL
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      DIMENSION DA(8),DX(6),DY(8),DZ(8)
      READ1 ,VA,EE,EP,PN,F,PX
      READ1 ,RPM,PI,PF,CK,POL,DI
      READ1 ,DU,CL,SS,HC,SF,QN
      READ1 ,WL,BK,ZZ,BO,B1,B2
      READ1 ,B3,BS,HO,HX,HY,HZ
      READ1 ,HS,HT,HW,QQ,W,RF
      READ1 ,SC,YY,C,TS,SN,DB
      READ1 ,CE,SH,SD,TT,SK,RB
      READ1 ,  ALCO,TP,D1,FE,RD,RT
      READ1 ,T2,RR,SNL,WF,PE,SN1
      READ1 ,DW1,BP1,BP2,TP1,TP2,ALP
      READ 1,DR,WR,DS1,ALSH
      READ1 ,P1,P2,P3,P4,P5,P7
      READ1 , RS,GC,PT,C1,CW,CP
      READ1 , EL,CM,CQ,DW,CC,PBA
      READ1 , GE,CS,CF,FS,EC,DF
      READ1 ,ALG3,DC1,DG3,DG2,AL1,AL2
      READ 1,AL3,ALCO,G2,G3,ALZ
      DT=DW1
      IF(ZZ-3.0)49,50,51
   49 SM=TT-BS
      GO TO 53
   50 SM=(3.1416*(DI+2.*HS)/QQ)-B3
      GO TO 53
   51 IF(ZZ-4.0)50,52,49
   52 SM=TT-.94*BS
```

```
53 HM=CL+EL
   IF(DT) 61,61,62
61 AC=0.785*DW*DW*SN1
   GO TO 72
62 ZY=0.0
   DA(1)=0.05
   DA(2)=0.072
   DA(3)=0.125
   DA(4)=0.165
   DA(5)=0.225
   DA(6)=0.438
   DA(7)=0.688
   DA(8)=1.5
   DX(1)=0.000124
   DX(2)=0.00021
   DX(3)=0.00021
   DX(4)=0.00084
   DX(5)=0.00189
   DX(6)=0.00189
   DY(1)=0.000124
   DY(2)=0.000124
   DY(3)=0.00084
   DY(4)=0.00084
   DY(5)=0.00189
   DY(6)=0.00335
   DY(7)=0.00754
   DY(8)=0.03020
   DZ(1)=0.000124
   DZ(2)=0.000124
```

```
      DZ(3)=0.000124
      DZ(4)=0.00335
      DZ(5)=0.00335
      DZ(6)=0.00754
      DZ(7)=0.0134
      DZ(8)=0.0302
   63 IF(DT-.05)201,201,200
  200 JA=0
      JB=0
      JC=0
      JD=0
   64 JA=JA+1
      JB=JB+1
      JC=JC+1
      JD=JD+1
      IF(DT-DA(JA))65,65,64
  201 D=0
      IF(ZY)71,71,54
   65 IF(DW-0.188)66,66,67
   66 CY=DX(JB-1)
      CZ=DX(JB)
      GO TO 70
   67 IF(DW-0.75)68,68,69
   68 CY=DY(JC-1)
      CZ=DY(JC)
      GO TO 70
   69 CY=DZ(JD-1)
      CZ=DZ(JD)
   70 D=CY+(CZ-CY)*(DT-DA(JA-1))/(DA(JA)-DA(JA-1))
```

```
      IF(ZY)71,71,54
   71 AC=(DT*DW-D)*SN1
   72 IF(RT)73,73,74
   73 AS=0.785*RD*RD
      GO TO 55
   74 ZY=1.0
      DT=RT
      DW=RD
      GO TO 63
   54 AS=RT*RD-D
   55 S=PI/(C*AC)
      CY=PT   *FE*0.000001/AS
      FK=RR*CY
      FR=(T2+234.5)*FK*0.00394
      RC=0.321*PT   *FE*AS
      IF(SH)202,203,202
  203 ET=1
      EB=1
      GO TO 204
  202 AA=0.584+(SN*SN-1.0)*0.0625*(SD*CL/(SH*HM))**2.0
      AB=(SH*SC*F*AC/(BS*RB))**2.0
      ET=AA*AB*0.00335+1.0
      EB=ET-0.00168*AB
  204 RY=SC*QQ*0.000001*HM/(PN*AC*C*C)
      RG=RS*RY
      RP=RB*RY
      A=PI*SC*CF/(C*TS)
      PUNCH1,VA,EE,EP,PN,F,PX
      PUNCH1,RPM,PI,PF,CK,POL,DI
```

```
PUNCH1,DU,CL,SS,HC,SF,QN
PUNCH1,WL,BK,ZZ,BO,B1,B2
PUNCH1,B3,BS,HO,HX,HY,HZ
PUNCH1,HS,HT,HW,QQ,W,RF
PUNCH1,SC,YY,C,TS,SN,DB
PUNCH1,CE,SH,SD,TT,SK,RB
PUNCH1,  ALCO,TP,D1,FE,RD,RT
PUNCH1,T2,RR,SNL,WF,PE,SN1
PUNCH1,DW1,BP1,BP2,TP1,TP2,ALP
PUNCH1,DR,WR,DS1,ALSH,ALZ
PUNCH1,P1,P2,P3,P4,P5,P7
PUNCH1, RS,GC,PT,C1,CW,CP
PUNCH1, EL,CM,CQ,DW,CC,PBA
PUNCH1, GE,CS,CF,FS,EC,DF
PUNCH1,ALG3,DC1,DG3,DG2,AL1,AL2
PUNCH1,AL3,ALCO,G2,G3,A
PUNCH1,HM,SM,AS,AC,ET,EB
PUNCH1,S,FK,FR,RC,RG,RP
PAUSE
END
```

```
C     PASS 3  INSIDE COIL
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      READ1 ,VA,EE,EP,PN,F,PX
      READ1 ,RPM,PI,PF,CK,POL,DI
      READ1 ,DU,CL,SS,HC,SF,QN
      READ1 ,WL,BK,ZZ,BO,B1,B2
      READ1 ,B3,BS,HO,HX,HY,HZ
      READ1 ,HS,HT,HW,QQ,W,RF
      READ1 ,SC,YY,C,TS,SN,DB
      READ1 ,CE,SH,SD,TT,SK,RB
      READ1 ,  ALCO,TP,D1,FE,RD,RT
      READ1 ,T2,RR,SNL,WF,PE,SN1
      READ1 ,DW1,BP1,BP2,TP1,TP2,ALP
      READ 1,DR,WR,DS1,ALSH,ALZ
      READ1 ,P1,P2,P3,P4,P5,P7
      READ1 , RS,GC,PT,C1,CW,CP
      READ1 , EL,CM,CQ,DW,CC,PBA
      READ1 , GE,CS,CF,FS,EC,DF
      READ1 ,ALG3,DC1,DG3,DG2,AL1,AL2
      READ1 ,AL3,ALCO,G2,G3,A
      READ 1,HM,SM,AS,AC,ET,EB
      READ 1,S,FK,FR,RC,RG,RP
      IF(PBA-60.0)105,105,108
  105 IF(CS-0.667)106,106,107
  106 FF=0.25*(6.0*CS-1.0)
  107 FF=0.25*(3.*CS+1.0)
      GO TO 75
  108 IF(CF-0.667)109,109,110
  109 FF=0.05*(24.0*CS-1.0)
```

```
      GO TO 75
  110 FF=0.75
   75 CX=FF/(CF*CF*DF*DF)
      Z=CX*20.0/(PN*QN)
      BT=3.142*DI/QQ-BO
      ZA=BT*BT/(16.0*TS*GC)
      ZB=0.35*BT/TS
      ZC=HO/BO
      ZD=HX*0.333/BS
      ZE=HY/BS
      IF(ZZ-2.0) 76,77,78
   76 PC=Z*(ZE+ZD+ZA+ZB)
      GO TO 82
   77 PC=Z*(ZC+(2.0*HT/(BO+BS))+(HW/BS)+ZD+ZA+ZB)
      GO TO 82
   78 IF(ZZ-4.0) 79,80,81
   79 PC=Z*(ZC+(2.0*HT/(BO+B1))+(2.0*HW/(B1+B2))+(HX*0.333/B2)+ZA+ZB)
      GO TO 82
   80 PC=Z*(ZC+0.62)
      GO TO 82
   81 PC=Z*(ZE+ZD+(0.5*GC/TS)+(0.25*TS/GC)+0.6)
   82 EK=EL/(10.0**(0.103*YY*TS+0.402))
      IF(DI-8.0) 83,83,84
   83 EK=SQRT(EK)
   84 ZF=.612*LOG(10.0*CS)
      EW=6.28*EK*ZF*(TP**(0.62-(0.228*LOG(ZF))))/(CL*DF*DF)
   87 ZA=3.1416*(DI+HS)/QQ
      IF(ZZ-3.0) 88,89,88
   88 TM=ZA-BS
```

```
      GO TO 90
   89 TM=(3.1416*(DI+2.*HS)/QQ)-B3
   90 WI=(TM*QQ*SS*HS+(DU-HC)*3.142*HC*SS)*0.283
      IF(WF)445,446,445
  446 WF=2.52E-6*(DR**2.5)*ALP*RPM**1.5
  445 WC=.321*HM*QQ*AC*SC
      PUNCH1,VA,EE,EP,PN,F,PX
      PUNCH1,RPM,PI,PF,CK,POL,DI
      PUNCH1,DU,CL,SS,HC,SF,QN
      PUNCH1,WL,BK,ZZ,B0,B1,B2
      PUNCH1,B3,BS,HO,HX,HY,HZ
      PUNCH1,HS,HT,HW,QQ,W,RF
      PUNCH1,SC,YY,C,TS,SN,DB
      PUNCH1,CE,SH,SD,TT,SK,RB
      PUNCH1,  ALCO,TP,D1,FE,RD,RT
      PUNCH1,T2,RR,SNL,WF,PE,SN1
      PUNCH1,DW1,BP1,BP2,TP1,TP2,ALP
      PUNCH1,DR,WR,DS1,ALSH
      PUNCH1,P1,P2,P3,P4,P5,P7
      PUNCH1, RS,GC,PT,C1,CW,CP
      PUNCH1, EL,CM,CQ,DW,CC,PBA
      PUNCH1, GE,CS,CF,FS,EC,DF
      PUNCH1,ALG3,DC1,DG3,DG2,AL1,AL2
      PUNCH1,AL3,ALCO,G2,G3,A
      PUNCH1,HM,SM,AS,AC,ET,EB
      PUNCH1,S,FK,FR,RC,RG,RP
      PUNCH1,FF,CX,PC,EK,EW,TM
      PUNCH1,WI,WC,ALZ
      PAUSE
```

END

```
C     PASS 4  INSIDE COIL
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      READ1 ,VA,EE,EP,PN,F,PX
      READ1 ,RPM,PI,PF,CK,POL,DI
      READ1 ,DU,CL,SS,HC,SF,QN
      READ1 ,WL,BK,ZZ,BO,B1,B2
      READ1 ,B3,BS,HO,HX,HY,HZ
      READ1 ,HS,HT,HW,QQ,W,RF
      READ1 ,SC,YY,C,TS,SN,DB
      READ1 ,CE,SH,SD,TT,SK,RB
      READ1 ,  ALCO,TP,D1,FE,RD,RT
      READ1 ,T2,RR,SNL,WF,PE,SN1
      READ1 ,DW1,BP1,BP2,TP1,TP2,ALP
      READ1 ,DR,WR,DS1,ALSH
      READ1 ,P1,P2,P3,P4,P5,P7
      READ1 , RS,GC,PT,C1,CW,CP
      READ1 , EL,CM,CQ,DW,CC,PBA
      READ1 , GE,CS,CF,FS,EC,DF
      READ1 ,ALG3,DC1,DG3,DG2,AL1,AL2
      READ1 ,AL3,ALCO,G2,G3,A
      READ1 ,HM,SM,AS,AC,ET,EB
      READ1 ,S,FK,FR,RC,RG,RP
      READ1 ,FF,CX,PC,EK,EW,TM
      READ 1,WI,WC,ALZ
      A2=.7854*DG2*DG2
      A3=3.1416*DG3*ALG3
      AP=BP2*TP2
      IF(P1)401,402,401
  402 P1=3.19*BP1*TP1/AL1
```

```
401  IF(P2)403,404,403
404  P2=1.595*(TP1+TP2)*ALP/AL2
403  IF(P3)405,406,405
406  P3=3.19*((3.*BP1+BP2)/8.)*ALP/AL3
405  IF(P4)407,408,407
408  Z=TP-(BP1+BP2)/2.
     P4=(3.19*ALP/3.1416)*LOG(1.+(BP1+BP2)/Z)
     IF(PX-6.)409,407,407
409  P4=1.5*P4
407  IF(P5)410,411,410
411  P5=(2.505/ALCO)*(DC1**2-DS1**2)*.667
410  IF(P7)412,413,412
413  P7=2.5*(DU+DR)
412  TG=6.E6*EE/(CW*EC*RPM)
     BT1=TG/(QQ*SM*SS)
     FQ=TG*CP/PX
     BC1=FQ/(2. *HC*SS)
     BG1=TG/(3.1416*DI*CL)
     FG=BG1*GE/.00319
     WQ=(DU-HC)*1.42*HC*SS*(BC1/BK)**2.0*WL
     WT=  SM   *QQ*SS*HS*0.453*(BT1/BK)**2.0*WL
132  D2=BG1**2.5*0.000061
     D3=(0.0167*QQ*RPM)**1.65*0.000015147
     IF(TS-0.9)133,133,134
133  D4=TS**1.285*0.81
     GO TO 137
134  IF(TS-2.0)135,135,136
135  D4=TS**1.145*0.79
     GO TO 137
```

```
136 D4=TS**0.79*0.92
137 D7=BO/GC
    IF(D7-1.7)138,138,139
138 D5=D7**2.31*0.3
    GO TO 144
139 IF(D7-3.0)140,140,141
140 D5=D7**2.0*0.35
    GO TO 144
141 IF(D7-5.0)142,142,143
142 D5=D7**1.4*0.625
    GO TO 144
143 D5=D7**0.965*1.38
144 D6=10.0**(0.932*C1-1.606)
    BA=3.142*DI*CL
    WN=D1*D2*D3*D4*D5*D6*BA
    PUNCH1,VA,EE,EP,PN,F,PX
    PUNCH1,RPM,PI,PF,CK,POL,DI
    PUNCH1,DU,CL,SS,HC,SF,QN
    PUNCH1,WL,BK,ZZ,BO,B1,B2
    PUNCH1,B3,BS,HO,HX,HY,HZ
    PUNCH1,HS,HT,HW,QQ,W,RF
    PUNCH1,SC,YY,C,TS,SN,DB
    PUNCH1,CE,SH,SD,TT,SK,RB
    PUNCH1,  ALCO,TP,D1,FE,RD,RT
    PUNCH1,T2,RR,SNL,WF,PE,SN1
    PUNCH1,DW1,BP1,BP2,TP1,TP2,ALP
    PUNCH1,DR,WR,DS1,ALSH
    PUNCH1, RS,GC,PT,C1,CW,CP
    PUNCH1, EL,CM,CQ,DW,CC,PBA
```

```
PUNCH1, GE,CS,CF,FS,EC,DF
PUNCH1,ALG3,DC1,DG3,DG2,AL1,AL2
PUNCH1,AL3,ALCO,G2,G3,A
PUNCH1,HM,SM,AS,AC,ET,EB
PUNCH1,S,FK,FR,RC,RG,RP
PUNCH1,FF,CX,PC,EK,EW,TM
PUNCH1,WI,WC,WT,WQ,WN
PUNCH1,TG,FQ,BC1,BT1,BG1,FG
PUNCH1,P1,P2,P3,P4,P5,P7
PUNCH1,PX,ALP,A2,G2,A3,G3
PUNCH1,DU,PT,FK,AS,ALZ
PUNCH1,HC,AP,HS,DS1,ALSH
PAUSE
END
```

```
C       PASS 5  INSIDE COIL
        DIMENSION AI(90)
      1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
    888 FORMAT(F10.0,F10.0,F10.0,F10.0,F10.0,F10.0)
        K=1
    823 READ888,AI(K),AI(K+1),AI(K+2),AI(K+3),AI(K+4),AI(K+5)
        K=K+6
        IF(K-89)823,824,824
    824 DO 825 J=1,21
        READ 1,R1,R2,R3,R4,R5,R6
    825 PUNCH1,R1,R2,R3,R4,R5,R6
        READ1 ,TG,FQ,BC1,BT1,BG1,FG
        READ1 ,P1,P2,P3,P4,P5,P7
        READ1 ,PX,ALP,A2,G2,A3,G3
        READ 1,DU,PT,FK,AS,ALZ
        READ1 ,HC,AP,HS,DS1,ALSH
        LOAD=1
        COREL=3.1416*(DU-HC)/(4.*PX)
        X=BT1
        NA=1
        K=1
        GO TO 802
    806 FT=HS*AT
        X=BC1
        K=2
        NA=1
        GO TO 802
    807 FC=COREL*AT
        FS=FT+FC
```

```
      PL=PX*(2.*(FG+FT)+FC)*(P1+P2+P3+P4)*.001
      PLT=FQ+2.*PL/PX
      BP=PLT/AP
      X=BP
      NA=31
      K=3
      GO TO 802
  808 FP=ALP*AT
      PL7=.001*P7*(FC+FT+FG+FP)
      PG2=PLT*PX/2.+PL7
      BG2=PG2/A2
      FG2=BG2*G2/.00319
      BG3=PG2/A3
      FG3=BG3*G3/.00319
      PL5=P5*(FG2+2.*(FG+FT+FP)+FC+FG3)*.001
      PSH=PG2+PL5
      ASH=.7854*DS1*DS1
      BSH=PSH/ASH
      X=BSH
      K=4
      NA=61
      GO TO 802
  809 FSH=ALSH*AT
      FNL=2.*(FG+FT)+FC+FSH+FG2+FG3+2.*FP
      AINL=FNL/PT
      CD=AINL/AS
      EPNL=AINL*FK
      PUNCH1,TG,FQ,BC1,BT1,BG1,FG
      PUNCH1,P1,P2,P3,P4,P5,P7
```

```
      PUNCH1,PX,ALP,A2,G2,A3,G3
      PUNCH1,DU,PT,FK,AS,FG2,FG3
      PUNCH1,HC,AP,HS,DS1,ALSH,EPNL
      PUNCH1,COREL,ASH,FC,FT,BP,BSH
      PUNCH1,PL,PLT,BG2,BG3,CD,AINL
      PUNCH1,FNL,ALZ
      PAUSE
  802 IF(AI(NA)-X)830,831,831
  831 NA=NA+3
  835 IF(AI(NA)-X)833,834,834
  833 NA=NA+2
      GO TO 835
  834 AX=AI(NA)
      BB1=AI(NA-2)
      DC=AI(NA+1)
      D=AI(NA-1)
      XX= (AX-BB1)/(.4343*(LOG(DC)-LOG(D+.0001)))
      Y=AX-XX*.4343*LOG(DC)
         AT=EXP(2.306*(X-Y)/XX)
      GO TO (838,839),LOAD
  838 GO TO (806,807,808,809,810),K
  830 GO TO (836,837),LOAD
  836 PRINT 850,
  850 FORMAT (17HMACHINE SATURATED)
      PAUSE
      END
```

```
C     PASS 6  INSIDE COIL
    3 FORMAT(9X F12.5,2X F12.5)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
  870 FORMAT(23X F12.5/)
      READ1 ,VA,EE,EP,PN,F,PX
      READ1 ,RPM,PI,PF,CK,POL,DI
      READ1 ,DU,CL,SS,HC,SF,QN
      READ1 ,WL,BK,ZZ,BO,B1,B2
      READ1 ,B3,BS,HO,HX,HY,HZ
      READ1 ,HS,HT,HW,QQ,W,RF
      READ1 ,SC,YY,C,TS,SN,DB
      READ1 ,CE,SH,SD,TT,SK,RB
      READ1 ,  ALCO,TP,D1,FE,RD,RT
      READ1 ,T2,RR,SNL,WF,PE,SN1
      READ1 ,DW1,BP1,BP2,TP1,TP2,ALP
      READ1 ,DR,WR,DS1,ALSH
      READ1 , RS,GC,PT,C1,CW,CP
      READ1 , EL,CM,CQ,DW,CC,PBA
      READ1 , GE,CS,CF,FS,EC,DF
      READ1 ,ALG3,DC1,DG3,DG2,AL1,AL2
      READ1 ,AL3,ALCO,G2,G3,A
      READ1 ,HM,SM,AS,AC,ET,EB
      READ1 ,S,FK,FR,RC,RG,RP
      READ1 ,FF,CX,PC,EK,EW,TM
      READ1 ,WI,WC,WT,WQ,WN
      READ1 ,TG,FQ,BC1,BT1,BG1,FG
      READ1 ,P1,P2,P3,P4,P5,P7
      READ1 ,PX,ALP,A2,G2,A3,G3
      READ 1,DU,PT,FK,AS,FG2,FG3
```

```
      READ1 ,HC,AP,HS,DS1,ALSH,EPNL
      READ1 ,COREL,ASH,FC,FT,BP,BSH
      READ1 ,PL,PLT,BG2,BG3,CD,AINL
      READ 1,FNL,ALZ
      XR=.0707*A*DF/(BG1*C1)
      XL=XR*(PC+EW+ALZ)
      XD=90.*EC*PI*CM*DF/(PX*(2.*FG+FG2+FG3))
      XQ=CQ*XD/(CM*C1)
      XA=XL+XD
      XB=XL+XQ
      VR=3.1416*DR*RPM/12.
      AGE=GE*(2.*FG+FG2+FG3)/(2.*FG)
      PEE=PX*(P1+P2+P3+P4)+P5
      ALF=PEE/CL
      ALA=6.38*DI/(PX*AGE)
      XF=XD*(1.-((CM/C1)/(2.*PX+1.273*ALF/ALA)))
      SI=PT*PT*PEE*1.E-8
      XU=XL+XF
      XS=.88*XU
      XX=XS
      XY=XB
      XN=.5*(XX+XY)
      IF(W)414,415,414
  415 XO=0.
      GO TO 422
  414 IF(CS-1.)417,418,417
  418 AKX=1.
      AKX1=1.
      GO TO 419
```

```
417 AA=(3.*YY/(PN*QN))
    AKX=AA-2.
    IF(AA/3.-.667)420,420,421
420 AKX1=.75*AA-.25
    GO TO 419
421 AKX1=.75*AA+.25
419 ABL=(AKX/(CF**2))*.07*ALA
    XO=AKX*(ABL+PC)/AKX1
    XO=XR*(XO+(1.667*(HX+2.*HZ))/(PN*QN*CF**2*DF**2*BS)+.2*EW)
422 TC=SI/(FK)
    RA=PN*PI*PI*RG/(VA*1000.)
    TA=XN/(628.32*F*RA)
    T5=XS*TC/XA
    T4=2./F
    FSC=XA*(2.*FG+FG2+FG3)/100.
    SCR=FNL/FSC
    PRINT3,AC,A,S,XR,HM,XL,RG,XD,RP,XQ,ET,XA,EB,XB,PC,XF,EW,SI,WC,XU
    PRINT3,WI,XS,TP,XX,WR,XY,VR,XN,AS,XO,FK,TC,FR,TA,RC,T5,P1,T4
    PRINT3,P2,TG,P3,FQ,P4,BG1,P5,BT1,P7,BC1,FSC,FT,SCR,FC
    PRINT870,FG
    PUNCH1,BO,GC,PI,PN,EP,ET
    PUNCH1,EB,SC,C,XB,XD,PF
    PUNCH1,EE,XA,RG,WF,WQ,WT
    PUNCH1,WN,SNL,POL,RP,FR,FNL
    PUNCH1,TG,FQ,BC1,BT1,BG1,FG
    PUNCH1,P1,P2,P3,P4,P5,P7
    PUNCH1,PX,ALP,A2,G2,A3,G3
    PUNCH1,DU,PT,FK,AS,FG2,FG3
    PUNCH1,HC,AP,HS,DS1,ALSH,EPNL
```

```
PUNCH1,COREL,ASH,FC,FT,BP,BSH
PUNCH1,PL,PLT,BG2,BG3,CD,AINL
PUNCH1,CK
PAUSE
END
```

```
C     PASS 7  INSIDE COIL
      DIMENSION GB(4),AE(4),DX(4)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      READ1 ,BO,GC,PI,PN,EP,ET
      READ1 ,EB,SC,C,XB,XD,PF
      READ1 ,EE,XA,RG,WF,WQ,WT
      READ1 ,WN,SNL,POL,RP,FR,FNL
      READ1 ,TG,FQ,BC1,BT1,BG1,FG
      READ1 ,P1,P2,P3,P4,P5,P7
      READ1 ,PX,ALP,A2,G2,A3,G3
      READ1 ,DU,PT,FK,AS,FG2,FG3
      READ1 ,HC,AP,HS,DS1,ALSH,EPNL
      READ1 ,COREL,ASH,FC,FT,BP,BSH
      READ1 ,PL,PLT,BG2,BG3,CD,AINL
      READ 1,CK
      AXX=BO/GC
      IF(AXX-1.)964,965,964
  965 AKSC=2.6
      GO TO 957
  964 IF(AXX-3.75)955,955,956
  955 AKSC=10.**.178/((AXX-1.)**.334)
      GO TO957
  956 AKSC=10.**.11/((AXX-1.)**.174)
  957 XX1=PI*PI*PN
      XX3=3.*EP*PI*PF
      XX2=(ET+EB)/2.-1.
      XX4=AKSC*PI*SC/(C*FG)
      GB(1)=1.
      GB(2)=1.5
```

```
      GB(3)=2.
      GB(4)=POL
      AN=ATAN(SQRT(1.-PF*PF)/PF)
      AN1=SIN(AN)
      DO 777 K=1,4
      YB=GB(K)
      AA    =ATAN((AN1+XB*YB/100.)/PF)
      AE(K)=COS(AA-AN)+XA*SIN(AA)*YB/100.
  777 DX(K)=.93*XD*YB*SIN(AA)/100.
      PUNCH1,AE(1),AE(2),AE(3),AE(4)
      PUNCH1,DX(1),DX(2),DX(3),DX(4)
      PUNCH1,BO,GC,PI,PN,EP,ET
      PUNCH1,EB,SC,C,XB,XD,PF
      PUNCH1,EE,XA,RG,WF,WQ,WT
      PUNCH1,WN,SNL,POL,RP,FR,FNL
      PUNCH1,TG,FQ,BC1,BT1,BG1,FG
      PUNCH1,P1,P2,P3,P4,P5,P7
      PUNCH1,PX,ALP,A2,G2,A3,G3
      PUNCH1,DU,PT,FK,AS,FG2,FG3
      PUNCH1,HC,AP,HS,DS1,ALSH,EPNL
      PUNCH1,COREL,ASH,FC,FT,BP,BSH
      PUNCH1,PL,PLT,BG2,BG3,CD,AINL
      PUNCH1,XX1,XX2,XX3,XX4,CK
      PAUSE
      END
```

```
C     PASS 8  INSIDE COIL
      DIMENSION AI(90)
      DIMENSION AE(4),DX(4),BPL(4),PLL(4),BG3L(4),BSHL(4),PTLL(4)
      DIMENSION  FFL(4),AIFL(4),CDD(4),EPFL(4),BG2L(4)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
  888 FORMAT(F10.0,F10.0,F10.0,F10.0,F10.0,F10.0)
      K=1
  823 READ888,AI(K),AI(K+1),AI(K+2),AI(K+3),AI(K+4),AI(K+5)
      K=K+6
      IF(K-89)823,824,824
  824 READ1 ,AE(1),AE(2),AE(3),AE(4)
      READ1 ,DX(1),DX(2),DX(3),DX(4)
      READ1 ,BO,GC,PI,PN,EP,ET
      READ1 ,EB,SC,C,XB,XD,PF
      READ1 ,EE,XA,RG,WF,WQ,WT
      READ1 ,WN,SNL,POL,RP,FR,FNL
      READ1 ,TG,FQ,BC1,BT1,BG1,FG
      READ1 ,P1,P2,P3,P4,P5,P7
      READ1 ,PX,ALP,A2,G2,A3,G3
      READ1 ,DU,PT,FK,AS,FG2,FG3
      READ1 ,HC,AP,HS,DS1,ALSH,EPNL
      READ1 ,COREL,ASH,FC,FT,BP,BSH
      READ1 ,PL,PLT,BG2,BG3,CD,AINL
      READ 1,XX1,XX2,XX3,XX4,CK
      LOAD=2
      DO 900 J=1,4
      AED=AE(J)
      AA=AED*FG+(1.+PF)*FT+FC
      PLL(J)=PL*AA /(FG+FT+FC)
```

```
      IF(PF-.95)880,880,881
  881 PR=FQ*CK
      GO TO 882
  880 PR=FQ*(AED-DX(J))
  882 PTLL(J)=PR+(PLL(J)*2./PX)
      X=PTLL(J)/AP
      BPL(J)=X
      NA=31
      K=1
      GO TO 802
  841 FPL= AT* ALP
      PL7L=P7*.001*(AA+FPL)
      PG2L=(PTLL(J)*PX/2.)+PL7L
      BG2L(J)=PG2L/A2
      FG2L=BG2L(J)*G2/.00319
      BG3L(J)=PG2L/A3
      FG3L=BG3L(J)*G3/.00319
      PL5L=P5*.001*(2.*AED*FG+FG2L+FG3L+2.*FT*(1.+PF)+2.*FPL+FC)
      PSHL=PG2L+PL5L
      X= PSHL/ASH
      BSHL(J)=X
      NA=61
      K=2
      GO TO 802
  842 FSHL=ALSH*AT
      FFL(J)=FSHL+FG2L+FG3L+2.*FG*AED+2.*FT*(1.+PF)+FC+2.*FPL
      AIFL(J)=FFL(J)/PT
      CDD(J)=AIFL(J)/AS
  900 EPFL(J)=AIFL(J)*FR
```

```
837 JA=JA/2
    PUNCH 860,JA
860 FORMAT (I3)
    IF(JA)861,862,861
861 DO 863 J=1,JA
    PUNCH1,PLL(J),PTLL(J),BSHL(J),BG3L(J),BG2L(J),BPL(J)
863 PUNCH1,FFL(J),AIFL(J),CDD(J),EPFL(J)
862 PUNCH1,BO,GC,PI,PN,EP,ET
    PUNCH1,EB,SC,C,XB,XD,PF
    PUNCH1,EE,XA,RG,WF,WQ,WT
    PUNCH1,WN,SNL,POL,RP,FR,FNL
    PUNCH1,TG,FQ,BC1,BT1,BG1,FG
    PUNCH1,P1,P2,P3,P4,P5,P7
    PUNCH1,PX,ALP,A2,G2,A3,G3
    PUNCH1,DU,PT,FK,AS,FG2,FG3
    PUNCH1,HC,AP,HS,DS1,ALSH,EPNL
    PUNCH1,COREL,ASH,FC,FT,BP,BSH
    PUNCH1,PL,PLT,BG2,BG3,CD,AINL
    PUNCH1,XX1,XX2,XX3,XX4
    PAUSE
802 IF(AI(NA)-X)830,831,831
831 NA=NA+3
835 IF(AI(NA)-X)833,834,834
833 NA=NA+2
    GO TO 835
834 AX=AI(NA)
    BB1=AI(NA-2)
    DC=AI(NA+1)
    D=AI(NA-1)
```

```
      XX= (AX-BB1)/(.4343*(LOG(DC)-LOG(D+.0001)))
      Y=AX-XX*.4343*LOG(DC)
         AT=EXP(2.306*(X-Y)/XX)
      GO TO (838,839),LOAD
  838 GO TO (806,807,808,809,810),K
  839 JA=JA+1
      GO TO (841,842,843),K
  830 GO TO (836,837),LOAD
  836 PRINT 850,
  850 FORMAT (17HMACHINE SATURATED)
      PAUSE
      END
```

```
C     PASS 9  INSIDE COIL
      DIMENSION  WNL(4),STTL(4),SCUL(4),EDDL(4),TOTL(4),PEFF(4),GB(4)
      DIMENSION BPL(4),BG2L(4),FFL(4),AIFL(4),CDD(4),EPFL(4),FCUL(4)
      DIMENSION PLL(4),PTLL(4),BG3L(4),BSHL(4)
  961 FORMAT(F11.3,8X F11.3,F11.3,F11.3,F11.3)
  860 FORMAT (I3)
    1 FORMAT (E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      DO 705  N=1,4
      PLL(N)=0
      PTLL(N)=0
      BPL(N)=0
      BG2L(N)=0


      GB(4)=POL
      DO 711 K=1,JA
      YB=GB(K)
      FCUL(K)=AIFL(K)**2*FR
      STTL(K)=((.0027*XA*YB)**2*2.+1.)*WT
      WNL(K)=((XX4*YB)**2+1.)*WN
      SCUL(K)=XX1*RP*YB
      EDDL(K)=SCUL(K)*XX2
      TOTL(K)=EDDL(K)+SCUL(K)+WNL(K)+STTL(K)+FCUL(K)+WQ+WF
  711 PEFF(K)=XX3*YB*100./(XX3*YB+TOTL(K))
  712 IF(POL)958,959,958
  958 PRINT961,PL,PLL(1),PLL(2),PLL(3),PLL(4)
      PRINT961,PLT,PTLL(1),PTLL(2),PTLL(3),PTLL(4)
      PRINT961,BP,BPL(1),BPL(2),BPL(3),BPL(4)
      PRINT961,BG2,BG2L(1),BG2L(2),BG2L(3),BG2L(4)
      PRINT961,BG3,BG3L(1),BG3L(2),BG3L(3),BG3L(4)
      PRINT961,BSH,BSHL(1),BSHL(2),BSHL(3),BSHL(4)
      PRINT961,FNL,FFL(1),FFL(2),FFL(3),FFL(4)
```

```
      XX= (AX-BB1)/(.4343*(LOG(DC)-LOG(D+.0001)))
      Y=AX-XX*.4343*LOG(DC)
        AT=EXP(2.306*(X-Y)/XX)
      GO TO (838,839),LOAD
  838 GO TO (806,807,808,809,810),K
  839 JA=JA+1
      GO TO (841,842,843),K
  830 GO TO (836,837),LOAD
  836 PRINT 850,
  850 FORMAT (17HMACHINE SATURATED)
      PAUSE
      END
```

```
C     PASS 9  INSIDE COIL
      DIMENSION  WNL(4),STTL(4),SCUL(4),EDDL(4),TOTL(4),PEFF(4),GB(4)
      DIMENSION BPL(4),BG2L(4),FFL(4),AIFL(4),CDD(4),EPFL(4),FCUL(4)
      DIMENSION PLL(4),PTLL(4),BG3L(4),BSHL(4)
  961 FORMAT(F11.3,8X F11.3,F11.3,F11.3,F11.3)
  860 FORMAT (13)
    1 FORMAT (E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      DO 705  N=1,4
      PLL(N)=0
      PTLL(N)=0
      BPL(N)=0
      BG2L(N)=0
      BSHL(N)=0
      BG3L(N)=0
      FFL(N)=0
      AIFL(N)=0
      CDD(N)=0
      EPFL(N)=0
      FCUL(N)=0
      WNL(N)=0
      STTL(N)=0
      SCUL(N)=0
      EDDL(N)=0
      TOTL(N)=0
  705 PEFF(N)=0
      READ860,JA
      IF(JA)702,703,702
  702 DO 704 J=1,JA
      READ1 ,PLL(J),PTLL(J),BSHL(J),BG3L(J),BG2L(J),BPL(J)
```

```
704 READ1 ,FFL(J),AIFL(J),CDD(J),EPFL(J)
703 READ1 ,BO,GC,PI,PN,EP,ET
    READ1 ,EB,SC,C,XB,XD,PF
    READ1 ,EE,XA,RG,WF,WQ,WT
    READ1 ,WN,SNL,POL,RP,FR,FNL
    READ1 ,TG,FQ,BC1,BT1,BG1,FG
    READ1 ,P1,P2,P3,P4,P5,P7
    READ1 ,PX,ALP,A2,G2,A3,G3
    READ1 ,DU,PT,FK,AS,FG2,FG3
    READ1 ,HC,AP,HS,DS1,ALSH,EPNL
    READ1 ,COREL,ASH,FC,FT,BP,BSH
    READ1 ,PL,PLT,BG2,BG3,CD,AINL
    READ1 ,XX1,XX2,XX3,XX4
    IF(SNL)707,706,707
707 PUNCH1,TG,FQ,BC1,BT1,BG1,FG
    PUNCH1,P1,P2,P3,P4,P5,P7
    PUNCH1,PX,ALP,A2,G2,A3,G3
    PUNCH1,ASH,COREL,HC,AP,HS,ALSH
    PUNCH1,DU,EE
706 FEL=AINL*AINL*FK
    TL=FEL+WT+WQ+WN+WF
    ABX=0
    IF(JA)714,712,714
714 IF(JA-4) 708,709,708
709 IF(POL)708,710,708
710 JA=JA-1
708 GB(1)=1.
    GB(2)=1.5
    GB(3)=2.
```

```
      GB(4)=POL
      DO 711 K=1,JA
      YB=GB(K)
      FCUL(K)=AIFL(K)**2*FR
      STTL(K)=((.0027*XA*YB)**2*2.+1.)*WT
      WNL(K)=((XX4*YB)**2+1.)*WN
      SCUL(K)=XX1*RP*YB
      EDDL(K)=SCUL(K)*XX2
      TOTL(K)=EDDL(K)+SCUL(K)+WNL(K)+STTL(K)+FCUL(K)+WQ+WF
  711 PEFF(K)=XX3*YB*100./(XX3*YB+TOTL(K))
  712 IF(POL)958,959,958
  958 PRINT961,PL,PLL(1),PLL(2),PLL(3),PLL(4)
      PRINT961,PLT,PTLL(1),PTLL(2),PTLL(3),PTLL(4)
      PRINT961,BP,BPL(1),BPL(2),BPL(3),BPL(4)
      PRINT961,BG2,BG2L(1),BG2L(2),BG2L(3),BG2L(4)
      PRINT961,BG3,BG3L(1),BG3L(2),BG3L(3),BG3L(4)
      PRINT961,BSH,BSHL(1),BSHL(2),BSHL(3),BSHL(4)
      PRINT961,FNL,FFL(1),FFL(2),FFL(3),FFL(4)
      PRINT961,AINL,AIFL(1),AIFL(2),AIFL(3),AIFL(4)
      PRINT961,CD,CDD(1),CDD(2),CDD(3),CDD(4)
      PRINT961,EPNL,EPFL(1),EPFL(2),EPFL(3),EPFL(4)
      PRINT961,WQ,WQ,WQ,WQ,WQ
      PRINT961,WT,STTL(1),STTL(2),STTL(3),STTL(4)
      PRINT961,ABX,SCUL(1),SCUL(2),SCUL(3),SCUL(4)
      PRINT961,ABX,EDDL(1),EDDL(2),EDDL(3),EDDL(4)
      PRINT961,WN,WNL(1),WNL(2),WNL(3),WNL(4)
      PRINT961,FEL,FCUL(1),FCUL(2),FCUL(3),FCUL(4)
      PRINT961,WF,WF,WF,WF,WF
      PRINT961,TL,TOTL(1),TOTL(2),TOTL(3),TOTL(4)
```

```
      PRINT961,ABX,PEFF(1),PEFF(2),PEFF(3),PEFF(4)
      PAUSE
  959 PRINT961,PL,PLL(1),PLL(2),PLL(3)
      PRINT961,PLT,PTLL(1),PTLL(2),PTLL(3)
      PRINT961,BP,BPL(1),BPL(2),BPL(3)
      PRINT961,BG2,BG2L(1),BG2L(2),BG2L(3)
      PRINT961,BG3,BG3L(1),BG3L(2),BG3L(3)
      PRINT961,BSH,BSHL(1),BSHL(2),BSHL(3)
      PRINT961,FNL,FFL(1),FFL(2),FFL(3)
      PRINT961,AINL,AIFL(1),AIFL(2),AIFL(3)
      PRINT961,CD,CDD(1),CDD(2),CDD(3)
      PRINT961,EPNL,EPFL(1),EPFL(2),EPFL(3)
      PRINT961,WQ,WQ,WQ,WQ
      PRINT961,WT,STTL(1),STTL(2),STTL(3)
      PRINT961,ABX,SCUL(1),SCUL(2),SCUL(3)
      PRINT961,ABX,EDDL(1),EDDL(2),EDDL(3)
      PRINT961,WN,WNL(1),WNL(2),WNL(3)
      PRINT961,FEL,FCUL(1),FCUL(2),FCUL(3)
      PRINT961,WF,WF,WF,WF
      PRINT961,TL,TOTL(1),TOTL(2),TOTL(3)
      PRINT961,ABX,PEFF(1),PEFF(2),PEFF(3)
      PAUSE
      END
```

```
C       PASS 10  INSIDE COIL
        DIMENSION AI(90)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
  888 FORMAT(F10.0,F10.0,F10.0,F10.0,F10.0,F10.0)
  878 FORMAT(F12.5,F12.5,F12.5,F12.5,F12.5,F12.5)
  879 FORMAT(F12.5,F12.5,F12.5,F12.5,F12.5,F12.5//)
      K=1
  823 READ888,AI(K),AI(K+1),AI(K+2),AI(K+3),AI(K+4),AI(K+5)
      K=K+6
      IF(K-89)823,824,824
  824 READ1 ,TG,FQ,BC1,BT1,BG1,FG
      READ1 ,P1,P2,P3,P4,P5,P7
      READ1 ,PX,ALP,A2,G2,A3,G3
      READ1 ,ASH,COREL,HC,AP,HS,ALSH
      READ1 ,DU,EE
      LOAD=1
      YB=.8
      DO 800 N=1,9
      NA=1
      R1=BT1*YB
      R2=FQ*YB
      R3=BC1*YB
      R4=FG*YB
      R5=EE*YB
      X=R1
          NA=1
      K=1
      GO TO 802
  806 FT=HS*AT
```

```
      X=R3
      K=2
      NA=1
      GO TO 802
  807 FC=COREL*AT
      FS=FT+FC
      PL=PX*(2.*(R4+FT)+FC)*(P1+P2+P3+P4)*.001
      PLT=R2+2.*PL/PX
      BP=PLT/AP
      X=BP
      NA=31
      K=3
      GO TO 802
  808 FP=ALP*AT
      PL7=.001*P7*(FC+FT+R4+FP)
      PG2=PLT*PX/2.+PL7
      BG2=PG2/A2
      FG2=BG2*G2/.00319
      BG3=PG2/A3
      FG3=BG3*G3/.00319
      PL5=P5*(FG2+2.*(R4+FT+FP)+FC+FG3)*.001
      PSH=PG2+PL5
      BSH=PSH/ASH
      X=BSH
      K=4
      NA=61
      GO TO 802
  809 FSH=ALSH*AT
      FNL=2.*(R4+FT)+FC+FSH+FG2+FG3+2.*FP
```

```
      PRINT878,R5,R4,R1,FT,R3,FC
      PRINT879,PLT,BP,BG2,BG3,BSH,FNL
  800 YB=YB+.1
      PAUSE
  802 IF(AI(NA)-X)830,831,831
  831 NA=NA+3
  835 IF(AI(NA)-X)833,834,834
  833 NA=NA+2
      GO TO 835
  834 AX=AI(NA)
      BB1=AI(NA-2)
      DC=AI(NA+1)
      D=AI(NA-1)
      XX= (AX-BB1)/(.4343*(LOG(DC)-LOG(D+.0001)))
      Y=AX-XX*.4343*LOG(DC)
         AT=EXP(2.306*(X-Y)/XX)
      GO TO (838,839),LOAD
  838 GO TO (806,807,808,809,810),K
  839 JA=JA+1
      GO TO (841,842),K
  830 GO TO (836,837),LOAD
  836 PRINT 850,
  850 FORMAT (17HMACHINE SATURATED)
      PAUSE
      END
```

INSIDE, TWO-COIL, STATIONARY-COIL LUNDELL A-C GENERATOR COMPUTER PROGRAM AND TEST DATA

TWO-COIL LUNDELL (BECKY-ROBINSON TYPE)

SUMMARY OF DESIGN CALCULATIONS - - - - - - - (OUTPUT)

MODEL ______________ EWO ________ DESIGN NO. ______________

Group	No.	Symbol	Item	Value	Value	Item	No.	Symbol	Group
STATOR	(17)	(ℓ_s)	SOLID CORE LENGTH	2.39200	1.02895	CARTER COEFFICIENT	(67)	(K_c)	CONSTANTS
STATOR	(24)	(h_c)	DEPTH BELOW SLOT	.54500	.03086	EFFECTIVE AIR GAP	(69)	(g_e)	CONSTANTS
STATOR	(26)	(τ_s)	SLOT PITCH	.20539	1.09500	FUND/MAX OF FIELD FLUX	(71)	(C_1)	CONSTANTS
STATOR	(27)	(τ_s 1/3)	SLOT PITCH 1/3 DIST. UP	.21509	.43000	WINDING CONST.	(72)	(C_w)	CONSTANTS
STATOR	(42)	(K_{sk})	SKEW FACTOR	1.00000	.67800	POLE CONST.	(73)	(C_p)	CONSTANTS
STATOR	(43)	(K_d)	DIST. FACTOR	.95492	4.15000	END. EXT. ONE TURN	(48)	(L_E)	CONSTANTS
STATOR	(44)	(K_p)	PITCH FACTOR	.86609	.85500	DEMAGNETIZING FACTOR	(74)	(C_M)	CONSTANTS
STATOR	(45)	(n_e)	EFF. CONDUCTORS	187.07614	.42000	CROSS MAGNETIZING FACTOR	(75)	(C_q)	CONSTANTS
STATOR	(46)	(a_c)	COND. ARE	.01184	695.77000	AMP COND/IN	(128)	(A)	REACTANCE
STATOR	(47)	(S_s)	CURRENT DENSITY (STA.)	6964.30000	.93897	REACTANCE FACTOR	(129)	(X)	REACTANCE
STATOR	(49)	(ℓ_t)	1/2 MEAN TURN LENGTH	6.75000	10.09522	LEAKAGE REACTANCE	(130)	(X_ℓ)	REACTANCE
STATOR	(53)	(R_{ph})	COLD STA. RES. @ 20° C	.02847	122.63436	REACTANCE OF ARMATURE REACTION	(131)	(X_{ad})	REACTANCE
STATOR	(54)	(R_{ph})	HOT STA. RES. @ 20 ° C	.05827	55.01501	REACTANCE OF ARMATURE REACTION	(132)	(X_{aq})	REACTANCE
STATOR	(55)	(EF_{top})	EDDY FACTOR TOP.	1.22960	132.72958	SYN REACT DIRECT AXIS	(133)	(X_d)	REACTANCE
STATOR	(56)	(EF_{bot})	EDDY FACTOR BOT	1.03240	65.11023	SYN REACT QUAD AXIS	(134)	(X_q)	REACTANCE
STATOR	(62)	(λ_i)	STATOR COND. PERM.	4.99360	67.61290	FIELD LEAKAGE REACT	(160)	(X'_f)	REACTANCE
STATOR	(64)	(λ_e)	END PERM.	5.75770	.22362	FIELD SELF INDUCTANCE	(161)	(L_f)	REACTANCE
STATOR	(65)	( )	WT. OF STA. COPPER	5.54410	24.09648	DAMPER LEAKAGE REACTANCES	(163)	(X_{Dd})	REACTANCE
STATOR	(66)	( )	WT. OF STA. IRON	13.73600	5.19697	DAMPER LEAKAGE REACTANCES	(165)	(X_{Dq})	REACTANCE
	(41)	(τ_p)	POLE PITCH	2.77280	77.70813	UNSAT. TRANS. REACT	(166)	(X'_{du})	REACTANCE
	(157)	(–)	WT. OF ROTOR IRON	.00000	68.38315	SAT. TRANS. REACT	(167)	(X'_d)	REACTANCE
	(145)	(V_r)	PERIPHERAL SPEED	11004.00000	34.19170	SUB. TRANSREACT DIRECT AX.	(168)	(X''_d)	REACTANCE
FIELD	(153)	(a_{cf})	FLD COND. AREA	.00675	15.29219	SUB. TRANSREACT QUAD AX.	(169)	(X''_q)	REACTANCE
FIELD	(154)	(R_f)	COLD FLD RES. @ 20° C	.39100	20.54119	NEG. SEQUENCE REACT	(170)	(X_2)	REACTANCE
FIELD	(155)	(R_f)	HOT FLD RES. @ 20° C	.84652	1.76872	ZERO SEQUENCE REACT	(172)	(X_0)	REACTANCE
FIELD	(156)	(–)	WT. OF FLD. COPPER	4.97260	2634.60000	TOTAL FLUX	(90)	(ϕ_T)	MAGNETIZATION
TIME CONST.	(176)	(T_{do})	OPEN CIR. TIME CONST.	.28595	223.27000	FLUX PER POLE	(93)	(ϕ_p)	MAGNETIZATION
TIME CONST.	(177)	(T_a)	ARM TIME CONST.	.00421	45.68600	GAP DENSITY (MAIN)	(95)	(B'_g)	MAGNETIZATION
TIME CONST.	(178)	(T'_d)	TRANS TIME CONST.	.14733	103.96000	TOOTH DENSITY	(91)	(B'_t)	MAGNETIZATION
TIME CONST.	(179)	(T''_d)	SUB TRANS TIME CONST.	.00500	85.63700	CORE DENSITY	(94)	(B'_c)	MAGNETIZATION
PERMEANCE	(80)	(P_1)	PERM OF LEAKAGE PATH 1	40.13900	62.80600	TOOTH AMPERE TURNS	(97)	(F'_t)	MAGNETIZATION
PERMEANCE	(81)	(P_2)	PERM OF LEAKAGE PATH 2	85.33700	13.24300	CORE AMPERE TURNS	(98)	(F'_c)	MAGNETIZATION
PERMEANCE	(82)	(P_3)	PERM OF LEAKAGE PATH 3	58.54000	442.08000	GAP AMPERE TURNS (MAIN)	(96)	(F'_g)	MAGNETIZATION
PERMEANCE	(83)	(P_4)	PERM OF LEAKAGE PATH 4	182.22000	1534.15030	SHORT CIR NI	(180)	(FSC)	MAGNETIZATION
PERMEANCE	(84)	(P_5)	PERM OF LEAKAGE PATH 5	23.88500	.91698	SHORT AIR RATIO	(181)	(SCR)	MAGNETIZATION
PERMEANCE	(85)	(P_6)	PERM OF LEAKAGE PATH 6	36.79600					
PERMEANCE	(86)	(P_7)	PERM OF LEAKAGE PATH 7	22.16300					

PERCENT LOAD	0		100	150	200	OPTIONAL
(B_{np}) (116) N.P. DENSITY	62.968	(B_{npfl}) (234)	90.819	103.810	117.870	
(B_{sp}) (105) S.P. DENSITY	76.907	(B_{spfl}) (215)	102.720	116.030	130.180	
(B_{y2}) (125) COIL YOKE DENSITY	73.110	(B_{y2fl}) (228)	105.440	120.530	136.860	
(B_{y4}) (113) SHAFT DENSITY	72.568	(B_{y4fl}) (232)	106.070	121.240	137.670	
(B_{g3}) (119) AUX. GAP(g3)DENSITY	30.125	(B_{g3fl}) (230)	43.450	49.668	56.395	
(B_{g2}) (122) AUX. GAP(g2)DENSITY	41.508	(B_{g2fl}) (224)	57.173	65.069	73.558	
(F_{nl}) (127) TOTAL NI	1406.800	(F_{fl}) (236)	2745.000	3479.600	4385.900	
(I_{fnl}) (127a) FIELD AMPERES	8.275	(I_{ffl}) (237)	16.147	20.468	25.799	
(S_f) (127c) CUR. DEN. FLD.	1225.900	(S_{fl}) (239)	2392.100	3032.300	3822.100	
(E_{fnl}) (127b) FIELD VOLTS	7.005	(E_{ffl}) (238)	13.669	17.327	21.839	
(W_c) (185) STA CORE LOSS	295.540	(W_c) (185)	295.540	295.540	295.540	
(W_{ml}) (184) STA TOOTH LOSS	156.930	(W_{tfl}) (242)	257.329	365.232	510.755	
(W_{dnl}) (193) DAMPER LOSS	1.362	(W_{dfl}) (244)	1.649	1.745	1.808	
(I^2R_s) (194) STATOR CU LOSS	.000	(I^2R_s) (245)	1189.963	1784.945	2379.927	
(–) (195) EDDY LOSS	.000	(–) (246)	155.885	233.827	311.770	
(W_{pnl}) (186) POLE FACE LOSS	197.050	(W_{pfl}) (243)	238.463	252.405	261.530	
(I^2R_f) (182) FIELD COIL LOSS	53.553	(I^2R_f) (241)	441.418	709.280	1126.867	
(F&W) (183) F&W LOSS	658.960	(F&W) (183)	658.960	658.960	658.960	
(–) (196) TOTAL LOSSES	1363.396	(–) (247)	3239.209	4301.938	5547.160	
(–) (–) PERCENT EFF.	.000	(–) (251)	87.395	88.676	89.008	

VARIABLE LOAD

TWO-COIL LUNDELL (BECKY-ROBINSON TYPE)

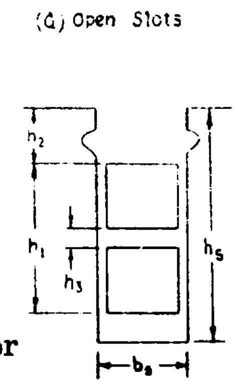
COMPUTER DESIGN - - - - - - - (INPUT)

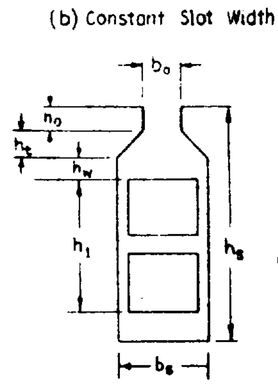
MODEL ______________ EWO ______________ DESIGN NO(1) ______________

PERMEANCE	(80)	P_1	PERM OF LEAKAGE PATH 1	0
	(81)	P_2	PERM OF LEAKAGE PATH 2	0
	(82)	P_3	PERM OF LEAKAGE PATH 3	0
	(83)	P_4	PERM OF LEAKAGE PATH 4	0
	(84)	P_5	PERM OF LEAKAGE PATH 5	0
	(85)	P_6	PERM OF LEAKAGE PATH 6	0
	(86)	P_7	PERM OF LEAKAGE PATH 7	0
	(80a)	ℓ_1	LENGTH OF LEAKAGE PATH 1	1.18
	(81a)	ℓ_2	LENGTH OF LEAKAGE PATH 2	.87
	(85)	ℓ_6	LENGTH OF LEAKAGE PATH 6	1.2
	(84)	ℓ_c	LENGTH OF LEAKAGE ACROSS COIL	1.24
ROTOR DIMENSIONS	(78)	d_{ir}	INSIDE DIA OF ROTOR TUBE	5.6
	(78)	d_Q	INSIDE DIA OF HOLLOW SHAFT	.66
	(78)	h_y	HEIGHT OF COIL YOKE	1.24
	(78)	ℓ_y	LENGTH OF COIL YOKE	.76
	(78)	ℓ_{sk}	LENGTH OF ROTOR SKIRT	.76
	(78)	ℓ_{y4}	EFFECTIVE LENGTH OF SHAFT	1.5
	(78)	ℓ_{g2}	HORIZONTAL LENGTH OF GAP g2	.76
	(78)	T_{sp}	THICKNESS OF SOUTH POLE	.8
	(78)	T_{sk}	THICKNESS OF ROTOR SKIRT	.8
GAP g3 DIMENSIONS	(78)	d_{t0}	TAPERED GAP DIMENSIONS	0
	(78)	d_{t1}		0
	(78)	d_{s1}		1.22
	(78)	d_{s2}		1.96
	(78)	d_{s3}	STEPPED GAP DIMENSIONS	2.54
	(78)	d_{s4}		0
	(78)	d_{s5}		0
	(78)	ℓ_{s1}		.657
	(78)	ℓ_{s2}		.657
	(78)	ℓ_{s3}	STEPPED GAP HORIZONTAL LENGTHS	.657
	(78)	ℓ_{s4}		0
	(78)	ℓ_{s5}		0
	(78)	d_{os}	EFFECTIVE SHAFT O.D.	3.16
	(243)	W_{PHR}	POLE FACE HARMONIC LOSS	0
	(244)	W_{DHR}	DAMPER BAR HARMONIC LOSS	0
	(157)		~~WEIGHT OF ROTOR IRON~~	0
MATERIAL	(18)		STATOR LAM. MTR'L	Curve 12
	(18)		SOUTH POLE, TUBE & SKIRT	16
	(18)		NORTH POLE, SPIDER & SHAFT	15
	(18)		COIL YOKE	15

TYPE 1

(Type 5 is an open slot with 1 conductor per slot)



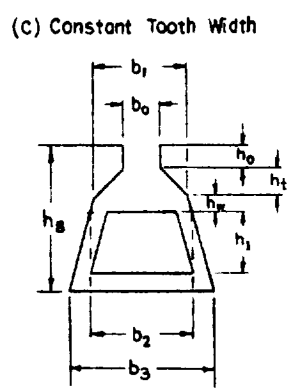


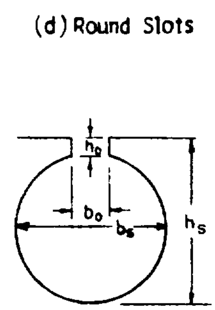
TYPE 2

TYPE 3

b_s for type 3 is

$$b_s = \left(\frac{b_2 + b_3}{2}\right)$$





TYPE 4

INPUT PARAMETERS FOR BECKEY ROBINSON DESIGN

INPUT 1

30.	211.	121.	3.	400.	8.	6000.	82.5	.75	1.
0.0	7.060	9.150	2.6	0.0	0.0	.92	15.	77.	2.
.03	.117	0.0	0.0	.117	.030	.400	0.0	.00	.500
0.0	.038	108.0	1.	1.	2.	9.	1.	.19	1.0
1.	.063	.25	.25	.190	0.	60.	.001	285.	.694
1.0	.030	.01	.015	1.095	.43	.678	4.15	.855	.42
.658	1.45	2.20	2.20	1.45	2.4	2.4	7.0	1.92	7.
.030	.030	.050	.170	.05	5.	5.65	.28	.694	285.
6.87	.0396	170.	13.5	1.125	.006	315.	1.15	0.	0.

INPUT 2

0.	0.	0.	0.	0.	0.	0.	1.18	.87	1.2
1.24	5.6	.66	1.24	.76	.76	1.5	.76	.8	.8
0.	0.	1.22	1.9	2.54	0.	0.	.657	.657	.657
0.	0.	3.16	0.	0.	0.				

SATURATION CURVE (STATOR MATERIAL)

140.	10.	1.	38.	1.9	59.
3.8	75.	7.6	86.	16.	93.
35.	100.	90.	107.	160.	118.
230.	140.	950.			

SATURATION CURVE (SOUTH POLE, TUBE + SKIRT MATERIAL)

143.	0.	3.3	55.	12.0	80.
24.0	95.	40.0	109.	72.0	135.
300.0	143.	500.			

SATURATION CURVE (NORTH POLE, SPIDER + SHAFT MATERIAL)

150.	0.	3.	34.	10.	57.
16.	85.	24.	103.	35.	125.
70.	137.	130.	145.	260.	148.
600.	150.	1500.			

SATURATION CURVE (COIL YOKE MATERIAL)

150.	0.	3.	34.	10.	57.
16.	85.	24.	103.	35.	125.
70.	137.	130.	145.	260.	148.
600.	150.	1500.			

TWO-COIL LUNDELL (BECKY-ROBINSON TYPE)

COMPUTER DESIGN - - - - - - - (INPUT)

MODEL 30KVA Lee R.R. EWO ________ DESIGN NO(1) ________

Group	No.	Symbol	Item	Value
PARAMETERS	(2)	KVA	GENERATOR KVA	30
	(3)	E	LINE VOLTS	211
	(4)	E_{ph}	PHASE VOLTS	121
	(5)	m	PHASES	3
	(5a)	f	FREQUENCY	400
	(6)	p	POLES	8
	(7)	RPM	RPM	6000
	(8)	I_{ph}	PHASE CURRENT	82.5
	(9)	P F	POWER FACTOR	.75
	(9a)	K_c	ADJ. FACTOR	1.0
	(10)		OPTIONAL LOAD POINT	0
STATOR STACK	(11)	d	STATOR I.D.	7.060
	(12)	D	STATOR O.D.	9.150
	(13)	ℓ	GROSS CORE LENGTH	2.6
	(14)	n_v	NO. OF DUCTS	0
	(15)	b_v	WIDTH OF DUCT	0
	(16)	K_i	STACKING FACTOR (STATOR)	.92
	(19)	k	WATTS/LB.	15.0
	(20)	B	DENSITY	77
STATOR SLOT	(21)		TYPE OF SLOT	2
	(22)	b_o	SLOT OPENING	.03
	(22)	b_1	SLOT WIDTH TOP	.117
	(22)	b_2		0
	(22)	b_3		0
	(22)	b_s	SLOT WIDTH	.117
	(22)	h_o		.030
	(22)	h_1		.400
	(22)	h_2		0
	(22)	h_3		0
	(22)	h_s	SLOT DEPTH	.500
	(22)	h_t		0
	(22)	h_w		.038
	(23)	Q	NO. OF SLOTS	108
STATOR WINDING	(28)		TYPE OF WDG.	1
	(29)		TYPE OF COIL	1
	(30)	n_s	CONDUCTORS/SLOT	2
	(31)	y	SLOTS SPANNED	9
	(32)	c	PARALLEL CIRCUITS	1
	(33)		STRAND DIA. OR WIDTH	.14
	(34)	N_{st}	STRANDS/CONDUCTOR IN DEPTH	1
	(34a)	N'_{st}	STRANDS/CONDUCTOR	1
	(39)		STATOR STRAND T'KNS.	.063
	(35)	d_b	DIA. OF PIN	.25
	(36)	ℓ_{e2}	COIL EXT. STR. PORT	.25
	(37)	h_{st}	UNINS. STRD. HT.	.190
	(38)	h'_{st}	DIST. BTWN. C_L OF STD.	0
	(42a)		PHASE BELT ANGLE	60
	(40)	T_{sk}	STATOR SLOT SKEW	.001
	(50)	X °C	STATOR TEMP °C	285
	(51)	ρ_s	RESISTIVITY STA. COND. @ 20 °C	.694
AIR GAP	(59b)		TYPE OF GAP g_3	1.0
	(59)	g	MAIN AIR GAP	.020
	(59a)	g_2	AUX GAP	.01
	(59f)	g_{3E}	EFFECTIVE g_3	.025

Value	Item	No.	Symbol	Group
1.095	FUND/MAX OF FIELD FLUX	(71)	C_1	CONSTANTS
.43	WINDING CONSTANT	(72)	C_w	
.678	POLE CONSTANT	(73)	C_p	
4.15	END EXTENSION ONE TURN	(48)	LE	
.855	DEMAGNETIZATION FACTOR	(74)	C_m	
.42	CROSS MAGNETIZING FACTOR	(75)	C_q	
.658	POLE EMBRACE	(77)	α	
1.45	WIDTH OF NORTH POLE (END)	(76)	$b_{np(end)}$	POLE
2.20	WIDTH OF SOUTH POLE (END)	(76)	$b_{sp(end)}$	
2.20	WIDTH OF NORTH POLE (MID)	(76)	$b_{np(mid)}$	
1.45	WIDTH OF SOUTH POLE (MID)	(76)	$b_{sp(mid)}$	
2.4	LENGTH OF NORTH POLE	(76)	ℓ_{np}	
2.4	LENGTH OF SOUTH POLE	(76)	ℓ_{sp}	
7.0	ROTOR DIAMETER	(11a)	d_r	
1.42	HEIGHT OF NORTH POLE	(78)	h_{np}	
7.0	POLE FACE LOSS FACTOR	(187)	(K_1)	
.030	WIDTH OF SLOT OPENING	(135)	b_{bo}	DAMPER BAR
.030	HEIGHT OF SLOT OPENING	(135)	h_{bo}	
.050	DAMPER BAR DIA. OR WIDTH	(136)	( )	
.170	RECTANGULAR BAR THICKNESS	(137)	h_{bl}	
.05	RECTANGULAR SLOT WIDTH	(135)	b_{bl}	
5.0	NO. OF DAMPER BARS/POLE	(138)	n_b	
5.65	DAMPER BAR LENGTH	(139)	ℓ_b	
.28	DAMPER BAR PITCH	(140)	τ_b	
.694	RESISTIVITY OF DAMP. BAR @ 20°	(141)	ρ_D	
285	DAMPER BAR TEMP °C	(142)	X °C	
6.87	DAMPER BAR END RING MEAN DIA.	(170)	d_{dr}	
.0346	DAMPER BAR END RING AREA	(170)	a_{dr}	
170	NO. OF FIELD TURNS/COIL	(146)	N_F	FIELD
13.5	MEAN LENGTH OF FLD. TURN	(147)	ℓ_{tF}	
1.125	FLD. COND. DIA. OR WIDTH	(148)		
.002	FLD. COND. THICKNESS	(149)		
315	FLD. TEMP IN °C	(150)	X_f °C	
1.15	RESISTIVITY OF FIELD COND @ 20°	(151)	ρ_f	
0	NO LOAD SAT.	(87)		
0	FRICTION & WINDAGE	(183)	(F&W)	

STATOR SLOT	POLE
DAMPER SLOT	REMARKS

DESIGNER ________ DATE ________

TWO-COIL LUNDELL (BECKY-ROBINSON TYPE)

NO LOAD SATURATION OUTPUT SHEET

ITEMS → / ORS	(3) (E) Volts (125) B_{y2} Coil yoke	(95) B'_g Density Main gap (105) B_{SP} Density S. P.	(122) B_{g2} Density g2 (116) B_{NP} Density N. P.	(119) B_{g3} Density g3 (113) B_{y4} Shaft density	(94) B_c Density Stator core (93) ϕ'_P Flux per pole	(91) B'_T Density Stator tooth (127) F_{NL} Total NI
0%	168.80000 57.14238	36.53040 60.21276	32.42266 49.21551	23.54603 56.78554	68.47527 178.53424	83.13275 1015.92030
[illegible]%	189.90000 64.65303	41.10238 68.09763	36.68989 55.68427	26.64086 64.22996	77.04533 200.87879	93.53727 1173.37650
[illegible]%	211.00000 73.11561	45.68795 76.91285	41.51155 62.97291	30.12794 72.57350	85.64086 223.28973	103.97271 1406.94120
110%	232.10000 81.91592	50.27786 86.05598	46.53098 70.55242	33.75419 81.23396	94.24453 245.72192	114.41804 1670.84960
120%	253.20000 92.86159	54.89966 97.29131	52.80304 79.97969	38.26445 91.91632	102.90799 268.30995	124.93594 2115.06860
1[illegible]%	274.30000 106.53195	59.55786 111.16922	60.67270 91.75368	43.89744 105.15264	111.63966 291.07587	135.53667 2810.30000
1[illegible]%	MACHINE SATURATED					
1[illegible]%						
160%						

SATURATION CURVE VALUES (STATOR)

140.	10.	1.	38.	1.9	59.
3.8	75.	7.6	86.	16.	93.
35.	100.	90.	107.	160.	118.
230.	140.	950.			

SATURATION CURVE VALUES (NORTH POLE AND SHAFT)

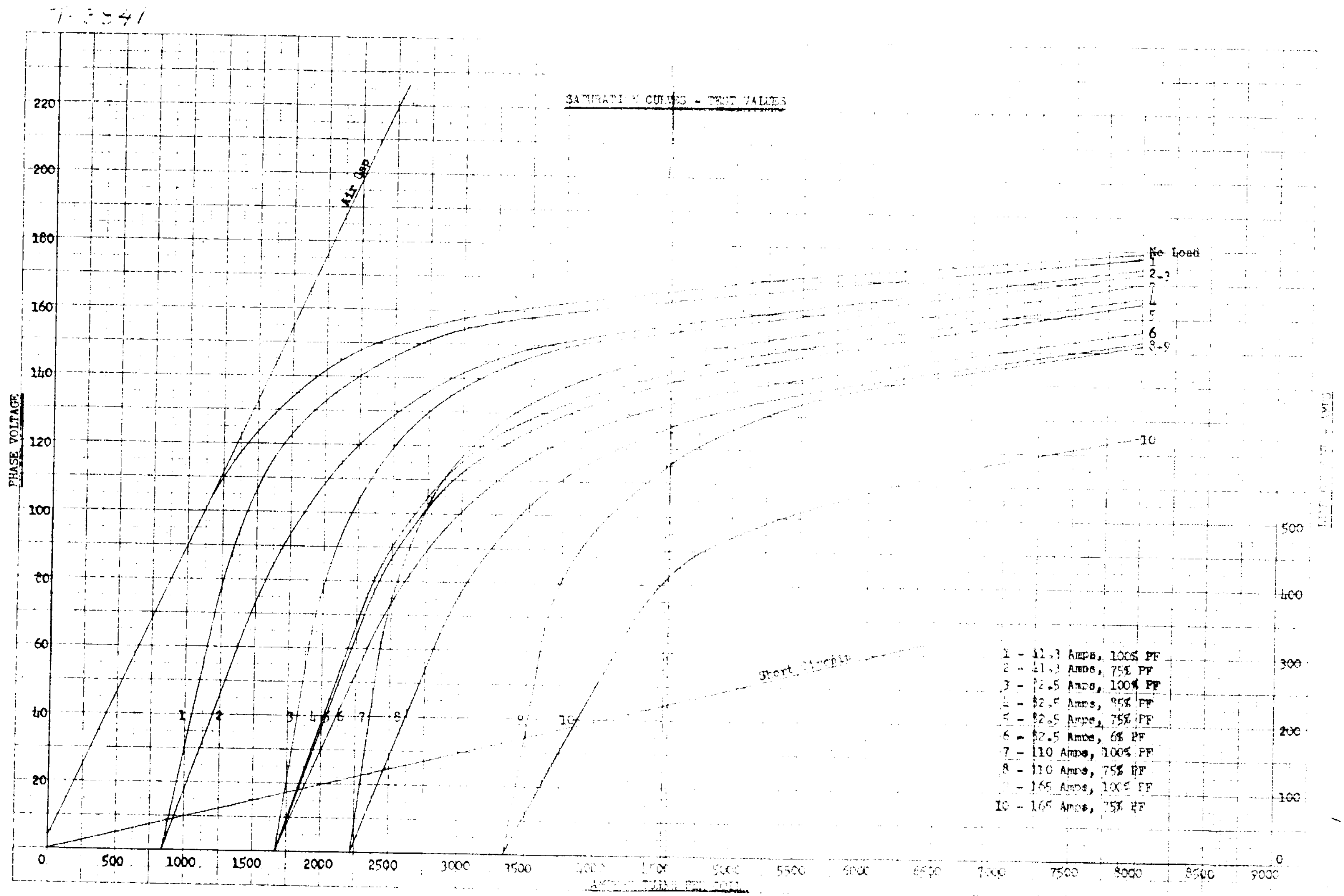
143.	0.	3.3	55.	12.0	80.
24.0	95.	40.0	109.	72.0	135.
300.0	143.	500.			

SATURATION CURVE VALUES (SOUTH POLE AND TUBE)

150.	0.	3.	34.	10.	57.
16.	85.	24.	103.	35.	125.
70.	137.	130.	145.	260.	148.
600.	150.	1500.			

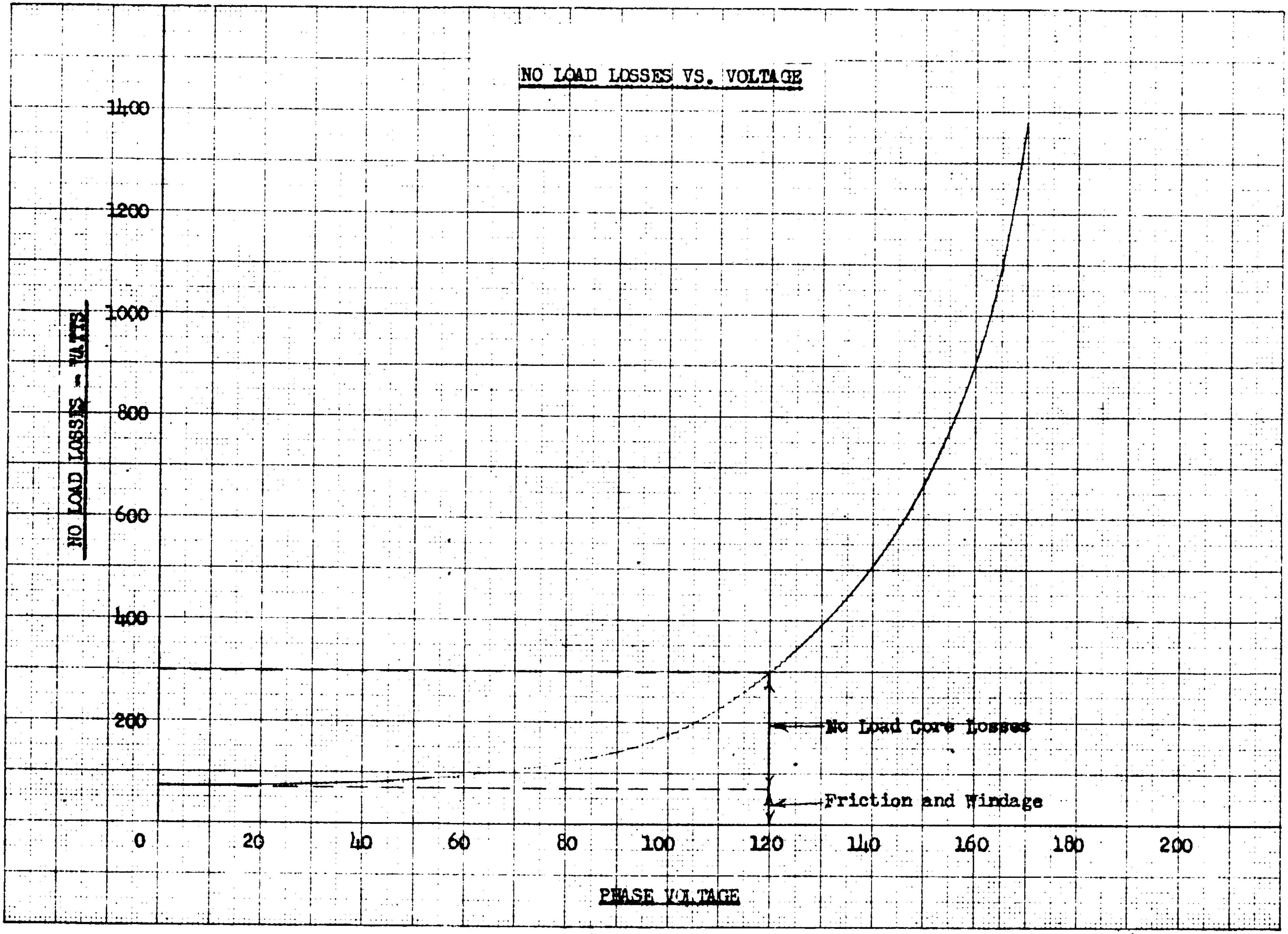
SATURATION CURVE VALUES (YOKE)

150.	0.	3.	34.	10.	57.
16.	85.	24.	103.	35.	125.
70.	137.	130.	145.	260.	148.
600.	150.	1500.			

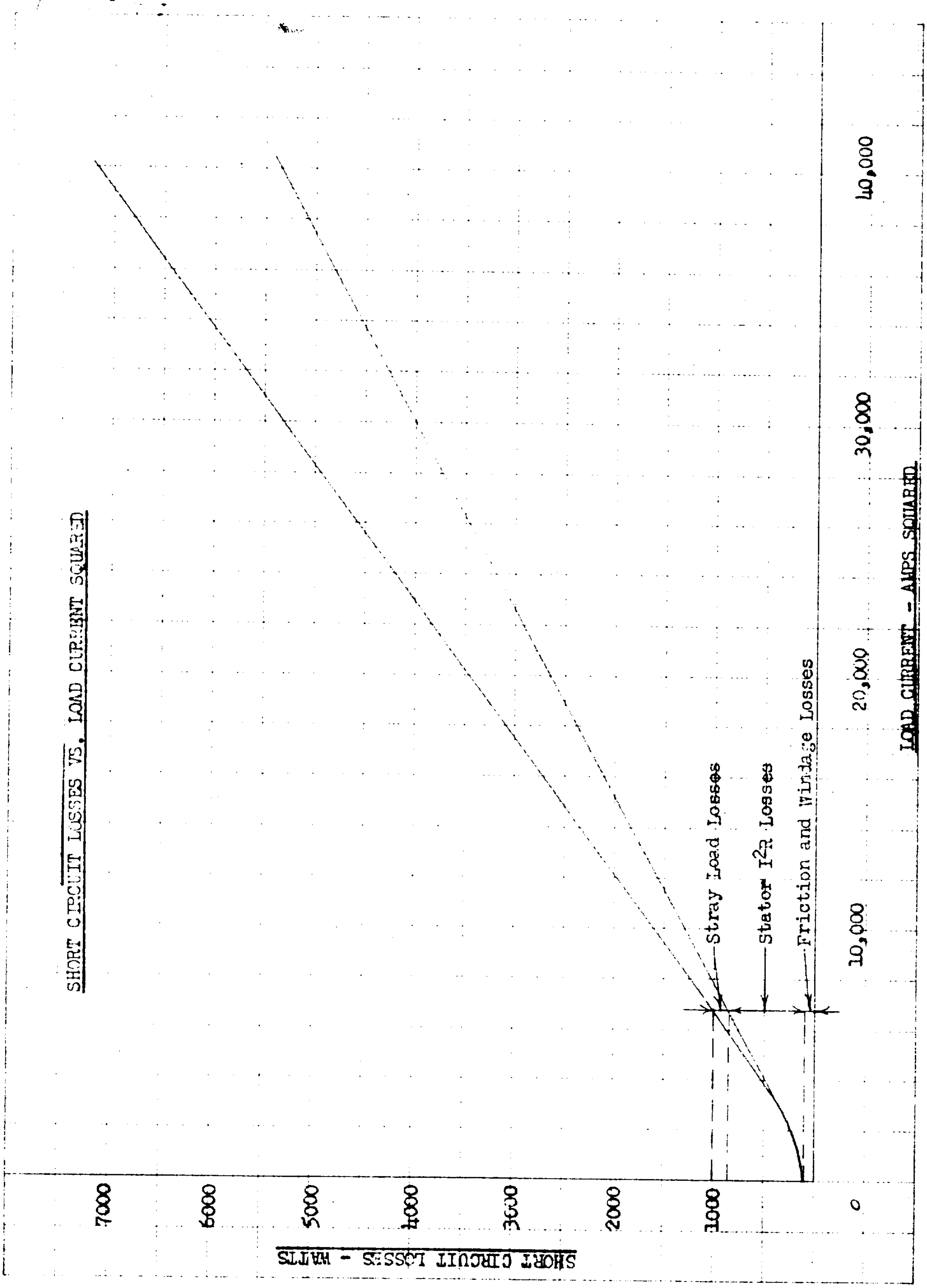

PHASE VOLTAGE
Air Gap
No Load
Short Circuit
7 - 110 Amps, 100% PF
8 - 110 Amps, 75% PF
10 - 165 Amps, 75% PF

COOLING PROPERTIES OF STOVEPIPE UNIT AT SEA LEVEL

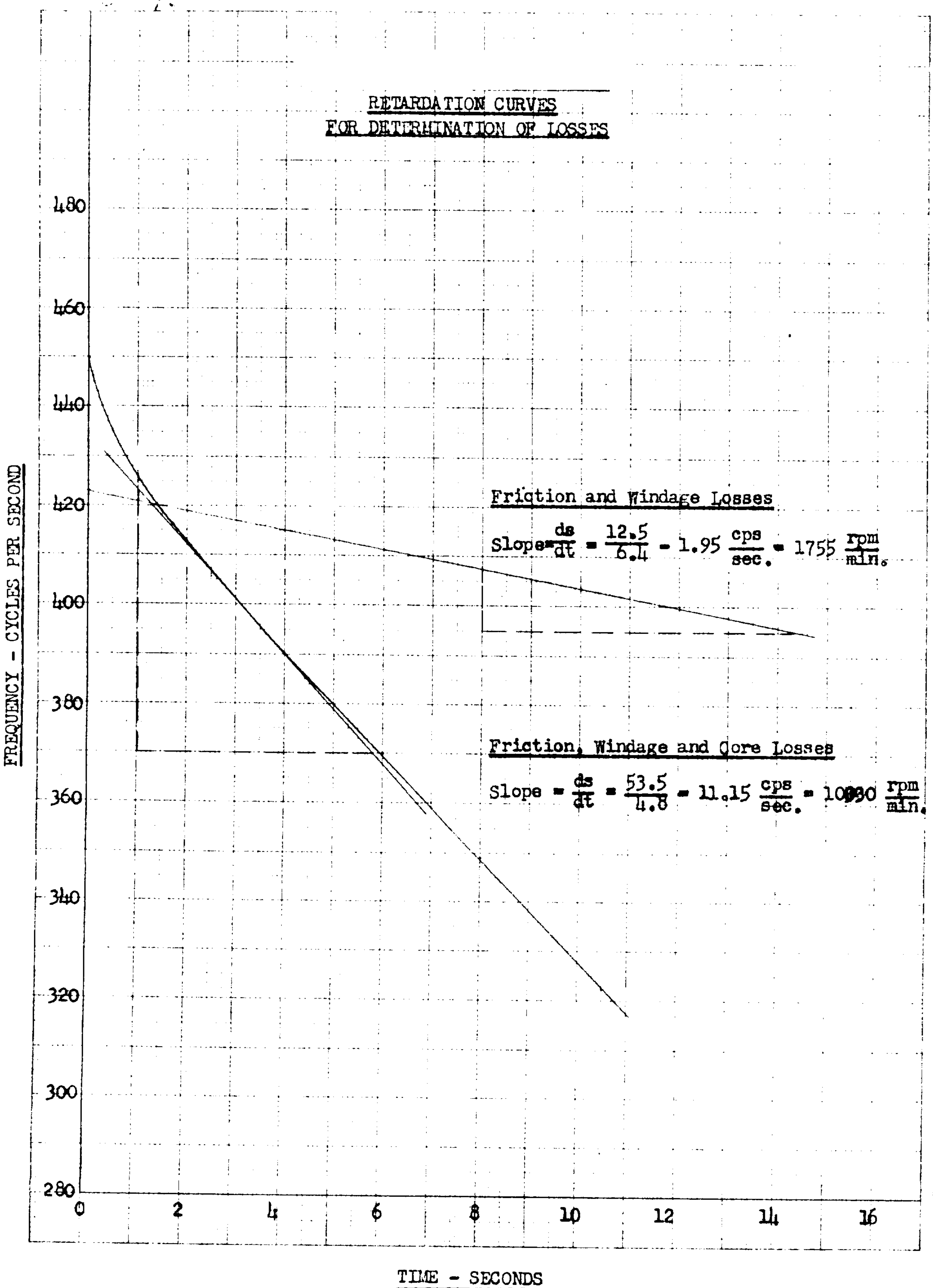
Run No.	1	2	3	4	5	6	7	8	9	10
KVA	15	30	10	20	25	30	10	20	25	30
Speed - RPM	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Avg. Phase Voltage	121.5	121.9	121.9	121.9	121.9	121.9	121.9	121.9	121.9	121.9
Avg. Line Current - Amps	40.8	82.8	27.4	54.8	69.6	82.2	27.6	54.8	69.0	82.2
Avg. Phase Power - Kilowatts	3.74	7.48	2.52	5.02	6.28	7.56	2.50	5.00	6.26	7.48
Avg. Power Factor - %	75.4	74.2	75.7	75.2	73.9	75.4	74.5	74.6	74.6	74.7
Field Current - Amps	13.0	19.9	11.6	15.6	18.4	21.0	11.6	15.6	18.0	20.5
Drive End Field Voltage	8.6	18.4	8.8	14.2	19.1	21.6	8.7	13.4	17.4	21.7
Anti-Drive End Field Voltage	7.6	16.1	8.9	14.0	18.5	21.1	8.9	13.2	16.7	20.[illegible]
Field Power - Watts	210	686	205	440	692	896	204	415	614	86[illegible]
Avg. Drive End Field Temp. - °F	237	486	329	472	593	583	320	424	525	613
Avg. Anti-Drive End Fld. Temp. - °F	139	340	302	420	516	516	302	374	447	51[illegible]
Drive End Bearing Temp. - °F	179	281	248	319	355	334	249	289	323	34[illegible]
Anti-Drive End Bearing Temp. - °F	130	192	—	—	—	—	—	—	—	—
Frame Temp. - °F	152	234	218	252	274	264	217	232	248	259
Pad Temp. - °F	145	223	203	252	277	258	207	232	253	26[illegible]
Avg. Stator Drive End Temp.-°F	189	338	310	402	448	441	298	353	402	44[illegible]
Avg. Stator Anti-Drive End Temp.-°F	167	291	293	369	419	422	280	324	364	398
Avg. Stator Slot Temp. - °F	—	—	313	419	507	519	301	362	419	477
Ambient Temperature - °F	80	109	76	76	82	79	90	90	89	9[illegible]
Air-In Temp. - °F	87	91	241	247	252	252	240	241	244	24[illegible]
Air-Out Temp. - °F	143	218	214	247	265	260	205	224	237	246
Air Upstream Temp. - °F	83	83	315	320	322	320	291	292	293	29[illegible]
stream Pressure - In. of Hg	3.70	3.70	3.75	3.75	3.70	3.75	3.70	3.70	3.70	3.7
Pressure Drop Across Orifice - Inches of H_2O	.75	.80	1.30	1.30	1.30	1.30	3.40	3.40	3.25	3.25
Pressure Drop Across Generator - Inches of H_2O	.85	.90	.80	.80	.80	.80	2.00	2.00	2.00	2.0
Mass Flow through Gen.-Lbs. per Min.	4.90	5.05	5.35	5.32	5.30	5.32	8.80	8.80	8.55	8.5[illegible]
Condition	Stab.	Stab.	Stab.	Stab.	Stab.	Not Stab.	Stab.	Stab.	Stab.	Not Stab



NO LOAD LOSSES VS. VOLTAGE
NO LOAD LOSSES - WATTS
1400
1200
1000
800
600
400
200
0
20
40
60
80
100
120
140
160
180
200
PHASE VOLTAGE
No Load Core Losses
Friction and Windage



SHORT CIRCUIT LOSSES VS. LOAD CURRENT SQUARED
SHORT CIRCUIT LOSSES - WATTS
7000
6000
5000
4000
3000
2000
1000
0
10,000
20,000
30,000
40,000
LOAD CURRENT - AMPS SQUARED
Stray Load Losses
Stator I^2R Losses
Friction and Windage Losses


RETARDATION CURVES
FOR DETERMINATION OF LOSSES
Friction and Windage Losses
Slope = ds/dt = 12.5/6.4 = 1.95 cps/sec. = 1755 rpm/min.
Friction, Windage and Core Losses
Slope = ds/dt = 53.5/4.8 = 11.15 cps/sec. = 10030 rpm/min.
FREQUENCY - CYCLES PER SECOND
480
460
440
420
400
380
360
340
320
300
280
0
2
4
6
8
10
12
14
16
TIME - SECONDS

LA-10

FRICTION, WINDAGE AND CORE LOSSES

AS DETERMINED BY THE RETARDATION METHOD

Loss in Watts $= \frac{77}{10^7} \; Wr^2 \; S \; \frac{ds}{dt}$

Wr^2 = Rotor moment of inertia in lb. ft.^{2}

S = Speed in RPM

$\frac{ds}{dt}$ = Rate of retardation in RPM per min.

1.) Friction & Windage Losses

$$P = \frac{77(1.801)\ (6000)\ (1755)}{10^7} = 146 \text{ Watts}$$

2.) Friction, Windage and Core Loss At No Load

$$P = \frac{77(1,801)\ (6000)\ (10030)}{10^7} = 845 \text{ Watts}$$

3.) Core Loss

$$P = 845 - 146 = 699 \text{ Watts}$$

GENERATOR (STOVEPIPE)

EFFICIENCY WITHOUT REGULATOR AND STATIC EXCITER

Rating KVA	Power Factor %	Cooling Condition	Total Output Watts	Shaft Input Watts	Field Input Watts	Total Input Watts	Efficiency %
15	75	Stabilized with 120°C Air-In	11080	12480	300	12780	86.8
30	75	Not Stabilized with 120°C Air-In	22680	25050	938	25988	87.4
30	100	Not Stabilized with 120°C Air-In	29980	31900	422	32322	92.8
40	85	Not Stabilized with 120°C Air-In	34080	37200	1180	38380	88.9

NEGATIVE SEQUENCE IMPEDANCE

$$Z_2 = \frac{100\ E_L\ I_{PH}}{\sqrt{3}\ I_L\ E_{PH}} \qquad \cos\theta = \frac{W}{E_L\ I_L}$$

$$X_2 = Z_2 \cos\theta \qquad R_2 = Z_2 \sin\theta$$

Z_2 = Percent Negative Sequence Impedance

X_2 = Percent Negative Sequence Reactance

R_2 = Percent Negative Sequence Resistance

E_L = Line to Line Voltage Between the Two Shorted Phases and the One Open Phase

I_L = Line Current Between the Two Shorted Phases

E_{PH} = Rated Phase Voltage

I_{PH} = Rated Phase Current

W = Power with Two Phases Shorted and One Phase Open

1. Negative Sequence Impedance with 120° Phase Belt Stator

$$Z_2 = \frac{100\ (45.3)(82.5)}{\sqrt{3}\ (82.6)(120)} = 21.8\% \qquad \cos\theta = \frac{3480}{45.3\ (82.6)} = .930$$

$$X_2 = 21.8\ (.930) = 20.3\% \qquad R_2 = 21.8(.369) = 8.04\%$$

2. Negative Sequence Impedance with 60° Phase Belt Stator

$$Z_2 = \frac{100\ (46.5)(82.5)}{\sqrt{3}\ (82.6)(120)} = 22.4\% \qquad \cos\theta = \frac{3580}{46.5\ (82.6)} = .932$$

$$X_2 = 22.4\ (.932) = 20.9\% \qquad R_2 = 22.4\ (.362) = 8.10\%$$

PERCENT HARMONIC CONTENT
120° PHASE BELT STATOR WITHOUT REGULATOR AND STATIC EXCITER

Harmonic	BALANCED LOAD CONDITION		
	No Load Percent Voltage	41.3 Amps, 100% PF Percent Voltage	82.5 Amps, 100% PF Percent Voltage
	L-N	L-N	L-N
1	100	100	100
2	.04	.6	1.3
3	.015	.06	.13
4	.18	.34	.36
5	1.1	.67	.35
6	0	0	0
7	.33	.22	.14
8	.53	.37	.19
9	0	0	0
10	.07	.09	.06
11	0	0	0
12	0	0	0
13	.05	0	0
14	.14	.07	0
15	0	0	0
16	.03	0	0
17	0	.08	.03
18	0	0	0
19	.15	.11	.10
20	.02	0	0
21	0	0	0
22	.025	.01	0
23	.04	.06	.07
24	0	0	0
25	.07	.05	.06
26	.22	.10	.05
27	0	0	0
28	.12	.02	.12
29	0	0	.02
30	0	0	0
31	.03	.02	.03
32	.02	0	0

PERCENT HARMONIC CONTENT
120° PHASE BELT STATOR WITH REGULATOR AND STATIC EXCITER

Harmonic	BALANCED LOAD CONDITION					
	No Load Percent Voltage		41.3 Amps, 75% PF Percent Voltage		82.5 Amps, 75% PF Percent Voltage	
	L-N	L-L	L-N	L-L	L-N	L-L
1	100	100	100	100	100	100
2	1.2	.86	1.3	1.3	1.8	1.9
3	.81	.18	.92	.26	.92	.11
4	1.3	1.3	1.3	1.3	1.3	1.2
5	.[illegible]4	.64	.40	.29	.44	.39
6	.12	.16	.26	.24	.56	.[illegible]6
7	.28	.42	.35	.35	.38	.39
8	.66	.64	.64	.46	.42	.38
9	.19	.11	.24	.12	.28	.04
10	.07	.05	.08	.12	.32	.32
11	.12	.06	.20	.06	.23	.08
12	.11	.10	.12	.04	.22	.04
13	.04	.04	.11	.10	.17	.14
14	.17	.16	.15	.05	.16	.04
15	.10	.05	.08	.05	.09	.02
16	.02	.03	.03	.06	.13	.10
17	.07	.09	.07	.04	.17	.08
18	0	.01	.05	.04	.11	.03
19	.08	.12	.20	.20	.22	.22
20	.02	.02	.07	.07	.12	.08
21	.04	.04	.04	.05	.04	.01
22	.03	.04	.08	.07	.02	.02
23	.02	0	.11	.12	.05	.05
24	.05	.03	.04	.06	.05	.0[illegible]
25	.06	.06	.03	.03	.03	.01
26	.28	.27	.16	.20	.03	.03
27	.02	.03	.04	.04	.04	.01
28	.12	.12	.07	.07	.10	.10
29	.02	.01	.05	.03	.05	0
30	.02	.01	.02	.02	.01	.01
31	.05	.03	.03	.03	.04	.03
32	.04	.04	.03	.02	.02	.01

PERCENT HARMONIC CONTENT
120° PHASE BELT STATOR WITH REGULATOR AND STATIC EXCITER

Harmonic	UNBALANCED LOAD CONDITION			
	0, 0, 13.75 Amps, 100% PF Percent Voltage		0, 0, 27.5 Amps, 100% PF Percent Voltage	
	L-N	L-L	L-N	L-L
1	100	100	100	100
2	.94	.86	.92	.85
3	.86	.18	.94	.35
4	1.4	1.2	1.4	1.2
5	.84	.68	.80	.65
6	.06	.16	.09	.15
7	.50	.49	.56	.48
8	.90	.64	.92	.69
9	.26	.14	.28	.13
10	.14	.10	.20	.12
11	.28	.04	.23	.05
12	.10	.07	.13	.08
13	.07	.08	.09	.09
14	.38	.22	.40	.24
15	.06	.05	.05	.03
16	.03	.09	.10	.10
17	.15	.12	.16	.12
18	.05	.04	.08	.01
19	.22	.18	.26	.28
20	.05	.05	.07	.01
21	.06	.05	.11	.11
22	.04	.04	.05	.06
23	.11	.07	.16	.10
24	.05	.06	.02	.03
25	.05	.10	.10	.14
26	.58	.35	.32	.50
27	.02	.05	.03	.03
28	.32	.20	.38	.34
29	.02	.04	.07	.08
30	.01	.01	.03	.01
31	.01	.01	.05	.06
32	.12	.08	.03	.03

PERCENT HARMONIC CONTENT
60° PHASE BELT STATOR WITHOUT REGULATOR AND STATIC EXCITER

Harmonic	BALANCED LOAD CONDITION		
	No Load Percent Voltage	41.3 Amps, 100% PF Percent Voltage	82.5 Amps, 100% PF Percent Voltage
	L-N	L-N	L-N
1	100	100	100
2	.03	.18	.34
3	.08	.10	.40
4	.05	.10	.10
5	1.7	.56	.72
6	0	0	.01
7	.09	.52	.40
8	.27	.10	.05
9	0	0	0
10	.07	.04	.01
11	0	.04	.02
12	0	0	0
13	.08	0	.03
14	.25	.04	0
15	0	0	0
16	.1	.03	0
17	0	.02	.01
18	0	0	0
19	.13	.03	.02
20	.09	0	.01
21	0	0	0
22	.06	0	.01
23	.04	.01	.01
24	0	0	0
25	.06	0	.01
26	.50	.04	.02
27	0	0	0
28	.18	.02	.04
29	0	0	0
30	0	0	0
31	.02	0	0
32	.02	.01	.01

PERCENT HARMONIC CONTENT
60° PHASE BELT STATOR WITH REGULATOR AND STATIC EXCITER

Harmonic	BALANCED LOAD CONDITION					
	No Load Percent Voltage		41.3 Amps, 75% PF Percent Voltage		82.5 Amps, 75% PF Percent Voltage	
	L-N	L-L	L-N	L-L	L-N	L-L
1	100	100	100	100	100	100
2	1.2	.86	.96	.84	1.4	1.4
3	.78	.18	.80	.26	.78	.11
4	1.2	.70	.94	.88	.98	.99
5	1.5	.40	.72	.63	.64	.6
6	.1	.20	.26	.24	.48	.06
7	.67	.94	.70	.72	.38	.31
8	.07	.18	.14	.22	.27	.15
9	.23	.10	.22	.11	.22	.06
10	.23	.14	.25	.24	.23	.22
11	.12	.03	.18	.08	.22	.10
12	.02	.06	.11	.04	.18	.05
13	.08	.09	.16	.16	.12	.12
14	.18	.18	.24	.20	.25	.18
15	.07	.04	.06	.04	.03	.04
16	.06	.10	.11	.09	.04	.03
17	.05	.05	.10	.03	.16	.09
18	0	.02	.06	.04	.04	.02
19	.12	.12	.10	.12	.05	.12
20	.03	.05	.12	.10	.06	.1
21	.04	.02	.04	.03	.04	.01
22	.04	.04	.10	.07	.04	.01
23	.03	.05	.03	.03	.03	.03
24	.04	.02	.02	.04	.03	.01
25	.06	.04	.02	.01	.05	.02
26	.32	.34	.07	.12	.06	.08
27	0	.01	.02	.02	.02	.01
28	.09	.12	.09	.06	.08	.05
29	.03	.04	.04	.01	.02	.02
30	.04	.01	.03	.02	.01	.02
31	.04	.02	.06	.03	.01	.01
32	.06	.06	.05	.04	.02	.01

PERCENT HARMONIC CONTENT
60° PHASE BELT STATOR WITH REGULATOR AND STATIC EXCITER

Harmonic	UNBALANCED LOAD CONDITION			
	0, 0, 13.75 Amps, 100% PF Percent Voltage		0, 0, 27.5 Amps, 100% PF Percent Voltage	
	L-N	L-L	L-N	L-L
1	100	100	100	100
2	.69	.58	.49	.50
3	.99	.38	1.2	.44
4	1.2	.93	.90	.85
5	1.3	1.2	1.10	1.00
6	.24	.28	.31	.25
7	.77	.8	.67	.70
8	.08	.15	.11	.27
9	.31	.25	.35	.22
10	.34	.28	.34	.28
11	.16	.10	.05	.01
12	.16	.16	.20	.12
13	.12	.08	.19	.10
14	.14	.16	.19	.20
15	.09	.08	.10	.01
16	.08	.05	.06	.11
17	.04	.01	.03	.01
18	.06	.04	.08	.10
19	.1	.04	.09	.08
20	.03	.03	.09	.03
21	.05	.04	.05	.05
22	.04	.03	.01	.02
23	.06	.02	.01	0
24	.1	.04	.11	.05
25	.04	.03	.01	.01
26	.34	.42	.35	.40
27	.03	.01	.06	.02
28	.20	.1	.18	.10
29	.03	.01	.02	.01
30	.02	0	.03	.01
31	.02	0	.01	.03
32	.02	.0[illegible]	.05	.04

TRANSIENT AND SUBTRANSIENT REACTANCES AND TIME CONSTANTS

Total Averages of Four Tests:

$X_d' = 54.12\%$ $T_d' = .0620$ seconds

$X_d'' = 26.52\%$ $T_d'' = .00114$ seconds

Total Averages of Three Tests:

$T_{do}' = .120$ seconds with average field temperature at 355°F

COMPUTER PROCEDURE FOR

BECKY ROBINSON DESIGN CALCULATIONS

1. Clear core (no switch control).
2. Insert output from #1 into typewriter, set margin for correct output and set typewriter for single space.
3. Load pass #1 followed by input #1 (output both printed and punched cards).
4. Reset and load pass #2 followed by output from pass #1 (output punched cards).
5. Reset and load pass #3 followed by output from pass #2 (output punched cards).
6. Reset and load pass #4 followed by input #2 and output from pass #3 (output punched cards).
7. Reset and load pass #5 followed by output from pass #4 (output punched cards).
8. Reset and load pass #6 followed by saturation curve values* and output #5 (output punched cards).
9. Reset and load pass #7 followed by output from pass #6 (output printed plus punched cards).
10. Reset and load pass #8 followed by output from pass #7 (output punched cards).
11. Reset and load pass #9 followed by output from pass #8 (output printed plus punched cards).
12. Reset and load pass #10 followed by output from pass #9 (output punched cards).

13. Reset and load pass #11 followed by saturation curve values* and output from pass #10 (output punched cards).

14. Reset and load pass #12 followed by output pass #11 (output printed and punched cards).

15. If there is punch card output from pass #12 no load saturation curve is required. Place output form #2 in typewriter and set margin. Load pass #13 followed by saturation curve values* and output from apss #12 (output printed).

* Saturation curve values are loaded in order shown on Input Form #1.

All Input Parameters are in Format F7.0 (Fig. 1)

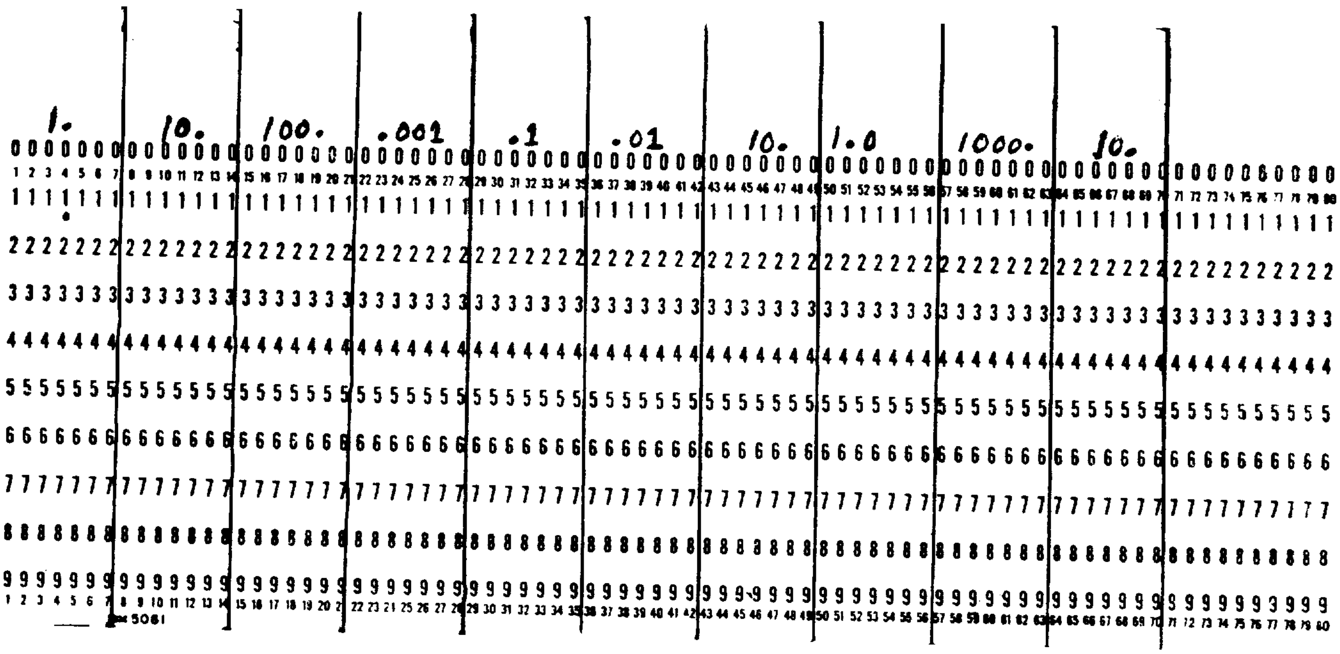


FIG. 1

All Saturation Curve Values are in Format F10.0 (Fig. 2)

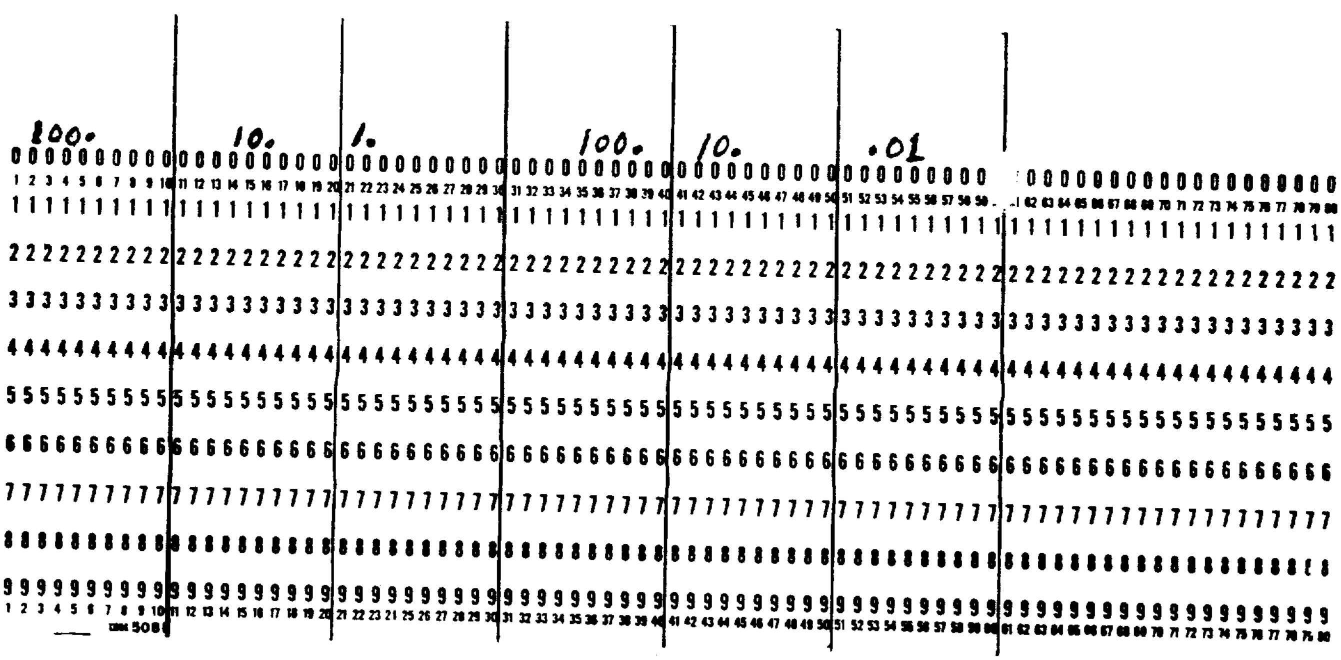


FIG. 2

TWO-COIL LUNDELL (BECKY-ROBINSON TYPE) (SECSYN)

Calculation Number	Electrical Symbol	Fortran Symbol
	A, a	
(128)	A	A
(46)	a_c	AC
(144)	a_{cd}	ACD
(153)	a_{cf}	AS
(170)	a_{dr}	AD
(68)	A_g	GA
(70)	A_{g2}	A2
(70a)	A_{g3}	A3
(79)	a_{np}	ANP
(79b)	a_{sk}	ASK
(79a)	a_{sp}	ASP
(124)	A_{y2}	AY2
(112)	A_{y4}	AY4
	B, b	
(20)	B	BK
(135)	b_{bo}	WO
(135)	b_{bl}	B
(22)	b_o	BO
(94)	B_c, B_c'	BC1

Calculation Number	Electrical Symbol	Fortran Symbol
(95)	B_g, B_g'	BG1
(122)	B_{g2}	BG2
(119)	B_{g3}	BG3
(224)	B_{g2FL}	BG2L
(230)	B_{g3FL}	BG3L
(116)	b_{NP}	BNP
(76)	$b_{NP(END)}$	BNE
(76)	$b_{NP(MID)}$	BNM
(234)	B_{NPFL}	BNPL
(22)	b_s	BS
(222)	B_{SKFL}	BSK
(105)	B_{SP}	BSP
(215)	B_{SPFL}	BSPL
(76)	$b_{SP(END)}$	BSE
(76)	$b_{SP(MID)}$	BSM
(57a)	$b_{t1/3}$	SM
(91)	B_T, B_T'	BT1
(205)	B_{TL}	BTL
(57)	b_{tm}	TM

Calculation Number	Electrical Symbol	Fortran Symbol
(15)	b_v	BV
(125)	B_{y2}	BY2
(228)	B_{y2FL}	BY2L
(113)	B_{y4}	BY4
(232)	B_{y4FL}	BY4L
	C, c	
(32)	c	C
(71)	C_1	C1
(74)	C_M	CM
(73)	C_P	CP
(75)	C_q	CQ
(72)	C_W	CW
	D, d	
(12)	D	DU
(11)	d	DI
(35)	d_b	DB
(170)	d_{dr}	DDR
(78)	d_{ir}	DIR
(11a)	d_r	DR

Calculation Number	Electrical Symbol	Fortran Symbol
	E, e	
(3)	E	EE
(55)	EF_{TOP}	ET
(56)	EF_{BOT}	EB
(238)	E_{FFL}	EPFL
(127b)	E_{FNL}	EPNL
(4)	E_{PH}	EP
	F, f	
(5a)	f	F
(98)	F_c, F_c'	FC
(201)	F_{CL}	FCL
(236)	F_{FL}	FFL
(96)	F_g, F_g'	FG
(208a)	F_{gL}	FGL
(123)	F_{g2}	FG2
(225)	F_{g2FL}	FG2L
(120)	F_{g3}	FG3
(231)	F_{g3FL}	FG3L
(117)	F_{NP}	FNP
(127)	F_{NL}	FNL

Calculation Number	Electrical Symbol	Fortran Symbol
(235)	F_{NPFL}	FNPL
(180)	F_{SC}	FSC
(223)	F_{SKFL}	FSK
(107)	F_{SP}	FSP
(216)	F_{SPFL}	FSPL
(97)	F_T, F_T'	FT
(206)	F_{TL}	FTL
(183)	F & W	WF
(126)	F_{y2}	FY2
(229)	F_{y2FL}	FY2L
(231)	F_{y3FL}	FG3L
(114)	F_{y4}	FY4
(233)	F_{y4FL}	FY4L
	G, g	
(59)	g	GC
(59a)	g_2	GP
(59c)	g_3	G3
(59d)	g_{3-1}	G2
(59e)	g_{3-2}	G1
(59f)	g_{3e}	G4
(69)	g_e	GE

Calculation Number	Electrical Symbol	Fortran Symbol
	H, h	
(135)	h_{bo}	HD
(135)	h_{b1}	H
(24)	h_c	HC
(78)	h_{NP}	HNP
(38)	h'_{ST}	SD
(39)	h_{ST}	SH
(78)	h_y	YH
	I, i	
(237)	I_{FFL}	AIFL
(127a)	I_{FNL}	AINL
(8)	I_{PH}	PI
(182)	$I^2 R_F$	FEL
(241)	$I^2 R_{FL}$	FCUL
(194)	$I^2 R$	PS
(245)	$I^2 R_S$	SCUL
	K, k	
(19)	k	WL
(9a)	K_c	CK
(43)	K_d	DF

Calculation Number	Electrical Symbol	Fortran Symbol
(63)	K_e	EK
(16)	K_i	SF
(44)	K_p	CF
(67)	K_s	CC
(42)	K_{SK}	FS
(2)	K_{VA}	VA
(61)	K_X	FF

L, l

(13)	ℓ	CL
(80a)	ℓ_1	PL1
(81a)	ℓ_2	PL2
(82a)	ℓ_3	PL3
(83)	ℓ_4	PL4
(83)	ℓ_{4a}	
(85)	ℓ_6	PL6
(86)	ℓ_7	AL7
(139)	ℓ_b	SB
(84)	ℓ_c	PLC
(48)	L_E	EL
(36)	ℓ_{e2}	CE

Calculation Number	Electrical Symbol	Fortran Symbol
(161)	L_F	SI
(78)	ℓ_{g2}	GP2
(76)	ℓ_{NP}	PNL
(17)	ℓ_s	SS
(76)	ℓ_{SP}	PSL
(49)	ℓ_t	HM
(147)	ℓ_{tf}	FE
(78)	ℓ_y	ALY
(78)	ℓ_{y4}	Y4
	M. m	
(5)	m	PN
	N, n	
(138)	n_b	BN
(146)	N_F	PT
(45)	n_e	EC
(30)	n_s	SC
(34)	N_{ST}	SN
(34a)	N'_{ST}	SN1
(14)	n_v	HV

Calculation Number	Electrical Symbol	Fortran Symbol
	P, p	
(6)	p	PX
(9)	PF	PF
(80)	P_1	P1
(81)	P_2	P2
(82)	P_3	P3
(83)	P_4	P4
(84)	P_5	P5
(85)	P_6	P6
(86)	P_7	P7
	Q, q	
(23)	Q	QQ
(25)	q	QN
	R, r	
(154)	$R_{f(cold)}$	FK
(155)	$R_{f(hot)}$	FR
(7)	RPM	RPM
(53)	$R_{SPH(cold)}$	RG
(54)	$R_{SPH(hot)}$	RP

Calculation Number	Electrical Symbol	Fortran Symbol
		S, s
(181)	SCR	SCR
(127c)	S_F	CD
(47)	S_S	S
		T, t
(177)	T_a	TA
(178)	T'_d	T5
(176)	T'_{do}	TC
(78)	T_{SK}	TSK
(78)	T_{SP}	TSP
		V, v
(145)	V_r	VR
		W, w
(185)	W_C	WQ
(244)	W_{DFL}	WDL
(193)	W_{DNL}	WD
(186)	W_{NPL}	WN
(243)	W_{PFL}	WNL
(242)	W_{TFL}	WTFL
(184)	W_{TNL}	WT

Calculation Number	Electrical Symbol	Fortran Symbol
	X, x	
(129)	X	XR
(131)	X_{ad}	XD
(132)	X_{aq}	XQ
(142)	X_D °C	T3
(167)	X_d'	XS
(168)	X_d''	XX
(163)	X_{Dd}	X1
(165)	X_{Dq}	X2
(166)	X_{du}'	XU
(160)	X_F'	XF
(150)	X_f °C	T2
(130)	X_ℓ	XL
(169)	X_q''	XY
(134)	X_q	XB
(50)	X_s °C	TI
(170)	X_2	XN
(172)	X_o	XO

Calculation Number	Electrical Symbol	Fortran Symbol
	Y, y	
(31)	y	YY
(100)	$\phi_{\ell 1}$	F1
(101)	$\phi_{\ell 2}$	F2
(102)	$\phi_{\ell 3}$	F3
(103)	$\phi_{\ell 4}$	F4
(118)	$\phi_{\ell 5}$	PL5
(121)	$\phi_{\ell 6}$	PL6
(99)	$\phi_{\ell 7}$	PL7
(209)	ϕ_{IL}	Q1
(210)	ϕ_{2L}	Q2
(211)	ϕ_{3L}	Q3
(212)	ϕ_{4L}	Q4
(226)	ϕ_{5L}	QL5
(220)	ϕ_{6L}	Q6
(207)	ϕ_{7L}	Q7
(93)	ϕ_{p}	FQ
(213)	ϕ_{PL}	FQL
(90)	ϕ_{T}, $\dot{\phi}_{T}$	TG
(208)	ϕ_{TL}	PTL

Calculation Number	Electrical Symbol	Fortran Symbol
		τ
(140)	τ_b	TB
(41)	τ_p	TP
(26)	τ_s	TS
(40)	τ_{SK}	SK
(27)	$\tau_{S\ 1/3}$	TT
		λ
(158)	λ_b	BD
(162)	λ_{Dd}	PU
(164)	λ_{Dq}	PV
(64)	λ_E	EW
(159)	λ_{pt}	BE
		ρ
(141)	ρ_D	RE
(143)	$\rho_{D\ hot}$	RM
(151)	ρ_f	RR
(152)	$\rho_{f\ (hot)}$	
(51)	ρ_s	RS

```
C      PASS  1  SECSYN
     1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
     2 FORMAT(F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0)
     3 FORMAT(9X F12.5,2X F12.5)
     7 READ2,VA,EE,EP,PN,F,PX,RPM,PI,PF,CK
       READ2,POL,DI,DU,CL,HV,BV,SF,WL,BK,ZZ
       READ2,BO,B1,B2,B3,BS,HO,HX,HY,HZ,HS
       READ2,HT,HW,QQ,W,RF,SC,YY,C,DW,SN
       READ2,SN1,DW1,DB,CE,SH,SD,PBA,SK,T1,RS
       READ2,G,GC,GP,G4,C1,CW,CP,EL,CM,CQ
       READ2,PE,BNE,BSE,BNM,BSM,PNL,PSL,DR,HNP,D1
       READ2,WO,HD,DD,H,B,BN,SB,TB,RE,T3
       READ2,DDR,AD,PT,FE,RD,RT,T2,RR,SNL,WF
       SS=SF*(CL-HV*BV)
       HC=(DU-DI-2.0*HS)*0.5
       QN=QQ/(PX*PN)
       TS=3.142*DI/QQ
       IF(ZZ-4.0)9,10,9
     9 TT=(0.667*HS+DI)*3.142/QQ
       GO TO 11
    10 TT=3.1416*(DI+2.*HO+1.32*BS)/QQ
    11 IF(ZZ-1.0)12,12,13
    12 BO=BS
       CC=(5.0*GC+BS)*TS/((5.0*GC+BS)*TS-BS*BS)
       GO TO 14
    13 QC=(4.44*GC+0.75*BO)*TS
       CC=QC/(QC-BO*BO)
    14 CS=YY/(PN*QN)
       TP=3.142*DI/PX
```

```
      IF(SK)18,18,19
   18 FS=1.0
      GO TO 20
   19 FS=SIN(1.571*SK/TP)*TP/(1.571*SK)
   20 IF(PBA-60.)21,21,22
   21 D=1.0
      GO TO 95
   22 D=2.0
   95 I=QN
      U=I
      IF(QN-U)23,23,24
   24 U=PX*PN
      XX=U
      N=U
      DO 25 K=1,N
      Z=U/XX
      I=Z
      Z1=I
      IF(Z-Z1)26,26,25
   26 ZY=QQ/XX
      I=ZY
      Z1=I
      IF(ZY-Z1)27,27,25
   25 XX=XX-1.
   23 ZY=QN
   27 DF=SIN(.5236*D)/(ZY*D*SIN(.5236/ZY))
      CF=SIN(YY*1.571/(PN*QN))
      EC=QQ*SC*CF*FS/C
      GE=CC*GC
```

```
   IF(C1)29,28,29
28 C1=0.649*LOG(PE)+1.359
29 IF(CW)30,30,31
30 CW=0.707*EE*C1*DF/(EP*PN)
31 IF(CP)32,32,33
32 CP=PE*(LOG(GC/TP)*.0378+1.191)
33 IF(EL)34,34,42
34 IF(RF)35,35,41
35 IF(PX-2.0)36,36,37
36 U=1.3
   GO TO 40
37 IF(PX-4.0)38,38,39
38 U=1.5
   GO TO 40
39 U=1.7
40 EL=3.142*U*YY*(DI+HS)/QQ+0.5
   GO TO 42
41 EL=2.0*CE+3.142*(0.5*HX+DB)+YY*TS*TS/SQRT(TS*TS-BS*BS)
42 AA=1.571*PE
   AB=3.142*PE
   IF(CM)43,43,44
43 CM=(AB+SIN(AB))/(SIN(AA)*4.)
44 IF(CQ)45,45,46
45 CQ=(0.5*COS(AA)+AB-SIN(AB))/(4.0*SIN(AA))
46 RB=(T1+234.5)*0.00394*RS
   PRINT3,SS,CC,HC,GE,TS,C1,TT,CW,FS,CP,DF,EL,CF,CM,EC,CQ
   PUNCH1,VA,EE,EP,PN,F,PX
   PUNCH1,RPM,PI,PF,CK,POL,DI
   PUNCH1,DU,CL,SS,HC,SF,QN
```

```
PUNCH1,WL,BK,ZZ,B0,B1,B2
PUNCH1,B3,BS,H0,HX,HY,HZ
PUNCH1,HS,HT,HW,QQ,W,RF
PUNCH1,SC,YY,C,TS,SN,DB
PUNCH1,CE,SH,SD,TT,SK,RB
PUNCH1,RS,GC,GP,C1,CW,CP
PUNCH1,EL,CM,CQ,DW,CC,PBA
PUNCH1,G4,CS,CF,FS,EC,DF
PUNCH1,G,GE,RS,TP,BNE,BSE
PUNCH1,BNM,BSM,PNL,PSL,DR,HNP
PUNCH1,D1,W0,HD,DD,H,B
PUNCH1,BN,SB,TB,RE,T3,PT
PUNCH1,FE,RD,RT,T2,RR,SNL
PUNCH1,WF,PE,DDR,AD,SN1,DW1
PAUSE
END
```

```
C     PASS 2 SECSYN
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      DIMENSION DA(8),DX(6),DY(8),DZ(8)
      READ1, VA,EE,EP,PN,F,PX
      READ1, RPM,PI,PF,CK,POL,DI
      READ1, DU,CL,SS,HC,SF,QN
      READ1, WL,BK,ZZ,BO,B1,B2
      READ1, B3,BS,HO,HX,HY,HZ
      READ1, HS,HT,HW,QQ,W,RF
      READ1, SC,YY,C,TS,SN,DB
      READ1, CE,SH,SD,TT,SK,RB
      READ1, RS,GC,GP,C1,CW,CP
      READ1, EL,CM,CQ,DW,CC,PBA
      READ1, G4,CS,CF,FS,EC,DF
      READ1,G,GE,RS,TP,BNE,BSE
      READ1,BNM,BSM,PNL,PSL,DR,HNP
      READ1,D1,WO,HD,DD,H,B
      READ1,BN,SB,TB,RE,T3,PT
      READ1,FE,RD,RT,T2,RR,SNL
      READ 1,WF,PE,DDR,AD,SN1,DW1
      DT=DW1
      IF(ZZ-3.0)49,50,51
   49 SM=TT-BS
      GO TO 53
   50 SM=(3.1416*(DI+2.*HS)/QQ)-B3
      GO TO 53
   51 IF(ZZ-4.0)50,52,49
   52 SM=TT-.94*BS
   53 HM=CL+EL
```

```
      IF(DT) 61,61,62
   61 AC=0.785*DW*DW*SN1
      GO TO 72
   62 ZY=0.0
      DA(1)=0.05
      DA(2)=0.072
      DA(3)=0.125
      DA(4)=0.165
      DA(5)=0.225
      DA(6)=0.438
      DA(7)=0.688
      DA(8)=1.5
      DX(1)=0.000124
      DX(2)=0.00021
      DX(3)=0.00021
      DX(4)=0.00084
      DX(5)=0.00189
      DX(6)=0.00189
      DY(1)=0.000124
      DY(2)=0.000124
      DY(3)=0.00084
      DY(4)=0.00084
      DY(5)=0.00189
      DY(6)=0.00335
      DY(7)=0.00754
      DY(8)=0.03020
      DZ(1)=0.000124
      DZ(2)=0.000124
      DZ(3)=0.000124
```

```
      DZ(4)=0.00335
      DZ(5)=0.00335
      DZ(6)=0.00754
      DZ(7)=0.0134
      DZ(8)=0.0302
   63 IF(DT-.05)201,201,200
  200 JA=0
      JB=0
      JC=0
      JD=0
   64 JA=JA+1
      JB=JB+1
      JC=JC+1
      JD=JD+1
      IF(DT-DA(JA))65,65,64
  201 D=0
      IF(ZY)71,71,54
   65 IF(DW-0.188)66,66,67
   66 CY=DX(JB-1)
      CZ=DX(JB)
      GO TO 70
   67 IF(DW-0.75)68,68,69
   68 CY=DY(JC-1)
      CZ=DY(JC)
      GO TO 70
   69 CY=DZ(JD-1)
      CZ=DZ(JD)
   70 D=CY+(CZ-CY)*(DT-DA(JA-1))/(DA(JA)-DA(JA-1))
      IF(ZY)71,71,54
```

```
 71 AC=(DT*DW-D)*SN1
 72 IF(RT)73,73,74
 73 AS=0.785*RD*RD
    GO TO 55
 74 ZY=1.0
    DT=RT
    DW=RD
    GO TO 63
 54 AS=RT*RD-D
 55 S=PI/(C*AC)
    CY=PT    *FE*0.000001/AS
    FK=RR*CY
    FR=(T2+234.5)*FK*0.00394
    RC=0.321*PT    *FE*AS
    IF(SH)202,203,202
203 ET=1
    EB=1
    GO TO 204
202 AA=0.584+(SN*SN-1.0)*0.0625*(SD*CL/(SH*HM))**2.0
    AB=(SH*SC*F*AC/(BS*RB))**2.0
    ET=AA*AB*0.00335+1.0
    EB=ET-0.00168*AB
204 RY=SC*QQ*0.000001*HM/(PN*AC*C*C)
    RG=RS*RY
    RP=RB*RY
    A=PI*SC*CF/(C*TS)
    PUNCH1,VA,EE,EP,PN,F,PX
    PUNCH1,RPM,PI,PF,CK,POL,DI
    PUNCH1,DU,CL,SS,HC,SF,QN
```

```
PUNCH1,WL,BK,ZZ,B0,B1,B2
PUNCH1,B3,BS,H0,HX,HY,HZ
PUNCH1,HS,HT,HW,QQ,W,RF
PUNCH1,SC,YY,C,TS,SN,DB
PUNCH1,CE,SH,SD,TT,SK,RB
PUNCH1,RS,GC,GP,C1,CW,CP
PUNCH1,EL,CM,CQ,DW,CC,PBA
PUNCH1,G4,CS,CF,FS,EC,DF
PUNCH1,G,GE,RS,TP,BNE,BSE
PUNCH1,BNM,BSM,PNL,PSL,DR,HNP
PUNCH1,D1,WO,HD,DD,H,B
PUNCH1,BN,SB,TB,RE,T3,PT
PUNCH1,FE,RD,RT,T2,RR,SNL
PUNCH1,WF,HM,SM,AC,AS,ET
PUNCH1,EB,S,FK,FR,RC,RG
PUNCH1,RP,A,PE,DDR,AD
PAUSE
END
```

```
C     PASS  3  SECSYN
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      READ1 ,VA,EE,EP,PN,F,PX
      READ1 ,RPM,PI,PF,CK,POL,DI
      READ1, DU,CL,SS,HC,SF,QN
      READ1, WL,BK,ZZ,BO,B1,B2
      READ1, B3,BS,HO,HX,HY,HZ
      READ1 ,HS,HT,HW,QQ,W,RF
      READ1 ,SC,YY,C,TS,SN,DB
      READ1 ,CE,SH,SD,TT,SK,RB
      READ1 ,RS,GC,GP,C1,CW,CP
      READ1 ,EL,CM,CQ,DW,CC,PBA
      READ1 ,G4,CS,CF,FS,EC,DF
      READ1 ,G,GE,RS,TP,BNE,BSE
      READ1 ,BNM,BSM,PNL,PSL,DR,HNP
      READ1 ,D1,WO,HD,DD,H,B
      READ1 ,BN,SB,TB,RE,T3,PT
      READ1 ,FE,RD,RT,T2,RR,SNL
      READ1 ,WF,HM,SM,AC,AS,ET
      READ1 ,EB,S,FK,FR,RC,RG
      READ1 ,RP,A,PE,DDR,AD
      IF(PBA-60.0)105,105,108
  105 IF(CS-0.667)106,106,107
  106 FF=0.25*(6.0*CS-1.0)
  107 FF=0.25*(3.*CS+1.0)
      GO TO 75
  108 IF(CF-0.667)109,109,110
  109 FF=0.05*(24.0*CS-1.0)
      GO TO 75
```

```
110 FF=0.75
 75 CX=FF/(CF*CF*DF*DF)
    Z=CX*20.0/(PN*QN)
    BT=3.142*DI/QQ-BO
    ZA=BT*BT/(16.0*TS*GC)
    ZB=0.35*BT/TS
    ZC=HO/BO
    ZD=HX*0.333/BS
    ZE=HY/BS
    IF(ZZ-2.0) 76,77,78
 76 PC=Z*(ZE+ZD+ZA+ZB)
       GO TO 82
 77 PC=Z*(ZC+(2.0*HT/(BO+BS))+(HW/BS)+ZD+ZA+ZB)
    GO TO 82
 78 IF(ZZ-4.0) 79,80,81
 79 PC=Z*(ZC+(2.0*HT/(BO+B1))+(2.0*HW/(B1+B2))+(HX*0.333/B2)+ZA+ZB)
    GO TO 82
 80 PC=Z*(ZC+0.62)
    GO TO 82
 81 PC=Z*(ZE+ZD+(0.5*GC/TS)+(0.25*TS/GC)+0.6)
 82 EK=EL/(10.0**(0.103*YY*TS+0.402))
    IF(DI-8.0) 83,83,84
 83 EK=SQRT(EK)
 84 ZF=.612*LOG(10.0*CS)
    EW=6.28*EK*ZF*(TP**(0.62-(0.228*LOG(ZF))))/(CL*DF*DF)
 87 ZA=3.1416*(DI+HS)/QQ
    IF(ZZ-3.0) 88,89,88
 88 TM=ZA-BS
    GO TO 90
```

```
89 TM=(3.1416*(DI+2.*HS)/QQ)-B3
90 WI=(TM*QQ*SS*HS+(DU-HC)*3.142*HC*SS)*0.283
   PUNCH1,VA,EE,EP,PN,F,PX
   PUNCH1,RPM,PI,PF,CK,POL,DI
   PUNCH1,DU,CL,SS,HC,SF,QN
   PUNCH1,WL,BK,ZZ,BO,B1,B2
   PUNCH1,B3,BS,HO,HX,HY,HZ
   PUNCH1,HS,HT,HW,QQ,W,RF
   PUNCH1,SC,YY,C,TS,SN,DB
   PUNCH1,CE,SH,SD,TT,SK,RB
   PUNCH1,RS,GC,GP,C1,CW,CP
   PUNCH1,EL,CM,CQ,DW,CC,AD
   PUNCH1,G4,CS,CF,FS,EC,DF
   PUNCH1,G,GE,RS,TP,BNE,BSE
   PUNCH1,BNM,BSM,PNL,PSL,DR,HNP
   PUNCH1,D1,WO,HD,DD,H,B
   PUNCH1,BN,SB,TB,RE,T3,PT
   PUNCH1,FE,RD,RT,T2,RR,SNL
   PUNCH1,WF,HM,SM,AC,AS,ET
   PUNCH1,EB,S,FK,FR,RC,RG
   PUNCH1,RP,A,FF,CX,PC,EK
   PUNCH1,EW,ZC,TM,WI,PE,DDR
   PAUSE
   END
```

```
C     PASS  4  SECSYN
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
    2 FORMAT(F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0,F7.0)
      READ2, P1,P2,P3,P4,P5,P6,P7,PL1,PL2,PL6
      READ2, PLC,DIR,DQ,YH,ALY,RSL,Y4,GP2,TSP,TSK
      READ2, DTO,DT1,DS1,DS2,DS3,DS4,DS5,S1,S2,S3
      READ2,S4,S5,DOS,PFHL,DBHL,WR
      READ1, VA,EE,EP,PN,F,PX
      READ1, RPM,PI,PF,CK,POL,DI
      READ1, DU,CL,SS,HC,SF,QN
      READ1, WL,BK,ZZ,BO,B1,B2
      READ1, B3,BS,HO,HX,HY,HZ
      READ1, HS,HT,HW,QQ,W,RF
      READ1, SC,YY,C,TS,SN,DB
      READ1, CE,SH,SD,TT,SK,RB
      READ1, RS,GC,GP,C1,CW,CP
      READ1, EL,CM,CQ,DW,CC,AD
      READ1, G4,CS,CF,FS,EC,DF
      READ1, G,GE,RS,TP,BNE,BSE
      READ1, BNM,BSM,PNL,PSL,DR,HNP
      READ1, D1,WO,HD,DD,H,B
      READ1, BN,SB,TB,RE,T3,PT
      READ1, FE,RD,RT,T2,RR,SNL
      READ1, WF,HM,SM,AC,AS,ET
      READ1, EB,S,FK,FR,RC,RG
      READ1, RP,A,FF,CX,PC,EK
      READ1,EW,ZC,TM,WI,PE,DDR
      IF(P1)405,404,405
  404 P1=3.19*(BNE+PL2)*TSP*PX/PL1
```

```
405 IF(P2)406,407,406
407 IF(BNE-BNM)438,437,438
438 P2=6.28*((SQRT((BNM-BNE)**2+PNL*PNL)/2.)+PL1/2.)*TSP*PX/PL2
    GO TO 406
437 P2=3.19*(PNL+PL1)*TSP*PX/PL2
406 IF(P3)408,409,408
409 P3=3.19*BNE*(HNP-TSP)*PX/((DR-DOS)*(3.1416/8.)-TSP)
408 IF(P4)410,411,410
411 TEM=3.19*((DR/2.)-TSP)*PX/((DR-DOS)/2.-TSP)
    TEM1=3.19*PX/(((DR/2.)-TSP)*SIN((6.28/PX)*(1.-PE/4.))-BNE/2.)
        IF(PX-4.)414,414,413
414 IF(BNE-BNM)415,416,415
416 P4=(PNL+PL1)*TEM
    GO TO 410
415 P4=(SQRT((BNM-BNE)**2+PNL**2)*.25+(PL1/2.))*2.*TEM
    GO TO 410
413 IF(BNE-BNM)417,418,417
418 P4=TEM1*((DR-DOS)/2.0-TSP)*(PNL+PL1)
    GO TO 410
417 P4=(SQRT((BNM-BNE)**2+PNL**2)*.25+(PL1/2.))*2.*TEM1*((DR/2.)-TSP)
410 IF(P5)419,420,419
420 P5=3.19*BNE*PL6*.667*PX/PLC
419 IF(P6)421,422,421
422 P6=3.19*PLC*PE*(DR-2.*TSP)*3.1416/PL6
421 IF(P7)424,423,424
423 P7=(3.19/4.)*3.1416*(DR+HC+HS)*(HC+HS+RSL)/(3.1416*(HC+HS)/2.)
424 TG=6.E6*EE/(CW*EC*RPM)
    PUNCH1,VA,EE,EP,PN,F,PX
    PUNCH1,RPM,PI,PF,CK,POL,DI
```

```
PUNCH1,DU,CL,SS,HC,SF,QN
PUNCH1,WL,BK,ZZ,BO,B1,B2
PUNCH1,B3,BS,HO,HX,HY,HZ
PUNCH1,HS,HT,HW,QQ,W,RF
PUNCH1,SC,YY,C,TS,SN,DB
PUNCH1,CE,SH,SD,TT,SK,RB
PUNCH1,RS,GC,GP,C1,CW,CP
PUNCH1,EL,CM,CQ,DW,CC,AD
PUNCH1,G4,CS,CF,FS,EC,DF
PUNCH1,G,GE,RS,TP,BNE,BSE
PUNCH1,BNM,BSM,PNL,PSL,DR,HNP
PUNCH1,D1,WO,HD,DD,H,B
PUNCH1,BN,SB,TB,RE,T3,PT
PUNCH1,FE,RD,RT,T2,RR,SNL
PUNCH1,WF,HM,SM,AC,AS,ET
PUNCH1,EB,S,FK,FR,RC,RG
PUNCH1,RP,A,PLC,PL1,PC,EK
PUNCH1,EW,ZC,TM,WI,PE,DDR
PUNCH1,TG,P1,P2,P3,P4,P5
PUNCH1,P6,P7,DIR,DQ,YH,ALY,
PUNCH1,RSL,Y4,GP2,TSP,TSK,PFHL
PUNCH1,DBHL,DOS,WR,DTO,DT1,DS1
PUNCH1,DS2,DS3,DS4,DS5,S1,S2
PUNCH1,S3,S4,S5
PAUSE
END
```

```
C      PASS  5  SECSYN
     1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
       READ1 ,VA,EE,EP,PN,F,PX
       READ1 ,RPM,PI,PF,CK,POL,DI
       READ1 ,DU,CL,SS,HC,SF,QN
       READ1 ,WL,BK,ZZ,BO,B1,B2
       READ1 ,B3,BS,HO,HX,HY,HZ
       READ1 ,HS,HT,HW,QQ,W,RF
       READ1 ,SC,YY,C,TS,SN,DB
       READ1 ,CE,SH,SD,TT,SK,RB
       READ1 ,RS,GC,GP,C1,CW,CP
       READ1 ,EL,CM,CQ,DW,CC,AD
       READ1 ,G4,CS,CF,FS,EC,DF
       READ1 ,G,GE,RS,TP,BNE,BSE
       READ1 ,BNM,BSM,PNL,PSL,DR,HNP
       READ1 ,D1,WO,HD,DD,H,B
       READ1 ,BN,SB,TB,RE,T3,PT
       READ1 ,FE,RD,RT,T2,RR,SNL
       READ1 ,WF,HM,SM,AC,AS,ET
       READ1 ,EB,S,FK,FR,RC,RG
       READ1 ,RP,A,PLC,PL1,PC,EK
       READ1 ,EW,ZC,TM,WI,PE,DDR
       READ1 ,TG,P1,P2,P3,P4,P5
       READ1 ,P6,P7,DIR,DQ,YH,ALY
       READ1 ,RSL,Y4,GP2,TSP,TSK,PFHL
       READ1 ,DBHL,DOS,WR,DTO,DT1,DS1
       READ1 ,DS2,DS3,DS4,DS5,S1,S2
       READ1 ,S3,S4,S5
       BTT=TG/(SS*SM*QQ)
```

```
      FQ=TG*CP/PX
      BC=FQ/(2.*HC*SS)
      BG=TG/(3.1416*DI*CL)
      ALCR= 3.1416*(DU-HC)/(4.*PX)
      AY4=(3.1416/4.)*(DOS*DOS-DQ*DQ)
      AY2=3.1416*DOS*ALY
      GA=DI*3.1416*CL
      A2=3.1416*GP2*(DIR+GP)
      IF(G-1.0)402,403,402
  402 A3=1.571*(DTO+DT1)*SQRT(4.*Y4*Y4+(DTO-DT1)**2)
      GO TO 444
  403 A3=(DS1*S1)+(DS2*S2)+(DS3*S3)+(DS4*S4)+(DS5*S5)
      A3=3.1416*A3+(DOS**2-DS1**2)*.78
  444 ANP=PNL*(BNE+BNM)/2.
      ASP=BSE*TSP
      ASK=3.1416*(DR-TSK)*TSK
      IF(WF)445,446,445
  446 WF=2.52E-6*(DR**2.5)*(PL1+PNL+GP2)*RPM**1.5
  445 WC=.321*HM*QQ*AC*SC
      PUNCH1,VA,EE,EP,PN,F,RPM
      PUNCH1,PI,PF,CK,POL,DI,DU
      PUNCH1,CL,SS,HC,SF,QN,WL
      PUNCH1,BK,ZZ,BO,B1,B2,B3
      PUNCH1,BS,HO,HX,HY,HZ,HT
      PUNCH1,HW,QQ,W,RF,SC,YY
      PUNCH1,C ,TS,SN,DB,CE,SH
      PUNCH1,SD,TT,SK,RB,RS,GC
      PUNCH1,C1,CW,CP,EL,CM,CQ
      PUNCH1,DW,CC,AD,CS,CF,FS
```

```
PUNCH1,EC,DF,G,RS,TP,BSE
PUNCH1,BSM,PNL,DR,D1,WO,HD
PUNCH1,DD,H,B,BN,SB,TB
PUNCH1,RE,T3,FE,RD,RT,T2
PUNCH1,RR,SNL,WF,HM,SM,AC
PUNCH1,ET,EB,S,FK,RC,RG
PUNCH1,RP,A,PLC,PL1,PC,EK
PUNCH1,EW,ZC,TM,WI,PE,DDR
PUNCH1,DIR,DOS,DQ,RSL,GP2,TSP
PUNCH1,TSK,PFHL,DBHL,GA,WC,ASK
PUNCH1,TG,BTT,FQ,BC,GE,HS
PUNCH1,ALCR,PX,ANP,ASP,HNP
PUNCH1,A2,A3,AY4,Y4,G4,GP
PUNCH1,AY2,YH,PT,FR,AS,PSL
PUNCH1,BNE,BNM,ALY,P1,P2,P3
PUNCH1,P4,P5,P6,P7,WR,BG
PAUSE
END
```

```
C     PASS  6  SECSYN
      DIMENSION AI(120)
  888 FORMAT(F10.0,F10.0,F10.0,F10.0,F10.0,F10.0)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      K=1
  823 READ888,AI(K),AI(K+1),AI(K+2),AI(K+3),AI(K+4),AI(K+5)
      K=K+6
      IF (K-119)823,824,824
  824 DO844 N=1,20
      READ1,R1,R2,R3,R4,R5,R6
      PUNCH1,R1,R2,R3,R4,R5,R6
  844 CONTINUE
      READ1,TG,BTT,FQ,BC,GE,HS
      READ1,ALCR,PX,ANP,ASP,HNP
      READ1,A2,A3,AY4,Y4,G4,GP
      READ1,AY2,YH,PT,FR,AS,PSL
      READ1,BNE,BNM,ALY,P1,P2,P3
      READ1,P4,P5,P6,P7,WR,BG
      LOAD=1
      PL71=.01*TG
  801 TTP=TG+PL71
      X=TTP/TG
      BT1=X*BTT
      Z=FQ/PX
      PP1=X*FQ
      BC1=(PP1/FQ)*BC
      BG1=BG*X
      FG=(BG1*GE)/.00319
      NA=1
```

```
      K=1
      X=BT1
      GO TO 802
  803 FT=AT*HS
      NA=1
      K=2
      X=BC1
      GO TO 802
  804 FC=AT*ALCR
      PL7=(FT+FG+FC)*P7*.001
      IF(1.1*PL71-PL7)810,811,811
  811 IF(.9*PL71-PL7)812,812,810
  810 PL71=PL7
      GO TO 801
  812 Z1=(.002*(FG+FC+FT))*(P1+P2+P3+P4)
      FQ=PP1
      Z=FQ/PX
      Y=Z1/PX+FQ
      BNP=Y/ANP
      BSP=Y/(2.*ASP)
      NA=61
      K=3
      X=BNP
      GO TO 802
  805 FNP=HNP*AT
      NA=31
      K=4
      X=BSP
      GO TO 802
```

```
806 IF(BNE-BNM)820,821,820
820 AXX=PSL/2.
    GO TO 822
821 AXX=PSL/3.
822 FSP=AXX*AT
    PG2=(FQ*PX+Z1+PL7)/4.
    BG2=PG2/A2
    FG2=BG2*GP/.00319
    BY4=PG2/AY4
    K=5
    NA=61
    X=BY4
    GO TO 802
807 FY4=AT*Y4
    Z2=2.*(FG+FC+FT)
    Z3=Z2+FSP+FG2
    PL5=(Z3+FNP)*P5*.001
816 BNP=(((Z1+PL7+PL5)/PX)+FQ)/ANP
    K=6
    NA=61
    X=BNP
    GO TO 802
808 FNP=HNP*AT
    PL51=(Z3+FNP)*P5*.001
    IF(1.1*PL5-PL51)813,814,814
814 IF(.9*PL5-PL51)815,815,813
813 PL5=PL51
    GO TO 816
815 BG3=(FQ*PX+(Z1+PL7+PL5))/(4.*A3)
```

```
      FG3=BG3*G4/.00319
      PL6=(Z2+FSP+FNP+FY4+FG3)*P6*.001
      BG2=(FQ*PX+Z1+PL7+PL6)/(4.*A2)
      FG2=BG2*GP/.00319
      BY2=(FQ*PX+Z1+PL7+PL5)/(4.*AY2)
      X=BY2
      K=7
      NA=91
      GO TO 802
  809 FY2=YH*AT/3.
      FNL=Z2+FNP+FSP+FG2+FY2+FG3+FY4
      AINL=FNL/PT
      EFNL=AINL*FR
      CD=AINL/AS
      TG=TTP
      PUNCH1,TG,BTT,FQ,BC,GE,HS
      PUNCH1,ALCR,PX,ANP,ASP,HNP
      PUNCH1,A2,A3,AY4,Y4,G4,GP
      PUNCH1,AY2,YH,PT,FR,AS,PSL
      PUNCH1,BNE,BNM,ALY,P1,P2,P3
      PUNCH1,P4,P5,P6,P7,WR,FC
      PUNCH1,BNP,BSP,BY2,BY4,BG2,BG3
      PUNCH1,PG2,FG,FG2,FG3,FNL,AINL
      PUNCH1,EFNL,CD,BC1,BT1,BG1,FT
        PAUSE
  802 IF(AI(NA)-X)830,831,831
  831 NA=NA+3
  835 IF(AI(NA)-X)833,834,834
  833 NA=NA+2
```

```
      GO TO 835
834   AA=AI(NA)
      BB1=AI(NA-2)
      DC=AI(NA+1)
      D=AI(NA-1)
      XX= (AA-BB1)/(.4343*(LOG(DC)-LOG(D+.0001)))
      Y=AA-XX*.4343*LOG(DC)
         AT=EXP(2.306*(X-Y)/XX)
      GO TO (838,839),LOAD
838   GO TO (803,804,805,806,807,808,809),K
830   GO TO (836,837),LOAD
836   PRINT 850,
850   FORMAT (17HMACHINE SATURATED)
      PAUSE
      END
```

```
C     PASS  7  SECSYN
    3 FORMAT(9X F12.5,2X F12.5)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      READ1 ,VA,EE,EP,PN,F,RPM
      READ1 ,PI,PF,CK,POL,DI,DU
      READ1 ,CL,SS,HC,SF,QN,WL
      READ1 ,BK,ZZ,B0,B1,B2,B3
      READ1 ,BS,HO,HX,HY,HZ,HT
      READ1 ,HW,QQ,W,RF,SC,YY
      READ1 ,C ,TS,SN,DB,CE,SH
      READ1 ,SD,TT,SK,RB,RS,GC
      READ1 ,C1,CW,CP,EL,CM,CQ
      READ1 ,DW,CC,AD,CS,CF,FS
      READ1 ,EC,DF,G,RS,TP,BSE
      READ1 ,BSM,PNL,DR,D1,WO,HD
      READ1 ,DD,H,B,BN,SB,TB
      READ1 ,RE,T3,FE,RD,RT,T2
      READ1 ,RR,SNL,WF,HM,SM,AC
      READ1 ,ET,EB,S,FK,RC,RG
      READ1 ,RP,A,PLC,PL1,PC
      READ1 ,EW,ZC,TM,WI,PE,DDR
      READ1 ,DIR,DOS,DQ,RSL,GP2,TSP
      READ1 ,TSK,PFHL,DBHL,GA,WC,ASK
      READ1 ,TG,BTT,FQ,BC,GE,HS
      READ1 ,ALCR,PX,ANP,ASP,HNP
      READ1 ,A2,A3,AY4,Y4,G4,GP
      READ1 ,AY2,YH,PT,FR,AS,PSL
      READ1 ,BNE,BNM,ALY,P1,P2,P3
      READ1 ,P4,P5,P6,P7,WR,FC
```

```
      READ1 ,BNP,BSP,BY2,BY4,BG2,BG3
      READ1 ,PG2,FG,FG2,FG3,FNL,AINL
      READ1 ,EFNL,CD,BC1,BT1,BG1,FT
      XR=.0707*A*DF/(C1*BG1)
      XL=XR*(PC+EW)
      XD=   EC*PI*CM*DF* 90./(PX*(2.*FG+FG2+FG3))
      XQ=CQ*XD/(CM*C1)
      XA=XL+XD
      XB=XL+XQ
      VR= .262*DR*RPM
      GE1=GE*(2.*FG+FG2+FG3)/(2.*FG)
      FL=(P1+P2+P3+P4+P5+P6)/CL
      ALA=6.38*DI/(PX*GE1)
      PGE=PG2/(AINL*PT*.001)
      XF=XD*(1.-((C1/CM)/(2.*CP+(4.*FL /(3.1416*ALA)))))
      SI=2.*PT*PT*PGE*1.E-8
      IF(BN)511,510,511
  511 IF(H)501,502,501
  502 BD=6.38*(HD/WO+1.12)
      GO TO 503
  501 BD=6.38*(HD/WO+H/(3.*B)+.5)
  503 BE=6.38*(BNE-TB*(BN-1.))/(3.*GE)
      X1=XR*COS((BN-1.)*TB*3.1416/(2.*TP))*(BD+BE)*FL/(BD+BE+FL)
      XXA=20.*TB/TP
      IF(H)504,505,504
  504 X2=XR*(.5+GC/TB+HD/WO+H/(3.*B))*XXA
      GO TO 506
  505 X2=XR*(GC/TB+1.12+HD/WO)*XXA
      GO TO 506
```

```
510 X1=0
    X2=0
506 XU=XF+XL
    XS=.88*XU
    IF(BN)507,508,507
507 XX=XL+X1
    XY=XL+X2
    GO TO 509
508 XX=XS
    XY=XB
509 PRINT3,AC,A,S,XR,HM,XL,RG,XD,RP,XQ,ET,XA,EB,XB,PC,XF,EW,SI,WC,X1
    PRINT3,WI,X2,TP,XU,WR,XS,VR,XX,AS,XY
    PUNCH1,TSK,PFHL,DBHL,GA,EP,ASK
    PUNCH1,BSP,BY2,BY4,BG2,ALCR,ANP
    PUNCH1,ASP,HNP,A2,A3,AY4,Y4
    PUNCH1,G4,GP,AY2,YH,PT,SNL
    PUNCH1,AS,PSL,BNE,BNM,ALY,BNP
    PUNCH1,BG3,AINL,EFNL,CD,CP
    PUNCH1,ET,EB,RP,PF,SM,WF
    PUNCH1,RSL,CK,C,PT,RP,POL
    PUNCH1,PI,FNL,PG2,FG,FG2,FG3
    PUNCH1,HZ,SC,YY,CM,CF,DF
    PUNCH1,AD,FK,RG,PC,EW,DDR
    PUNCH1,GE,SI,XL,XS,XA,XQ
    PUNCH1,XB,X2,XD,XR,TT,W
    PUNCH1,PN,F,RPM,DI,DU,CL
    PUNCH1,SS,HC,QN,WL,BK,BO
    PUNCH1,QQ,TS,GC,C1,CC,D1
    PUNCH1,WO,HD,DD,H,B,BN
```

```
PUNCH1,SB,TB,RE,T3,HS,PX
PUNCH1,BC1,BT1,BG1,VA,BS,HX
PUNCH1,FR,RC,FT,FC,FQ,TG
PUNCH1,P1,P2,P3,P4,P5,P6
PUNCH1,P7,EE,CW,SNL,EC,SM
PAUSE
END
```

```
C       PASS  8  SECSYN
      1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
        DO998 K=1,8
        READ1,R1,R2,R3,R4,R5,R6
        PUNCH1,R1,R2,R3,R4,R5,R6
    998 CONTINUE
        READ1,PI,FNL,PG2,FG,FG2,FG3
        READ1,HZ,SC,YY,CM,CF,DF
        READ1,AD,FK,RG,PC,EW,DDR
        READ1,GE,SI,XL,XS,XA,XQ
        READ1,XB,X2,XD,XR,TT,W
        READ1,PN,F,RPM,DI,DU,CL
        READ1,SS,HC,QN,WL,BK,BO
        READ1,QQ,TS,GC,C1,CC,D1
        READ1,WO,HD,DD,H,B,BN
        READ1,SB,TB,RE,T3,HS,PX
        READ1,BC1,BT1,BG1,VA,BS,HX
        READ1  ,FR,RC,FT,FC,FQ,TG
        READ1  ,P1,P2,P3,P4,P5,P6
        READ1,P7,EE,CW,SNL,EC,SM
        WQ=(DU-HC)*1.42*HC*SS*(BC1/BK)**2.0*WL
        WT=    SM   *QQ*SS*HS*0.453*(BT1/BK)**2.0*WL
        D2=BG1**2.5*0.000061
        D3=(0.0167*QQ*RPM)**1.65*0.000015147
        IF(TS-0.9)133,133,134
    133 D4=TS**1.285*0.81
        GO TO 137
    134 IF(TS-2.0)135,135,136
    135 D4=TS**1.145*0.79
```

```
      GO TO 137
136  D4=TS**0.79*0.92
137  D7=B0/GC
      IF(D7-1.7)138,138,139
138  D5=D7**2.31*0.3
      GO TO 144
139  IF(D7-3.0)140,140,141
140  D5=D7**2.0*0.35
      GO TO 144
141  IF(D7-5.0)142,142,143
142  D5=D7**1.4*0.625
      GO TO 144
143  D5=D7**0.965*1.38
144  D6=10.0**(0.932*C1-1.606)
      BA=3.142*DI*CL
      WN=D1*D2*D3*D4*D5*D6*BA
      IF(BN)210,211,210
210  AA=WO/(GC*CC)
      VT=0
      IF(AA)148,147,148
148  IF(AA-.65)145,145,146
145  VT=LOG(10.0*AA)*(-0.242)+0.59
      GO TO 147
146  VT=0.327-(AA*0.266)
147  FS1=2.0*QN*PN*F
      FS2=2.0*FS1
151  RM=RE*(T3+234.5)/254.5
153  AA=(FS1/RM)**0.5*DD*0.32
      AB=(FS2/RM)**0.5*DD*0.32
```

```
      IF(AA-2.5) 160,160,161
  160 V1=1.0-0.15*AA+0.3*AA*AA
      GO TO 162
  161 V1=AA
  162 IF(AB-2.5) 163,163,164
  163 V2=1.0-0.15*AB+0.3*AB*AB
      GO TO 165
  164 V2=AB
  165 IF(H-B) 167,166,167
  166 VC=0.75/V1
      GO TO 169
  167 IF(DD) 166,168,166
  168 VC=H/(3.0*B*V1)
  169 VS=HD/WO+VT+VC
      VG=TB/(CC*GC)
      Q1=1.0-(1.0/(((BO*0.5/GC)**2.0+1.0)**0.5))
      QZ=BO/TS
      Q2=1.05*SIN(QZ*2.844)
      IF(QZ-0.37)170,170,171
  170 Q3=0.46
      GO TO 172
  171 Q3=0.23*SIN(10.46*QZ-2.1)+0.23
  172 Q4=SIN(6.283*TB/TS-1.571)+1.0
      Q5=SIN(12.566*TB/TS-1.571)+1.0
      IF(H)173,173,174
  173 AB=0.785*DD*DD
      GO TO 175
  174 AB=H*DD
  175 W2=PX*BN*SB*RM*1.246/(AB*1000.)
```

```
      W3=(Q2/(2.0*VS+(VG/Q4)))**2.0*V1
      W5=(Q3/(2.0*VS+(VG/Q5)))**2.0*V2
      WD=(TS*BG1*Q1*CC)**2.0*W2*(W3+W5)
      GO TO 212
  211 WD=0
  212 PUNCH1,PI,FNL,PG2,FG,FG2,FG3
      PUNCH1,HZ,SC,YY,CM,CF,DF
      PUNCH1,AD,FK,RG,PC,EW,DDR
      PUNCH1,GE,SI,XL,XS,XA,XQ
      PUNCH1,XB,X2,XD,XR,TT,W
      PUNCH1,PN,F,RPM,DI,DU,CL
      PUNCH1,SS,HC,QN,WL,BK,BO
      PUNCH1,QQ,TS,GC,C1,CC,D1
      PUNCH1,WO,HD,DD,H,B,BN
      PUNCH1,SB,TB,RE,T3,HS,PX
      PUNCH1,BC1,BT1,BG1,VA,BS,HX
      PUNCH1,WT,WQ,WN,WD,FR,RC
      PUNCH1,FQ,TG,FC,FT,P1,P2
      PUNCH1,P3,P4,P5,P6,P7,RM
      PUNCH1,EE,CW,SNL,EC,AB
      PAUSE
      END
```

```
C      PASS  9  SECSYN
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
    3 FORMAT(9X F12.5,2X F12.5)
    4 FORMAT(9X F12.5/9X F12.5/)
      DO999 K=1,8
      READ1,R1,R2,R3,R4,R5,R6
      PUNCH1,R1,R2,R3,R4,R5,R6
  999 CONTINUE
      READ1,PI,FNL,PG2,FG,FG2,FG3
      READ1,HZ,SC,YY,CM,CF,DF
      READ1,AD,FK,RG,PC,EW,DDR
      READ1,GE,SI,XL,XS,XA,XQ
      READ1,XB,X2,XD,XR,TT,W
      READ1,PN,F,RPM,DI,DU,CL
      READ1,SS,HC,QN,WL,BK,BO
      READ1,QQ,TS,GC,C1,CC,D1
      READ1,WO,HD,DD,H,B,BN
      READ1,SB,TB,RE,T3,HS,PX
      READ1,BC1,BT1,BG1,VA,BS,HX
      READ1  ,WT,WQ,WN,WD,FR,RC
      READ1,FQ,TG,FC,FT,P1,P2
      READ 1,P3,P4,P5,P6,P7,RM
      READ 1,EE,CW,SNL,EC,AB
      IF(BN)601,610,601
  601 XM=(XD/(C1*CM))*(2.*FG+FG2+FG3)/FNL
      RDB=((100.*XR*PX*RM)/(F*SS))
      RDB=RDB*((SB/(BN*AB*PX))+(.637*DDR/(AD*PX*PX)))
      ANN=RDB/XM
      IF(H)606,607,606
```

```
606 XDD=(20.*XR/BN)*(H/(3.*B)+WO/AD)+ 5.*XM/(6.*BN*BN)
    GO TO 608
607 XDD=(20.*XR/BN)*(.62+WO/HD)+ 5.*XM/(6.*BN*BN)
608 SIG= XDD/XM
    AA=4.*SIG*SIG+ANN*ANN
    XN=(XM*(4.*SIG+AA)/((1.+SIG)**2*4.+ANN*ANN))+XL
    AA=3.*YY/(4.*PN*QN)
    AA1=AA*4.
    IF(W) 609,610,609
610 XO=0.
    GO TO 621
609 IF(SC-1.) 611,612,611
612 AKX=1.
    GO TO 615
611 AKX=AA1-2.
615 IF(SC-1.)613,614,613
614 AKX1=1.
    GO TO 618
613 IF((YY/(PN*QN))-.667)616,617,617
616 AKX1=AA+.25
    GO TO 618
617 AKX1=AA-.25
618 IF(AKX)622,623,622
623 ABL=0.
    GO TO 620
622 BB=6.35*DI/(PX*GE)
    ABL=(AKX/(CF*CF))*.07*BB
    IF(BN)619,620,619
619 ABL=((AKX*X2/AKX1)+ABL)/((AKX*X2/AKX1)*ABL)
```

```
620 XO=(AKX/AKX1)*(ABL+PC)+ .2*EW
    XO=XO+(1.667*(HX+2.*HZ)/(PN*QN*CF*CF*DF*DF*BS))
621 TC= SI/(2.*FK)
    TA=XN/(628.32*F*(PN*PI*PI*RG/VA))*1.E3
    T5=XS*TC/XA
    IF(F-60.)624,625,624
625 T4=.035
    GO TO 626
624 T4=.005
626 FSC=XA*(2.*FG+FG2+FG3)/100.
    SCR=FNL/FSC
    PRINT3,FK,XN,FR,XO,RC,TG,TC,FQ,TA,BG1,T5,BT1,T4,BC1,P1,FT,P2,FC
    PRINT3,P3,FG,P4,FSC,P5,SCR
    PRINT4,P6,P7
    PUNCH1,PI,FNL,PG2,FG,FG2,FG3
    PUNCH1,HZ,SC,YY,CM,CF,DF
    PUNCH1,AD,FK,RG,PC,EW,DDR
    PUNCH1,GE,SI,XL,XS,XA,XQ
    PUNCH1,XB,X2,XD,XR,TT,W
    PUNCH1,PN,F,RPM,DI,DU,CL
    PUNCH1,SS,HC,QN,WL,BK,BO
    PUNCH1,QQ,TS,GC,C1,CC,D1
    PUNCH1,WO,HD,DD,H,B,BN
    PUNCH1,SB,TB,RE,T3,HS,PX
    PUNCH1,BC1,BT1,BG1,VA,BS,HX
    PUNCH1,WT,WQ,WN,WD,FR,RC
    PUNCH1,FQ,TG,FC,FT,FSC,SCR
    PUNCH1,P1,P2,P3,P4,P5,P6
    PUNCH1,P7,EE,CW,SNL,EC
```

```
PAUSE
END
```

```
C      PASS 10  SECSYN
        DIMENSION YB(4),EX(4),EDA(4),DX(4)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
  994 FORMAT (I3)
  824 READ1 ,TSK,PFHL,DBHL,GA,EP,ASK
      READ1 ,BSP,BY2,BY4,BG2,ALCR,ANP
      READ1 ,ASP,HNP,A2,A3,AY4,Y4
      READ1 ,G4,GP,AY2,YH,PT
      READ1 ,AS,PSL,BNE,BNM,ALY,BNP
      READ1 ,BG3,AINL,EFNL,CD,CP
      READ1 ,ET,EB,RP,PF,SM,WF
      READ1 ,RSL,CK,C,PT,RP,POL
      READ1 ,PI,FNL,PG2,FG,FG2,FG3
      READ1 ,HZ,SC,YY,CM,CF,DF
      READ1 ,AD,FK,RG,PC,EW,DDR
      READ1 ,GE,SI,XL,XS,XA,XQ
      READ1 ,XB,X2,XD,XR,TT,W
      READ1 ,PN,F,RPM,DI,DU,CL
      READ1 ,SS,HC,QN,WL,BK,BO
      READ1 ,QQ,TS,GC,C1,CC,D1
      READ1 ,WO,HD,DD,H,B,BN
      READ1 ,SB,TB,RE,T3,HS,PX
      READ1 ,BC1,BT1,BG1,VA,BS,HX
      READ1 ,WT,WQ,WN,WD,FR,RC
      READ1 ,FQ,TG,FC,FT,FSC,SCR
      READ1 ,P1,P2,P3,P4,P5,P6
      READ1 ,P7,EE,CW,SNL,EC
      AN=ATAN(SQRT(1.-PF*PF)/PF)
      AX=SIN(AN)
```

```
      YB(1)=1.
      YB(2)=1.5
      YB(3)=2.
      YB(4)=POL
  703 DO777 K=1 ,4
      AE=ATAN((AX+YB(K)*XB/100.)/PF)
     EDA(K)=COS(AE-AN)+YB(K)*(XA/100.)*SIN(AE)
      DX(K)=EDA(K)-(.93*YB(K)*XD/100.)*SIN(AE)
  777 EX(K)=EP+PI*YB(K)*RP
      AAX=(P1+P2+P3+P4)*.001
      P5=.001*P5
      P6=.001*P6
      P7=.001*P7
      IF(BNE-BNM)924,925,924
  925 AA=PSL/3.
      GO TO 927
  924 AA=PSL/2.
  927  PUNCH1,EDA(1),EDA(2),EDA(3),EDA(4)
       PUNCH1,EX(1),EX(2),EX(3),EX(4)
       PUNCH1,DX(1),DX(2),DX(3),DX(4)
       PUNCH1,POL,FG,FT,FC,PF,GE
       PUNCH1,GA,TG,EP,CP,SS,SM
       PUNCH1,QQ,HS,PX,CK,ASP,AA
       PUNCH1,ANP,HNP,ASK,RSL,GP,AY2
       PUNCH1,YH,A2,A3,G4,AY4,ALY
       PUNCH1,PT,FR,AS,P5,P6,P7
       PUNCH1,AAX,GC
      IF(SNL)928,929,928
  929 KA=6
```

```
      GO TO 930
  928 KA=13
  930 PUNCH994,KA
      PUNCH1,PFHL,DBHL,BSP,BY2,BY4,SNL
       PUNCH1,BG2,SC,BNP,BG3,AINL,EFNL
       PUNCH1,CD,ET,EB,WF,C,PI
       PUNCH1,FNL,FK,RG,XA,XQ,XD
       PUNCH1,PN,BO,RE,T3,WT,WQ
       PUNCH1,WN,WD,RP,RC,FSC,SCR
      IF(SNL)931,932,931
  931 PUNCH1,GE,SS,SM,QQ,HS,PX
      PUNCH1,ASP,ANP,HNP,GP,AY2,YH
      PUNCH1,A2,A3,G4,AY4,ALY,PT
      PUNCH1,FR,AS,P5,P6,P7,GA
      PUNCH1,ALCR,Y4,RPM,HC,AAX,GC
      PUNCH1,EE,CW,SNL,EC,BNE,BNM
      PUNCH1,P1,P2,P3,P4,CP,PSL
  932 PAUSE
      END
```

```
C     PASS 11  SECSYN
      DIMENSION AI(120),EDA(4),EX(4),DX(4),BNPL(4),BSPL(4),BY2L(4)
      DIMENSION BY4L(4),BG2L(4),BG3L(4),FFL(4),AIFL(4),EPFL(4),CDD(4)
      DIMENSION FGL(4)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
  888 FORMAT(F10.0,F10.0,F10.0,F10.0,F10.0,F10.0)
  994 FORMAT (I3)
      K=1
  823 READ888,AI(K),AI(K+1),AI(K+2),AI(K+3),AI(K+4),AI(K+5)
      K=K+6
      IF (K-119)823,824,824
  824 READ1  ,EDA(1),EDA(2),EDA(3),EDA(4)
      READ1  ,EX(1),EX(2),EX(3),EX(4)
      READ1  ,DX(1),DX(2),DX(3),DX(4)
      READ1 ,POL,FG,FT,FC,PF,GE
      READ1 ,GA,TG,EP,CP,SS,SM
      READ1 ,QQ,HS,PX,CK,ASP,AA
      READ1 ,ANP,HNP,ASK,RSL,GP,AY2
      READ1 ,YH,A2,A3,G4,AY4,ALY
      READ1 ,PT,FR,AS,P5,P6,P7
      READ1 ,AAX,GC
      READ 994,KA
      DO 995K=1,KA
      READ1,ED,ENL,FTL,FCL,X,PTT
  995 PUNCH1,ED,ENL,FTL,FCL,X,PTT
      LOAD=2
      JA=0
      DO996 J=1,4
      ED=EDA(J)
```

```
      ENL=EX(J)
      BB=ED*FG
      FTL=FT*(1.+PF)
      FCL=FC
      PL7L=P7      *(BB+FTL+FCL)
      BB=BB+(PL7L*GE)/(.00319*GA)
      PLL=TG*ENL/EP
      PTL1=PLL+PL7L/CP
      X  =PTL1/(SS*SM*QQ)
      NA=1
      K=1
      GO TO 802
  910 FTL=AT*HS*(1.+PF)
      PL7L=P7     *(BB+FTL+FCL)
      PTL=PLL+PL7L/CP
      FGL(J)=BB+(PL7L*GE)/(GA*.00319)
       PTT=(2.*(FGL(J)+FTL+FCL))*AAX
      FQ=PTL*CP/PX
      IF(PF-.95)921,921,922
  922 FQL=CK*FQ
      GO TO 923
  921  FQL=FQ*DX(J)
  923 PSPL=FQL/2.+PTT/(2.*PX)
       X=PSPL/ASP
       BSPL(J)=X
      NA=31
      K=2
      GO TO 802
  911 FSPL=AA*AT
```

```
      PNPL=FQL+PTT/PX
      X=PNPL/ANP
      K=3
      NA=61
      GO TO 802
  912 FNPL=AT*HNP
      BB=2.*(FGL(J)+FTL+FCL)
      P6L=P6*      (FSPL+FNPL+BB)
      PSK=PSPL*PX/2.+P6L/2.
      BSK=PSK/ASK
      NA=31
      K=4
      X=BSK
      GO TO 802
  913 FSK=RSL*AT
       BG2L(J)=PSK/A2
      FG2L=BG2L(J)*GP/.00319
      PL5=P5*      (FNPL+BB+FSPL+FG2L)
      PY2=PSK+PL5/2.
       X=PY2/AY2
       BY2L(J)=X
      K=5
      NA=91
      GO TO 802
  914 FY2L=AT*YH/3.
       BG3L(J)=PY2/A3
      FG3L=BG3L(J)*G4/.00319
       X=PY2/AY4
       BY4L(J)=X
```

```
      NA=61
      K=6
      GO TO 802
  915 FY4L=ALY*AT/2.
      X=2.*PY2/(4.*ANP)
      BNPL(J)=X
      NA=61
      K=7
      GO TO 802
  916 FNPL=HNP*AT
      FFL(J)=BB+FSPL+FNPL+FSK+FG2L+FY2L+FG3L+FY4L
      AIFL(J)=FFL(J)/PT
      EPFL(J)=AIFL(J)*FR
  996 CDD(J)=AIFL(J)/AS
  837 JA=JA/7
      PUNCH994,JA
      IF(JA)970,971,970
  970 DO 997 K=1,JA
      PUNCH1,BNPL(K),BSPL(K),BY2L(K),BY4L(K),BG2L(K),BG3L(K)
  997 PUNCH1,FFL(K),AIFL(K),EPFL(K),CDD(K),FGL(K)
  971 PUNCH1,POL,FG,PF,EP,GE,FR
      PUNCH1,PT,GC
      PAUSE
  802 IF(AI(NA)-X)830,831,831
  831 NA=NA+3
  835 IF(AI(NA)-X)833,834,834
  833 NA=NA+2
      GO TO 835
  834 A=AI(NA)
```

```
      BB1=AI(NA-2)
      DC=AI(NA+1)
      D=AI(NA-1)
      XX=(A-BB1)/(.4343*(LOG(DC)-LOG(D+.0001)))
      Y=A-XX*.4343*LOG(DC)
         AT=EXP(2.306*(X-Y)/XX)
      GO TO (838,839),LOAD
  839 JA=JA+1
      GO TO (910,911,912,913,914,915,916),K
  830 GO TO (836,837),LOAD
      END
```

```
C       PASS 12  SECSYN
        DIMENSION BNPL(4),BSPL(4),BY2L(4),BY4L(4),BG2L(4),BG3L(4),FFL(4)
        DIMENSION AIFL(4),EPFL(4),CDD(4),FGL(4), STTL(4),WDL(4)
        DIMENSION SCUL(4),EDDL(4),WNL(4),FCUL(4),TOTL(4),PEFF(4),YB(4)
  961 FORMAT(F11.3,8X F11.3,F11.3,F11.3,F11.3)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
  994 FORMAT (I3)
      DO 950 K=1,4
      BSPL(K)=0
      BNPL(K)=0
      BY2L(K)=0
      BY4L(K)=0
      BG2L(K)=0
      BG3L(K)=0
      FFL(K)=0
      CDD(K)=0
      AIFL(K)=0
      EPFL(K)=0
      FGL(K)=0
      STTL(K)=0
      WDL(K)=0
      SCUL(K)=0
      EDDL(K)=0
      WNL(K)=0
      FCUL(K)=0
      TOTL(K)=0
  950 PEFF(K)=0
      READ1,PFHL,DBHL,BSP,BY2,BY4,SNL
      READ1,BG2,SC,BNP,BG3,AINL,EPNL
```

```
      READ1,CD,ET,EB,WF,C,PI
      READ1,FNL,FK,RG,XA,XQ,XD
      READ1,PN,BO,RE,T3,WT,WQ
      READ1,WN,WD,RP,RC,FSC,SCR
      IF(SNL)993,993,992
  992 DO 991 L=1,7
      READ1 ,POL,FG,PF,EP,GE,FR
  991 PUNCH1,POL,FG,PF,EP,GE,FR
  993 READ994,JA
      IF(JA)941,942,941
  941 DO 943 K=1,JA
      READ1,BNPL(K),BSPL(K),BY2L(K),BY4L(K),BG2L(K),BG3L(K)
  943 READ1,FFL(K),AIFL(K),EPFL(K),CDD(K),FGL(K)
  942 READ1,POL,FG,PF,EP,GE,FR
      READ1,PT,GC
      ABX=0
      YB(1)=1.
      YB(2)=1.5
      YB(3)=2.
      YB(4)=POL
  973 BX=PFHL+DBHL
      AXX=BO/GC
      IF(AXX-1.)965,965,964
  965 AKSC=2.6
      GO TO 957
  964 IF(AXX-3.75)955,955,956
  955 AKSC=10.**.178/((AXX-1.)**.334)
      GO TO957
  956 AKSC=10.**.11/((AXX-1.)**.174)
```

```
957 FEL=AINL*AINL*FK*2.
    TL=WF+WQ+WT+WD+WN+FEL
    IF(POL)966,967,966
967 IF(JA-4 )966,968,966
968 JA=JA-1
966 DO 951 K=1,JA
    FCUL(K)=2.*(AIFL(K)**2)*FR
    AXX=(.4*XA/100.)*YB(K)
    IF(AXX-1.)952,953,953
952 AXX=AXX**1.8
    GO TO 954
953 AXX=AXX**2
954 STTL(K)=(2.*AXX+1.)*WT
    AXX =  ((AKSC*PI*YB(K)*SC)/(C*FGL(K)))**2+1.
    WNL(K)=AXX*WN
    WDL(K)=AXX*WD
    SCUL(K)=PN*PI*PI*YB(K)*RP
    EDDL(K)=(((ET+EB)/2.)-1.)*SCUL(K)
    TOTL(K)=SCUL(K)+WF+STTL(K)+WQ+WNL (K)+WDL(K)+EDDL(K)+FCUL(K)+BX
    PEF=3.*EP*PI*YB(K)*PF
951 PEFF(K)=PEF*100./(PEF+TOTL(K))
    IF(POL)958,959,958
958 PRINT961,BNP,BNPL(1),BNPL(2),BNPL(3),BNPL(4)
    PRINT961,BSP,BSPL(1),BSPL(2),BSPL(3),BSPL(4)
    PRINT961,BY2,BY2L(1),BY2L(2),BY2L(3),BY2L(4)
    PRINT961,BY4,BY4L(1),BY4L(2),BY4L(3),BY4L(4)
    PRINT961,BG3,BG3L(1),BG3L(2),BG3L(3),BG3L(4)
    PRINT961,BG2,BG2L(1),BG2L(2),BG2L(3),BG2L(4)
    PRINT961,FNL,FFL(1),FFL(2),FFL(3),FFL(4)
```

```
      PRINT961,AINL,AIFL(1),AIFL(2),AIFL(3),AIFL(4)
      PRINT961,CD,CDD(1),CDD(2),CDD(3),CDD(4)
      PRINT961,EPNL,EPFL(1),EPFL(2),EPFL(3),EPFL(4)
      PRINT961,WQ,WQ,WQ,WQ,WQ
      PRINT961,WT,STTL(1),STTL(2),STTL(3),STTL(4)
      PRINT961,WD,WDL(1),WDL(2),WDL(3),WDL(4)
      PRINT961,ABX,SCUL(1),SCUL(2),SCUL(3),SCUL(4)
      PRINT961,ABX,EDDL(1),EDDL(2),EDDL(3),EDDL(4)
      PRINT961,WN,WNL(1),WNL(2),WNL(3),WNL(4)
      PRINT961,FEL,FCUL(1),FCUL(2),FCUL(3),FCUL(4)
      PRINT961,WF,WF,WF,WF,WF
      PRINT961,TL,TOTL(1),TOTL(2),TOTL(3),TOTL(4)
      PRINT961,ABX,PEFF(1),PEFF(2),PEFF(3),PEFF(4)
      PAUSE
  959 PRINT961,BNP,BNPL(1),BNPL(2),BNPL(3)
      PRINT961,BSP,BSPL(1),BSPL(2),BSPL(3)
      PRINT961,BY2,BY2L(1),BY2L(2),BY2L(3)
      PRINT961,BY4,BY4L(1),BY4L(2),BY4L(3)
      PRINT961,BG3,BG3L(1),BG3L(2),BG3L(3)
      PRINT961,BG2,BG2L(1),BG2L(2),BG2L(3)
      PRINT961,FNL,FFL(1),FFL(2),FFL(3)
      PRINT961,AINL,AIFL(1),AIFL(2),AIFL(3)
      PRINT961,CD,CDD(1),CDD(2),CDD(3)
      PRINT961,EPNL,EPFL(1),EPFL(2),EPFL(3)
      PRINT961,WQ,WQ,WQ,WQ
      PRINT961,WT,STTL(1),STTL(2),STTL(3)
      PRINT961,WD,WDL(1),WDL(2),WDL(3)
      PRINT961,ABX,SCUL(1),SCUL(2),SCUL(3)
      PRINT961,ABX,EDDL(1),EDDL(2),EDDL(3)
```

```
PRINT961,WN,WNL(1),WNL(2),WNL(3)
PRINT961,FEL,FCUL(1),FCUL(2),FCUL(3)
PRINT961,WF,WF,WF,WF
PRINT961,TL,TOTL(1),TOTL(2),TOTL(3)
PRINT961,ABX,PEFF(1),PEFF(2),PEFF(3)
PAUSE
END
```

```
C     PASS 13  SECSYN
      DIMENSION AI(120)
  979 FORMAT(F12.5,F12.5,F12.5,F12.5,F12.5,F12.5//)
  977 FORMAT(F12.5,F12.5,F12.5,F12.5,F12.5,F12.5)
  888 FORMAT(F10.0,F10.0,F10.0,F10.0,F10.0,F10.0)
    1 FORMAT(E11.5,E11.5,E11.5,E11.5,E11.5,E11.5)
      K=1
  823 READ888,AI(K),AI(K+1),AI(K+2),AI(K+3),AI(K+4),AI(K+5)
      K=K+6
      IF (K-119)823,824,824
  824 READ1 ,GE,SS,SM,QQ,HS,PX
      READ1 ,ASP,ANP,HNP,GP,AY2,YH
      READ1 ,A2,A3,G4,AY4,ALY,PT
      READ1 ,FR,AS,P5,P6,P7,GA
      READ1 ,ALCR,Y4,RPM,HC,AAX,GC
      READ1 ,EE,CW,SNL,EC,BNE,BNM
      READ1 ,P1,P2,P3,P4,CP,PSL
      LOAD =1
      YA=.8
      P5=1000.*P5
      P6=1000.*P6
      P7=1000.*P7
      DO 899 L=1,9
      BX=YA*EE
      YA=YA+.1
      TG=6.E6*BX/(CW*EC*RPM)
      BTT=TG/(SS*SM*QQ)
      FQ=TG*CP/PX
      BC=FQ/(2.*HC*SS)
```

```
      BG=TG/GA
      PL71=.01*TG
  801 TTP=TG+PL71
      X=TTP/TG
      BT1=X*BTT
      Z=FQ/PX
      PP1=X*FQ
      BC1=(PP1/FQ)*BC
      BG1=BG*X
      FG=(BG1*GE)/.00319
      NA=1
      K=1
      X=BT1
      GO TO 802
  803 FT=AT*HS
      NA=1
      K=2
      X=BC1
      GO TO 802
  804 FC=AT*ALCR
      PL7=(FT+FG+FC)*P7*.001
      IF(1.1*PL71-PL7)810,811,811
  811 IF(.9*PL71-PL7)812,812,810
  810 PL71=PL7
      GO TO 801
  812 Z1=(.002*(FG+FC+FT))*(P1+P2+P3+P4)
      FQ=PP1
      Z=FQ/PX
      Y=Z1/PX+FQ
```

```
      BNP=Y/ANP
      BSP=Y/(2.*ASP)
      NA=61
      K=3
      X=BNP
      GO TO 802
  805 FNP=HNP*AT
      NA=31
      K=4
      X=BSP
      GO TO 802
  806 IF(BNE-BNM)820,821,820
  820 AXX=PSL/2.
      GO TO 822
  821 AXX=PSL/3.
  822 FSP=AXX*AT
      PG2=(FQ*PX+Z1+PL7)/4.
      BG2=PG2/A2
      FG2=BG2*GP/.00319
      BY4=PG2/AY4
      K=5
      NA=61
      X=BY4
      GO TO 802
  807 FY4=AT*Y4
      Z2=2.*(FG+FC+FT)
      Z3=Z2+FSP+FG2
      PL5=(Z3+FNP)*P5*.001
  816 BNP=(((Z1+PL7+PL5)/PX)+FQ)/ANP
```

```
      K=6
      NA=61
      X=BNP
      GO TO 802
  808 FNP=HNP*AT
      PL51=(Z3+FNP)*P5*.001
      IF(1.1*PL5-PL51)813,814,814
  814 IF(.9*PL5-PL51)815,815,813
  813 PL5=PL51
      GO TO 816
  815 BG3=(FQ*PX+(Z1+PL7+PL5))/(4.*A3)
      FG3=BG3*G4/.00319
      PL6=(Z2+FSP+FNP+FY4+FG3)*P6*.001
      BG2=(FQ*PX+Z1+PL7+PL6)/(4.*A2)
      FG2=BG2*GP/.00319
      BY2=(FQ*PX+Z1+PL7+PL5)/(4.*AY2)
      X=BY2
      K=7
      NA=91
      GO TO 802
  809 FY2=YH*AT/3.
      FNL=Z2+FNP+FSP+FG2+FY2+FG3+FY4
      PRINT977,BX,BG1,BG2,BG3,BC1,BT1
  899 PRINT979,BY2,BSP,BNP,BY4,FQ,FNL
         PAUSE
  802 IF(AI(NA)-X)830,831,831
  831 NA=NA+3
  835 IF(AI(NA)-X)833,834,834
  833 NA=NA+2
```

```
      GO TO 835
  834 A=AI(NA)
      BB1=AI(NA-2)
      DC=AI(NA+1)
      D=AI(NA-1)
      XX=(A-BB1)/(.4343*(LOG(DC)-LOG(D+.0001)))
      Y=A-XX*.4343*LOG(DC)
         AT=EXP(2.306*(X-Y)/XX)
      GO TO (838,839),LOAD
  838 GO TO (803,804,805,806,807,808,809),K
  830 GO TO (836,837),LOAD
  836 PRINT 850,
  850 FORMAT (17HMACHINE SATURATED)
      PAUSE
      END
```