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FORTRAN PROGRAMS FOR CALCULATING WIND-TUNNEL BOUNDARY INTERFERENCE

by Harry H. Heyson

Langley Research Center
Langley Station, Hampton, Va.

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FORTRAN PROGRAMS FOR CALCULATING WIND-TUNNEL BOUNDARY INTERFERENCE

By Harry H. Heyson
Langley Research Center

SUMMARY

Boundary-interference programs, developed in NASA TR R-302, are presented without comment. These programs should be utilized only after careful consideration of the assumptions and procedures given in that report.

INTRODUCTION

Reference 1 develops a systematic computer procedure for calculating the wind-tunnel interference factors for arbitrary configurations from the interference calculations for a vanishingly small model. The method is not limited to any one tunnel configuration since it is necessary only to substitute a subroutine appropriate to the tunnel for that given herein.

The underlying theory (subroutine DLTAS) in the present computer programs is that of reference 2. It is directly applicable to models which produce large wake deflections, such as V/STOL models. These programs may also be used directly for more conventional testing at moderate lift coefficients by means of the few simple modifications described in reference 1.

No sample calculations or check cases are provided herewith. The numerical values provided in reference 1 should be adequate for this purpose. The reader is cautioned against using these programs without first carefully considering the assumptions, limitations, and procedures given in reference 1.

COMPUTER PROGRAMS

The programs are given in the appendixes. The following table should aid in locating the program of interest:

Appendix	Model	Interference	Page
A	Small	At point	4
B	Wing	Average	6
C	Wing	Span distribution	9
D	Wing	At tail	12
E	Jet	At wing	16
F	Jet	Wing distribution	20
G	Jet	At tail	24
H	Rotor	Average	28
I	Rotor	Lateral axis	31
J	Rotor	Longitudinal axis	34
K	Rotor	At tail	37
L	Tandem rotors	Average	41
M	Unloaded rotors	Average	46
N	Unloaded rotors	At tail	52
O	Side-by-side rotors	Average	57
P	Side-by-side rotors	At tail	64
Q	Subroutine DLTAS		70

Langley Research Center,
National Aeronautics and Space Administration,
Langley Station, Hampton, Va., December 11, 1968,
721-01-00-20-23.

REFERENCES

1. Heyson, Harry H.: Use of Superposition in Digital Computers to Obtain Wind-Tunnel Interference Factors for Arbitrary Configurations, With Particular Reference to V/STOL Models. NASA TR R-302, 1969.

2. Heyson, Harry H.: Linearized Theory of Wind-Tunnel Jet-Boundary Corrections and Ground Effect for VTOL-STOL Models. NASA TR R-124, 1962.

APPENDIX A

FORTRAN PROGRAM FOR CALCULATING WIND-TUNNEL INTERFERENCE NEAR A VANISHINGLY SMALL MODEL

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

THIS IS THE BASIC WIND-TUNNEL INTERFERENCE PROGRAM FOR WHICH THE DERIVATIONS ARE GIVEN IN NASA TR R-124 (REF 2). THE SUCEEDING PROGRAMS ARE ALL DEVELOPED FROM THIS ONE PROGRAM. INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. THE REQUIRED INPUT VARIABLES ARE

ZETA	SEMIHEIGHT OF WIND TUNNEL DIVIDED BY HEIGHT OF MODEL ABOVE FLOOR
ETA	DISTANCE FROM MODEL TO RIGHT-HAND WALL DIVIDED BY WIND-TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
XOVERH	LONGITUDINAL POSITION OF POINT AT WHICH INTERFERENCE IS NEEDED, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT
YOVERH	LATERAL POSITION OF POINT AT WHICH INTERFERENCE IS NEEDED, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT
ZOVERH	VERTICAL POSITION OF POINT AT WHICH INTERFERENCE IS NEEDED, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)              (A 1)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)                (A 2)
      DIMENSION C(8)                                                      (A 3)
      DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./                  (A 4)
    1 READ (5,103)  ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH                   (A 5)
      IF (EOF,5)  999,2                                                   (A 6)
    2 WRITE (6,148)  GAMMA,ZETA,ETA,XOVERH,YOVERH,ZOVERH                  (A 7)
      WRITE (6,210)                                                       (A 8)
      WRITE (6,211)                                                       (A 9)
      WRITE (6,212)                                                       (A 10)
      WRITE (6,213)                                                       (A 11)
      WRITE (6,214)                                                       (A 12)
      WRITE (6,215)                                                       (A 13)
      WRITE (6,216)                                                       (A 14)
      WRITE (6,217)                                                       (A 15)
```

```
      WRITE (6,218)
      DO 41 K=1,8
      CALL DLTAS (C(K))
******************** SEE APPENDIX Q FOR SUBROUTINE DLTAS ********************
      WRITE (6,149) C(K)
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
   41 CONTINUE
      GO TO 1
  103 FORMAT (6F10.3)
  148 FORMAT (1H1//35X*INTERFERENCE FACTORS AT A POINT NEAR A VANISHINGL
     1Y SMALL MODEL*//35X*GAMMA =*F8.3,9X*ZETA =*F8.3,11X*ETA =*
     2F8.3//35X*X/H   =*F8.3,9X*Y/H  =*F8.3,11X*Z/H =*F8.3//)
  149 FORMAT ( /5X6H CHI =F6.2/)
  150 FORMAT (3X5H(W,L)7(F17.4))
  151 FORMAT (3X5H(U,L)7(F17.4))
  152 FORMAT (3X5H(W,D)7(F17.4))
  153 FORMAT (3X5H(U,D)7(F17.4)/)
  210 FORMAT (1X131(1H-))
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
     1WIND TUNNEL WHICH IS25X1HI)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
     2I)
  215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I6X4H
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)
  216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)
  217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1
     1HI)
  218 FORMAT (1X131(1H-)/)
  999 STOP
      END
```

APPENDIX B

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A SWEPT WING

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX C.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE APEX OF THE SWEPT LIFTING LINE. THE REQUIRED INPUT VARIABLES ARE

LI	LOAD INDICATOR, LI=1 FOR UNIFORM LOADING, L=2 FOR ELLIPTIC LOADING
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA	RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA	WING SWEEP ANGLE, DEG
ALPHA	ANGLE OF ATTACK OF WING, DEG

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION XDELTA(28),XLOAD(10),XLE(10),C(8)
      REAL LAMBDA
      DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./
      XLE(1)=XLE(10)=0.43579
      XLE(2)=XLE(9)=0.71422
      XLE(3)=XLE(8)=0.86603
      XLE(4)=XLE(7)=0.95394
      XLE(5)=XLE(6)=0.99499
      DO 803 L1=1,28
  803 XDELTA(L1)=0.
      PI=3.14159265358979
      RAD=.0174532925199
    1 READ (5,900) LI,ZETA1,ETA1,GAMMA,SIGMA,LAMBDA,ALPHA
      IF (EOF,5) 999,47
```

```
 47 IF (LI.EQ.1) GO TO 804
    IALPHA=8HELLIPTIC
    SUML=0.0126104
    DO 808 M2=1,10
808 XLOAD(M2)=XLE(M2)
    GO TO 160
804 SUML=0.01
    IALPHA=8HUNIFORM
    DO 809 M2=1,10
809 XLOAD(M2)=1.0
160 WRITE (6,901)  IALPHA,GAMMA,ETA1,SIGMA,ZETA1,ALPHA,LAMBDA
    WRITE (6,210)
    WRITE (6,211)
    WRITE (6,212)
    WRITE (6,213)
    WRITE (6,214)
    WRITE (6,215)
    WRITE (6,216)
    WRITE (6,217)
    WRITE (6,218)
    CONST1=1.
    LAMBDA=LAMBDA*RAD
    ALPHA=ALPHA*RAD
    DO 41  K=1,8
    IF (SIGMA.NE.0.) GO TO 811
    M6=M7=N6=N7=1
    XLOAD(1)=1.0
    SUML=1.
    GO TO 812
811 IF (ETA1.NE.1.) GO TO 813
    N6=1
    M6=6
    N7=M7=10
    CONST1=2.
    GO TO 812
813 M6=N6=1
    M7=N7=10
812 DO 801 M1=M6,M7
    DO 802 N1=N6,N7
    XSTAR=(11.-2.*FLOAT(M1))/10.
    YSTAR=(2.*FLOAT(N1)-11.)/10.
    ZSTAR=(11.-2.*FLOAT(N1))/10.
    ETA=ETA1+YSTAR*SIGMA
    ZETA=ZETA1/(1.-ABS(YSTAR)*SIGMA*GAMMA*ZETA1*TAN(LAMBDA)*SIN(ALPHA)
   1)
    XOVERH=SIGMA*GAMMA*TAN(LAMBDA)*COS(ALPHA)*(ABS(XSTAR)-ABS(ZSTAR))
    YOVERH=(FLOAT(M1)-FLOAT(N1))*SIGMA*GAMMA*(-.2)
    ZOVERH=SIGMA*GAMMA*TAN(LAMBDA)*SIN(ALPHA)*(ABS(ZSTAR)-ABS(XSTAR))
    CALL DLTAS  (C(K))
********************* SEE APPENDIX Q FOR SUBROUTINE DLTAS *********************
    DO 805 L1=1,28
805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1)
802 CONTINUE
801 CONTINUE
    DO 807 L3=1,28
807 DELTA(L3)=XDELTA(L3)*SUML*CONST1
    WRITE (6,149) C(K)
    WRITE (6,150) (DELTA(I),I=1,25,4)
    WRITE (6,151) (DELTA(I),I=2,26,4)
    WRITE (6,152) (DELTA(I),I=3,27,4)
    WRITE (6,153) (DELTA(I),I=4,28,4)
```

```
      DO 814 L4=1,28
  814 XDELTA(L4)=0.
   41 CONTINUE
      GO TO 1
  149 FORMAT (1X*CHI =*F7.3/)
  150 FORMAT (3X5H(W,L)7(F17.4))
  151 FORMAT (3X5H(U,L)7(F17.4))
  152 FORMAT (3X5H(W,D)7(F17.4))
  153 FORMAT (3X5H(U,D)7(F17.4)//)
  210 FORMAT (1X131(1H-))
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
     1WIND TUNNEL WHICH IS25X1HI)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
     2I)
  215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I6X4H
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)
  216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)
  217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1
     1HI)
  218 FORMAT (1X131(1H-)/)
  900 FORMAT (I1,F9.3,5F10.3)
  901 FORMAT (1H1///42X*AVERAGE INTERFERENCE OF SWEPT WING OF FINITE SPA
     1N*//58XA8,* LOADING*//36X*GAMMA =*F6.3,10X*ETA    =*F7.3,10X
     2*SIGMA  =*F7.3//36X*ZETA  =*F6.3,10X*ALPHA =*F7.3,10X
     3*LAMBDA =*F7.3//)
  999 STOP
      END
```

APPENDIX C

FORTRAN PROGRAM FOR CALCULATING THE DISTRIBUTION OF WIND-TUNNEL INTERFERENCE OVER THE SPAN OF A SWEPT WING

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE APEX OF THE SWEPT LIFTING LINE. THE REQUIRED INPUT VARIABLES ARE

LI	LOAD INDICATOR, LI=1 FOR UNIFORM LOADING, L=2 FOR ELLIPTIC LOADING
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA	RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA	WING SWEEP ANGLE, DEG
ALPHA	ANGLE OF ATTACK OF WING, DEG
C	EFFECTIVE WAKE SKEW-ANGLE, DEG

IN SYMMETRICAL CASES THIS PROGRAM COMPUTES THE INTERFERENCE DISTRIBUTION OVER ONE SEMISPAN ONLY. THIS PROGRAM REJECTS CASES OF ZERO SPAN. FOR SUCH CASES, THE INTERFERENCE IS UNIFORM AND THE VALUES ARE IDENTICAL TO THOSE PROVIDED BY THE PROGRAM OF APPENDIX B.

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)             (C 1)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)               (C 2)
      DIMENSION XDELTA(28),XLOAD(10),XLE(10)                             (C 3)
      REAL LAMBDA                                                        (C 4)
      XLE(1)=XLE(10)=.43579                                              (C 5)
      XLE(2)=XLE(9)=.71422                                               (C 6)
```

```
      XLE(3)=XLE(8)=.86603
      XLE(4)=XLE(7)=.95394
      XLE(5)=XLE(6)=.99499
      DO 805 N2=1,28
  805 XDELTA(N2)=0.
      RAD=.0174532925199
    1 READ (5,103)  LI,ZETA1,ETA1,GAMMA,SIGMA,LAMBDA,ALPHA,C
      IF (EOF,5) 999,814
  814 IF (LI.EQ.1) GO TO 806
      IALPHA=8HELLIPTIC
      SUML=.126104
      DO 808 M2=1,10
  808 XLOAD(M2)=XLE(M2)
      GO TO 803
  806 SUML=.1
      IALPHA=8HUNIFORM
      DO 809 M2=1,10
  809 XLOAD(M2)=1.0
  803 XOVERH=ZOVERH=0.
      M1=0
      IF (ETA1.EQ.1.) M1=6
      WRITE (6,900) GAMMA,ZETA1,IALPHA,ALPHA,SIGMA,ETA1,LAMBDA,C
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      IF (SIGMA.NE.0.)  GO TO 813
      WRITE (6,901)
      GO TO 1
  813 ALPHA=ALPHA*RAD
      LAMBDA=LAMBDA*RAD
  804 XSTAR=(11.-2.*FLOAT(M1))/10.
      DO 800 N1=1,10
      YSTAR=(2.*FLOAT(N1)-11.)/10.
      ZSTAR=(11.-2.*FLOAT(N1))/10.
      ETA=ETA1+YSTAR*SIGMA
      ZETA=ZETA1/(1.-ABS(YSTAR)*SIGMA*GAMMA*ZETA1*TAN(LAMBDA)*SIN(ALPHA)
     1)
      XOVERH=SIGMA*GAMMA*TAN(LAMBDA)*COS(ALPHA)*(ABS(XSTAR)-ABS(ZSTAR))
      YOVERH=(FLOAT(M1)-FLOAT(N1))*SIGMA*GAMMA*(-.2)
      ZOVERH=SIGMA*GAMMA*TAN(LAMBDA)*SIN(ALPHA)*(ABS(ZSTAR)-ABS(XSTAR))
      CALL DLTAS  (C)
******************** SEE APPENDIX Q FOR SUBROUTINE DLTAS ********************
      DO 801 N2=1,28
  801 XDELTA(N2)=XDELTA(N2)+DELTA(N2)*XLOAD(N1)
  800 CONTINUE
      DO 802 N2=1,28
  802  DELTA(N2)=XDELTA(N2)*SUML
      WRITE (6,149) XSTAR
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
      DO 810 N2=1,28
  810 XDELTA(N2)=0.0
      M1=M1+1
```

```
      IF (M1.LT.12) GO TO 804
      GO TO 1
  103 FORMAT (I1,F9.3,6F10.3)
  149 FORMAT (10X12HY/SEMISPAN =F4.1/)
  150 FORMAT (3X5H(W,L)7(F17.4))
  151 FORMAT (3X5H(U,L)7(F17.4))
  152 FORMAT (3X5H(W,D)7(F17.4))
  153 FORMAT (3X5H(U,D)7(F17.4)//)
  210 FORMAT (1X131(1H-))
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
     1WIND TUNNEL WHICH IS25X1HI)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
     2I)
  215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I6X4H
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)
  216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)
  217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1
     1HI)
  218 FORMAT (1X131(1H-)/)
  900 FORMAT (1H1///38X*INTERFERENCE DISTRIBUTION OVER SWEPT WING OF FIN
     1ITE SPAN*///15X*GAMMA =*F7.3,15X*ZETA =*F7.3,15X,A8* LOADING*
     215X*ALPHA =*F7.3//15X*SIGMA =*F7.3,15X*ETA   =*F7.3,15X*LAMBDA =*
     3F8.3,15X*CHI    =*F7.3//)
  901 FORMAT (////40X*SIGMA EQUALS ZERO - USE AVERAGE INTERFERENCE PROGR
     1AM*///)
999   STOP
      END
```

APPENDIX D

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL BEHIND A SWEPT WING

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (TWO CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE APEX OF THE SWEPT LIFTING LINE. THE REQUIRED INPUT VARIABLES FOR THE WING, GIVEN ON THE FIRST CARD, ARE

LI	LOAD INDICATOR, LI=1 FOR UNIFORM LOADING, L=2 FOR ELLIPTIC LOADING
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAW	RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA	WING SWEEP ANGLE, DEG
ALPHA	ANGLE OF ATTACK OF WING, DEG

THE REQUIRED INPUT VARIABLES FOR THE TAIL, GIVEN ON THE SECOND CARD, ARE

SIGMAT	RATIO OF TAIL SPAN TO TUNNEL WIDTH
TL	TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT
TL	TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)             (D 1)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)               (D 2)
```

```
      DIMENSION XDELTA(28),XLOAD(10),XLE(10),C(8)
      REAL LAMBDA
      DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./
      XLE(1)=XLE(10)=0.43579
      XLE(2)=XLE(9)=0.71422
      XLE(3)=XLE(8)=0.86603
      XLE(4)=XLE(7)=0.95394
      XLE(5)=XLE(6)=0.99499
      DO 803 L1=1,28
  803 XDELTA(L1)=0.
      RAD=.0174532925199
      PI=3.14159265358979
    1 READ (5,900)  LI,ZETA1,ETA1,GAMMA,SIGMAW,LAMBDA,ALPHA,
     1    SIGMAT,TL,TH
      IF (EOF,5) 999,47
   47 IF (LI.EQ.1) GO TO 804
      IALPHA=8HELLIPTIC
      SUML=0.031526
      DO 808 M2=1,10
  808 XLOAD(M2)=XLE(M2)
      GO TO 48
  804 SUML=0.025
      IALPHA=8HUNIFORM
      DO 809 M2=1,10
  809 XLOAD(M2)=1.0
   48 WRITE (6,901) SIGMAW,TH,IALPHA,GAMMA,ZETA1,SIGMAT,TL,LAMBDA,ALPHA,
     1ETA1
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      LAMBDA=LAMBDA*RAD
      ALPHA=ALPHA*RAD
      DO 41   K=1,8
      IF (SIGMAW.EQ.0..AND.SIGMAT.EQ.0.)  GO TO 850
      IF (SIGMAW.EQ.0..AND.SIGMAT.NE.0.)  GO TO 855
      IF (SIGMAW.NE.0..AND.SIGMAT.EQ.0.)  GO TO 860
      M7=4
      N7=10
      CONST1=1.0
      IF (ETA1.NE.1.)  GO TO 812
      M7=2
      CONST1=2.0
      GO TO 812
  850 M7=N7=1
      XLOAD(1)=1.0
      SUML=0.025
      CONST1=40.0
      GO TO 812
  855 M7=4
      N7=1
      XLOAD(1)=1.0
      SUML=0.025
      CONST1=10.0
      IF (ETA1.NE.1.)  GO TO 812
      M7=2
```

```
      CONST1=20.0
      GO TO 812
  860 M7=1
      N7=10
      CONST1=4.0
      IF (ETA1.NE.1.)  GO TO 812
      N7=5
      CONST1=8.0
  812 DO 801  M1=1,M7
      DO 802  N1=1,N7
      XSTAR=(2.*FLOAT(N1)-11.)/10.
      YSTAR=(11.-2.*FLOAT(N1))/10.
      ZSTAR=(5.-2.*FLOAT(M1))/4.
      ETA=ETA1+XSTAR*SIGMAW
      ZETA=ZETA1/(1.-ABS(YSTAR)*SIGMAW*GAMMA*ZETA1*TAN(LAMBDA)*SIN(ALPHA
     1))
      XOVERH=TL*COS(ALPHA)+TH*SIN(ALPHA)-SIGMAW*GAMMA*TAN(LAMBDA)*COS(AL
     1PHA)*ABS(YSTAR)
      YOVERH=ZSTAR*SIGMAT*GAMMA-YSTAR*SIGMAW*GAMMA
      ZOVERH=TH*COS(ALPHA)-TL*SIN(ALPHA)+SIGMAW*GAMMA*TAN(LAMBDA)*SIN(AL
     1PHA)*ABS(YSTAR)
      CALL DLTAS  (C(K))
******************** SEE APPENDIX Q FOR SUBROUTINE DLTAS ********************
      DO 805 L1=1,28
  805 XDELTA(L1)=XDELTA(L1)+(DELTA(L1)*XLOAD(N1))
  802 CONTINUE
  801 CONTINUE
      DO 807 L3=1,28
  807 DELTA(L3)=XDELTA(L3)*SUML*CONST1
      WRITE (6,149) C(K)
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
      DO 814 L4=1,28
  814 XDELTA(L4)=0.
   41 CONTINUE
      GO TO 1
  149 FORMAT (5X5HCHI =F7.3/)
  150 FORMAT (3X5H(W,L)7(F17.4))
  151 FORMAT (3X5H(U,L)7(F17.4))
  152 FORMAT (3X5H(W,D)7(F17.4))
  153 FORMAT (3X5H(U,D)7(F17.4)//)
  210 FORMAT (1X131(1H-))
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
     1WIND TUNNEL WHICH IS25X1HI)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
     2I)
  215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I6X4H
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)
  216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)
  217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1
     1HI)
  218 FORMAT (1X131(1H-)/)
  900 FORMAT (I1,F9.3,5F10.3/3F10.3)
  901 FORMAT (1H1///39X*INTERFERENCE AT TAIL BEHIND SWEPT WING OF FINITE
     1 SPAN*///10X*SIGMA (WING) =*F7.3,7X*TAIL HEIGHT =*F7.3,8XA8,* LOAD
```

```
     2ING*7X*GAMMA =*F8.3,7X*ZETA=*F7.3//10X*SIGMA (TAIL) =*F7.3,7X*TAIL  (D 124)
     3 LENGTH =*F7.3,8X*LAMBDA =*F8.3,7X*ALPHA =*F8.3,7X*ETA =*F7.3///)   (D 125)
999   STOP                                                                (D 126)
      END                                                                 (D 127)
```

APPENDIX E

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A SWEPT WING CAUSED BY THE PRESENCE OF LIFTING JETS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT, AND ABOVE, ADDRESS 1. NOTE THAT THE REFERENCE ORIGIN HAS BEEN CHOSEN AT THE APEX OF THE SWEPT LIFTING LINE. ONLY ONE CONFIGURATION OF JETS CAN BE TREATED PER RUN. ANY NUMBER OF WING CONFIGURATIONS, MAY, HOWEVER, BE TREATED IN ONE RUN FOR THIS ONE JET CONFIGURATION. THE FIRST VARIABLE REQUIRED (IN FORMAT 103) IS

NJ — TOTAL NUMBER OF JETS IN CONFIGURATION

AS MANY AS 10 JETS CAN BE CONSIDERED BY THE PROGRAM AS LISTED HEREIN. IF MORE JETS ARE REQUIRED, AS MANY AS 99 CAN BE OBTAINED BY SUITABLE INCREASES IN XH1, YH1, ZH1, AND XLOAD IN THE DIMENSION STATEMENT. FURTHER INCREASES REQUIRE ALTERATION OF FORMAT 103.

THE NEXT VARIABLES REQUIRED ARE THE LOCATIONS AND THE RELATIVE STRENGTHS OF THE JETS. AS MANY CARDS MAY BE USED AS NEEDED, HOWEVER, THE TOTAL NUMBER OF SETS OF DATA MUST AGREE WITH NJ. INPUT VARIABLES FOR THE JETS (IN FORMAT 904) ARE

XH1 — X-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT

YH1 — Y-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT

ZH1 — Z-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT

XLOAD — RELATIVE PORTION OF LOAD CARRIED BY JET

SUBSEQUENT TO SPECIFICATION OF THE JETS, MODEL CONFIGURATIONS ARE GIVEN (ONE CARD PER CASE) IN FORMAT 900. THE REQUIRED INPUT VARIABLES ARE

ZETA1 SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR

ETA1 DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH

GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL

SIGMA RATIO OF WING SPAN TO TUNNEL WIDTH

LAMBDA WING SWEEP ANGLE, DEG

ALPHA ANGLE OF ATTACK OF WING, DEG

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION XDELTA(28),XLOAD(10),XH1(10),YH1(10),ZH1(10),C(8)
      REAL LAMBDA
      DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./
      DO 803 L1=1,28
  803 XDELTA(L1)=0.
      RAD=.0174532925199
      IFIRST=0
      READ (5,103)  NJ
      READ (5,904) (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)
    1 READ (5,900)  ZETA1,ETA1,GAMMA,SIGMA,LAMBDA,ALPHA
      IF (EOF,5)  999,48
   48 IF (IFIRST.NE.0)  GO TO 47
      WRITE (6,903)  (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)
   47 WRITE (6,901)  GAMMA,ZETA1,LAMBDA,SIGMA,ETA1,ALPHA
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      IFIRST=1
      LAMBDA=LAMBDA*RAD
      ALPHA=ALPHA*RAD
      SUML=0.
      DO 820 M2=1,NJ
      SUML=SUML+XLOAD(M2)
  820 CONTINUE
      SUML=1./(10.*SUML)
      DO 41 K=1,8
      IF (ETA1.NE.1.) GO TO 813
      M3=0
      DO 815 M4=1,NJ
      IF (YH1(M4).EQ.0.) GO TO 817
      DO 816 M5=1,NJ
      IF (M4.EQ.M5) GO TO 816
      IF (XH1(M4).EQ.XH1(M5).AND.ZH1(M4).EQ.ZH1(M5).AND.YH1(M4).EQ.-YH1(
     1M5)) GO TO 821
      GO TO 816
  821 M3=M3+1
  816 CONTINUE
```

```
      GO TO 815
  817 M3=M3+1
  815 CONTINUE
      IF (M3.NE.NJ) GO TO 813
      IALPHA=10H SYMMETRIC
      M6=N6=1
      M7=5
      N7=NJ
      CONST1=2.
      IF (SIGMA.NE.0.)  GO TO 812
      M7=1
      CONST1=10.
      GO TO 812
  813 M6=N6=1
      M7=10
      N7=NJ
      CONST1=1.
      IALPHA=10HASYMMETRIC
      IF (SIGMA.NE.0.)  GO TO 812
      M7=1
      CONST1=10.
  812 DO 801 M1=M6,M7
      DO 802 N1=N6,N7
      YSTAR=(11.-2.*FLOAT(M1))/10.
      ZETA=ZETA1/ (1.+ZETA1*(ZH1(N1)*COS(ALPHA)-XH1(N1)*SIN(ALPHA)))
      ETA=ETA1-((1./GAMMA)*YH1(N1))
      XOVERH=ABS(YSTAR)*SIGMA*GAMMA*TAN(LAMBDA)*COS(ALPHA)-(XH1(N1)*COS(
     1ALPHA))-(ZH1(N1)*SIN(ALPHA))
      YOVERH=YSTAR*SIGMA*GAMMA-YH1(N1)
      ZOVERH=-ABS(YSTAR)*SIGMA*GAMMA*TAN(LAMBDA)*SIN(ALPHA)-(ZH1(N1)*COS
     1(ALPHA))+(XH1(N1)*SIN(ALPHA))
      CALL DLTAS  (C(K))
******************** SEE APPENDIX Q FOR SUBROUTINE DLTAS ********************
      DO 805 L1=1,28
  805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)
  802 CONTINUE
  801 CONTINUE
      DO 807 L3=1,28
  807 DELTA(L3)=XDELTA(L3)*SUML*CONST1
      WRITE (6,149) C(K),IALPHA
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
      DO 814 L4=1,28
  814 XDELTA(L4)=0.
   41 CONTINUE
      GO TO 1
  103 FORMAT (I2)
  149 FORMAT (1X*CHI =*F7.3,6XA10,* JET CONFIGURATION*/)
  150 FORMAT (3X5H(W,L)7(F17.4))
  151 FORMAT (3X5H(U,L)7(F17.4))
  152 FORMAT (3X5H(W,D)7(F17.4))
  153 FORMAT (3X5H(U,D)7(F17.4)//)
  210 FORMAT (1X131(1H-))
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
     1WIND TUNNEL WHICH IS25X1HI)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
```

```
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
     2I)
  215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I6X4H
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)
  216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)
  217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1
     1HI)
  218 FORMAT (1X131(1H-)/)
  900 FORMAT (6F10.3)
  901 FORMAT (1H1///37X*AVERAGE INTERFERENCE OF SEVERAL JETS ON A FINITE
     1 SWEPT WING*///30X*GAMMA =*F7.3,16X*ZETA =*F7.3,15X*LAMBDA =*
     2F7.3//30X*SIGMA =*F7.3,16X*ETA   =*F7.3,15X*ALPHA   =*F7.3//)
  903 FORMAT (//101X*RELATIVE*/25X*XOVERH*20X*YOVERH*20X*ZOVERH*18X
     1*STRENGTH*//(24XF7.3,19XF7.3,19XF7.3,19XF6.3/))
  904 FORMAT (3F7.3,F5.3,3F7.3,F5.3,3F7.3,F5.3)
999   STOP
      END
```

APPENDIX F

FORTRAN PROGRAM FOR CALCULATING THE DISTRIBUTION OF WIND-TUNNEL INTERFERENCE OVER THE SPAN OF A SWEPT WING CAUSED BY THE PRESENCE OF LIFTING JETS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT, AND ABOVE, ADDRESS 1. NOTE THAT THE REFERENCE ORIGIN HAS BEEN CHOSEN AT THE APEX OF THE SWEPT LIFTING LINE. ONLY ONE CONFIGURATION OF JETS CAN BE TREATED PER RUN. ANY NUMBER OF WING CONFIGURATIONS, MAY, HOWEVER, BE TREATED IN ONE RUN FOR THIS ONE JET CONFIGURATION. THE FIRST VARIABLE REQUIRED (IN FORMAT 103) IS

NJ — TOTAL NUMBER OF JETS IN CONFIGURATION

AS MANY AS 10 JETS CAN BE CONSIDERED BY THE PROGRAM AS LISTED HEREIN. IF MORE JETS ARE REQUIRED, AS MANY AS 99 CAN BE OBTAINED BY SUITABLE INCREASES IN XH1, YH1, ZH1, AND XLOAD IN THE DIMENSION STATEMENT. FURTHER INCREASES REQUIRE ALTERATION OF FORMAT 103.

THE NEXT VARIABLES REQUIRED ARE THE LOCATIONS AND THE RELATIVE STRENGTHS OF THE JETS. AS MANY CARDS MAY BE USED AS NEEDED, HOWEVER, THE TOTAL NUMBER OF SETS OF DATA MUST AGREE WITH NJ. INPUT VARIABLES FOR THE JETS (IN FORMAT 904) ARE

XH1 — X-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT

YH1 — Y-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT

ZH1 — Z-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT

XLOAD — RELATIVE PORTION OF LOAD CARRIED BY JET

SUBSEQUENT TO SPECIFICATION OF THE JETS, MODEL CONFIGURATIONS ARE GIVEN (ONE CARD PER CASE) IN FORMAT 900. THE REQUIRED INPUT VARIABLES ARE

ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA	RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA	WING SWEEP ANGLE, DEG
ALPHA	ANGLE OF ATTACK OF WING, DEG
C	EFFECTIVE WAKE SKEW-ANGLE, DEG

IN SYMMETRICAL CASES THIS PROGRAM COMPUTES THE INTERFERENCE DISTRIBUTION OVER ONE SEMISPAN ONLY. THIS PROGRAM REJECTS CASES OF ZERO SPAN. FOR SUCH CASES, THE INTERFERENCE IS UNIFORM AND THE VALUES ARE IDENTICAL TO THOSE PROVIDED BY THE PROGRAM OF APPENDIX E.

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION XDELTA(28),XLOAD(10),XH1(10),YH1(10),ZH1(10),DATE(2)
      REAL LAMBDA
      DO 803 L1=1,28
  803 XDELTA(L1)=0.
      RAD=.0174532925199
      IFIRST=0
      READ (5,103)  NJ
      READ (5,904)  (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)
    1 READ (5,900)  ZETA1,ETA1,GAMMA,SIGMA,LAMBDA,ALPHA,C
      IF (EOF,5)  999,48
   48 IF (IFIRST.NE.0)  GO TO 47
      WRITE (6,903)  (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)
   47 WRITE (6,901)  GAMMA,ZETA1,LAMBDA,SIGMA,ETA1,ALPHA,C
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      IFIRST=1
      LAMBDA=LAMBDA*RAD
      ALPHA=ALPHA*RAD
      SUML=0.
      DO 820 M2=1,NJ
      SUML=SUML+XLOAD(M2)
  820 CONTINUE
      SUML=1./SUML
      IF (SIGMA.NE.0.) GO TO 811
      WRITE (6,905)
      CALL DAYTIM (DATE)
```

```
      WRITE (6,906)  DATE
      GO TO 1
  811 IF (ETA1.NE.1.) GO TO 813
      M3=0
      DO 815 M4=1,NJ
      IF (YH1(M4).EQ.0.) GO TO 817
      DO 816 M5=1,NJ
      IF (M4.EQ.M5) GO TO 816
      IF (XH1(M4).EQ.XH1(M5).AND.ZH1(M4).EQ.ZH1(M5).AND.YH1(M4).EQ.-YH1(
     1M5)) GO TO 821
      GO TO 816
  821 M3=M3+1
  816 CONTINUE
      GO TO 815
  817 M3=M3+1
  815 CONTINUE
      IF (M3.NE.NJ) GO TO 813
      IALPHA=10H SYMMETRIC
      M1CHEK=5
      GO TO 812
  813 M1CHEK=11
      IALPHA=10HASYMMETRIC
  812 M1=0
  801 DO 802 N1=1,NJ
      YSTAR=(11.-2.*FLOAT(M1))/10.
      ZETA=ZETA1/ (1.+ZETA1*(ZH1(N1)*COS(ALPHA)-XH1(N1)*SIN(ALPHA)))
      ETA=ETA1-((1./GAMMA)*YH1(N1))
      XOVERH=ABS(YSTAR)*SIGMA*GAMMA*TAN(LAMBDA)*COS(ALPHA)-(XH1(N1)*COS(
     1ALPHA))-(ZH1(N1)*SIN(ALPHA))
      YOVERH=YSTAR*SIGMA*GAMMA-YH1(N1)
      ZOVERH=-ABS(YSTAR)*SIGMA*GAMMA*TAN(LAMBDA)*SIN(ALPHA)-(ZH1(N1)*COS
     1(ALPHA))+(XH1(N1)*SIN(ALPHA))
      CALL DLTAS  (C)
********************* SEE APPENDIX Q FOR SUBROUTINE DLTAS *********************
      DO 805 L1=1,28
  805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1)
  802 CONTINUE
      DO 807 L3=1,28
  807 DELTA(L3)=XDELTA(L3)*SUML
      WRITE (6,149)  YSTAR,IALPHA
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
      DO 814 L4=1,28
  814 XDELTA(L4)=0.
      M1=M1+1
      IF (M1.LE.M1CHEK) GO TO 801
      GO TO 1
  103 FORMAT (I2)
  149 FORMAT (//1X*Y/SEMISPAN =*F4.1,10XA10* JET CONFIGURATION*/)
  150 FORMAT (3X5H(W,L)7(F17.4))
  151 FORMAT (3X5H(U,L)7(F17.4))
  152 FORMAT (3X5H(W,D)7(F17.4))
  153 FORMAT (3X5H(U,D)7(F17.4))
  210 FORMAT (1X131(1H-))
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
     1WIND TUNNEL WHICH IS25X1HI)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
```

```
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP  (F  96)
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H  (F  97)
     2I)                                                                  (F  98)
  215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I6X4H  (F  99)
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)                                      (F 100)
  216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)                            (F 101)
  217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1 (F 102)
     1HI)                                                                 (F 103)
  218 FORMAT (1X131(1H-))                                                 (F 104)
  900 FORMAT (7F10.3)                                                     (F 105)
  901 FORMAT (1H1///37X*DISTRIBUTION OVER FINITE SWEPT WING CAUSED BY SE (F 106)
     1VERAL JETS*//30X*GAMMA =*F7.3,16X*ZETA =*F7.3,15X*LAMBDA =*F7.3//  (F 107)
     230X*SIGMA =*F7.3,16X*ETA  =*F7.3,15X*ALPHA  =*F7.3//60X*CHI  =*    (F 108)
     3F7.3//)                                                             (F 109)
  903 FORMAT (101X*RELATIVE*/25X*XOVERH*20X*YOVERH*20X*ZOVERH*18X         (F 110)
     1*STRENGTH*//(24XF7.3,19XF7.3,19XF7.3,19XF6.3//))                    (F 111)
  904 FORMAT (3F7.3,F5.3,3F7.3,F5.3,3F7.3,F5.3)                           (F 112)
  905 FORMAT (////40X*SIGMA EQUALS ZERO - USE AVERAGE INTERFERENCE PROGR (F 113)
     1AM*//)                                                              (F 114)
999    STOP                                                               (F 115)
       END                                                                (F 116)
```

APPENDIX G

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL CAUSED BY THE PRESENCE OF LIFTING JETS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT, AND ABOVE, ADDRESS 1. NOTE THAT THE REFERENCE ORIGIN HAS BEEN CHOSEN AT THE APEX OF THE SWEPT LIFTING LINE. ONLY ONE CONFIGURATION OF JETS CAN BE TREATED PER RUN. ANY NUMBER OF WING CONFIGURATIONS, MAY, HOWEVER, BE TREATED IN ONE RUN FOR THIS ONE JET CONFIGURATION. THE FIRST VARIABLE REQUIRED (IN FORMAT 103) IS

NJ — TOTAL NUMBER OF JETS IN CONFIGURATION

AS MANY AS 10 JETS CAN BE CONSIDERED BY THE PROGRAM AS LISTED HEREIN. IF MORE JETS ARE REQUIRED, AS MANY AS 99 CAN BE OBTAINED BY SUITABLE INCREASES IN XH1, YH1, ZH1, AND XLOAD IN THE DIMENSION STATEMENT. FURTHER INCREASES REQUIRE ALTERATION OF FORMAT 103.

THE NEXT VARIABLES REQUIRED ARE THE LOCATIONS AND THE RELATIVE STRENGTHS OF THE JETS. AS MANY CARDS MAY BE USED AS NEEDED, HOWEVER, THE TOTAL NUMBER OF SETS OF DATA MUST AGREE WITH NJ. INPUT VARIABLES FOR THE JETS (IN FORMAT 904) ARE

XH1 — X-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT

YH1 — Y-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT

ZH1 — Z-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT

XLOAD — RELATIVE PORTION OF LOAD CARRIED BY JET

SUBSEQUENT TO SPECIFICATION OF THE JETS, MODEL CONFIGURATIONS ARE GIVEN (ONE CARD PER CASE) IN FORMAT 903. THE REQUIRED INPUT VARIABLES ARE

```
ZETA1      SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR

ETA1       DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL
                SEMIWIDTH

GAMMA      WIDTH-HEIGHT RATIO OF WIND TUNNEL

SIGMAT     RATIO OF TAIL SPAN TO TUNNEL WIDTH

TL         TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSION-
                ALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT

TH         TAIL HEIGHT ABOVE ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSION-
                ALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT

ALPHA      ANGLE OF ATTACK OF WING, DEG
```

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION XDELTA(28),XLOAD(10),XH1(10),YH1(10),ZH1(10),C(8)
      DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./
      DO 803 L1=1,28
  803 XDELTA(L1)=0.
      PI=3.14159265358979
      RAD=.0174532925199
      IFIRST=0
      READ (5,103)  NJ
      READ (5,904)  (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)
    1 READ (5,900)  ZETA1,ETA1,GAMMA,SIGMAT,TL,TH,ALPHA
      IF (EOF,5) 999,48
   48 IF (IFIRST.NE.0)  GO TO 47
      WRITE (6,903)  (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)
   47 WRITE (6,901)  GAMMA,ZETA1,TL,SIGMAT,ETA1,TH,ALPHA
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      IFIRST=1
      LAMBDA=LAMBDA*RAD
      ALPHA=ALPHA*RAD
      SUML=0.
      DO 820 M2=1,NJ
      SUML=SUML+XLOAD(M2)
  820 CONTINUE
      SUML=1./(4.*SUML)
      DO 41 K=1,8
      IF (ETA1.NE.1.) GO TO 813
      M3=0
      DO 815 M4=1,NJ
      IF (YH1(M4).EQ.0.) GO TO 817
      DO 816 M5=1,NJ
      IF (M4.EQ.M5) GO TO 816
      IF (XH1(M4).EQ.XH1(M5).AND.ZH1(M4).EQ.ZH1(M5).AND.YH1(M4).EQ.-YH1(
```

```
     1M5)) GO TO 821                                                    (G 42)
      GO TO 816                                                         (G 43)
  821 M3=M3+1                                                           (G 44)
  816 CONTINUE                                                          (G 45)
      GO TO 815                                                         (G 46)
  817 M3=M3+1                                                           (G 47)
  815 CONTINUE                                                          (G 48)
      IF (M3.NE.NJ) GO TO 813                                           (G 49)
      IALPHA=10H SYMMETRIC                                              (G 50)
      M6=N6=1                                                           (G 51)
      M7=2                                                              (G 52)
      N7=NJ                                                             (G 53)
      CONST1=2.                                                         (G 54)
      IF (SIGMAT.NE.0.)  GO TO 812                                      (G 55)
      M7=1                                                              (G 56)
      CONST1=4.                                                         (G 57)
      GO TO 812                                                         (G 58)
  813 M6=N6=1                                                           (G 59)
      M7=4                                                              (G 60)
      N7=NJ                                                             (G 61)
      CONST1=1.                                                         (G 62)
      IALPHA=10HASYMMETRIC                                              (G 63)
      IF (SIGMAT.NE.0.)  GO TO 812                                      (G 64)
      M7=1                                                              (G 65)
      CONST1=4.                                                         (G 66)
  812 DO 801 M1=M6,M7                                                   (G 67)
      DO 802 N1=N6,N7                                                   (G 68)
      YSTAR=(5.-2.*FLOAT(M1))/4.                                        (G 69)
      ZETA=ZETA1/ (1.+ZETA1*(ZH1(N1)*COS(ALPHA)-XH1(N1)*SIN(ALPHA)))    (G 70)
      ETA=ETA1-((1./GAMMA)*YH1(N1))                                     (G 71)
      XOVERH=(TL-XH1(N1))*COS(ALPHA)+(TH-ZH1(N1))*SIN(ALPHA)            (G 72)
      YOVERH= YSTAR*SIGMAT*GAMMA-YH1(N1)                                (G 73)
      ZOVERH=(TH-ZH1(N1))*COS(ALPHA)-(TL-XH1(N1))*SIN(ALPHA)            (G 74)
      CALL DLTAS  (C(K))                                                (G 75)
********************* SEE APPENDIX Q FOR SUBROUTINE DLTAS *********************
      DO 805 L1=1,28                                                    (G 76)
  805 XDELTA(L1)=XDELTA(L1)+(DELTA(L1)*XLOAD(N1))                       (G 77)
  802 CONTINUE                                                          (G 78)
  801 CONTINUE                                                          (G 79)
      DO 807 L3=1,28                                                    (G 80)
  807 DELTA(L3)=XDELTA(L3)*SUML*CONST1                                  (G 81)
      WRITE (6,149) C(K),IALPHA                                         (G 82)
      WRITE (6,150) (DELTA(I),I=1,25,4)                                 (G 83)
      WRITE (6,151) (DELTA(I),I=2,26,4)                                 (G 84)
      WRITE (6,152) (DELTA(I),I=3,27,4)                                 (G 85)
      WRITE (6,153) (DELTA(I),I=4,28,4)                                 (G 86)
      DO 814 L4=1,28                                                    (G 87)
  814 XDELTA(L4)=0.                                                     (G 88)
   41 CONTINUE                                                          (G 89)
      GO TO 1                                                           (G 90)
  103 FORMAT (I2)                                                       (G 91)
  149 FORMAT (//1X*CHI =*F7.3,6XA10,* JET CONFIGURATION*/)              (G 92)
  150 FORMAT (3X5H(W,L)7(F17.4))                                        (G 93)
  151 FORMAT (3X5H(U,L)7(F17.4))                                        (G 94)
  152 FORMAT (3X5H(W,D)7(F17.4))                                        (G 95)
  153 FORMAT (3X5H(U,D)7(F17.4))                                        (G 96)
  210 FORMAT (1X131(1H-))                                               (G 97)
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A (G 98)
     1WIND TUNNEL WHICH IS25X1HI)                                       (G 99)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)                                   (G 100)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1 (G 101)
```

```
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
     2I)
  215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I6X4H
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)
  216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)
  217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1
     1HI)
  218 FORMAT (1X131(1H-))
  900 FORMAT (7F10.3)
  901 FORMAT (1H1///37X*AVERAGE INTERFERENCE AT FINITE TAIL CAUSED BY SE
     1VERAL JETS*//31X*GAMMA    =*F7.3,10X*ZETA =*F7.3,10X*TAIL LENGTH/H
     2 =*F6.3//31X*SIGMA(T) =*F7.3,10X*ETA  =*F7.3,10X*TAIL HEIGHT/H =*
     3F6.3//57X*ALPHA =*F9.3//)
  903 FORMAT (101X*RELATIVE*/25X*XOVERH*20X*YOVERH*20X*ZOVERH*18X
     1*STRENGTH*//(24XF7.3,19XF7.3,19XF7.3,19XF6.3//))
  904 FORMAT (3F7.3,F5.3,3F7.3,F5.3,3F7.3,F5.3)
999   STOP
      END
```

APPENDIX H

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A SINGLE ROTOR

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES ARE

LI	LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2 FOR TRIANGULAR DISK-LOAD DISTRIBUTION
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
ALPHA	ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION XDELTA(28),PSI(20),XLOAD(20),RUNIF(20),RTRIA(20),C(8)
      DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/
      DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/
      DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./
      PI=3.14159265358979
      RAD=0.0174532925199
      DO 803 L1=1,28
  803 XDELTA(L1)=0.
      PSI(1)=(PI/4.)
      PSI(2)=3.*PSI(1)
      PSI(3)=5.*PSI(1)
      PSI(4)=7.*PSI(1)
      PSI(5)=PSI(13)=(PI/8.)
      PSI(6)=PSI(14)=3.*PSI(5)
      PSI(7)=PSI(15)=5.*PSI(5)
      PSI(8)=PSI(16)=7.*PSI(5)
      PSI(9)=PSI(17)=9.*PSI(5)
```

```
      PSI(10)=PSI(18)=11.*PSI(5)
      PSI(11)=PSI(19)=13.*PSI(5)
      PSI(12)=PSI(20)=15.*PSI(5)
    1 READ (5,900)  LI,ZETA1,ETA1,GAMMA,SIGMA,ALPHA
      SUML=.0025
      IF (EOF,5) 999,47
   47 IF (LI.EQ.1) GO TO 804
      IALPHA=10HTRIANGULAR
      DO 808 M2=1,20
  808 XLOAD(M2)=RTRIA(M2)
      GO TO 160
  804 IALPHA=10H   UNIFORM
      DO 809 M2=1,20
  809 XLOAD(M2)=RUNIF(M2)
  160 WRITE (6,901) SIGMA,IALPHA,ZETA1,ETA1,GAMMA,ALPHA
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      ALPHA=ALPHA*RAD
      DO 41  K=1,8
      M7=N7=20
      IF (SIGMA.NE.0.) GO TO 815
      M7=N7=1
      CONST1=400.
      GO TO 812
  815 IF (ETA1.NE.1.)GO TO 813
      CONST1=2.
      GO TO 812
  813 CONST1=1.
  812 DO 801 M1=1,M7
      DO 802 N1=1,N7
      IF (ETA1.NE.1.)  GO TO 811
      IF (PSI(N1).GT.PI) GO TO 802
  811 ETA=ETA1-(XLOAD(N1)*SIGMA *SIN(PSI(N1)))
      ZETA=1./((1./ZETA1)-(XLOAD(N1)*SIGMA *SIN(ALPHA)*COS(PSI(N1))*GAMM
     1A))
      XOVERH=SIGMA *GAMMA*COS(ALPHA)*(XLOAD(M1)*COS(PSI(M1))-XLOAD(N1)*C
     1OS(PSI(N1)))
      YOVERH=SIGMA *GAMMA*(XLOAD(M1)*SIN(PSI(M1))-XLOAD(N1)*SIN(PSI(N1))
     1)
      ZOVERH=-SIGMA *GAMMA*SIN(ALPHA)*(XLOAD(M1)*COS(PSI(M1))-XLOAD(N1)*
     1COS(PSI(N1)))
      CALL DLTAS (C(K))
******************** SEE APPENDIX Q FOR SUBROUTINE DLTAS *********************
      DO 805 L1=1,28
  805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)
  802 CONTINUE
  801 CONTINUE
      DO 807 L3=1,28
  807 DELTA(L3)=XDELTA(L3)*SUML*CONST1
      WRITE (6,149) C(K)
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
```

```
      CO 814 L4=1,28
  814 XDELTA(L4)=0.
   41 CONTINUE
      GC TO 1
  149 FORMAT (//1X*CHI =* F7.3/)
  150 FORMAT (3X5H(W,L)7(F17.4))
  151 FORMAT (3X5H(U,L)7(F17.4))
  152 FORMAT (3X5H(W,D)7(F17.4))
  153 FORMAT (3X5H(U,D)7(F17.4))
  210 FORMAT (1X131(1H-))
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
     1WIND TUNNEL WHICH IS25X1HI)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
     2I)
  215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GRCUND EFFECT) I6X4H
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)
  216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)
  217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTC GROUND EFFECT8X1
     1HI)
  218 FORMAT (1X131(1H-))
  900 FORMAT (I1,F9.3,6F10.3)
  901 FORMAT (1H1////40X*AVERAGE INTERFERENCE OVER FINITE SPAN ROTOR*//
     140X*SIGMA =*F6.3,12XA10,* LOADING*//40X*ZETA  =*F6.3,19X*ETA =*F6.
     23//40X*GAMMA =*F6.3,18X*ALPHA =*F5.1//)
999   STOP
      END
```

APPENDIX I

FORTRAN PROGRAM FOR CALCULATING THE DISTRIBUTION OF WIND-TUNNEL INTERFERENCE OVER THE LATERAL AXIS OF A SINGLE ROTOR

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES ARE

LI	LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2 FOR TRIANGULAR DISK-LOAD DISTRIBUTION
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
ALPHA	ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG
C	EFFECTIVE WAKE SKEW-ANGLE, DEG

IN SYMMETRICAL CASES THIS PROGRAM COMPUTES THE INTERFERENCE DISTRIBUTION OVER ONE SEMISPAN ONLY. THIS PROGRAM REJECTS CASES OF ZERO SPAN. FOR SUCH CASES, THE INTERFERENCE IS UNIFORM AND THE VALUES ARE IDENTICAL TO THOSE PROVIDED BY THE PROGRAM OF APPENDIX H.

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION XDELTA(28),PSI(20),XLOAD(20),RUNIF(20),RTRIA(20)
      DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/
      DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/
      PI=3.14159265358979
      RAD=0.0174532925199
      PSI(1)=(PI/4.)
```

```
      PSI(2)=3.*PSI(1)
      PSI(3)=5.*PSI(1)
      PSI(4)=7.*PSI(1)
      PSI(5)=PSI(13)=(PI/8.)
      PSI(6)=PSI(14)=3.*PSI(5)
      PSI(7)=PSI(15)=5.*PSI(5)
      PSI(8)=PSI(16)=7.*PSI(5)
      PSI(9)=PSI(17)=9.*PSI(5)
      PSI(10)=PSI(18)=11.*PSI(5)
      PSI(11)=PSI(19)=13.*PSI(5)
      PSI(12)=PSI(20)=15.*PSI(5)
      SUML=.05
      DO 805 N2=1,28
  805 XDELTA(N2)=0.
    1 READ (5,103)  LI,ZETA1,ETA1,GAMMA,SIGMA,ALPHA,C
      IF (EOF,5)  999,700
  700 IF (LI.EQ.1) GO TO 806
      IALPHA=10HTRIANGULAR
      DO 808 M2=1,20
  808 XLOAD(M2)=RTRIA(M2)
      GO TO 702
  806 IALPHA=10H   UNIFORM
      DO 809 M2=1,20
  809 XLOAD(M2)=RUNIF(M2)
  702 IF (ETA1.NE.1.) GO TO 813
      M1CHEK=6
      GO TO 47
  813 M1CHEK=12
   47 WRITE (6,900)  SIGMA,IALPHA,ZETA1,ETA1,GAMMA,ALPHA,C
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      IF (SIGMA.NE.0.)  GO TO 803
      WRITE (6,903)
      GO TO 1
  803 ALPHA=ALPHA*RAD
      M1=0
  804 YSTAR=1.2-0.2*FLOAT(M1)
      DO 800 N1=1,20
      ETA=ETA1-(XLOAD(N1)*SIGMA *SIN(PSI(N1)))
      ZETA=1./((1./ZETA1)-(XLOAD(N1)*SIGMA *SIN(ALPHA)*COS(PSI(N1))*GAMM
     1A))
      XOVERH=-SIGMA*GAMMA*COS(ALPHA)* XLOAD(N1)*COS(PSI(N1))
      YOVERH=SIGMA *GAMMA* (YSTAR-(XLOAD(N1)*SIN(PSI(N1))))
      ZOVERH= SIGMA *GAMMA*SIN(ALPHA)* XLOAD(N1)*COS(PSI(N1))
      CALL DLTAS  (C)
******************** SEE APPENDIX Q FOR SUBROUTINE DLTAS *********************
      DO 801 N2=1,28
  801 XDELTA(N2)=XDELTA(N2)+DELTA(N2)
  800 CONTINUE
      DO 802 N2=1,28
  802  DELTA(N2)=XDELTA(N2)*SUML
      WRITE (6,149) YSTAR
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
```

```
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
      DO 810 N2=1,28
  810 XDELTA(N2)=0.0
      M1=M1+1
      IF (M1.LE.M1CHEK) GO TO 804
      GO TO 1
  103 FORMAT(I1,F9.3,5F10.3)
  149 FORMAT (//10X*Y/R =*F4.1/)
  150 FORMAT (3X5H(W,L)7(F17.4))
  151 FORMAT (3X5H(U,L)7(F17.4))
  152 FORMAT (3X5H(W,D)7(F17.4))
  153 FORMAT (3X5H(U,D)7(F17.4))
  210 FORMAT (1X131(1H-))
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
     1WIND TUNNEL WHICH IS25X1HI)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
     2I)
  215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I5X4H
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)
  216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)
  217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1
     1HI)
  218 FORMAT (1X131(1H-))
  900 FORMAT (1H1///31X*INTERFERENCE DISTRIBUTION OVER LATERAL AXIS OF
     1FINITE SPAN ROTOR*//
     240X*SIGMA =*F6.3,15XA10,* LOADING*//40X*ZETA  =*F6.3,21X*ETA =*F7.
     33//40X*GAMMA =*F6.3,19X*ALPHA =*F7.3//56X*CHI  =*F8.3//)
  903 FORMAT ( ///40X54HSIGMA EQUALS ZERO --- USE AVERAGE INTERFERENCE P
     1ROGRAM)
  999  STOP
       END
```

APPENDIX J

FORTRAN PROGRAM FOR CALCULATING THE DISTRIBUTION OF WIND-TUNNEL INTERFERENCE OVER THE LONGITUDINAL AXIS OF A SINGLE ROTOR

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES ARE

LI — LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2 FOR TRIANGULAR DISK-LOAD DISTRIBUTION

ZETA1 — SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR

ETA1 — DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH

GAMMA — WIDTH-HEIGHT RATIO OF WIND TUNNEL

SIGMA — RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH

ALPHA — ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

C — EFFECTIVE WAKE SKEW-ANGLE, DEG

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES ARE

LI — LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2 FOR TRIANGULAR DISK-LOAD DISTRIBUTION

ZETA1 — SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR

ETA1 — DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH

GAMMA — WIDTH-HEIGHT RATIO OF WIND TUNNEL

SIGMA RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH

ALPHA ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

C EFFECTIVE WAKE SKEW-ANGLE, DEG

THIS PROGRAM REJECTS CASES OF ZERO SPAN. FOR SUCH CASES, THE INTERFERENCE IS UNIFORM AND THE VALUES ARE IDENTICAL TO THOSE PROVIDED BY THE PROGRAM OF APPENDIX H.

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION XDELTA(28),PSI(20),XLOAD(20),RUNIF(20),RTRIA(20)
      DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/
      DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/
      PI=3.14159265358979
      RAD=0.0174532925199
      PSI(1)=(PI/4.)
      PSI(2)=3.*PSI(1)
      PSI(3)=5.*PSI(1)
      PSI(4)=7.*PSI(1)
      PSI(5)=PSI(13)=(PI/8.)
      PSI(6)=PSI(14)=3.*PSI(5)
      PSI(7)=PSI(15)=5.*PSI(5)
      PSI(8)=PSI(16)=7.*PSI(5)
      PSI(9)=PSI(17)=9.*PSI(5)
      PSI(10)=PSI(18)=11.*PSI(5)
      PSI(11)=PSI(19)=13.*PSI(5)
      PSI(12)=PSI(20)=15.*PSI(5)
      DO 805 N2=1,28
  805 XDELTA(N2)=0.
    1 READ (5,103)  LI,ZETA1,ETA1,GAMMA,SIGMA,ALPHA,C
      IF (EOF,5)  999,700
  700 SUML=.05
      CONST=1.
      IF (LI.EQ.1) GO TO 806
      IALPHA=10HTRIANGULAR
      DO 808 M2=1,20
  808 XLOAD(M2)=RTRIA(M2)
      GO TO 47
  806 IALPHA=10H   UNIFORM
      DO 809 M2=1,20
  809 XLOAD(M2)=RUNIF(M2)
   47 WRITE (6,900)  SIGMA,IALPHA,ZETA1,ETA1,GAMMA,ALPHA,C
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      IF (SIGMA.NE.0.)  GO TO 803
      WRITE (6,903)
      GO TO 1
  803 ALPHA=ALPHA*RAD
      M1=0
```

```
  804 YSTAR=.2*FLOAT(M1)-1.2
      DO 800 N1=1,20
      IF (ETA1.NE.1.) GO TO 813
      CONST=2.
      IF (PSI(N1).GT.PI) GO TO 800
  813 ETA=ETA1-(XLOAD(N1)*SIGMA *SIN(PSI(N1)))
      ZETA=1./((1./ZETA1)-(XLOAD(N1)*SIGMA *SIN(ALPHA)*COS(PSI(N1))*GAMM
     1A))
      XOVERH=SIGMA *GAMMA*COS(ALPHA)*(YSTAR-(XLOAD(N1)*COS(PSI(N1))))
      YOVERH=-SIGMA *GAMMA*XLOAD(N1)*SIN(PSI(N1))
      ZOVERH=-SIGMA *GAMMA*SIN(ALPHA)*(YSTAR-(XLOAD(N1)*COS(PSI(N1))))
      CALL DLTAS  (C)
******************* SEE APPENDIX Q FOR SUBROUTINE DLTAS ********************
      DO 801 N2=1,28
  801 XDELTA(N2)=XDELTA(N2)+DELTA(N2)
  800 CONTINUE
      DO 802 N2=1,28
  802  DELTA(N2)=XDELTA(N2)*SUML*CONST
      WRITE (6,149) YSTAR
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
      DO 810 N2=1,28
  810 XDELTA(N2)=0.0
      M1=M1+1
      IF (M1.LE.12) GO TO 804
      GO TO 1
  103 FORMAT(I1,F9.3,5F10.3)
  149 FORMAT  (//10X*X/R =*F4.1/)
  150 FORMAT  (3X5H(W,L)7(F17.4))
  151 FORMAT  (3X5H(U,L)7(F17.4))
  152 FORMAT  (3X5H(W,D)7(F17.4))
  153 FORMAT  (3X5H(U,D)7(F17.4))
  210 FORMAT  (1X131(1H-))
  211 FORMAT  (1X1HI1X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
     1WIND TUNNEL WHICH IS25X1HI)
  212 FORMAT  (1X1HI1X1HI117(1H-)1HI)
  213 FORMAT  (1X1HI1X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
  214 FORMAT  (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
     2I)
  215 FORMAT  (1X1HI1X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I5X4H
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)
  216 FORMAT  (1X1HI1X1HI84(1H-)1HI32(1H-)1HI)
  217 FORMAT  (1X1HI1X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1
     1HI)
  218 FORMAT  (1X131(1H-))
  900 FORMAT  (1H1////28X*INTERFERENCE DISTRIBUTION OVER LONGITUDINAL AXI
     1S OF FINITE SPAN ROTOR*//
     240X*SIGMA =*F6.3,15XA10,* LOADING*//40X*ZETA =*F7.3,23X*ETA =*F5.3
     3//40X*GAMMA =*F6.3,19X*ALPHA =*F7.3//56X*CHI =*F8.3//)
  903 FORMAT ( ///41X54HSIGMA EQUALS ZERO --- USE AVERAGE INTERFERENCE P
     1ROGRAM)
999    STOP
       END
```

APPENDIX K

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL BEHIND A SINGLE ROTOR

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (TWO CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES FOR THE ROTOR, ON THE FIRST CARD, ARE

LI	LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2 FOR TRIANGULAR DISK-LOAD DISTRIBUTION
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAR	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
ALPHA1	ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

THE REQUIRED INPUT VARIABLES FOR THE TAIL, ON THE SECOND CARD, ARE

SIGMAT	RATIO OF TAIL SPAN TO TUNNEL WIDTH
TL	TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
TH	TAIL HEIGHT ABOVE ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
ALPHA2	ANGLE OF ATTACK OF BODY CARRYING TAIL, DEG

THIS PROGRAM REJECTS CASES OF ZERO SPAN. SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS. THE PROGRAM OF

APPENDIX D CAN BE USED FOR SUCH CASES SINCE THE REPRESENTATION OF THE LIFTING SYSTEMS ARE IDENTICAL WHEN THE SPAN IS VANISHINGLY SMALL.

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION XDELTA(28),PSI(20),XLOAD(20),RUNIF(20),RTRIA(20),C(8)
      DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./
      DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/
      DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/
      RAD=0.0174532925199
      PI=3.14159265358979
      PSI(1)=(PI/4.)
      PSI(2)=3.*PSI(1)
      PSI(3)=5.*PSI(1)
      PSI(4)=7.*PSI(1)
      PSI(5)=PSI(13)=(PI/8.)
      PSI(6)=PSI(14)=3.*PSI(5)
      PSI(7)=PSI(15)=5.*PSI(5)
      PSI(8)=PSI(16)=7.*PSI(5)
      PSI(9)=PSI(17)=9.*PSI(5)
      PSI(10)=PSI(18)=11.*PSI(5)
      PSI(11)=PSI(19)=13.*PSI(5)
      PSI(12)=PSI(20)=15.*PSI(5)
      DO 803 L1=1,28
  803 XDELTA(L1)=0.
    1 READ (5,900)  LI,ZETA1,ETA1,GAMMA,SIGMAR,ALPHA1,SIGMAT,TL,TH,
     1    ALPHA2
      IF (EOF,5)  999,47
   47 SUML=0.0125
      IF (LI.EQ.1) GO TO 804
      IALPHA=10HTRIANGULAR
      DO 808 M2=1,20
  808 XLOAD(M2)=RTRIA(M2)
      GO TO 48
  804 IALPHA=10HUNIFORM
      DO 809 M2=1,20
  809 XLOAD(M2)=RUNIF(M2)
   48 WRITE (6,901)  IALPHA,ZETA1,SIGMAR,TL,ALPHA1,ETA1,SIGMAT,TH,
     1    ALPHA2,GAMMA
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      IF (SIGMAR.NE.0.)  GO TO 800
      WRITE (6,101)
      GO TO 1
  800 ALPH1 =ALPHA1*RAD
      ALPH2=ALPHA2*RAD
      DO 41  K=1,8
      IF (SIGMAT.NE.0.) GO TO 811
      N6=M6=M7=1
      N7=20
      CONST1=4.
      GO TO 812
  811 IF (ETA1.NE.1.) GO TO 813
```

```
811 IF (ETA1.NE.1.) GO TO 813
    N6=M6=1
    M7=2
    N7=20
    CONST1=2.
    GO TO 812
813 M6=N6=1
    M7=4
    N7=20
    CONST1=1
812 DO 801 M1=M6,M7
    DO 802 N1=N6,N7
    ETA=ETA1-(XLOAD(N1)*SIGMAR*SIN(PSI(N1)))
    ZETA=1./((1./ZETA1)-XLOAD(N1)*SIGMAR*GAMMA*SIN(ALPH1)*COS(PSI(N1))
   1)
    XOVERH=SIGMAR*GAMMA*((TL*COS(ALPH2))+(TH*SIN(ALPH2))-(XLOAD(N1)*CO
   1S(ALPH1)*COS(PSI(N1))))
    XM1=FLOAT(M1)
    YOVERH=SIGMAR*GAMMA*(-((2.*XM1-5.)/4.)*(SIGMAT/SIGMAR)-(XLOAD(N1)*
   1SIN(PSI(N1))))
    ZOVERH=SIGMAR*GAMMA*((TH*COS(ALPH2))-(TL*SIN(ALPH2))+(XLOAD(N1)*SI
   1N(ALPH1)*COS(PSI(N1))))
    CALL DLTAS  (C(K))
******************** SEE APPENDIX Q FOR SUBROUTINE DLTAS ********************
    DO 805 L1=1,28
805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)
802 CONTINUE
801 CONTINUE
    DO 807 L3=1,28
807 DELTA(L3)=XDELTA(L3)*SUML*CONST1
    WRITE (6,149) C(K)
    WRITE (6,150) (DELTA(I),I=1,25,4)
    WRITE (6,151) (DELTA(I),I=2,26,4)
    WRITE (6,152) (DELTA(I),I=3,27,4)
    WRITE (6,153) (DELTA(I),I=4,28,4)
    DO 814 L4=1,28
814 XDELTA(L4)=0.
 41 CONTINUE
    GO TO 1
101 FORMAT (//40X*SIGMA(ROTOR) EQUALS ZERO --- USE BASIC PROGRAM*)
149 FORMAT (//5X*CHI =*F5.2/)
150 FORMAT (3X5H(W,L)7(F17.4))
151 FORMAT (3X5H(U,L)7(F17.4))
152 FORMAT (3X5H(W,D)7(F17.4))
153 FORMAT (3X5H(U,D)7(F17.4))
210 FORMAT (1X131(1H-))
211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
   1WIND TUNNEL WHICH IS25X1HI)
212 FORMAT (1X1HI11X1HI117(1H-)1HI)
213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
   1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
   1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
   2I)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I6X4H
   1ONLY6X1HI16X1HI6X4HONLY5X1HI)
216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)
217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTC GROUND EFFECT8X1
   1HI)
218 FORMAT (1X131(1H-))
900 FORMAT (I1,F9.3,4F10.3/4F10.3)
```

```
 901 FORMAT (1H1///38X*AVERAGE INTERFERENCE OVER TAIL BEHIND FINITE-SPA (K 118)
 900 FORMAT (I1,F9.3,4F10.3/4F10.3)                                     (K 119)
 901 FORMAT (1H1///38X*AVERAGE INTERFERENCE OVER TAIL BEHIND FINITE-SPA (K 120)
    1N ROTOR*//56XA10,* LOADING*//15X*ZETA =*F6.3,9X*SIGMA(ROTOR) =*    (K 121)
    2F6.3,9X*TAIL LENGTH/R =*F6.3,9X*ALPHA(ROTOR) =*F7.3//15X*ETA  =*   (K 122)
    3F6.3,9X*SIGMA(TAIL)  =*F6.3,9X*TAIL HEIGHT/R =*F6.3,9X*ALPHA(BODY) (K 123)
    4  =*F7.3//58X*GAMMA =*F7.3//)                                      (K 124)
999   STOP                                                              (K 125)
      END                                                               (K 126)
```

APPENDIX L

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER TANDEM ROTORS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (TWO CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE FRONT ROTOR. THE DIAMETERS AND LOAD DISTRIBUTIONS OF THE TWO ROTORS ARE ASSUMED TO BE IDENTICAL. THE REQUIRED INPUT VARIABLES FOR THE FRONT ROTOR, ON THE FIRST CARD, ARE

LI	LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2 FOR TRIANGULAR DISK-LOAD DISTRIBUTION
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
BETA	SIDE-SLIP ANGLE, DEG
ALPHAF	ANGLE OF ATTACK OF TIP-PATH PLANE OF FRONT ROTOR, DEG
ALPHAB	ANGLE OF ATTACK OF BODY CARRYING REAR ROTOR, DEG

THE REQUIRED INPUT VARIABLES FOR THE REAR ROTOR, ON THE SECOND CARD, ARE

LRR	DISTANCE OF REAR ROTOR BEHIND ORIGIN AT ALPHAB = 0, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
HRR	HEIGHT OF REAR ROTOR ABOVE ORIGIN AT ALPHAB = 0, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
ALPHAR	ANGLE OF ATTACK OF TIP-PATH PLANE OF REAR ROTOR, DEG

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE AT EACH ROTOR DUE TO

ITS OWN PRESENCE AND THE INTERFERENCE AT EACH ROTOR DUE TO THE PRESENCE OF THE OTHER ROTOR. IN THE LIMIT, WHEN SIGMA IS ZERO, THE TWO ROTORS ARE COINCIDENT, ALL FOUR INTERFERENCES ARE IDENTICAL, AND ONLY ONE SET OF INTERFERENCES IS CALCULATED.

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION XDELTA(28),PSI(20),XLOAD(20),RUNIF(20),RTRIA(20),C(8)
      REAL LRR
      DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/
      DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/
      DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./
      PI=3.14159265358979
      RAD=0.0174532925199
      DO 803 L1=1,28
  803 XDELTA(L1)=0.
      PSI(1)=(PI/4.)
      PSI(2)=3.*PSI(1)
      PSI(3)=5.*PSI(1)
      PSI(4)=7.*PSI(1)
      PSI(5)=PSI(13)=(PI/8.)
      PSI(6)=PSI(14)=3.*PSI(5)
      PSI(7)=PSI(15)=5.*PSI(5)
      PSI(8)=PSI(16)=7.*PSI(5)
      PSI(9)=PSI(17)=9.*PSI(5)
      PSI(10)=PSI(18)=11.*PSI(5)
      PSI(11)=PSI(19)=13.*PSI(5)
      PSI(12)=PSI(20)=15.*PSI(5)
    1 READ (5,900) LI,ZETA1,ETA1,GAMMA,SIGMA,BETA,ALPHAF,ALPHAB,
     1    LRR,HRR,ALPHAR
      IF (EOF,5) 999,47
   47 AALPF=ALPHAF
      AALPR=ALPHAR
      AALPB=ALPHAB
      ABETA=BETA
      ALPHAF=ALPHAF*RAD
      ALPHAR=ALPHAR*RAD
      ALPHAB=ALPHAB*RAD
      BETA=BETA*RAD
      WRITE (6,100)
      SUML=.0025
      IF (LI.EQ.1) GO TO 804
      IALPHA=10HTRIANGULAR
      DO 808 M2=1,20
  808 XLOAD(M2)=RTRIA(M2)
      GO TO 160
  804 IALPHA=10HUNIFORM
      DO 809 M2=1,20
  809 XLOAD(M2)=RUNIF(M2)
  160 NROT=4
      IF (SIGMA.EQ.0.) NROT=1
      DO 42 IRTR=1,NROT
      WRITE (6,701)
      GO TO (601,602,603,604), IRTR
  601 IF (SIGMA.EQ.0.) WRITE (6,707)
      IF (SIGMA.EQ.0.) GO TO 610
      WRITE (6,702)
      GO TO 610
  602 WRITE (6,703)
      GO TO 610
```

```
603 WRITE (6,704)
    GO TO 610
604 WRITE (6,705)
610 WRITE (6,706) IALPHA,GAMMA,SIGMA,LRR,AALPF,AALPB,ZETA1,ETA1,
   1     HRR,AALPR,ABETA
    WRITE (6,210)
    WRITE (6,211)
    WRITE (6,212)
    WRITE (6,213)
    WRITE (6,214)
    WRITE (6,215)
    WRITE (6,216)
    WRITE (6,217)
    WRITE (6,218)
    DO 41  K=1,8
    M7=N7=20
    IF (SIGMA.NE.0.) GO TO 815
    M7=N7=1
    CONST1=400.
    GO TO 812
815 IF (ETA1.NE.1..OR.ABETA.NE.0.)  GO TO 813
    CONST1=2.
    GO TO 812
813 CONST1=1.
812 DO 801 M1=1,M7
    DO 802 N1=1,N7
    IF (ETA1.NE.1..OR.ABETA.NE.0.)  GO TO 811
    IF (PSI(N1).GT.PI) GO TO 802
811 GO TO (621,622,623,624), IRTR
621 ETA=ETA1-XLOAD(N1)*SIGMA*(SIN(PSI(N1))*COS(BETA)+
   1     COS(PSI(N1))*COS(ALPHAF)*SIN(BETA))
    ZETA=ZETA1/(1.0-XLOAD(N1)*SIGMA*GAMMA*ZETA1*COS(PSI(N1))
   1     *SIN(ALPHAF))
    XOVERH=SIGMA*GAMMA*(XLOAD(M1)*(COS(PSI(M1))*COS(ALPHAF)*COS(BETA)
   1     -SIN(PSI(M1))*SIN(BETA))-XLOAD(N1)*(COS(PSI(N1))*COS(ALPHAF)
   2     *COS(BETA)-SIN(PSI(N1))*SIN(BETA)))
    YOVERH=SIGMA*GAMMA*(XLOAD(M1)*(SIN(PSI(M1))*COS(BETA)+COS(PSI
   1     (M1))*COS(ALPHAF)*SIN(BETA))- XLOAD(N1)*(SIN(PSI(N1))*
   2     COS(BETA)-COS(PSI(N1))*COS(ALPHAF)*SIN(BETA)))
    ZOVERH=-SIGMA*GAMMA*SIN(ALPHAF)*(XLOAD(M1)*COS(PSI(M1))-
   1     XLOAD(N1)*COS(PSI(N1)))
    GO TO 630
622 ETA=ETA1-XLOAD(N1)*SIGMA*(SIN(PSI(N1))*COS(BETA)+COS(PSI(N1))*
   1     COS(ALPHAR)*SIN(BETA))-SIGMA*SIN(BETA)*(LRR*COS(ALPHAB)+
   2     HRR*SIN(ALPHAB))
    ZETA=ZETA1/(1.0-SIGMA*GAMMA*ZETA1*(XLOAD(N1)*COS(PSI(N1))*
   1     SIN(ALPHAR)+LRR*SIN(ALPHAB)-HRR*COS(ALPHAB)))
    XOVERH=SIGMA*GAMMA*(XLOAD(M1)*(COS(PSI(M1))*COS(ALPHAF)*COS
   1     (BETA)-SIN(PSI(M1))*SIN(BETA))-XLOAD(N1)*(COS(PSI(N1))*
   2     COS(ALPHAR)*COS(BETA)-SIN(PSI(N1))*SIN(BETA))-COS(BETA)*
   3     (LRR*COS(ALPHAB)+HRR*SIN(ALPHAB)))
    YOVERH=SIGMA*GAMMA*(XLOAD(M1)*(SIN(PSI(M1))*COS(BETA)+
   1     COS(PSI(M1))*COS(ALPHAF)*SIN(BETA))-XLOAD(N1)*(SIN(PSI(N1))
   2     *COS(BETA)+COS(PSI(N1))*COS(ALPHAR)*SIN(BETA))-SIN(BETA)*
   3     (LRR*COS(ALPHAB)+HRR*SIN(ALPHAB)))
    ZOVERH=-SIGMA*GAMMA*(XLOAD(M1)*COS(PSI(M1))*SIN(ALPHAF)-
   1     XLOAD(N1)*COS(PSI(N1))*SIN(ALPHAR)-LRR*SIN(ALPHAB)+
   2     HRR*COS(ALPHAB))
    GO TO 630
623 ETA=ETA1-XLOAD(N1)*SIGMA*(SIN(PSI(N1))*COS(BETA)+COS(PSI(N1))
   1     *COS(ALPHAR)*SIN(BETA))-SIGMA*SIN(BETA)*(LRR*COS(ALPHAB)
```

```
     2     +HRR*SIN(ALPHAB))
      ZETA=ZETA1/(1.0-SIGMA*GAMMA*ZETA1*(XLOAD(N1)*COS(PSI(N1))*SIN
     1     (ALPHAR)+LRR*SIN(ALPHAB)-HRR*COS(ALPHAB)))
      XOVERH=SIGMA*GAMMA*(XLOAD(M1)*(COS(PSI(M1))*COS(ALPHAR)*COS
     1     (BETA)-SIN(PSI(M1))*SIN(BETA))-XLOAD(N1)*(COS(PSI(N1))*
     2     COS(ALPHAR)*COS(BETA)-SIN(PSI(N1))*SIN(BETA)))
      YOVERH=SIGMA*GAMMA*(XLOAD(M1)*(SIN(PSI(M1))*COS(BETA)+COS
     1     (PSI(M1))*COS(ALPHAR)*SIN(BETA))-XLOAD(N1)*(SIN(PSI(N1))
     2     *COS(BETA)+COS(PSI(N1))*COS(ALPHAR)*SIN(BETA)))
      ZOVERH=-SIGMA*GAMMA*SIN(ALPHAR)*(XLOAD(M1)*COS(PSI(M1))-
     1     XLOAD(N1)*COS(PSI(N1)))
      GO TO 630
  624 ETA=ETA1-XLOAD(N1)*SIGMA*(SIN(PSI(N1))*COS(BETA)+COS(PSI(N1))*
     1     COS(ALPHAF)*SIN(BETA))
      ZETA=ZETA1/(1.0-XLOAD(N1)*SIGMA*GAMMA*ZETA1*COS(PSI(N1))*
     1     SIN(ALPHAF))
      XOVERH=SIGMA*GAMMA*(XLOAD(M1)*(COS(PSI(M1))*COS(ALPHAR)*COS
     1     (BETA)-SIN(PSI(M1))*SIN(BETA))+COS(BETA)*(LRR*COS(ALPHAB)
     2     +HRR*SIN(ALPHAB))-XLOAD(N1)*(COS(PSI(N1))*COS(ALPHAF)*
     3     COS(BETA)-SIN(PSI(N1))*SIN(BETA)))
      YOVERH=SIGMA*GAMMA*(XLOAD(M1)*(SIN(PSI(M1))*COS(BETA)+COS(PSI
     1     (M1))*COS(ALPHAR)*SIN(BETA))+SIN(BETA)*(LRR*COS(ALPHAB)+
     2     HRR*SIN(ALPHAB))-XLOAD(N1)*(SIN(PSI(N1))*COS(BETA)+
     3     COS(PSI(N1))*COS(ALPHAF)*SIN(BETA)))
      ZOVERH=-SIGMA*GAMMA*(XLOAD(M1)*COS(PSI(M1))*SIN(ALPHAR)+
     1     LRR*SIN(ALPHAB)-HRR*COS(ALPHAB)-XLOAD(N1)*COS(PSI(N1))*
     2     SIN(ALPHAF))
  630 CALL DLTAS  (C(K))
********************* SEE APPENDIX Q FOR SUBROUTINE DLTAS *********************
      DO 805 L1=1,28
  805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)
  802 CONTINUE
  801 CONTINUE
      DO 807 L3=1,28
  807 DELTA(L3)=XDELTA(L3)*SUML*CONST1
      DO 500  LL=1,28
  500 DELTA(LL)=DELTA(LL)*PI*(SIGMA**2)*GAMMA/4.0
      WRITE (6,149) C(K)
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
      DO 814 L4=1,28
  814 XDELTA(L4)=0.
   41 CONTINUE
   42 CONTINUE
      GO TO 1
  100 FORMAT (1H1/////////59X*START NEW CASE*)
  149 FORMAT (1X*CHI =* F7.3/)
  150 FORMAT (3X5H(W,L)7(F17.4))
  151 FORMAT (3X5H(U,L)7(F17.4))
  152 FORMAT (3X5H(W,D)7(F17.4))
  153 FORMAT (3X5H(U,D)7(F17.4)//)
  210 FORMAT (1X131(1H-))
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
     1WIND TUNNEL WHICH IS25X1HI)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
```

```
     2I)
  215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GRCUND EFFECT) I6X4H
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)
  216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)
  217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTC GROUND EFFECT8X1
     1HI)
  218 FCRMAT (1X131(1H-)/)
  701 FORMAT (1H1//41X*AVERAGE WIND-TUNNEL INTERFERENCE OVER TANDEM ROTO
     1RS*/)
  702 FORMAT (49X*EFFECT OF FRCNT ROTOR ON FRONT ROTOR*//)
  703 FORMAT (49X*EFFECT OF REAR ROTOR ON FRONT ROTOR*//)
  704 FORMAT (48X*EFFECT OF REAR ROTOR ON REAR ROTOR*//)
  705 FORMAT (49X*EFFECT OF FRCNT ROTOR ON REAR ROTOR*//)
  706 FORMAT (58XA10* LOADING*//6X*GAMMA =*F7.3,10X*SIGMA =*F6.3,
     110X*L(RR)/R =*F6.3,10X*ALPHA(FR) =*F8.3,10X*ALPHA(BODY) =*
     2F8.3//6X*ZETA  =*F7.3,10X*ETA   =*F6.3,10X*H(RR)/R =*F6.3,
     310X*ALPHA(RR) =*F8.3,14X*BETA    =*F8.3//)
  707 FORMAT (26X*FOR SIGMA = C, THE EFFECTS OF THE FRCNT ROTOR ON THE F
     1RCNT ROTOR, THE REAR ROTOR*/26X*ON THE FRONT ROTCR, THE REAR ROTOR
     2 ON THE REAR ROTOR, AND THE FRCNT ROTOR ON THE*/39X*REAR ROTOR ARE
     3 ALL IDENTICAL, ANC ARE GIVEN AS FOLLOWS,*//)
  900 FORMAT (I1,F9.3,6F10.3/3F10.3)
999   STOP
      END
```

APPENDIX M

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER UNLOADED-ROTOR CONFIGURATIONS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (TWO CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES FOR THE ROTOR, ON THE FIRST CARD, ARE

LIR	ROTOR DISK-LOAD-DISTRIBUTION INDICATOR, LIR=1 FOR UNIFORM LOADING, LIR=2 FOR TRIANGULAR LOADING
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAR	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
ALPHAR	ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

THE REQUIRED INPUT VARIABLES FOR THE WING, GIVEN ON THE SECOND CARD, ARE

LIW	WING SPAN-LOAD-DISTRIBUTION INDICATOR, LIW=1 FOR UNIFORM LOADING, LIW=2 FOR ELLIPTIC LOADING
LW	DISTANCE OF WING APEX BEHIND ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
HW	DISTANCE OF WING APEX ABOVE ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
SIGMAW	RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA	WING SWEEP ANGLE, DEG
ALPHAB	ANGLE OF ATTACK OF BODY CARRYING WING AND TAIL, DEG

THIS PROGRAM REJECTS CASES OF ZERO SPAN. SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS.

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE ON THE WING AND ROTOR DUE TO THEIR OWN PRESENCE, AS WELL AS THE INTERFERENCE ON EACH DUE TO THE PRESENCE OF THE OTHER.

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION XDELTA(28),PSI(20),RLOAD(20),RUNIF(20),RTRIA(20),
     1          XLE(10),XLOAD(20),C(8)
      REAL LAMBDA,LW
      DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/
      DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/
      DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./
      PI=3.14159265358979
      RAD=0.0174532925199
      DO 803 L1=1,28
  803 XDELTA(L1)=0.
      PSI(1)=(PI/4.)
      PSI(2)=3.*PSI(1)
      PSI(3)=5.*PSI(1)
      PSI(4)=7.*PSI(1)
      PSI(5)=PSI(13)=(PI/8.)
      PSI(6)=PSI(14)=3.*PSI(5)
      PSI(7)=PSI(15)=5.*PSI(5)
      PSI(8)=PSI(16)=7.*PSI(5)
      PSI(9)=PSI(17)=9.*PSI(5)
      PSI(10)=PSI(18)=11.*PSI(5)
      PSI(11)=PSI(19)=13.*PSI(5)
      PSI(12)=PSI(20)=15.*PSI(5)
      XLE(1)=XLE(10)=0.43579
      XLE(2)=XLE(9) =0.71422
      XLE(3)=XLE(8) =0.86603
      XLE(4)=XLE(7) =0.95394
      XLE(5)=XLE(6) =0.99499
    1 READ (5,900)  LIR,ZETA1,ETA1,GAMMA,SIGMAR,ALPHAR,LIW,LW,HW,
     1    SIGMAW,LAMBDA,ALPHAB
      IF (EOF,5) 999,47
   47 AALPR=ALPHAR
      AALPB=ALPHAB
      ALAM=LAMBDA
      LAMBDA=LAMBDA*RAD
      ALPHAR=ALPHAR*RAD
      ALPHAB=ALPHAB*RAD
      WRITE (6,100)
      IF (LIR.EQ.1)  GO TO 804
      IALPHA=10HTRIANGULAR
      DO 808 M2=1,20
  808 RLOAD(M2)=RTRIA(M2)
      GO TO 806
  804 IALPHA=10HUNIFORM
      DO 809 M2=1,20
  809 RLOAD(M2)=RTRIA(M2)
  806 IF (LIW.EQ.1)  GO TO 852
      IBETA=8HELLIPTIC
      DO 851  M3=1,10
  851 XLOAD(M3)=XLE(M3)
```

```
      GO TO 850
  852 IBETA=8HUNIFORM
      DO 853  M3=1,10
  853 XLOAD(M3)=1.0
  850 IF (SIGMAR.NE.0.)  GO TO 855
      WRITE (6,701)
      WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,
     1     HW,AALPB,GAMMA,ALAM
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      WRITE (6,707)
      GO TO 1
  855 DO 42  IELEM=1,4
      WRITE (6,701)
      GO TO (601,602,603,604), IELEM
  601 WRITE (6,702)
      GO TO 610
  602 WRITE (6,703)
      GO TO 610
  603 WRITE (6,704)
      GO TO 610
  604 WRITE (6,705)
  610 WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,
     1     HW,AALPB,GAMMA,ALAM
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      DO 41  K=1,8
      M7=N7=20
      GO TO (611,612,613,614), IELEM
C
C     ROTOR ON ROTOR
C
  611 SUML=0.0025
      IF (ETA1.EQ.1.)  SUML=0.005
      GO TO 812
C
C     WING ON ROTOR
C
  612 SUML=0.0063052
      IF (SIGMAW.EQ.0.)  GO TO 615
      IF (LIW.EQ.1)  SUML=0.005
      N7=10
      IF (ETA1.NE.1.)  GO TO 812
      SUML=0.0126104
      IF (LIW.EQ.1)  SUML=0.010
      N7=5
      GO TO 812
```

```
  615 SUML=0.05
      N7=1
      XLOAD(1)=1.0
      IF (ETA1.EQ.1.)  SUML=0.10
      GO TO 812
C
C     WING ON WING
C
  613 SUML=0.0126104
      IF (SIGMAW.EQ.0.)  GO TO 616
      IF (LIW.EQ.1)  SUML=0.010
      M7=10
      N7=10
      IF (ETA1.NE.1.)  GO TO 812
      SUML=0.0252208
      IF (LIW.EQ.1) SUML=0.020
      N7=5
      GO TO 812
  616 SUML=1.
      XLOAD(1)=1.0
      M7=N7=1
      GO TO 812
C
C     ROTOR ON WING
C
  614 SUML=0.0050
      IF (ETA1.EQ.1.)  SUML=0.010
      M7=10
      IF (SIGMAW.NE.0.)  GO TO 812
      M7=1
      SUML=0.05
      IF (ETA1.EQ.1.)  SUML=0.10
  812 DO 801  M1=1,M7
      DO 802  N1=1,N7
      XSTAR=(11.-2.*FLOAT(M1))/10.
      YSTAR=(11.-2.*FLOAT(N1))/10.
  811 GO TO (621,622,623,624), IELEM
C
C     ROTOR ON ROTOR
C
  621 IF (ETA1.NE.1.)  GO TO 625
      IF (PSI(N1).GT.PI)  GO TO 802
  625 ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))
      ZETA=ZETA1/(1.0-RLOAD(N1)*SIGMAR*GAMMA*ZETA1*COS(PSI(N1))
     1    *SIN(ALPHAR))
      XOVERH=SIGMAR*GAMMA*COS(ALPHAR)*(RLOAD(M1)*COS(PSI(M1))
     1    -RLOAD(N1)*COS(PSI(N1)))
      YOVERH=SIGMAR*GAMMA*(RLOAD(M1)*SIN(PSI(M1))-RLOAD(N1)*SIN(PSI(N1))
     1    )
      ZOVERH=-SIGMAR*GAMMA*SIN(ALPHAR)*(RLOAD(M1)*COS(PSI(M1))
     1    -RLOAD(N1)*COS(PSI(N1)))
      XLOAD(N1)=1.0
      GO TO 630
C
C     WING ON ROTOR
C
  622 IF (ETA1.NE.1..OR.SIGMAW.NE.0.)  GO TO 627
      IF (PSI(M1).GT.PI)  GO TO 802
  627 ETA=ETA1-YSTAR*SIGMAW
      ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*(ABS(YSTAR)*(SIGMAW/SIGMAR)
     1    *TAN(LAMBDA)*SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB)))
```

```
      XOVERH=SIGMAR*GAMMA*(RLOAD(M1)*COS(ALPHAR)*COS(PSI(M1))
     1    -ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*COS(ALPHAB)
     2    -LW*COS(ALPHAB)-HW*SIN(ALPHAB))
      YOVERH=SIGMAR*GAMMA*(RLOAD(M1)*SIN(PSI(M1))-YSTAR*(SIGMAW/
     1    SIGMAR))
      ZOVERH=-SIGMAR*GAMMA*(RLOAD(M1)*SIN(ALPHAR)*COS(PSI(M1))
     1    -ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*SIN(ALPHAB)
     2    -LW*SIN(ALPHAB)+HW*COS(ALPHAB))
      GO TO 630
C
C     WING ON WING
C
  623 ETA=ETA1-SIGMAW*YSTAR
      ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*(ABS(YSTAR)*(SIGMAW/SIGMAR)
     1    *TAN(LAMBDA)*SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB)))
      XOVERH=SIGMAW*GAMMA*TAN(LAMBDA)*COS(ALPHAB)*(ABS(XSTAR)
     1    -ABS(YSTAR))
      YOVERH=0.2*SIGMAW*GAMMA*(FLOAT(N1)-FLOAT(M1))
      ZOVERH=-SIGMAW*GAMMA*TAN(LAMBDA)*SIN(ALPHAB)*(ABS(XSTAR)
     1    -ABS(YSTAR))
      GO TO 630
C
C     ROTOR ON WING
C
  624 IF (ETA1.NE.1.)  GO TO 626
      IF (PSI(N1).GT.PI)  GO TO 802
  626 ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))
      ZETA=ZETA1/(1.0-RLOAD(N1)*SIGMAR*GAMMA*ZETA1*COS(PSI(N1))
     1    *SIN(ALPHAR))
      XOVERH=SIGMAR*GAMMA*(ABS(XSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*
     1    COS(ALPHAB)+LW*COS(ALPHAB)+HW*SIN(ALPHAB)-RLOAD(N1)*
     2    COS(ALPHAR)*COS(PSI(N1)))
      YOVERH=SIGMAR*GAMMA*(XSTAR*(SIGMAW/SIGMAR)-RLOAD(N1)*SIN(PSI(N1)))
      ZOVERH=-SIGMAR*GAMMA*(ABS(XSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*
     1    SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB)-RLOAD(N1)*
     2    SIN(ALPHAR)*COS(PSI(N1)))
      XLOAD(N1)=1.0
  630 CALL DLTAS  (C(K))
******************** SEE APPENDIX Q FOR SUBROUTINE DLTAS ********************
      DO 805 L1=1,28
  805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1)
  802 CONTINUE
  801 CONTINUE
      DO 807 L3=1,28
  807 DELTA(L3)=XDELTA(L3)*SUML
      WRITE (6,149) C(K)
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
      DO 814 L4=1,28
  814 XDELTA(L4)=0.
   41 CONTINUE
   42 CONTINUE
      GO TO 1
  100 FORMAT (1H1/////////59X*START NEW CASE*)
  149 FORMAT (1X*CHI =* F7.3/)
  150 FORMAT (3X5H(W,L)7(F17.4))
  151 FORMAT (3X5H(U,L)7(F17.4))
  152 FORMAT (3X5H(W,D)7(F17.4))
  153 FORMAT (3X5H(U,D)7(F17.4)//)
```

```
  210 FORMAT (1X131(1H-))                                              (M 234)
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A (M 235)
     1WIND TUNNEL WHICH IS25X1HI)                                      (M 236)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)                                  (M 237)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1 (M 238)
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)                            (M 239)
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (M 240)
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (M 241)
     2I)                                                               (M 242)
  215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I5X4H (M 243)
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)                                    (M 244)
  216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)                         (M 245)
  217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1 (M 246)
     1HI)                                                              (M 247)
  218 FORMAT (1X131(1H-)/)                                             (M 248)
  701 FORMAT (1H1//42X*AVERAGE INTERFERENCE OVER AN UNLOADED ROTOR MODEL (M 249)
     1*/)                                                              (M 250)
  702 FORMAT (54X*EFFECT OF ROTOR ON ROTOR*//)                         (M 251)
  703 FORMAT (55X*EFFECT OF WING ON ROTOR*//)                          (M 252)
  704 FORMAT (55X*EFFECT OF WING ON WING*//)                           (M 253)
  705 FORMAT (55X*EFFECT OF ROTOR ON WING*//)                          (M 254)
  706 FORMAT (34X,A10* ROTOR  LOADING*19X,A8* WING LOADING*//          (M 255)
     119X*SIGMA(ROTOR) =*F6.3,10X*ZETA =*F6.3,10X*LW/R =*F6.3,10X      (M 256)
     2*ALPHA(ROTOR) =*F7.3//19X*SIGMA(WING)  =*F6.3,10X*ETA  =*F6.3,   (M 257)
     310X*HW/R =*F6.3,10X*ALPHA(BODY)  =*F7.3//39X*GAMMA =*F6.3,       (M 258)
     427X*LAMBDA =*F7.3//)                                             (M 259)
  707 FORMAT (40X*SIGMA(ROTOR) EQUALS ZERO, THIS PROGRAM IS NOT SUITABLE (M 260)
     1 FOR USE WITH SUCH CASES.*//)                                    (M 261)
  900 FORMAT (I1,F9.3,4F10.3/I1,F9.3,4F10.3)                           (M 262)
999   STOP                                                             (M 263)
      END                                                              (M 264)
```

APPENDIX N

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL BEHIND AN UNLOADED-ROTOR CONFIGURATION

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (THREE CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES FOR THE ROTOR, ON THE FIRST CARD, ARE

LIR	ROTOR DISK-LOAD-DISTRIBUTION INDICATOR, LIR=1 FOR UNIFORM LOADING, LIR=2 FOR TRIANGULAR LOADING
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAR	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
ALPHAR	ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

THE REQUIRED INPUT VARIABLES FOR THE WING, GIVEN ON THE SECOND CARD, ARE

LIW	WING SPAN-LOAD-DISTRIBUTION INDICATOR, LIW=1 FOR UNIFORM LOADING, LIW=2 FOR ELLIPTIC LOADING
LW	DISTANCE OF WING APEX BEHIND ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
HW	DISTANCE OF WING APEX ABOVE ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
SIGMAW	RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA	WING SWEEP ANGLE, DEG

ALPHAB   ANGLE OF ATTACK OF BODY CARRYING WING AND TAIL, DEG

THE REQUIRED INPUT VARIABLES FOR THE TAIL, ON THE THIRD CARD, ARE

SIGMAT   RATIO OF TAIL SPAN TO TUNNEL WIDTH

TL   TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS

TH   TAIL HEIGHT ABOVE ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS

THIS PROGRAM REJECTS CASES OF ZERO SPAN. SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS.

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE AT THE TAIL DUE TO THE PRESENCE OF BOTH THE WING AND THE ROTOR.

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION XDELTA(28),PSI(20),RLOAD(20),RUNIF(20),RTRIA(20),
     1          XLE(10),XLOAD(20),C(8)
      REAL LAMBDA,LW
      DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/
      DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/
      DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./
      PI=3.14159265358979
      RAD=0.0174532925199
      DO 803 L1=1,28
  803 XDELTA(L1)=0.
      PSI(1)=(PI/4.)
      PSI(2)=3.*PSI(1)
      PSI(3)=5.*PSI(1)
      PSI(4)=7.*PSI(1)
      PSI(5)=PSI(13)=(PI/8.)
      PSI(6)=PSI(14)=3.*PSI(5)
      PSI(7)=PSI(15)=5.*PSI(5)
      PSI(8)=PSI(16)=7.*PSI(5)
      PSI(9)=PSI(17)=9.*PSI(5)
      PSI(10)=PSI(18)=11.*PSI(5)
      PSI(11)=PSI(19)=13.*PSI(5)
      PSI(12)=PSI(20)=15.*PSI(5)
      XLE(1)=XLE(10)=0.43579
      XLE(2)=XLE(9) =0.71422
      XLE(3)=XLE(8) =0.86603
      XLE(4)=XLE(7) =0.95394
      XLE(5)=XLE(6) =0.99499
    1 READ (5,900) LIR,ZETA1,ETA1,GAMMA,SIGMAR,ALPHAR,LIW,LW,HW,
     1   SIGMAW,LAMBDA,ALPHAB,SIGMAT,TL,TH
      IF (EOF,5) 999,47
   47 AALPR=ALPHAR
      AALPB=ALPHAB
      ALAM=LAMBDA
      LAMBDA=LAMBDA*RAD
      ALPHAR=ALPHAR*RAD
```

```
      ALPHAB=ALPHAB*RAD
      WRITE (6,100)
      IF (LIR.EQ.1)  GO TO 804
      IALPHA=10HTRIANGULAR
      DO 808 M2=1,20
  808 RLOAD(M2)=RTRIA(M2)
      GO TO 806
  804 IALPHA=10HUNIFORM
      DO 809 M2=1,20
  809 RLOAD(M2)=RTRIA(M2)
  806 IF (LIW.EQ.1)  GO TO 852
      IBETA=8HELLIPTIC
      DO 851  M3=1,10
  851 XLOAD(M3)=XLE(M3)
      GO TO 850
  852 IBETA=8HUNIFORM
      DO 853  M3=1,10
  853 XLOAD(M3)=1.0
  850 IF (SIGMAR.NE.0.)  GO TO 855
      WRITE (6,701)
      WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,
     1    HW,AALPB,SIGMAT,TL,TH,GAMMA,ALAM
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      WRITE (6,707)
      GO TO 1
  855 DO 42  IELEM=1,2
      WRITE (6,701)
      GO TO (601,602), IELEM
  601 WRITE (6,702)
      GO TO 610
  602 WRITE (6,703)
  610 WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,
     1    HW,AALPB,SIGMAT,TL,TH,GAMMA,ALAM
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      DO 41  K=1,8
      N7=20
      M7=4
      GO TO (611,613),  IELEM
C
C     EFFECT OF ROTOR
C
  611 SUML=0.0125
      IF (ETA1.EQ.1.)  SUML=0.025
      IF (SIGMAT.NE.0.)  GO TO 812
      SUML=0.050
```

```
      IF (ETA1.EQ.1.)  SUML=0.100
      M7=1
      GO TO 812
C
C     EFFECT OF WING
C
  613 SUML=0.031526
      IF (SIGMAW.EQ.0..OR.SIGMAT.EQ.0.)  GO TO 616
      IF (LIW.EQ.1)  SUML=0.025
      M7=4
      N7=10
      IF (ETA1.NE.1.)  GO TO 812
      SUML=0.063052
      IF (LIW.EQ.1)  SUML=0.050
      N7=5
      GO TO 812
  616 IF (SIGMAW.EQ.0..AND.SIGMAT.NE.0.)  GO TO 612
      IF (SIGMAW.NE.0..AND.SIGMAT.EQ.0.)  GO TO 614
      SUML=1.0
      XLOAD(1)=1.0
      M7=N7=1
      GO TO 812
  612 SUML=0.25
      M7=4
      N7=1
      XLOAD(1)=1.0
      IF (ETA1.NE.1.)  GO TO 812
      M7=2
      SUML=0.50
      GO TO 812
  614 SUML=0.126104
      IF (LIW.EQ.1)  SUML=0.100
      N7=10
      M7=1
      IF (ETA1.NE.1.)  GO TO 812
      SUML=0.25208
      IF (LIW.EQ.1)  SUML=0.200
      N7=5
  812 DO 801  M1=1,M7
      DO 802  N1=1,N7
      XSTAR=(11.-2.*FLOAT(M1))/10.
      YSTAR=(11.-2.*FLOAT(N1))/10.
      GO TO (621,622), IELEM
C
C     EFFECT OF ROTOR
C
  621 ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))
      ZETA=ZETA1/(1.0-RLOAD(N1)*SIGMAR*GAMMA*ZETA1*COS(PSI(N1))*
     1    SIN(ALPHAR))
      XOVERH=SIGMAR*GAMMA*(TL*COS(ALPHAB)+TH*SIN(ALPHAB)-RLOAD(N1)*
     1    COS(ALPHAR)*COS(PSI(N1)))
      YOVERH=SIGMAR*GAMMA*(0.25*(5.0-2.0*FLOAT(M1))*(SIGMAT/SIGMAR)-
     1    RLOAD(N1)*SIN(PSI(N1)))
      ZOVERH=SIGMAR*GAMMA*(TH*COS(ALPHAB)-TL*SIN(ALPHAB)+RLOAD*
     1    SIN(ALPHAR)*COS(PSI(N1)))
      XLOAD(N1)=1.0
      GO TO 630
C
C     EFFECT OF WING
C
  622 ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*(ABS(YSTAR)*(SIGMAW/SIGMAR)
```

```
    1     *TAN(LAMBDA)*SIN(ALPHAB)+LW SIN(ALPHAB)-HW*COS(ALPHAB)))
      ETA=ETA1-YSTAR*SIGMAW
      XOVERH=SIGMAR*GAMMA*((TL-LW)*COS(ALPHAB)+(TH-HW)*SIN(ALPHAB)-
    1     ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*COS(ALPHAB))
      YOVERH=GAMMA*(0.25*(5.0-2.0*FLOAT(M1))*SIGMAT-YSTAR*SIGMAW)
      ZOVERH=-SIGMAR*GAMMA*((TL-LW)*SIN(ALPHAB)+(TH-HW)*COS(ALPHAB)-
    1     ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*SIN(ALPHAB))
  630 CALL DLTAS  (C(K))
********************* SEE APPENDIX Q FOR SUBROUTINE DLTAS **********************
      DO 805 L1=1,28
  805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1)
  802 CONTINUE
  801 CONTINUE
      DO 807 L3=1,28
  807 DELTA(L3)=XDELTA(L3)*SUML
      WRITE (6,149) C(K)
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
      DO 814 L4=1,28
  814 XDELTA(L4)=0.
   41 CONTINUE
   42 CONTINUE
      GO TO 1
  100 FORMAT (1H1/////////59X*START NEW CASE*)
  149 FORMAT (1X*CHI =* F7.3/)
  150 FORMAT (3X5H(W,L)7(F17.4))
  151 FORMAT (3X5H(U,L)7(F17.4))
  152 FORMAT (3X5H(W,D)7(F17.4))
  153 FORMAT (3X5H(U,D)7(F17.4)//)
  210 FORMAT (1X131(1H-))
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
     1WIND TUNNEL WHICH IS25X1HI)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
     2I)
  215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I6X4H
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)
  216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)
  217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1
     1HI)
  218 FORMAT (1X131(1H-)/)
  701 FORMAT (1H1//35X*AVERAGE INTERFERENCE OVER A TAIL BEHIND AN UNLOAD
     1ED ROTOR MODEL*//)
  702 FORMAT (55X*EFFECT OF ROTOR ON TAIL*//)
  703 FORMAT (55X*EFFECT OF WING ON TAIL*//)
  706 FORMAT (34X,A10* ROTOR  LOADING*19X,A8* WING LOADING*//
     119X*SIGMA(ROTOR) =*F6.3,10X*ZETA =*F6.3,10X*LW/R =*F6.3,10X
     2*ALPHA(ROTOR) =*F7.3//19X*SIGMA(WING)  =*F6.3,10X*ETA  =*F6.3,
     310X*HW/R =*F6.3,10X*ALPHA(BODY)  =*F7.3//19X*SIGMA(TAIL)  =*
     4F6.3,21X*TL/R =*F6.3,30X*TH/R =*F6.3//39X*GAMMA =*F6.3,27X
     5*LAMBDA =*F7.3//)
  707 FORMAT (40X*SIGMA(ROTOR) EQUALS ZERO, THIS PROGRAM IS NOT SUITABLE
     1 FOR USE WITH SUCH CASES.*//)
  900 FORMAT (I1,F9.3,4F10.3/I1,F9.3,4F10.3/3F10.3)
999   STOP
      END
```

APPENDIX O

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER SIDE-BY-SIDE ROTOR CONFIGURATIONS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE OLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (THREE CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN AT THE POINT MIDWAY BETWEEN THE TWO ROTORS. THE REQUIRED INPUT VARIABLES FOR THE ROTORS, GIVEN ON THE FIRST CARD, ARE

LIR	ROTOR DISK-LOAD-DISTRIBUTION INDICATOR, LIR=1 FOR UNIFORM LOADING, LIR=2 FOR TRIANGULAR LOADING
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAR	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
SR	DISTANCE BETWEEN ROTOR CENTERS DIVIDED BY ROTOR DIAMETER
ALPHAR	ANGLE OF ATTACK OF TIP-PATH PLANE OF ROTORS, DEG

THE REQUIRED INPUT VARIABLES FOR THE WING, GIVEN ON THE SECOND CARD, ARE

LIW	WING SPAN-LOAD-DISTRIBUTION INDICATOR, LIW=1 FOR UNIFORM LOADING, LIW=2 FOR ELLIPTIC LOADING
LW	DISTANCE OF WING APEX BEHIND ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
HW	DISTANCE OF WING APEX ABOVE ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
SIGMAW	RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA	WING SWEEP ANGLE, DEG

```
ALPHAB    ANGLE OF ATTACK OF BODY CARRYING WING AND TAIL, DEG
```

THIS PROGRAM REJECTS CASES OF ZERO SPAN. SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS. THIS PROGRAM ALSO DETERMINES AND REJECTS CASES IN WHICH TOTAL ROTOR SPAN EXCEEDS THE TUNNEL WIDTH.

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE AT EACH OF THE THREE ELEMENTS DUE TO ITS OWN PRESENCE, AS WELL AS THE INTERFERENCE ON EACH DUE TO THE PRESENCE OF THE OTHER TWO ELEMENTS. IN SYMMETRICAL CASES, THE EFFECTS ON, AND CAUSED BY, EACH OF THE ROTORS IS IDENTICAL. CONSEQUENTLY, ONLY THE INTERFERENCES RELATED TO ONE OF THE ROTORS IS CALCULATED.

NOTE THAT THIS PROGRAM IS ALSO SUITABLE FOR TWIN-PROPELLER TILT-WING MODELS, TILT-ROTOR MODELS, FAN-IN-WING MODELS, AND OTHER SIMILAR TYPES. JUDICIOUS CHOICE OF INPUT VARIABLES WILL SATISFY THE REQUIREMENTS OF THESE, AND MANY OTHER MODELS.

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION XDELTA(28),PSI(20),RLOAD(20),RUNIF(20),RTRIA(20),
     1          XLE(10),XLOAD(20),C(8)
      REAL LAMBDA,LW
      DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/
      DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/
      DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./
      PI=3.14159265358979
      RAD=0.0174532925199
      DO 803 L1=1,28
  803 XDELTA(L1)=0.
      PSI(1)=(PI/4.)
      PSI(2)=3.*PSI(1)
      PSI(3)=5.*PSI(1)
      PSI(4)=7.*PSI(1)
      PSI(5)=PSI(13)=(PI/8.)
      PSI(6)=PSI(14)=3.*PSI(5)
      PSI(7)=PSI(15)=5.*PSI(5)
      PSI(8)=PSI(16)=7.*PSI(5)
      PSI(9)=PSI(17)=9.*PSI(5)
      PSI(10)=PSI(18)=11.*PSI(5)
      PSI(11)=PSI(19)=13.*PSI(5)
      PSI(12)=PSI(20)=15.*PSI(5)
      XLE(1)=XLE(10)=0.43579
      XLE(2)=XLE(9) =0.71422
      XLE(3)=XLE(8) =0.86603
      XLE(4)=XLE(7) =0.95394
      XLE(5)=XLE(6) =0.99499
    1 READ (5,900)  LIR,ZETA1,ETA1,GAMMA,SIGMAR,SR,ALPHAR,LIW,LW,HW,
     1    SIGMAW,LAMBDA,ALPHAB
      IF (EOF,5) 999,47
   47 AALPR=ALPHAR
      AALPB=ALPHAB
      ALAM=LAMBDA
      LAMBDA=LAMBDA*RAD
      ALPHAR=ALPHAR*RAD
      ALPHAB=ALPHAB*RAD
      WRITE (6,100)
      IF (LIR.EQ.1)  GO TO 804
```

```
      IALPHA=10HTRIANGULAR
      DO 808 M2=1,20
  808 RLOAD(M2)=RTRIA(M2)
      GO TO 806
  804 IALPHA=10HUNIFORM
      DO 809 M2=1,20
  809 RLOAD(M2)=RUNIF(M2)
  806 IF (LIW.EQ.1)  GO TO 852
      IBETA=8HELLIPTIC
      DO 851  M3=1,10
  851 XLOAD(M3)=XLF(M3)
      GO TO 850
  852 IBETA=8HUNIFORM
      DO 853  M3=1,10
  853 XLOAD(M3)=1.0
  850 WIDTH=SIGMAR*(1.0+SR)
      IF (WIDTH.LT.1..AND.SIGMAR.NE.0.)  GO TO 855
      WRITE (6,701)
      WRITE (6,711)  IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,
     1    HW,AALPB,GAMMA,SR,ALAM
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      IF (SIGMAR.EQ.0.)  WRITE (6,712)
      IF (WIDTH.GE.1.)  WRITE (6,717)
      GO TO 1
  855 DO 42   IELEM=1,9
      IF (ETA1.EQ.1.) GO TO (600,600,600,42,42,42,600,600,42), IELEM
  600 WRITE (6,701)
      IF (ETA1.EQ.1.)  GO TO (501,502,503,42,42,42,607,504,42), IELEM
      GO TO  (601,602,603,604,605,606,607,608,609),  IELEM
  601 WRITE (6,702)
      GO TO 610
  602 WRITE (6,703)
      GO TO 610
  603 WRITE (6,704)
      GO TO 610
  604 WRITE (6,705)
      GO TO 610
  605 WRITE (6,706)
      GO TO 610
  606 WRITE (6,707)
      GO TO 610
  607 WRITE (6,708)
      GO TO 610
  608 WRITE (6,709)
      GO TO 610
  609 WRITE (6,710)
      GO TO 610
  501 WRITE (6,713)
      GO TO 610
  502 WRITE (6,714)
      GO TO 610
  503 WRITE (6,715)
      GO TO 610
```

```
  504 WRITE (6,716)
  610 WRITE (6,711)  IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,
     1    HW,AALPB,GAMMA,SR,ALAM
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      DO 41  K=1,8
      M7=N7=20
      GO TO (611,611,612,611,611,612,613,614,614),  IELEM
C
C     ROTOR ON ROTOR
C
  611 SUML=0.0025
      GO TO 812
C
C     WING ON ROTOR
C
  612 SUML=0.0063052
      IF (SIGMAW.EQ.0.)  GO TO 615
      IF (LIW.EQ.1)  SUML=0.005
      N7=10
      GO TO 812
  615 SUML=0.05
      XLOAD(1)=1.0
      N7=1
      GO TO 812
C
C     WING ON WING
C
  613 SUML=0.0126104
      IF (SIGMAW.EQ.0.)  GO TO 616
      IF (LIW.EQ.1)  SUML=0.010
      M7=10
      N7=10
      IF (ETA1.NE.1.)  GO TO 812
      SUML=0.0252208
      IF (LIW.EQ.1) SUML=0.020
      N7=5
      GO TO 812
  616 SUML=1.
      XLOAD(1)=1.0
      M7=N7=1
      GO TO 812
C
C     ROTOR ON WING
C
  614 SUML=0.0050
      M7=10
      IF (SIGMAW.NE.0.)  GO TO 812
      M7=1
      SUML=0.05
  812 DO 801  M1=1,M7
      DO 802  N1=1,N7
      XSTAR=(11.-2.*FLOAT(M1))/10.
      YSTAR=(11.-2.*FLOAT(N1))/10.
```

```
  811 GO TO (621,622,623,624,625,626,627,628,629),   IELEM
C
C      RIGHT ROTOR ON RIGHT ROTOR
C
  621 ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))-SR*SIGMAR
      YOVERH=SIGMAR*GAMMA*(RLOAD(M1)*SIN(PSI(M1))-RLOAD(N1)*SIN(PSI
     1      (N1)))
      GO TO 631
C
C      LEFT ROTOR ON RIGHT ROTOR
C
  622 ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))+SR*SIGMAR
      YOVERH=SIGMAR*GAMMA*(RLOAD(M1)*SIN(PSI(M1))-RLOAD(N1)*SIN(PSI
     1      (N1))+2.0*SR)
      GO TO 631
C
C      LEFT ROTOR ON LEFT ROTOR
C
  624 ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))+SR*SIGMAR
      YOVERH=SIGMAR*GAMMA*(RLOAD(M1)*SIN(PSI(M1))-RLOAD(N1)*SIN(PSI
     1      (N1)))
      GO TO 631
C
C      RIGHT ROTOR ON LEFT ROTOR
C
  625 ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))-SR*SIGMAR
      YOVERH=SIGMAR*GAMMA*(RLOAD(M1)*SIN(PSI(M1))-RLOAD(N1)*SIN(PSI
     1      (N1))-2.0*SR)
  631 ZETA=ZETA1/(1.0-RLOAD(N1)*SIGMAR*GAMMA*ZETA1*COS(PSI(N1))*
     1      SIN(ALPHAR))
      XOVERH=SIGMAR*GAMMA*COS(ALPHAR)*(RLOAD(M1)*COS(PSI(M1))-
     1      RLOAD(N1)*COS(PSI(N1)))
      ZOVERH=-SIGMAR*GAMMA*SIN(ALPHAR)*(RLOAD(M1)*COS(PSI(M1))-
     1      RLOAD(N1)*COS(PSI(N1)))
      XLOAD(N1)=1.0
      GO TO 640
C
C      WING ON RIGHT ROTOR
C
  623 YOVERH=SIGMAR*GAMMA*(RLOAD(M1)*SIN(PSI(M1))+SR-YSTAR*
     1      (SIGMAW/SIGMAR))
      GO TO 632
C
C      WING ON LEFT ROTOR
C
  626 YOVERH=SIGMAR*GAMMA*(RLOAD(M1)*SIN(PSI(M1))-SR-YSTAR*
     1      (SIGMAW/SIGMAR))
  632 ETA=ETA1-YSTAR*SIGMAW
      ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*(ABS(YSTAR)*(SIGMAW/SIGMAR)*
     1      TAN(LAMBDA)*SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB)))
      ZOVERH=-SIGMAR*GAMMA*(RLOAD(M1)*SIN(ALPHAR)*COS(PSI(M1))-
     1      ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*SIN(ALPHAB)-
     2      LW*SIN(ALPHAB)+HW*COS(ALPHAB))
      XOVERH=SIGMAR*GAMMA*(RLOAD(M1)*COS(ALPHAR)*COS(PSI(M1))-
     1      ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*COS(ALPHAB)-
     2      LW*COS(ALPHAB)-HW*SIN(ALPHAB))
      GO TO 640
C
C      WING ON WING
C
  627 ETA=ETA1-YSTAR*SIGMAW
```

```
      ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*(YSTAR*(SIGMAW/SIGMAR)*
     1     TAN(LAMBDA)*SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB)))
      XOVERH=SIGMAW*GAMMA*TAN(LAMBDA)*COS(ALPHAB)*(ABS(XSTAR)-
     1     ABS(YSTAR))
      YOVERH=0.2*SIGMAW*GAMMA*(FLOAT(N1)-FLOAT(M1))
      ZOVERH=-SIGMAW*GAMMA*TAN(LAMBDA)*SIN(ALPHAB)*(ABS(XSTAR)-
     1     ABS(YSTAR))
      GO TO 640
C
C     RIGHT ROTOR ON WING
C
  628 ETA=ETA1-RLOAD*SIGMAR*SIN(PSI(N1))-SR*SIGMAR
      YOVERH=SIGMAR*GAMMA*(XSTAR*(SIGMAW/SIGMAR)-RLOAD(N1)*SIN(PSI
     1     (N1))-SR)
      GO TO 633
C
C     LEFT ROTOR ON WING
C
  629 ETA=ETA1-RLOAD*SIGMAR*SIN(PSI(N1))+SR*SIGMAR
      YOVERH=SIGMAR*GAMMA*(XSTAR*(SIGMAW/SIGMAR)-RLOAD(N1)*SIN(PSI
     1     (N1))+SR)
  633 ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*RLOAD(N1)*SIN(ALPHAR)*
     1     COS(PSI(N1)))
      XOVERH=SIGMAR*GAMMA*(ABS(XSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*
     1     COS(ALPHAB)+LW*COS(ALPHAB)+HW*SIN(ALPHAB)-RLOAD(N1)*
     2     COS(ALPHAR)*COS(PSI(N1)))
      ZOVERH=-SIGMAR*GAMMA*(ABS(XSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*
     1     SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB)-RLOAD(N1)*
     2     SIN(ALPHAR)*COS(PSI(N1)))
      XLOAD(N1)=1.0
  640 CALL DLTAS  (C(K))
******************** SEE APPENDIX Q FOR SUBROUTINE DLTAS ********************
      DO 805 L1=1,28
  805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1)
  802 CONTINUE
  801 CONTINUE
      DO 807 L3=1,28
  807 DELTA(L3)=XDELTA(L3)*SUML
      WRITE (6,149) C(K)
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
      DO 814 L4=1,28
  814 XDELTA(L4)=0.
   41 CONTINUE
   42 CONTINUE
      GO TO 1
  100 FORMAT (1H1/////////59X*START NEW CASE*)
  149 FORMAT (1X*CHI =* F7.3/)
  150 FORMAT (3X5H(W,L)7(F17.4))
  151 FORMAT (3X5H(U,L)7(F17.4))
  152 FORMAT (3X5H(W,D)7(F17.4))
  153 FORMAT (3X5H(U,D)7(F17.4)//)
  210 FORMAT (1X131(1H-))
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
     1WIND TUNNEL WHICH IS25X1HI)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
```

```
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
     2I)
 215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I6X4H
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)
 216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)
 217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1
     1HI)
 218 FORMAT (1X131(1H-)/)
 701 FORMAT (1H1//35X*AVERAGE INTERFERENCE OVER SIDE-BY-SIDE AND/OR TIL
     1T-ROTOR MODELS*/)
 702 FORMAT (48X*EFFECT OF RIGHT ROTOR ON RIGHT ROTOR*//)
 703 FORMAT (48X*EFFECT OF LEFT ROTOR ON RIGHT ROTOR*//)
 704 FORMAT (51X*EFFECT OF WING ON RIGHT ROTOR*//)
 705 FORMAT (49X*EFFECT OF LEFT ROTOR ON LEFT ROTOR*//)
 706 FORMAT (48X*EFFECT OF RIGHT ROTOR ON LEFT ROTOR*//)
 707 FORMAT (52X*EFFECT OF WING ON LEFT ROTOR*//)
 708 FORMAT (55X*EFFECT OF WING ON WING*//)
 709 FORMAT (51X*EFFECT OF RIGHT ROTOR ON WING*//)
 710 FORMAT (52X*EFFECT OF LEFT ROTOR ON WING*//)
 711 FORMAT (34X,A10* ROTOR  LOADING*19X,A8* WING LOADING*//
     119X*SIGMA(ROTOR) =*F6.3,10X*ZETA =*F6.3,10X*LW/R =*F6.3,10X
     2*ALPHA(ROTOR) =*F7.3//19X*SIGMA(WING)  =*F6.3,10X*ETA  =*F6.3,
     310X*HW/R =*F6.3,10X*ALPHA(BODY)  =*F7.3//19X*GAMMA =*F6.3,
     428X*SR/R =*F6.3,27X*LAMBDA =*F7.3//)
 712 FORMAT (40X*SIGMA(ROTOR) EQUALS ZERO, THIS PROGRAM IS NOT SUITABLE
     1 FOR USE WITH SUCH CASES.*//)
 713 FORMAT (50X*EFFECT OF EITHER ROTOR ON ITSELF*//)
 714 FORMAT (47X*EFFECT OF OTHER ROTOR ON EITHER ROTOR*//)
 715 FORMAT (51X*EFFECT OF WING ON EITHER ROTOR*//)
 716 FORMAT (51X*EFFECT OF EITHER ROTOR ON WING*//)
 717 FORMAT (40X*ROTOR SYSTEM IS TOO WIDE FOR THE WIND TUNNEL*//)
 900 FORMAT (I1,F9.3,5F10.3/I1,F9.3,4F10.3)
999   STOP
      END
```

APPENDIX P

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL BEHIND A SIDE-BY-SIDE ROTOR CONFIGURATION

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (THREE CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN AT THE POINT MIDWAY BETWEEN THE TWO ROTORS. THE REQUIRED INPUT VARIABLES FOR THE ROTORS, GIVEN ON THE FIRST CARD, ARE

LIR	ROTOR DISK-LOAD-DISTRIBUTION INDICATOR, LIR=1 FOR UNIFORM LOADING, LIR=2 FOR TRIANGULAR LOADING
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAR	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
SR	DISTANCE BETWEEN ROTOR CENTERS DIVIDED BY ROTOR DIAMETER
ALPHAR	ANGLE OF ATTACK OF TIP-PATH PLANE OF ROTORS, DEG

THE REQUIRED INPUT VARIABLES FOR THE WING, GIVEN ON THE SECOND CARD, ARE

LIW	WING SPAN-LOAD-DISTRIBUTION INDICATOR, LIW=1 FOR UNIFORM LOADING, LIW=2 FOR ELLIPTIC LOADING
LW	DISTANCE OF WING APEX BEHIND ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
HW	DISTANCE OF WING APEX ABOVE ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
SIGMAW	RATIO OF WING SPAN TO TUNNEL WIDTH

LAMBDA WING SWEEP ANGLE, DEG

ALPHAB ANGLE OF ATTACK OF BODY CARRYING WING AND TAIL, DEG

THE REQUIRED INPUT VARIABLES FOR THE TAIL, ON THE THIRD CARD, ARE

SIGMAT RATIO OF TAIL SPAN TO TUNNEL WIDTH

TL TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS

TH TAIL HEIGHT ABOVE ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE AT THE TAIL CAUSED BY THE PRESENCE OF THE THREE LIFTING ELEMENTS. IN SYMMETRICAL CASES, THE EFFECT OF THE TWO ROTORS IS IDENTICAL. CONSEQUENTLY, ONLY THE INTERFERENCE CAUSED BY ONE ROTOR IS CALCULATED.

THIS PROGRAM REJECTS CASES OF ZERO SPAN. SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS. THIS PROGRAM ALSO DETERMINES AND REJECTS CASES IN WHICH TOTAL ROTOR SPAN EXCEEDS THE TUNNEL WIDTH.

NOTE THAT THIS PROGRAM IS ALSO SUITABLE FOR TWIN-PROPELLER TILT-WING MODELS, TILT-ROTOR MODELS, FAN-IN-WING MODELS, AND OTHER SIMILAR TYPES. JUDICIOUS CHOICE OF INPUT VARIABLES WILL SATISFY THE REQUIREMENTS OF THESE, AND MANY OTHER MODELS.

```
      PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION XDELTA(28),PSI(20),RLOAD(20),RUNIF(20),RTRIA(20),
     1          XLE(10),XLOAD(20),C(8)
      REAL LAMBDA,LW
      DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/
      DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/
      DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./
      PI=3.14159265358979
      RAD=0.0174532925199
      DO 803 L1=1,28
  803 XDELTA(L1)=0.
      PSI(1)=(PI/4.)
      PSI(2)=3.*PSI(1)
      PSI(3)=5.*PSI(1)
      PSI(4)=7.*PSI(1)
      PSI(5)=PSI(13)=(PI/8.)
      PSI(6)=PSI(14)=3.*PSI(5)
      PSI(7)=PSI(15)=5.*PSI(5)
      PSI(8)=PSI(16)=7.*PSI(5)
      PSI(9)=PSI(17)=9.*PSI(5)
      PSI(10)=PSI(18)=11.*PSI(5)
      PSI(11)=PSI(19)=13.*PSI(5)
      PSI(12)=PSI(20)=15.*PSI(5)
      XLE(1)=XLE(10)=0.43579
      XLE(2)=XLE(9) =0.71422
      XLE(3)=XLE(8) =0.86603
```

```
      XLE(4)=XLE(7) =0.95394
      XLE(5)=XLE(6) =0.99499
    1 READ (5,900)  LIR,ZETA1,ETA1,GAMMA,SIGMAR,SR,ALPHAR,LIW,LW,HW,
     1     SIGMAW,LAMBDA,ALPHAB,SIGMAT,TL,TH
      IF (EOF,5) 999,47
   47 AALPR=ALPHAR
      AALPB=ALPHAB
      ALAM=LAMBDA
      LAMBDA=LAMBDA*RAD
      ALPHAR=ALPHAR*RAD
      ALPHAB=ALPHAB*RAD
      WRITE (6,100)
      IF (LIR.EQ.1)  GO TO 804
      IALPHA=10HTRIANGULAR
      DO 808 M2=1,20
  808 RLOAD(M2)=RTRIA(M2)
      GO TO 806
  804 IALPHA=10HUNIFORM
      DO 809 M2=1,20
  809 RLOAD(M2)=RUNIF(M2)
  806 IF (LIW.EQ.1)  GO TO 852
      IBETA=8HELLIPTIC
      DO 851  M3=1,10
  851 XLOAD(M3)=XLE(M3)
      GO TO 850
  852 IBETA=8HUNIFORM
      DO 853  M3=1,10
  853 XLOAD(M3)=1.0
  850 WIDTH=SIGMAR*(1.0+SR)
      IF (WIDTH.LT.1..AND.SIGMAR.NE.0.)  GO TO 855
      WRITE (6,701)
      WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,
     1     HW,AALPB,SIGMAT,TL,TH,SR,GAMMA,ALAM
      WRITE (6,210)
      WRITE (6,211)
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      IF (SIGMAR.EQ.0.)  WRITE (6,707)
      IF (WIDTH.GE.1.)  WRITE (6,708)
      GO TO 1
  855 DO 42  IELEM=1,3
      IF (ETA1.EQ.1.)  GO TO (600,42,600),  IELEM
  600 WRITE (6,701)
      IF (ETA1.EQ.1.)  GO TO (604,42,603),  IELEM
      GO TO (601,602,603), IELEM
  601 WRITE (6,702)
      GO TO 610
  602 WRITE (6,703)
      GO TO 610
  603 WRITE (6,704)
      GO TO 610
  604 WRITE (6,705)
  610 WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,
     1     HW,AALPB,SIGMAT,TL,TH,SR,GAMMA,ALAM
      WRITE (6,210)
      WRITE (6,211)
```

```
      WRITE (6,212)
      WRITE (6,213)
      WRITE (6,214)
      WRITE (6,215)
      WRITE (6,216)
      WRITE (6,217)
      WRITE (6,218)
      DO 41  K=1,8
      N7=20
      M7=4
      GO TO (611,611,612), IELEM
C
C     EFFECT OF ROTOR
C
  611 SUML=0.0125
      GO TO 812
C
C     EFFECT OF WING
C
  612 SUML=0.031526
      IF (SIGMAW.EQ.0..OR.SIGMAT.EQ.0.)  GO TO 615
      IF (LIW.EQ.1) SUML=0.025
      N7=10
      IF (ETA1.NE.1.)  GO TO 812
      SUML=0.0126104
      IF (LIW.EQ.1) SUML=0.050
      N7=5
      GO TO 812
  615 IF (SIGMAW.EQ.0..AND.SIGMAT.NE.0.) GO TO 613
      IF (SIGMAW.NE.0..AND.SIGMAT.EQ.0.) GO TO 616
      SUML=1.0
      XLOAD(1)=1.0
      M7=N7=1
      GO TO 812
  613 SUML=0.25
      M7=4
      N7=1
      XLOAD(1)=1.0
      IF (ETA1.NE.1.)  GO TO 812
      SUML=0.50
      M7=2
      GO TO 812
  616 SUML=0.126104
      IF (LIW.EQ.1)  SUML=0.100
      N7=10
      M7=1
      IF (ETA1.NE.1.)  GO TO 812
      SUML=0.25208
      IF (LIW.EQ.1)  SUML=0.200
      N7=5
  812 DO 801  M1=1,M7
      DO 802  N1=1,N7
      XSTAR=(11.-2.*FLOAT(M1))/10.
      YSTAR=(11.-2.*FLOAT(N1))/10.
      GO TO (622,623,621),  IELEM
C
C     EFFECT OF RIGHT ROTOR
C
  622 ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))-SR*SIGMAR
      YOVERH=-SIGMAR*GAMMA*(0.25*(2.0*FLOAT(M1)-5.0)*(SIGMAT/SIGMAR)
     1     +RLOAD(N1)*SIN(PSI(N1))+SR)
```

```
      GO TO 625
C
C     EFFECT OF LEFT RCTOR
C
  623 ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))+SR*SIGMAR
      YOVERH=-SIGMAR*GAMMA*(0.25*(2.0*FLOAT(M1)-5.0)*(SIGMAT/SIGMAR)
     1    +RLOAD(N1)*SIN(PSI(N1))-SR)
      GO TO 625
C
C     EFFECT OF WING
C
  621 YSTAR=(11.0-2.0*FLOAT(N1))/10.0
      ETA=ETA1-YSTAR*SIGMAW
      ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*(ABS(YSTAR)*(SIGMAW/SIGMAR)
     1    *TAN(LAMBDA)*SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB)))
      XOVERH=SIGMAR*GAMMA*((TL-LW)*COS(ALPHAB)+(TH-HW)*SIN(ALPHAB)
     1    -ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*COS(ALPHAB))
      YOVERH=GAMMA*(0.25*(5.0-2.0*FLOAT(M1))*SIGMAT-YSTAR*SIGMAW)
      ZOVERH=-SIGMAR*GAMMA*((TL-LW)*SIN(ALPHAB)-(TH-HW)*COS(ALPHAB)
     1    -ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*SIN(ALPHAB))
      GO TO 630
  625 ZETA=ZETA1/(1.0-RLOAD(N1)*SIGMAR*GAMMA*ZETA1*COS(PSI(N1))*
     1    SIN(ALPHAR))
      XOVERH=SIGMAR*GAMMA*(TL*COS(ALPHAB)+TH*SIN(ALPHAB)-
     1    RLOAD(N1)*COS(ALPHAR)*COS(PSI(N1)))
      ZOVERH=SIGMAR*GAMMA*(TH*COS(ALPHAB)-TL*SIN(ALPHAB)+RLOAD(N1)
     1    *SIN(ALPHAR)*COS(PSI(N1)))
      XLOAD(N1)=1.0
  630 CALL DLTAS  (C(K))
******************** SEE APPENDIX Q FOR SUBROUTINE DLTAS *********************
      DO 805 L1=1,28
  805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1)
  802 CONTINUE
  801 CONTINUE
      DO 807 L3=1,28
  807 DELTA(L3)=XDELTA(L3)*SUML
      WRITE (6,149) C(K)
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
      DO 814 L4=1,28
  814 XDELTA(L4)=0.
   41 CONTINUE
   42 CONTINUE
      GO TO 1
  100 FORMAT (1H1/////////59X*START NEW CASE*)
  149 FORMAT (1X*CHI =* F7.3/)
  150 FORMAT (3X5H(W,L)7(F17.4))
  151 FORMAT (3X5H(U,L)7(F17.4))
  152 FORMAT (3X5H(W,D)7(F17.4))
  153 FORMAT (3X5H(U,D)7(F17.4)//)
  210 FORMAT (1X131(1H-))
  211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
     1WIND TUNNEL WHICH IS25X1HI)
  212 FORMAT (1X1HI11X1HI117(1H-)1HI)
  213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1
     1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
  214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP
     1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H
     2I)
```

```
  215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I6X4H
     1ONLY6X1HI16X1HI6X4HONLY5X1HI)
  216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)
  217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1
     1HI)
  218 FORMAT (1X131(1H-)/)
  701 FORMAT (1H1//28X*AVERAGE INTERFERENCE OVER A TAIL BEHIND SIDE-BY-S
     1IDE AND/OR TILT ROTOR MODELS*/)
  702 FORMAT (55X*EFFECT OF RIGHT ROTOR*//)
  703 FORMAT (56X*EFFECT OF LEFT ROTOR*//)
  704 FORMAT (59X*EFFECT OF WING*//)
  705 FORMAT (55X*EFFECT OF EITHER ROTOR*//)
  706 FORMAT (34X,A10* ROTOR  LOADING*19X,A8* WING LOADING*//
     119X*SIGMA(ROTOR) =*F6.3,10X*ZETA =*F6.3,10X*LW/R =*F6.3,10X
     2*ALPHA(ROTOR) =*F7.3//19X*SIGMA(WING)  =*F6.3,10X*ETA  =*F6.3,
     310X*HW/R =*F6.3,10X*ALPHA(BODY)  =*F7.3//19X*SIGMA(TAIL)  =*F6.3,
     410X*TL/R =*F6.3,10X*TH/R =*F6.3,10X*SR/R          =*F7.3//39X
     5*GAMMA =*F6.3,29X*LAMBDA =*F7.3//)
  707 FORMAT (40X*SIGMA(ROTOR) EQUALS ZERO, THIS PROGRAM IS NOT SUITABLE
     1 FOR USE WITH SUCH CASES.*//)
  708 FORMAT (40X*ROTOR SYSTEM IS TOO WIDE FOR WIND TUNNEL*//)
  900 FORMAT (I1,F9.3,5F10.3/I1,F9.3,4F10.3/3F10.3)
999   STOP
      END
```

APPENDIX Q

SUBROUTINE DLTAS

THIS SUBROUTINE WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS SUBROUTINE HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS SUBROUTINE IS REQUIRED BY THE PROGRAMS OF ALL PRECEEDING APPENDICES.

```
      SUBROUTINE DLTAS  (ANGL)
      COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
      DIMENSION V(3,9),ADEL(28)
      SC=SIN(ANGL*0.0174532925199)
      CC=COS(ANGL*0.0174532925199)
      Z6=ZETA*ZOVERH+1.
      Z8=-Z6
      Z7=Z8-1.
      DO 8 J1=1,28
    8 DELTA(J1)=0.
      DO 10 M=1,7
      DO 10 N=1,7
      IF (N.EQ.4.AND.M.EQ.4)  GO TO 10
      DO 11  J1=1,3
      DO 11  J2=1,9
   11 V(J1,J2)=0.
      DO 12 J1=1,28
   12 ADEL(J1)=0.
      AM=M-4
      AN=N-4
      X=ZETA*XOVERH
      Y=ZETA*(YOVERH-2.*AM*GAMMA+GAMMA*(1.-ETA)*(1.-(-1.)**M))
      Z=ZETA*(ZOVERH-4.*AN)
      A=SQRT(X*X+Y*Y+Z*Z)
      B=A+Z*CC-X*SC
      V(1,1)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2
      V(2,1)=-(X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A)
      V(3,1)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2
      Z=-Z-2.
      A=SQRT(X*X+Y*Y+Z*Z)
      B=A+Z*CC-X*SC
      V(1,3)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2
      V(2,3)=-(X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A)
      V(3,3)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2
      IF (ANGL.EQ.90.0)  GO TO 13
      X=X-(SC/CC)
      Z=-Z-1.
      A=SQRT(X*X+Y*Y+Z*Z)
      B=A+Z*CC-X*SC
      V(1,2)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2
      V(2,2)=-(X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A)
```

```
      V(3,2)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2
      B=A-X
      V(1,5)=((X*X+Y*Y)/(B*A*A*A))-(Z/(B*A))**2
      V(2,5)=Z/(A*A*A)
      V(3,5)=X/(A*A*A)
      Z=-Z
      B=A+Z*CC-X*SC
      V(1,4)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2
      V(2,4)=-(X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A)
      V(3,4)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2
   13 ADEL(1)=V(1,1)-V(1,2)-V(1,3)+V(1,4)
      ADEL(2)=V(2,1)-V(2,2)+V(2,3)-V(2,4)
      ADEL(3)=V(2,1)-V(2,2)-V(2,3)+V(2,4)+2.*V(2,5)
      ADEL(4)=V(3,1)-V(3,2)+V(3,3)-V(3,4)+2.*V(3,5)
      ADEL(5)=((-1.)**(M+N))*ADEL(1)
      ADEL(6)=((-1.)**(M+N))*ADEL(2)
      ADEL(7)=((-1.)**(M+N))*ADEL(3)
      ADEL(8)=((-1.)**(M+N))*ADEL(4)
      ADEL(9)= ((-1.)**M)*(V(1,1)-V(1,2)+V(1,3)-V(1,4)+2.*V(1,5))
      ADEL(10)=((-1.)**M)*(V(2,1)-V(2,2)-V(2,3)+V(2,4)+2.*V(2,5))
      ADEL(11)=((-1.)**M)*(V(2,1)-V(2,2)+V(2,3)-V(2,4))
      ADEL(12)=((-1.)**M)*(V(3,1)-V(3,2)-V(3,3)+V(3,4))
      DO 14 J1=1,12
   14 DELTA(J1)=DELTA(J1)+ADEL(J1)
   10 CONTINUE
      DO 15 J1=1,8
   15 DELTA(J1+20)=DELTA(J1)
      X=ZETA*XOVERH
      Y=ZETA*YOVERH
      Z=Z7
      A=SQRT(X*X+Y*Y+Z*Z)
      B=A+Z*CC-X*SC
      V(1,7)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2
      V(2,7)=-(X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A)
      V(3,7)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2
      IF (ANGL.EQ.90.0)  GO TO 16
      X=X-(SC/CC)
      Z=Z6
      A=SQRT(X*X+Y*Y+Z*Z)
      B=A+Z*CC-X*SC
      V(1,6)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2
      V(2,6)=-(X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A)
      V(3,6)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2
      B=A-X
      V(1,9)=((X*X+Y*Y)/(B*A*A*A))-(Z/(B*A))**2
      V(2,9)=Z/(A*A*A)
      V(3,9)=X/(A*A*A)
      Z=Z8
      B=A+Z*CC-X*SC
      V(1,8)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2
      V(2,8)=-(X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A)
      V(3,8)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2
   16 DELTA(13)=-V(1,6)-V(1,7)+V(1,8)
      DELTA(14)=-V(2,6)+V(2,7)-V(2,8)
      DELTA(15)=-V(2,6)-V(2,7)+V(2,8)+2.*V(2,9)
      DELTA(16)=-V(3,6)+V(3,7)-V(3,8)+2.*V(3,9)
      DELTA(17)=-V(1,6)+V(1,7)-V(1,8)+2.*V(1,9)
      DELTA(18)=DELTA(15)
      DELTA(19)=DELTA(14)
      DELTA(20)=-V(3,6)-V(3,7)+V(3,8)
      DO 17 J1=1,4
```

```
17 DELTA(J1)=DELTA(J1)+DELTA(J1+12)
   DO 18 J1=5,12
18 DELTA(J1)=DELTA(J1)+DELTA(J1+8)
   AMT=-2.*GAMMA*ZETA*ZETA/3.14159265358979
   DO 19 J1=1,28
19 DELTA(J1)=AMT*DELTA(J1)
   RETURN
   END
```


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