```
***********************************************************************
*                                                                     *
*   APPENDIX A      ***** MAIN PROGRAM *****                          *
*                                    BY   NOBORU KITAHARA             *
*                                         SUPOTH WATTANAVICHEAN       *
*                                                                     *
*                                                                     *
*       This program was made for calculation of Cp,Cq                *
*        of windmill which we made , so if you want to                *
*        calculate Cp,Cq of another windmill , you must               *
*        change call statement's parameter and SUBROUTINE             *
*        CLCD .                                                       *
*                                                                     *
***********************************************************************

      DIMENSION R(51),C(51),SOL(51),FAI(51),A0(51),B0(51),CQ(20)
      DIMENSION ALD(51),ALPHA1(51),A(51),B(51),CP(20),XXX(20)
      PARAMETER (ALPHA0=4.0)

1     WRITE(5,*) '  DESIGN X=?'
      READ(5,*) XX0
      WRITE(5,*)
      WRITE(5,*) ' NUMBER OF DIVISION ?'
      READ(5,*) ND
      WRITE(5,*)
      WRITE(5,*) ' PITCH ANGLE ?'
      READ(5,*) PA
      WRITE(5,*) ' DO YOU NEED GRAPH OF ALPHA,a,b ?'
      READ(5,*) NG

      CALL SFAI(XX0,ALPHA0,8,97.5,0.06,125.0,625.0,ND,R,C,SOL,
     J          FAI,ALD,A0,B0,1)

      IF(NG.NE.1) GO TO 150
      CALL GRAPH1('r',5,2,125.0,625.0,'ALPHA',7,2,-20.0,50.0)
      DO 5 I=1,8
      XX=REAL(I)*0.5
      CALL ALPAB(XX,ND,R,SOL,ALD,PA,ALPHA1,A,B)
      IF(I.EQ.8) THEN
      NC=1
      ELSE
      NC=2
      END IF
      CALL GRAPH2(51,R,ALPHA1,0,1,NC)
5     CONTINUE
      CALL PSPACE(1)

      CALL GRAPH1('r',5,2,125.0,625.0,'a',3,2,0.0,0.3)
      DO 10 I=1,8
      XX=REAL(I)*0.5
      CALL ALPAB(XX,ND,R,SOL,ALD,PA,ALPHA1,A,B)
      IF(I.EQ.8) THEN
      NC=1
      ELSE
      NC=2
      END IF
      CALL GRAPH2(51,R,A,0,1,NC)
10    CONTINUE
      CALL PSPACE(1)

      CALL GRAPH1('r',5,2,125.0,625.0,'b',10,2,0.0,1.0)
      DO 20 I=1,8
      XX=REAL(I)*0.5
      CALL ALPAB(XX,ND,R,SOL,ALD,PA,ALPHA1,A,B)
```

```
      IF(I.EQ.8) THEN
      NC=1
      ELSE
      NC=2
      END IF
      CALL GRAPH2(51,R,B,0,1,NC)
20    CONTINUE
      CALL PSPACE(4)

150   CALL PRON
      CALL SPACE(5,2)
      WRITE(5,200) XX0,PA
200   FORMAT('          X=',F3.1,'     PITCH ANGLE=',F5.1)
      CALL PROFF

      DO 30 I=1,20
      XXX(I)=REAL(I)*0.2
      CALL ALPAB(XXX(I),50,R,SOL,ALD,PA,ALPHA1,A,B)
      CALL IITA(XXX(I),50,R,A,B,CP(I),CQ(I))
30    CONTINUE
      CALL PSPACE(2)
      CALL GRAPH1('X',5,2,0.0,5.0,'CP',4,2,0.0,0.4)
      CALL GRAPH2(20,XXX,CP,0,1,1)
      CALL PSPACE(10)
      CALL GRAPH1('X',5,2,0.0,5.0,'CQ',4,2,0.0,0.4)
      CALL GRAPH2(20,XXX,CQ,0,1,1)
      CALL PSPACE(11)
      CALL PRON
      CALL SPACE(5,10)
      DO 40 I=1,20
      WRITE(5,*)
      WRITE(5,100) XXX(I),CP(I),CQ(I)
40    CONTINUE
100   FORMAT('              X=',F3.1,'     CP=',F6.3,'     CQ=',F6.3)
      CALL SPACE(5,16)
      CALL PROFF
      WRITE(5,*) ' CONTINUE ?   1---YES   2---NO'
      READ(5,*) IC
      IF(IC.EQ.1) GO TO 1
      END
```

```
*****************************************************************************
*                                                                           *
*     ***** PROGRAM FOR CALCULATION OF TWIST ANGLE OF BLADE *****           *
*                                                                           *
*       SUBROUTINE SFAI(XX,ALPHAO,NB,C1,C2,RR,RT,NN,R,C,SOL,                *
*                                            FAI,ALD,A,B,KK)                *
*                                                                           *
*        --INPUT--                                                          *
*         XX      : Design tip speed ratio                                  *
*         ALPHAO  : Attack angle at maximum L/D                             *
*         NB      : Number of blade                                         *
*         C1,C2   : C(R)=C1-C2*R    (mm)                                    *
*         RR      : Radius from center of windmill to cone of blade         *
*         RT      : Radius from center of windmill to tip of blade          *
*         NN      : Number of division (radius)                             *
*                                                                           *
*        --OUTPUT--                                                         *
*         R       : Radius  (mm)                                            *
*         C       : Chord length  (mm)                                      *
*         SOL     : Solidity                                                *
*         FAI     : Angle between plane of rotation and relative            *
*                          flow velocity in the plane of rotation           *
*         ALD     : Design angle of blade                                   *
*         A       : Axial interference factor                               *
*         B       : Tangential interference factor                          *
*         KK      : Choice for display    1-- show   2-- not show           *
*                                                                           *
*****************************************************************************

      SUBROUTINE SFAI(XX,ALPHAO,NB,C1,C2,RR,RT,NN,R,C,SOL,
     J                FAI,ALD,A,B,KK)
      DIMENSION R(NN+1),C(NN+1),SOL(NN+1),X(100),ALD(NN+1)
      DIMENSION Z1(89),Z2(11),Z3(500),A(NN+1),B(NN+1),FAI(NN+1)
      CHARACTER STAR(100)*1
      PARAMETER (PAI=3.141593)

      CALL CLCD(ALPHAO,CL,CD)
      M=NN+1
      STEP=(RT-RR)/REAL(NN)
      DO 1 I=1,100
      STAR(I)=' '
1     CONTINUE
      DO 10 I=1,M
      R(I)=STEP*REAL(I)+RR-STEP
      C(I)=C1-C2*R(I)
      SOL(I)=NB*C(I)/(2.0*PAI*R(I))
      X(I)=XX*R(I)/RT
10    CONTINUE

      DO 60 I=1,M
      A1=SOL(I)*X(I)*CL-SOL(I)*CD
      A2=SOL(I)*X(I)*CD+SOL(I)*CL
      DO 20 L1=1,89
      PP=REAL(L1)
      PR=PAI*PP/180.0
      Z1(L1)=(A1-4.0*COS(PR))*TAN(PR)+4.0*X(I)*COS(PR)+A2
      IF(Z1(L1).LT.0.0) GO TO 100
20    CONTINUE
      GO TO 200
100   DO 30 L2=1,11
      PP=REAL(L1)+REAL(L2)/10.0-1.1
      PR=PAI*PP/180.0
      Z2(L2)=(A1-4.0*COS(PR))*TAN(PR)+4.0*X(I)*COS(PR)+A2
      IF(Z2(L2).LT.0.0) GO TO 300
30    CONTINUE
```

```
200     PR=PAI*40.0/180.0
        Z3(1)=(A1-4.0*COS(PR))*TAN(PR)+4.0*X(I)*COS(PR)+A2
        DO 40 L3=2,500
        PP=REAL(L3)/10.0+39.9
        PR=PAI*PP/180.0
        Z3(L3)=(A1-4.0*COS(PR))*TAN(PR)+4.0*X(I)*COS(PR)+A2
        IF((Z3(L3)-Z3(L3-1)).GE.0.0) GO TO 50
40      CONTINUE
50      FAI(I)=REAL(L3)/10.0+39.8
        STAR(I)='*'
        GO TO 500

300     PP=REAL(L1)+REAL(L2)/10.0-1.15
        PR=PAI*PP/180.0
        Z4=(A1-4.0*COS(PR))*TAN(PR)+4.0*X(I)*COS(PR)+A2
        IF(Z4.GE.0.0) THEN
        FAI(I)=REAL(L1)+REAL(L2)/10.0-1.1
        ELSE
        FAI(I)=REAL(L1)+REAL(L2)/10.0-1.2
        END IF
        ALD(I)=FAI(I)+ALPHA0

500     PR=PAI*FAI(I)/180.0
        E=4.0*COS(PR)+SOL(I)*(CL*TAN(PR)+CD)
        A(I)=SOL(I)*(CL*TAN(PR)+CD)/E
        B(I)=SOL(I)*(CL-CD*TAN(PR))/(X(I)*E)
        CALL DISPLY(KK,RR,R(I),FAI(I),A(I),B(I),STAR(I))
60      CONTINUE
        RETURN
        END


        SUBROUTINE DISPLY(KK,RR,R,FAI,A,B,S)
        CHARACTER S*1
        GO TO (10,20) KK
10      IF((ABS(R-RR)).LT.0.001) WRITE(5,*) ' '
        WRITE(5,*) R,FAI,A,B,S
20      RETURN
        END
```

```
*********************************************************************
*                                                                   *
*            ***** FIND CL,CD at ATTACK ANGLE *****                 *
*                                                                   *
*      SUBROUTINE CLCD(A,CL,CD)                                     *
*                                                                   *
*        --INPUT--                                                  *
*         A   : Effective attack angle                              *
*                                                                   *
*        --OUTPUT--                                                 *
*         CL : Lift coefficient                                     *
*         CD : Drag coefficient                                     *
*                                                                   *
*********************************************************************

      SUBROUTINE CLCD(A,CL,CD)
      DIMENSION CL0(22),CD0(22)
      DATA CL0/-.2269,-.1647,-.115,-.0528,.0653,.2393,.3947,
     J  .5253,.631,.7055,.805,.8485,.8672,.805,.7397,.6869,.6496,
     J  .6434,4*.631/
      DATA CD0/.0622,.0528,.0404,.0342,.028,.028,.028,.0249,
     J  .0249,.0289,.0398,.0522,.0746,.0964,.1181,.1337,.1492,
     J  .1616,.1741,.1865,.2145,.2424/
      IF (A.LT.-12.0) THEN
      C0=-12.0-A
      C1=(CL0(2)-CL0(1))/2.0
      C2=(CD0(2)-CD0(1))/2.0
      CL=CL0(1)-C1*C0
      CD=CD0(1)-C2*C0
      RETURN
      ELSE IF (A.GE.30.0) THEN
      C0=A-30.0
      C1=(CL0(22)-CL0(21))/2.0
      C2=(CD0(22)-CD0(21))/2.0
      CL=CL0(22)+C1*C0
      CD=CD0(22)+C2*C0
      RETURN
      END IF
      A1=(A+14.0003)/2.
      I1=INT(A1)
      A2=A/2.
      I2=INT(A2+0.00003)
      IF(A.GE.0.0) THEN
      B1=ABS(A2-REAL(I2))
      ELSE
      B1=1.0-ABS(A2-REAL(I2))
      END IF
      CL=B1*(CL0(I1+1)-CL0(I1))+CL0(I1)
      CD=B1*(CD0(I1+1)-CD0(I1))+CD0(I1)
      RETURN
      END
```

```
*************************************************************************
*                                                                       *
*          ***** PROGRAM FOR ATTACK ANGLE , a , b *****                *
*                                                                       *
*      SUBROUTINE ALPAB(XX,ND,R,SOL,ALD,PA,ALPHA,A,B)                   *
*                                                                       *
*        --INPUT--                                                      *
*         XX     : Tip speed ratio                                      *
*         ND     : Number of division (radious)                         *
*         R      : Radius                                               *
*         SOL    : Solidity                                             *
*         ALD    : Designed angle of blade                              *
*         PA     : Pitch angle                                          *
*                                                                       *
*        --OUTPUT--                                                     *
*         ALPHA  : Effective attack angle                               *
*         A      : Axial interference factor                            *
*         B      : Tangential interference factor                       *
*                                                                       *
*************************************************************************

      SUBROUTINE ALPAB(XX,ND,R,SOL,ALD,PA,ALPHA,A,B)
      DIMENSION R(ND+1),SOL(ND+1),ALD(ND+1),ALPHA(ND+1)
      DIMENSION A(ND+1),B(ND+1)
      PARAMETER (PAI=3.141593)
      DO 30 I=1,ND+1
      S=SOL(I)
      X=XX*R(I)/R(ND+1)
      AD=ALD(I)+PA
      DO 10 J1=1,101
      AA=81.0-REAL(J1)
      BB=(AD-AA)*PAI/180.0
      CALL CLCD(AA,CL,CD)
      Z1=(S*X*CL-S*CD-4.0*COS(BB))*TAN(BB)
      Z=Z1+4.0*X*COS(BB)+S*X*CD+S*CL
      IF(Z.LE.0.0) GO TO 100
10    CONTINUE
100   DO 20 J2=1,11
      AA=82.1-REAL(J1)-REAL(J2)/10.0
      BB=(AD-AA)*PAI/180.0
      CALL CLCD(AA,CL,CD)
      Z1=(S*X*CL-S*CD-4.0*COS(BB))*TAN(BB)
      Z=Z1+4.0*X*COS(BB)+S*X*CD+S*CL
      IF(Z.LE.0.0) GO TO 200
20    CONTINUE
200   AA=82.15-REAL(J1)-REAL(J2)/10.0
      BB=(AD-AA)*PAI/180.0
      CALL CLCD(AA,CL,CD)
      Z1=(S*X*CL-S*CD-4.0*COS(BB))*TAN(BB)
      Z=Z1+4.0*X*COS(BB)+S*X*CD+S*CL
      IF(Z.GE.0.0) THEN
      ALPHA(I)=82.1-REAL(J1)-REAL(J2)/10.0
      ELSE
      ALPHA(I)=82.2-REAL(J1)-REAL(J2)/10.0
      END IF
      CALL CLCD(ALPHA(I),CL,CD)
      F=ALD(I)+PA-ALPHA(I)
      FR=PAI*F/180.0
      E=4.0*COS(FR)+S*(CL*TAN(FR)+CD)
      A(I)=S*(CL*TAN(FR)+CD)/E
      B(I)=S*(CL-CD*TAN(FR))/(X*E)
30    CONTINUE
      RETURN
      END
```

```
**********************************************************************
*                                                                    *
*           ***** PROGRAM FOR POWER COEFFICIENT *****                *
*                                                                    *
*       SUBROUTINE IITA(XX,ND,R,A,B,CP,CQ)                           *
*                                                                    *
*       --INPUT--                                                    *
*          XX   : Tip speed ratio                                    *
*          ND   : Number of division (radius)                        *
*          R    : Radius                                             *
*          A    : Axial interference facter                          *
*          B    : Tangential interference facter                     *
*                                                                    *
*       --OUTPUT--                                                   *
*          CP   : Power coefficient                                  *
*          CQ   : Torque coefficient                                 *
*                                                                    *
**********************************************************************

      SUBROUTINE IITA(XX,ND,R,A,B,CP,CQ)
      DIMENSION R(ND+1),A(ND+1),B(ND+1),F(100)
      RT=R(ND+1)
      RR=R(1)
      STEP=(RT-RR)/REAL(ND)
      DO 10 I=1,ND+1
      F(I)=(1.0-A(I))*B(I)*(R(I)**3)
10    CONTINUE
      CALL SIMP(ND,STEP,F,F1,ICODE)
      CP=8.0*F1*XX**2/RT**4
      CQ=CP/XX
      RETURN
      END


      SUBROUTINE SIMP(N,STEP,A,RESULT,CODE)
      DIMENSION A(N+1),A2(100),A4(100)
      M2=N/2-1
      M4=M2+1
      IX=N/2
      X=REAL(IX)
      Y=REAL(N)/2.0
      IF((Y-X).GT.0.01) GO TO 30
      DO 10 I=1,M2
      I2=2*I+1
      A2(I)=A(I2)
10    CONTINUE
      DO 20 I=1,M4
      I4=2*I
      A4(I)=A(I4)
20    CONTINUE
      CALL SUM(M2,A2,S2)
      CALL SUM(M4,A4,S4)
      S=A(1)+A(N)+2.0*S2+4.0*S4
      RESULT=STEP*S/3.0
      CODE=1
      RETURN
30    CALL BELL(2)
      WRITE(5,*) ' '
      WRITE(5,*) ' NUMBER OF DIVISION MUST BE AN EVEN NUMBER'
      CODE=2
      RETURN
      END
```

```
      SUBROUTINE SUM(N,A,S)
      DIMENSION A(N)
      S=0.0
      DO 10 I=1,N
      S=S+A(I)
10    CONTINUE
      RETURN
      END

      SUBROUTINE BELL(N)
      LOGICAL*1 A
      DATA A/π007/
      DO 10 I=1,N
      WRITE(5,100) A
100   FORMAT('+',A1)
10    CONTINUE
      RETURN
      END
```

```
*********************************************************************
*                                                                   *
*          ***** MANEGEMENT OF PRINTER *****                        *
*                                                                   *
*      SUBROUTINE PSPACE(N)                                         *
*                                                                   *
*         N : Number of space line                                  *
*                                                                   *
*      SUBROUTINE SPACE(NO,NOL)                                     *
*                                                                   *
*         NO  : Uuit number                                         *
*         NOL : Number of space                                     *
*                                                                   *
*      SUBROUTINE PRON                                              *
*                                                                   *
*         PRINTER ON                                                *
*                                                                   *
*      SUBROUTINE PROFF                                             *
*                                                                   *
*         PRINTER OFF                                               *
*                                                                   *
*********************************************************************

      SUBROUTINE PSPACE(N)
      CALL PRON
      CALL SPACE(5,N)
      CALL PROFF
      RETURN
      END


      SUBROUTINE SPACE(NO,NOL)
      DO 10 I=1,NOL
      WRITE(NO,*)
10    CONTINUE
      RETURN
      END


      SUBROUTINE PRON
      LOGICAL*1 A
      DATA A/π033/
      WRITE(5,100) A,A
  100 FORMAT('+',A1,'[5i',A1,'Ω',∫)
      RETURN
      END


      SUBROUTINE PROFF
      LOGICAL*1 A
      DATA A/π033/
      WRITE(5,100) A,A
  100 FORMAT('+',A1,'[4i',A1,'Ω',∫)
      RETURN
      END
```

```
***********************************************************************
*                                                                     *
*              ***** GRAPH DRAWING *****                              *
*                                                                     *
*     SUBROUTINE GRAPH1(XNM,NDX1,NDX2,X0,X1,YNM,NDY1,NDY2,Y0,Y1)      *
*                                                                     *
*       XNM ,YNM   :  Axis label                                      *
*       NDX1,NDY1  :  Number of rough division                        *
*       NDX2,NDY2  :  Number of fine division                         *
*       X0   ,Y0   :  Minimum value of axis                           *
*       X1   ,Y1   :  Maximum value of axis                           *
*                                                                     *
*     SUBROUTINE GRAPH2(N,XAR,YAR,NP,NL,NC)                           *
*                                                                     *
*       N    :  Number of points                                      *
*       XAR  :  X-array                                               *
*       YAR  :  Y-array                                               *
*       NP   :  Marker                                                *
*       NL   :  Line type                                             *
*       NC   :  Choice for hardcopy   1---Copy  2---No copy           *
*                                                                     *
***********************************************************************

      SUBROUTINE GRAPH1(XNM,NDX1,NDX2,X0,X1,YNM,NDY1,NDY2,Y0,Y1)
      LOGICAL*1 XNM(15),YNM(15)
      CALL INITGR(5)
      CALL CLRTXT
      CALL CLRSCR
      CALL DPAPER('LIN',NDX1,NDX2,'LIN',NDY1,NDY2,'GRAY3')
      CALL LNAXIS('XB',XNM,X0,X1,.TRUE.)
      CALL LNAXIS('YL',YNM,Y0,Y1,.TRUE.)
      RETURN
      END


      SUBROUTINE GRAPH2(N,XAR,YAR,NP,NL,NC)
      DIMENSION XAR(N),YAR(N)
      CALL PDATA(N,XAR,YAR,'L','GRAY3',NP,NL,,,)
      IF(NC.EQ.1) THEN
      CALL CPYSCR
      CALL CLRSCR
      END IF
      RETURN
      END
```

APPENDIX B

The Use of Windmills in Thailand[14]

Locally constructed horizontal axis windmills have been used for lifting water for many years. There are 3 basic types of windmills that are usually used in many areas.

1. Low speed sail rotor windmill

This type of windmill has 6 or 8 triangular sails of bamboo matting or cloth mounted on bamboo poles with 6 to 8 m in diameter. The windmill is fixed in direction of prevailing wind as shown in Fig.B.1.

Fig. B. 1 Low speed sail rotor windmill

This type of windmill is used for pumping sea water at salt farms, for example, in Samut Songkram and Chonburi.

---

(14) Exell R. H. B., Thavapalachandran S. and Mukhia P. (1981) The Availability of Wind Energy in Thailand. AIT Research Report No. 134, p. 22.

2. High speed wooden rotor windmill

This type of windmill has 2 or 4 blades which is made from a wooden plank 8 m long, 0.2 m wide and .05 m thick forming a simple airfoil with some twist. The axis of the windmill rotor is supported on a pole and it can be turned manually to face the wind as shown in Fig.B.2.

Fig. B. 2 High speed wooden rotor windmill

This windmill is utilized mainly for irrigating rice fields, for example, in Chachoengsao and Pathum Thani.

3. Multiblade windmill

From the advantage of starting by itself at a low wind velocity, this type of windmill is becoming popular for pumping water in many areas. The windmill has 3-4 m in diameter and is fixed on a tower about 12-15 m above the ground as shown in Fig.B.3.

Fig. B. 3 Multiblade windmill

APPENDIX C

Experimental Results

Figs. C.1 to C.26 show the experimental results of wind tunnel experiment.

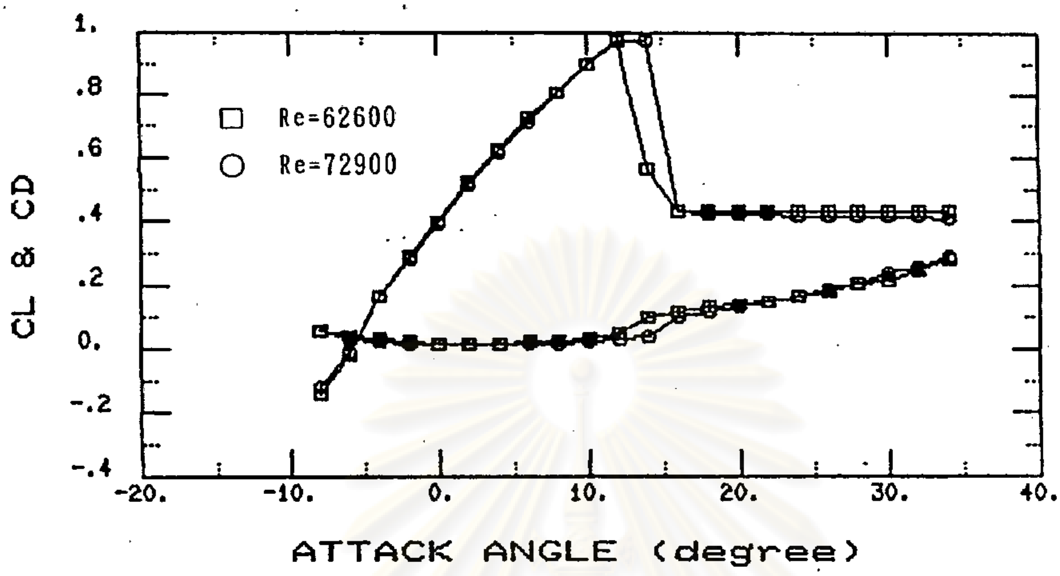

Fig. C.1 Relation of C_L, C_D vs attack angle (NACA 4418)

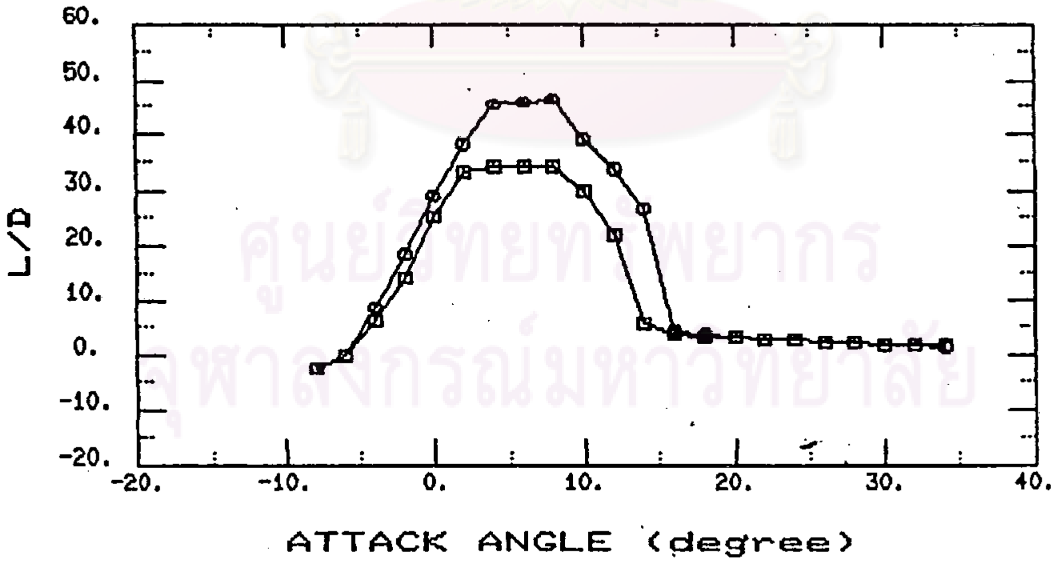

Fig. C.2 Relation of L/D ratio vs attack angle (NACA 4418)

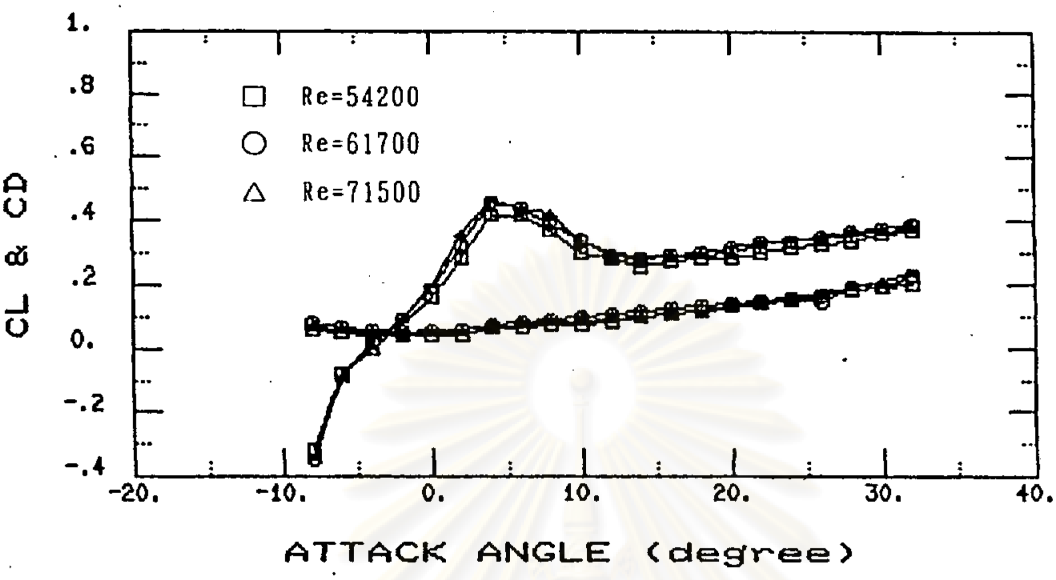

Fig. C.3 Relation of C_L, C_D vs attack angle (Straight plate)

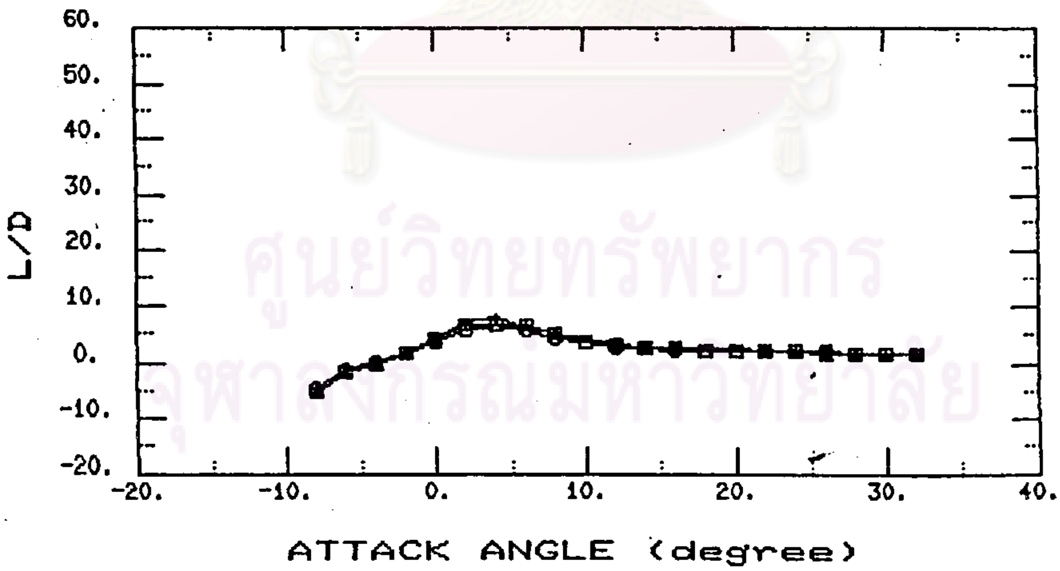

Fig. C.4 Relation of L/D ratio vs attack angle (Straight plate)

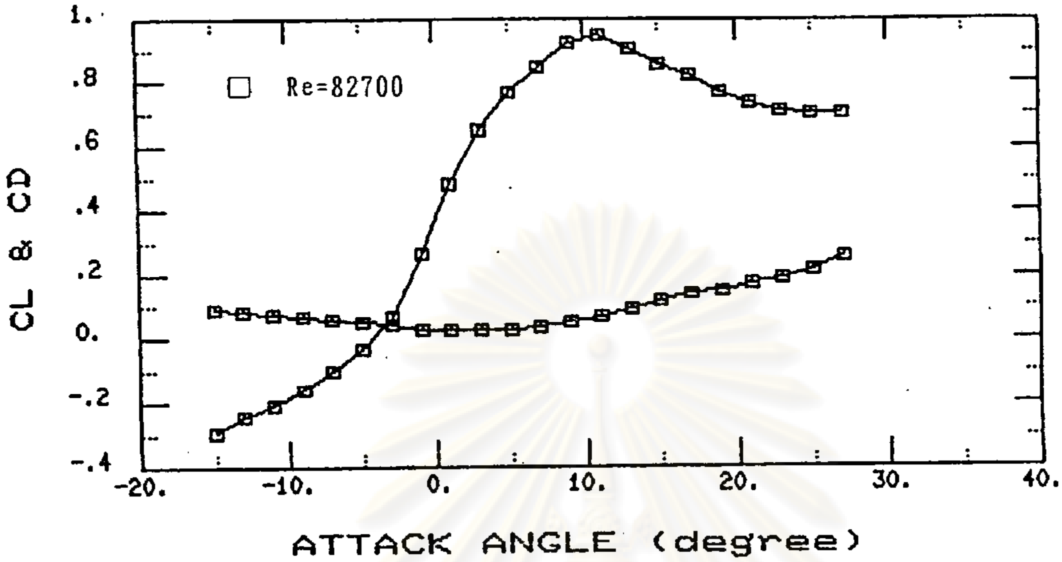

Fig. C.5 Relation of C_L, C_D vs attack angle (Arched plate No. 1)

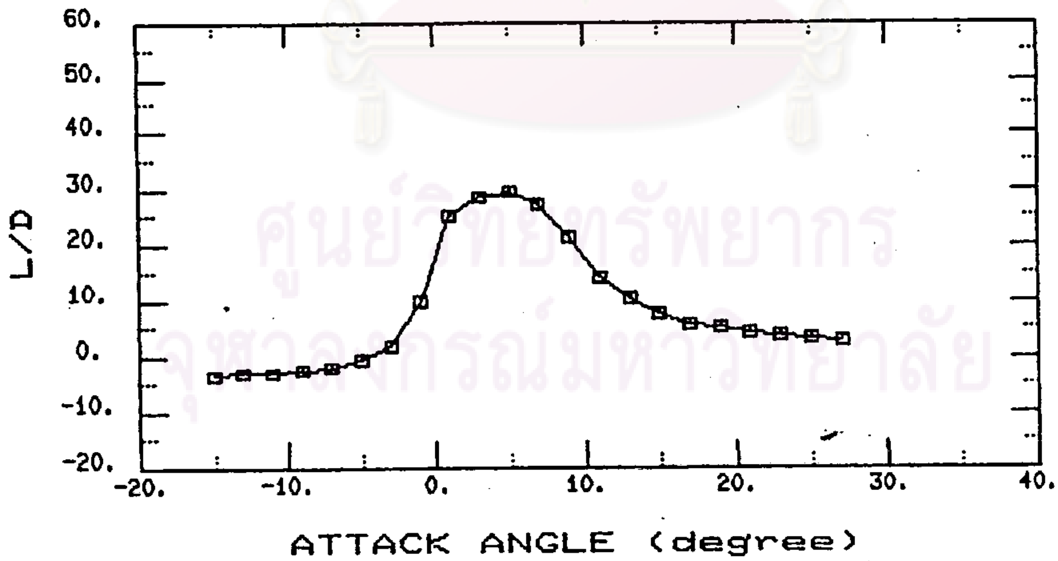

Fig. C.6 Relation of L/D ratio vs attack angle (Arched plate No. 1)

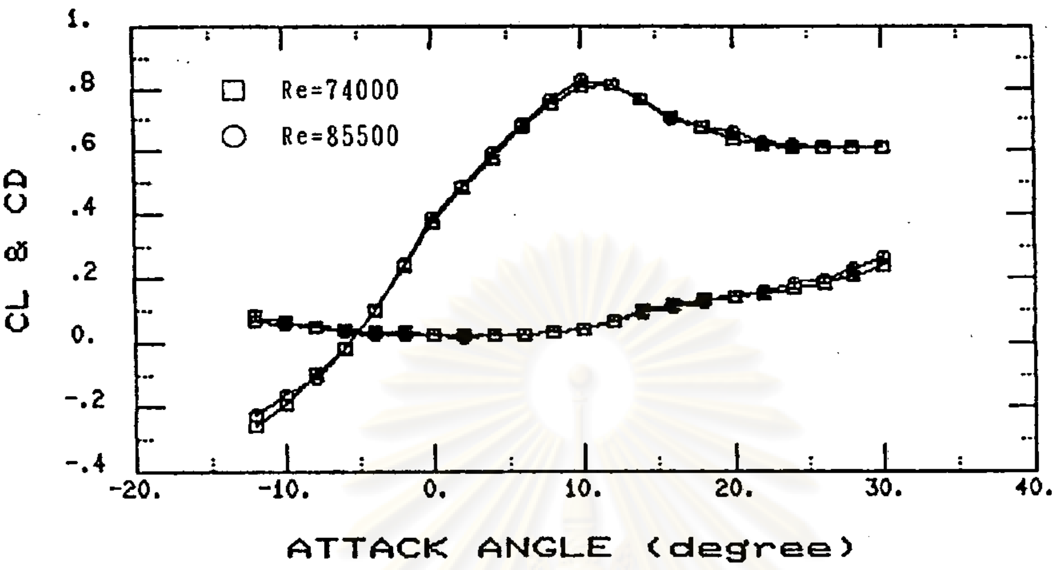

Fig. C.7 Relation of C_L, C_D vs attack angle (Arched plate No. 2)

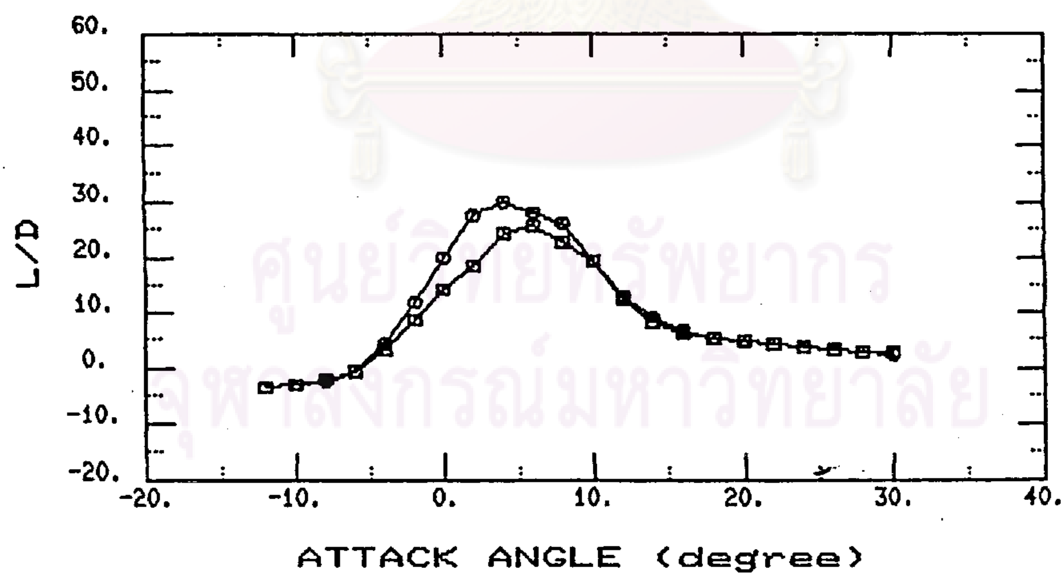

Fig. C.8 Relation of L/D ratio vs attack angle (Arched plate No. 2)

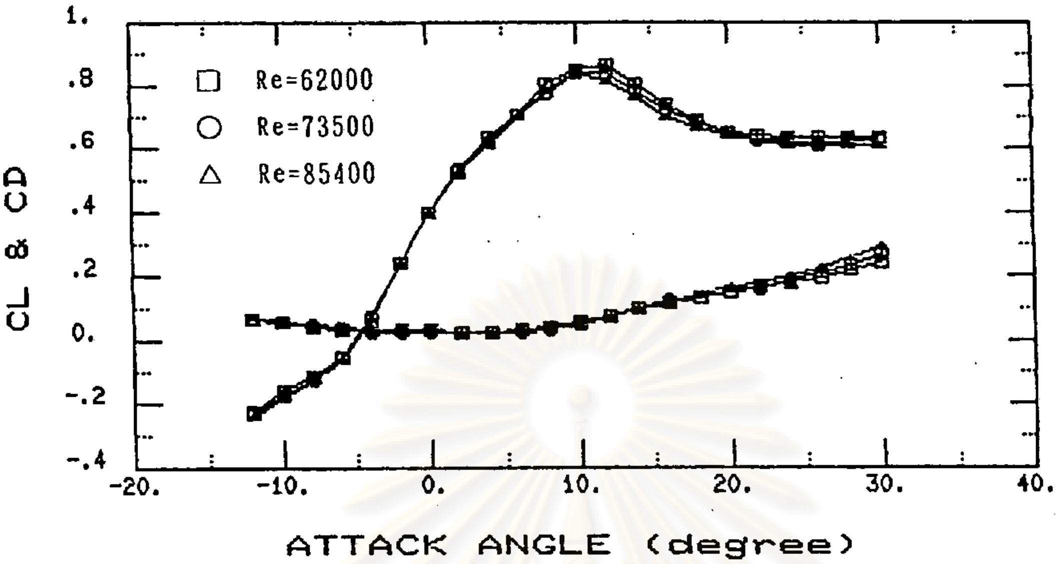

Fig. C.9 Relation of Cl, Cd vs attack angle (Arched steel plate No. 3)

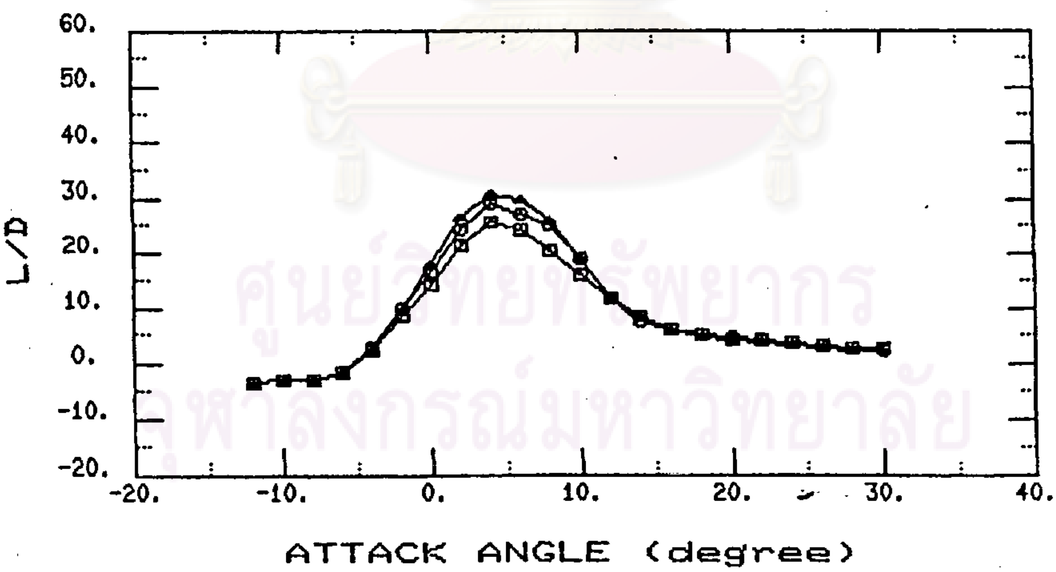

Fig.C.10 Relation of L/D ratio vs attack angle (Arched steel plate No. 3)

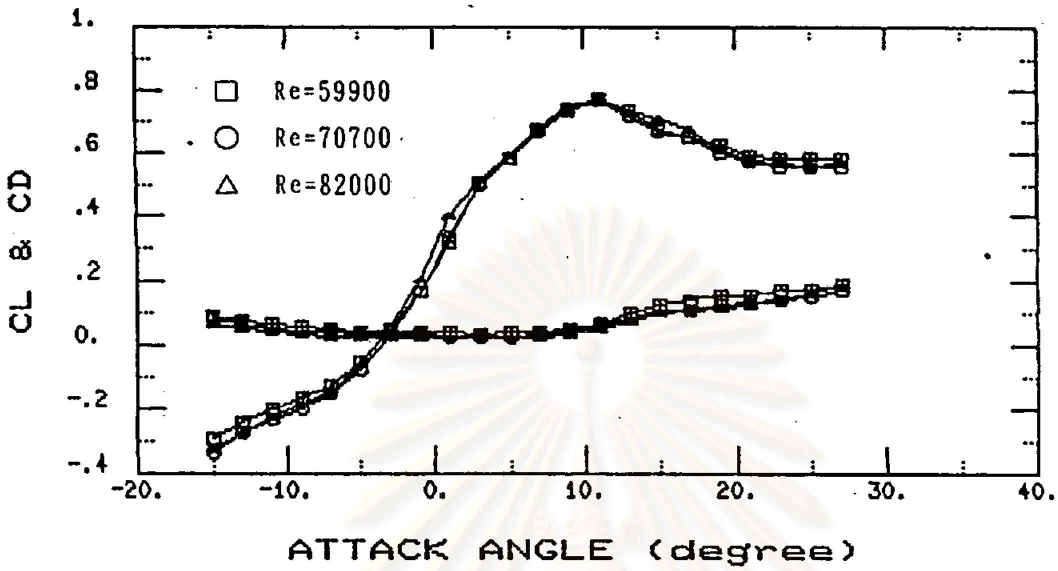

Fig. C.11 Relation of C_L, C_D vs attack angle (Arched plate No. 4)

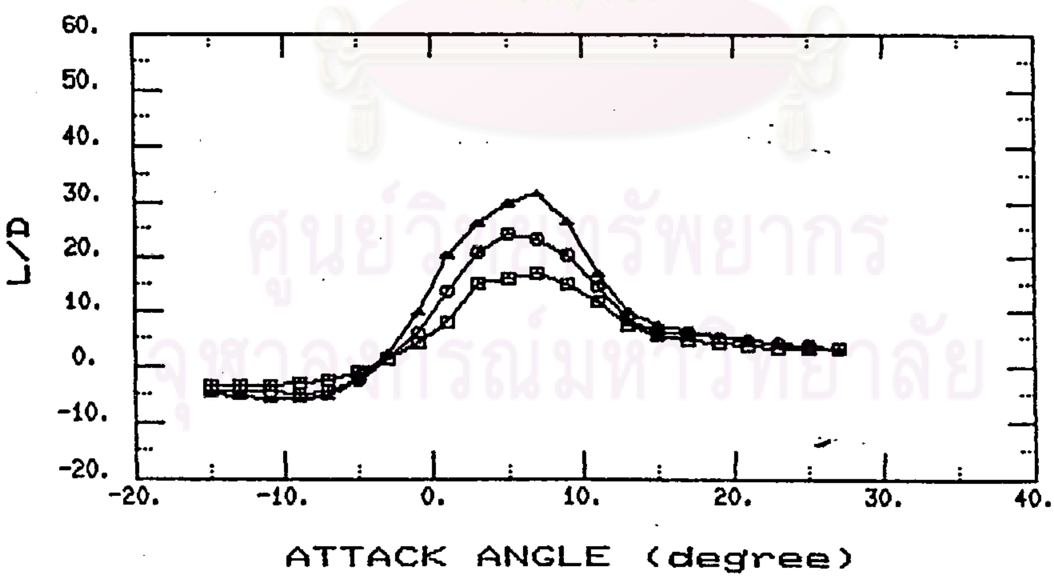

Fig. C.12 Relation of L/D ratio vs attack angle (Arched plate No. 4)

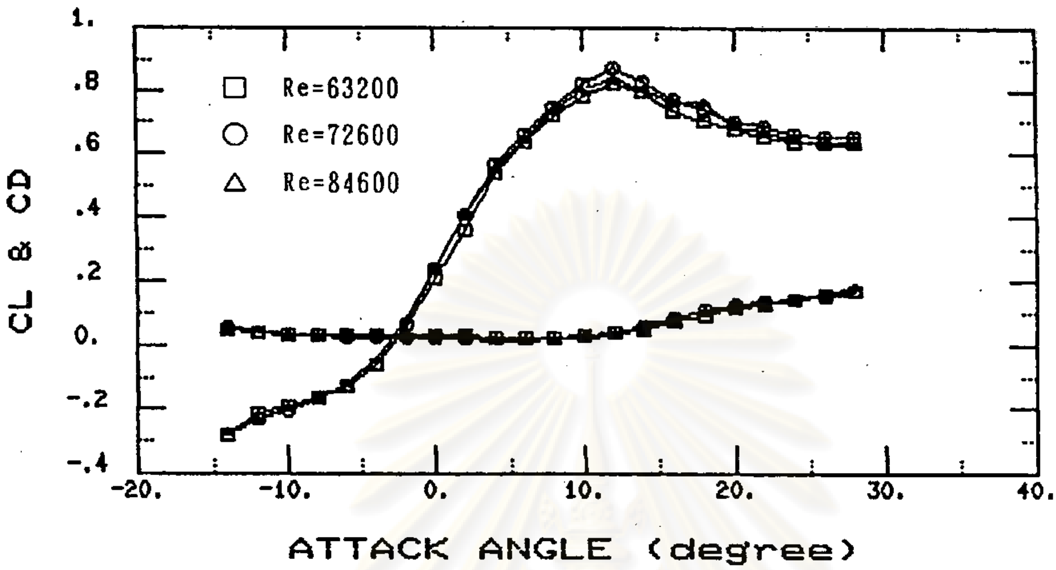

Fig. C.13 Relation of C_L, C_D vs attack angle (Arched plate No. 5)

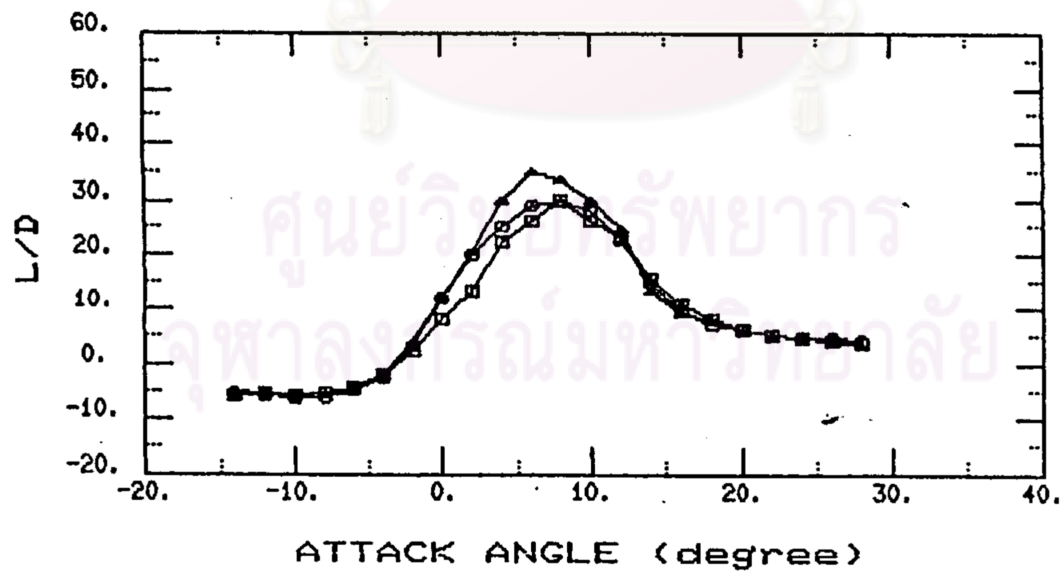

Fig. C.14 Relation of L/D ratio vs attack angle (Arched plate No. 5)

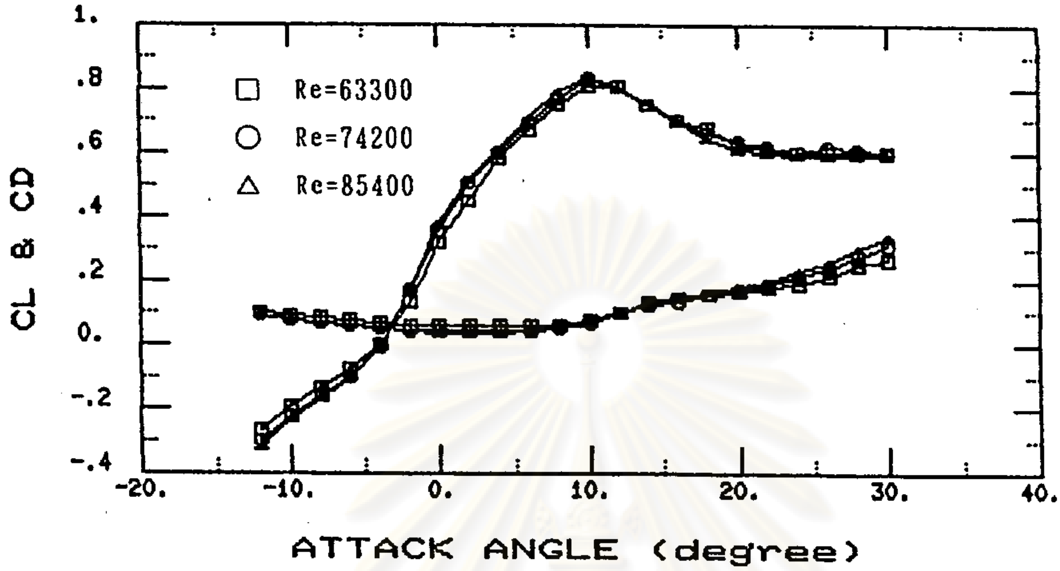

Fig. C.15 Relation of C_L, C_D vs attack angle (Arched steel plate No. 6)

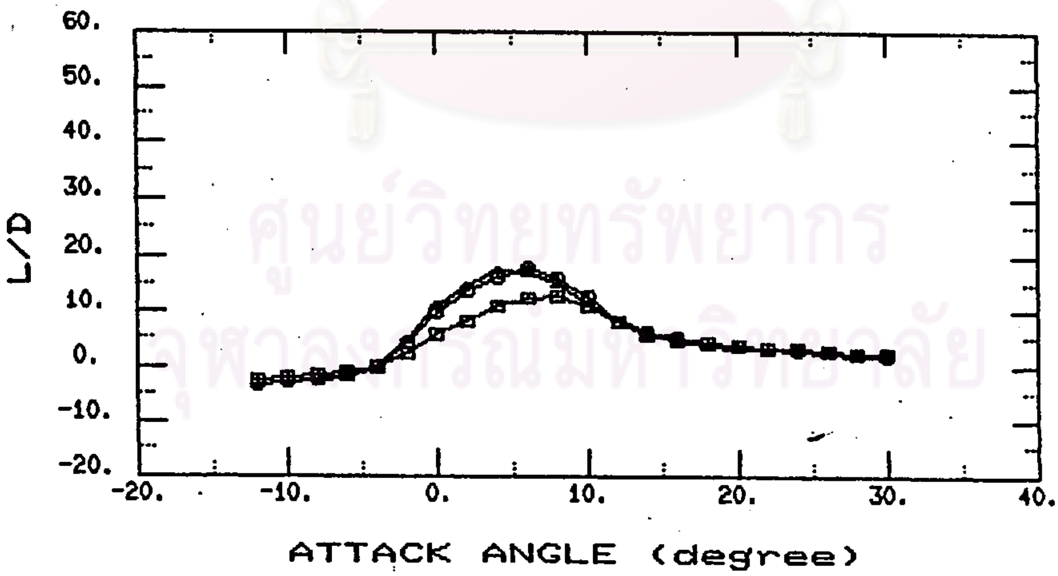

Fig. C.16 Relation of L/D ratio vs attack angle (Arched steel plate No. 6)

Re = 54000 - 64000

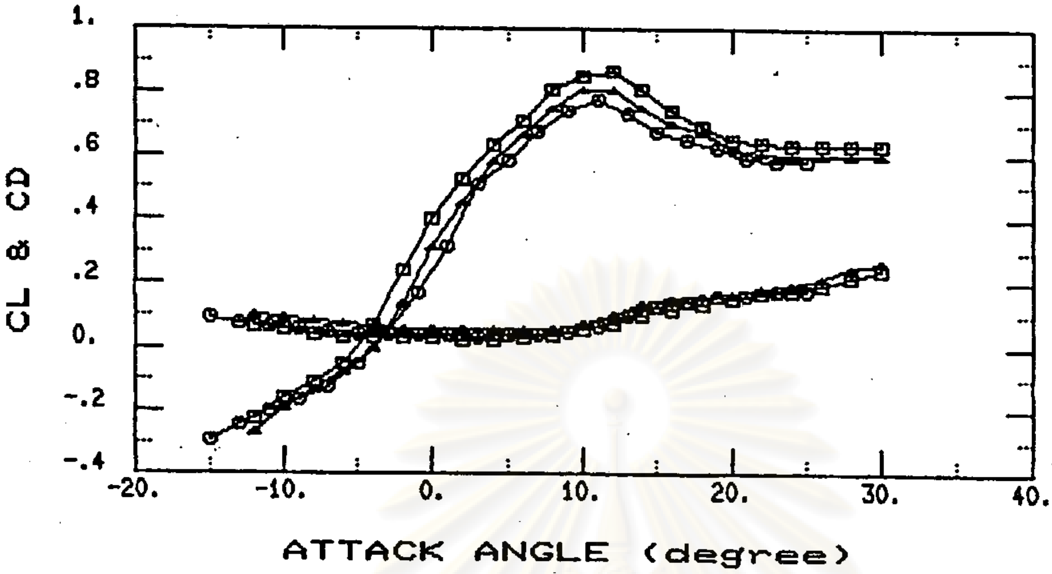

Fig. C.17 Comparison of C_L, C_D for different types of airfoils

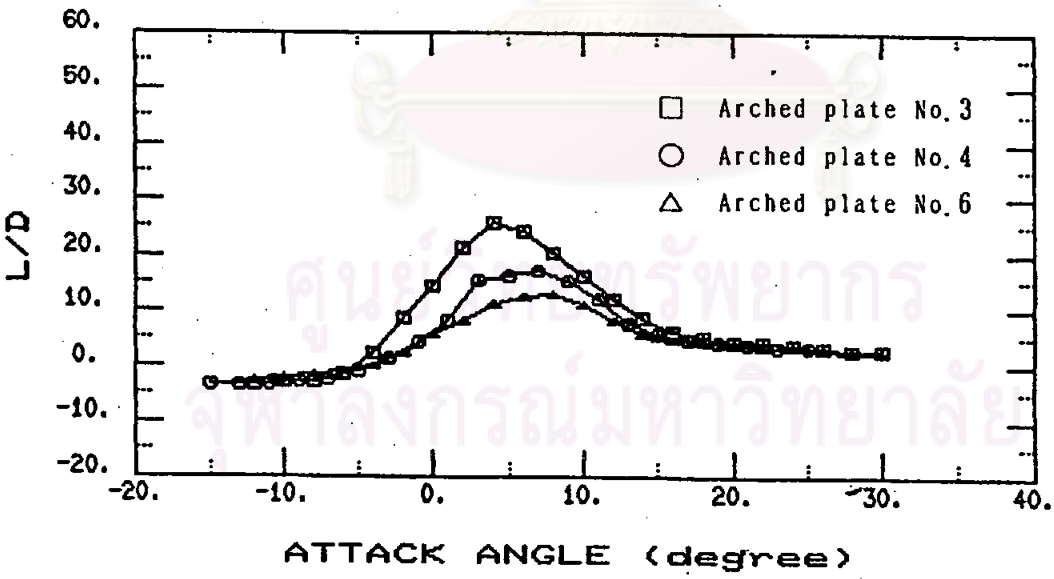

Fig. C.18 Comparison of L/D for different types of airfoils

Re = 61500 - 74500

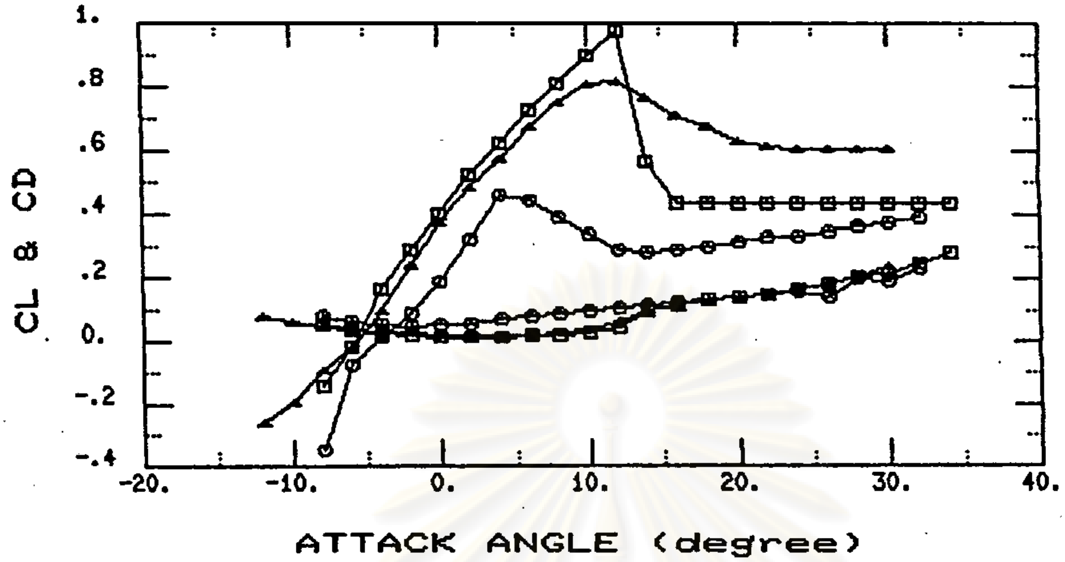

Fig. C.19 Comparison of C_L, C_D for different types of airfoils

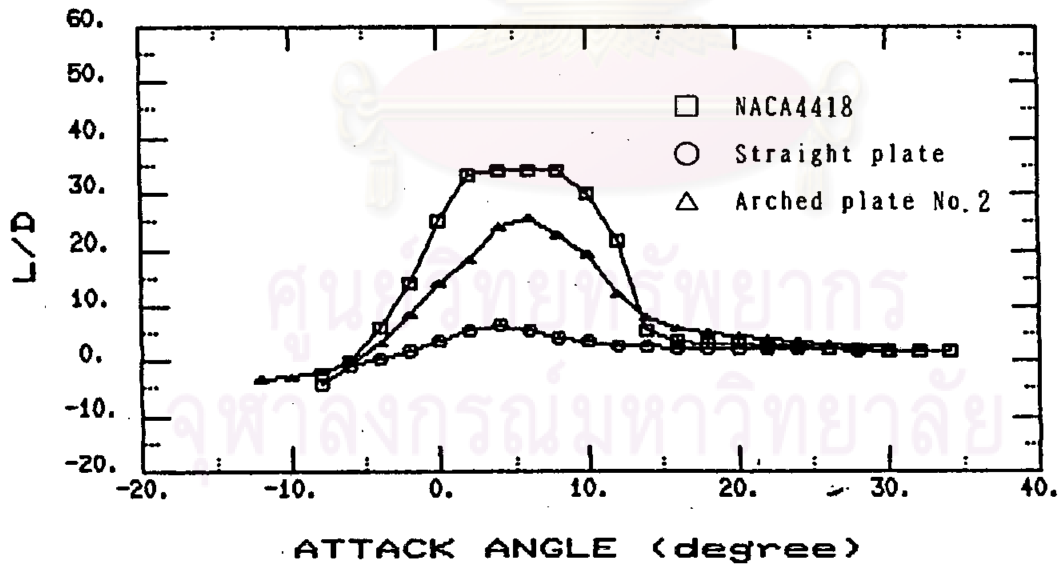

Fig. C.20 Comparison of L/D for different types of airfoils

Re = 61500 - 74500

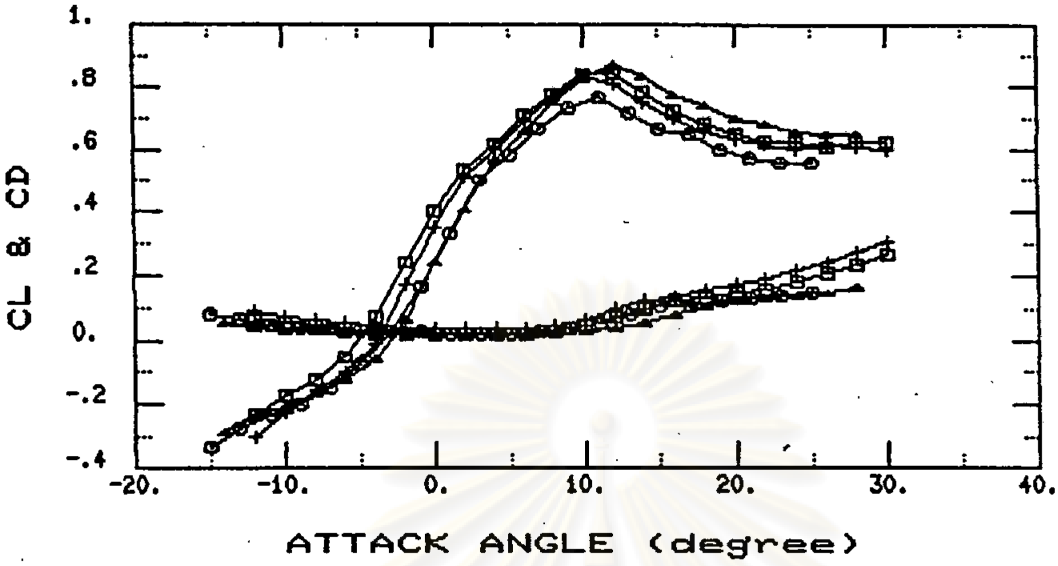

Fig.C.21 Comparison of C_L, C_D for different types of airfoils

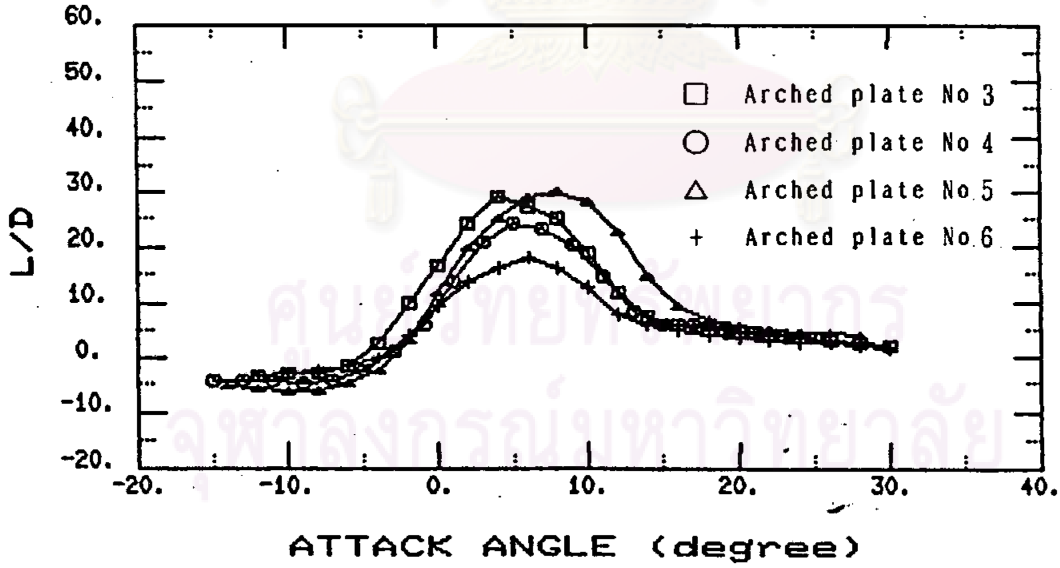

Fig. C.22 Comparison of L/D for different types of airfoils

Re = 71500 - 85500

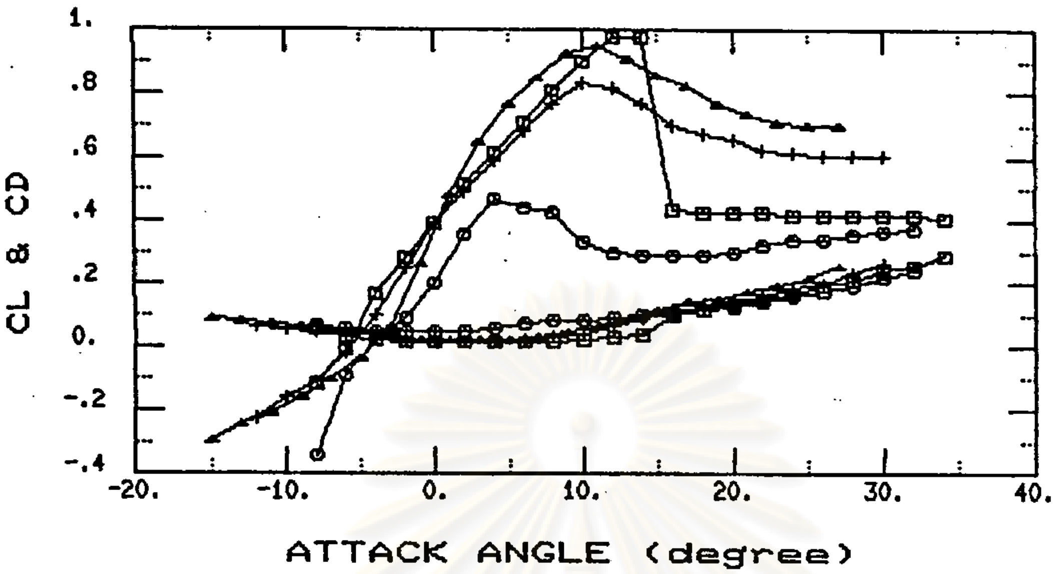

Fig.C.23 Comparison of C_L, C_D for different types of airfoils

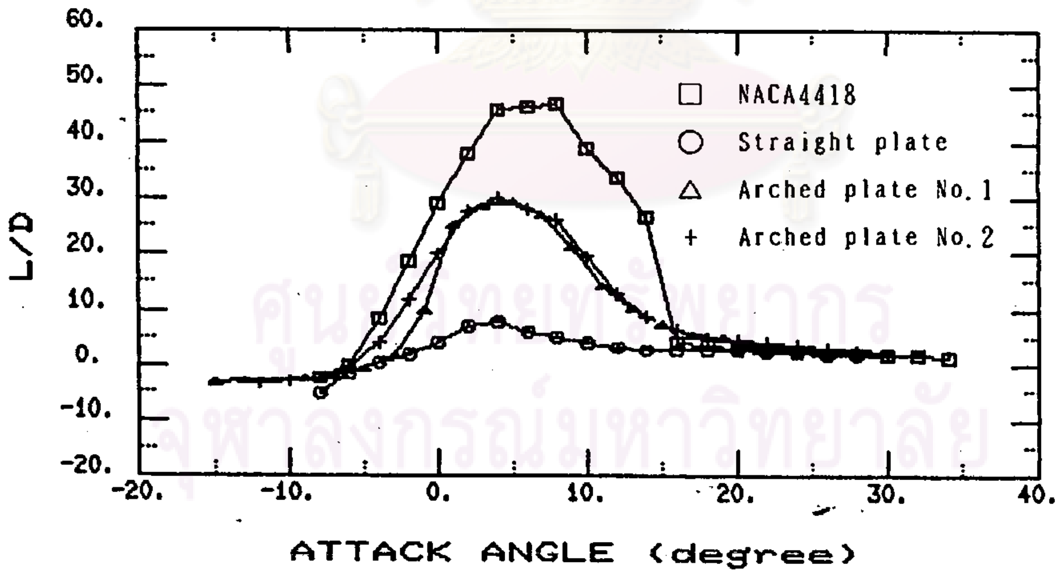

Fig.C.24 Comparison of L/D for different types of airfoils

Re = 71500 - 85500

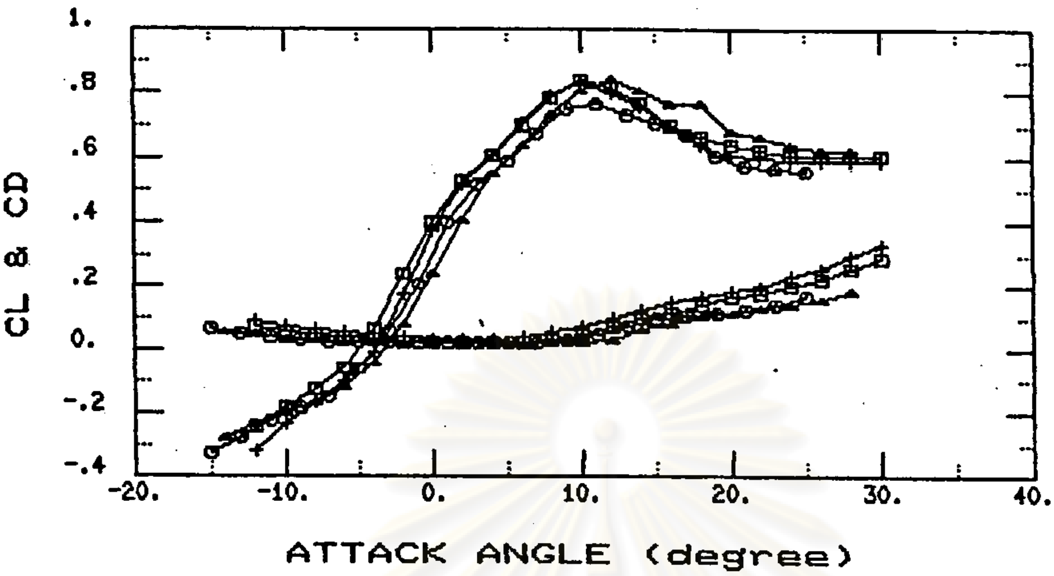

Fig.C.25 Comparison of C_L, C_D for different types of airfoils

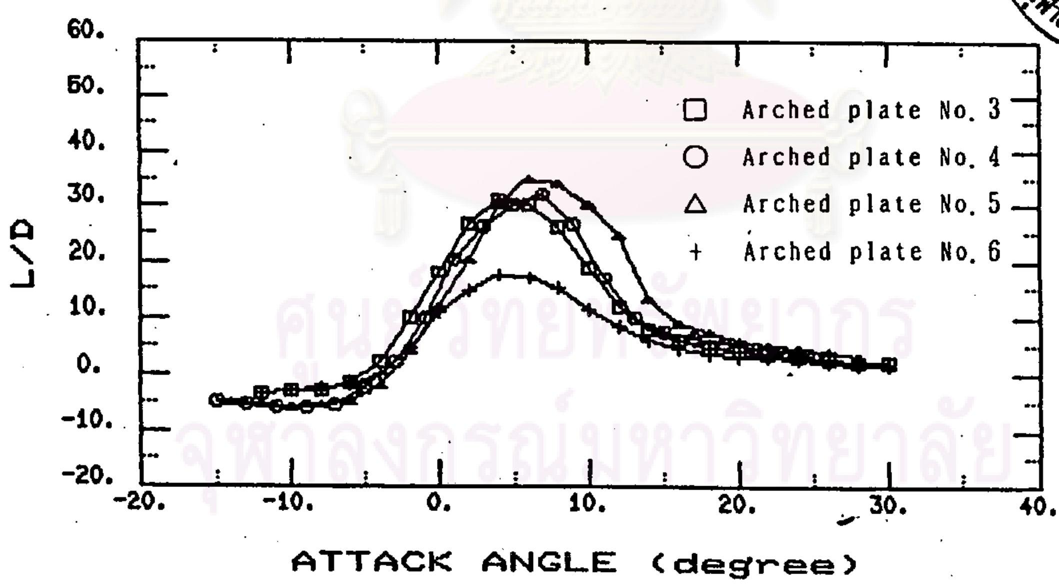

Fig. C.26 Comparison of L/D for different types of airfoils

STRAIGHT PLATE

RE = 46000

Figures C.27 to C.84 showed the flow visualization results of each model.

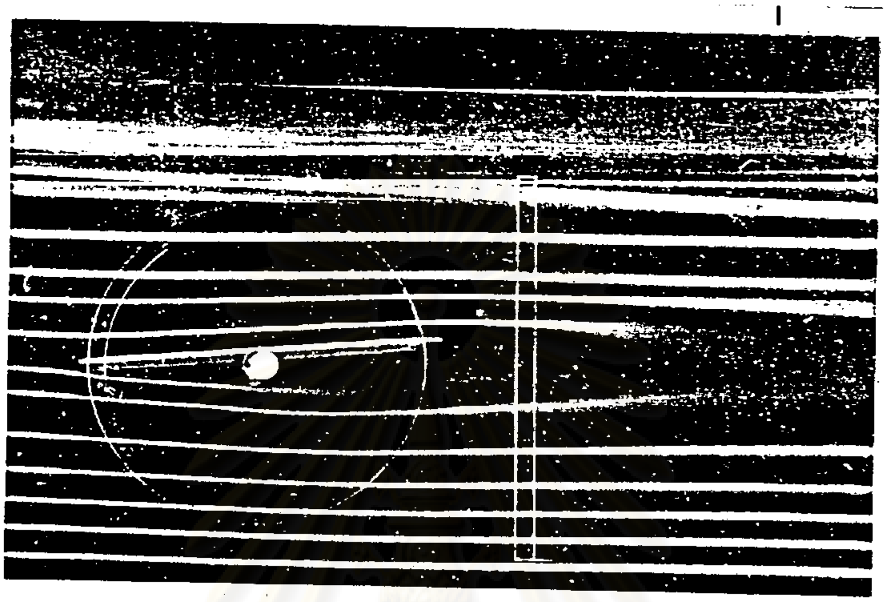

Fig. C.27 Attack angle = - 5 degrees

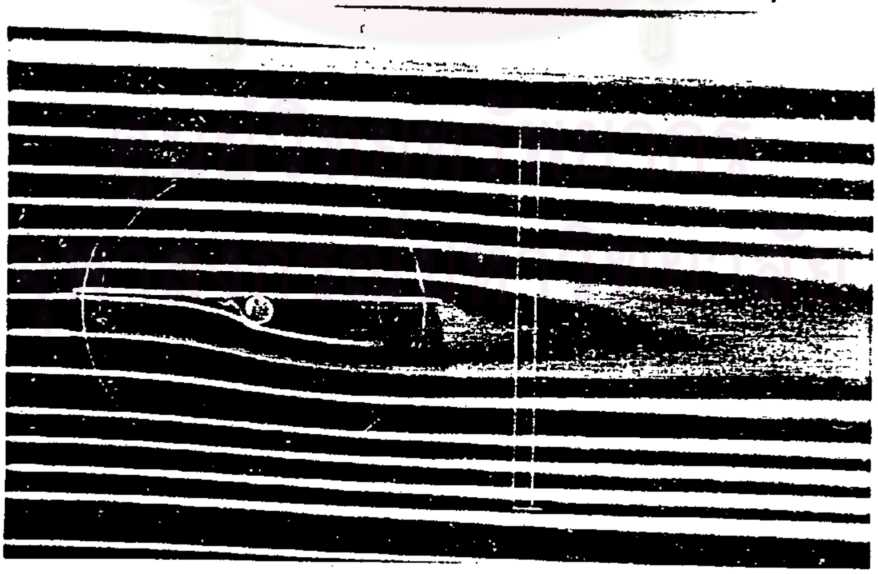

Fig. C.28 Attack angle = 0 degrees

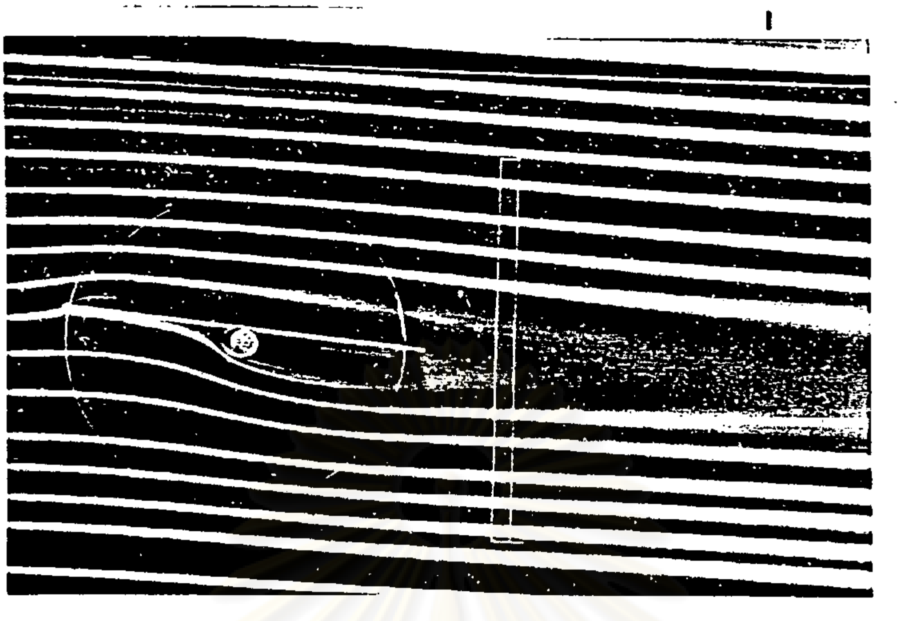

Fig. C.29 Attack angle = 5 degrees

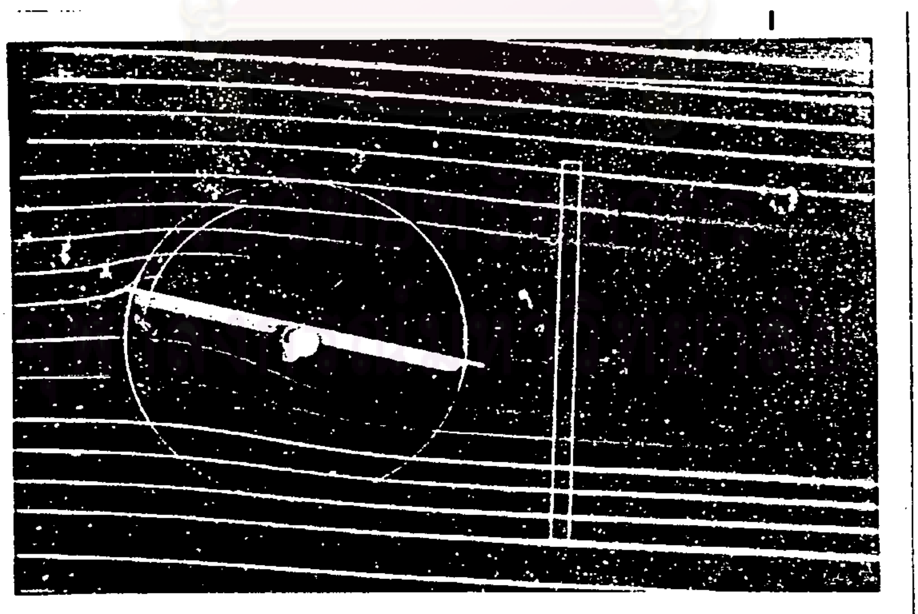

Fig. C.30 Attack angle = 10 degrees

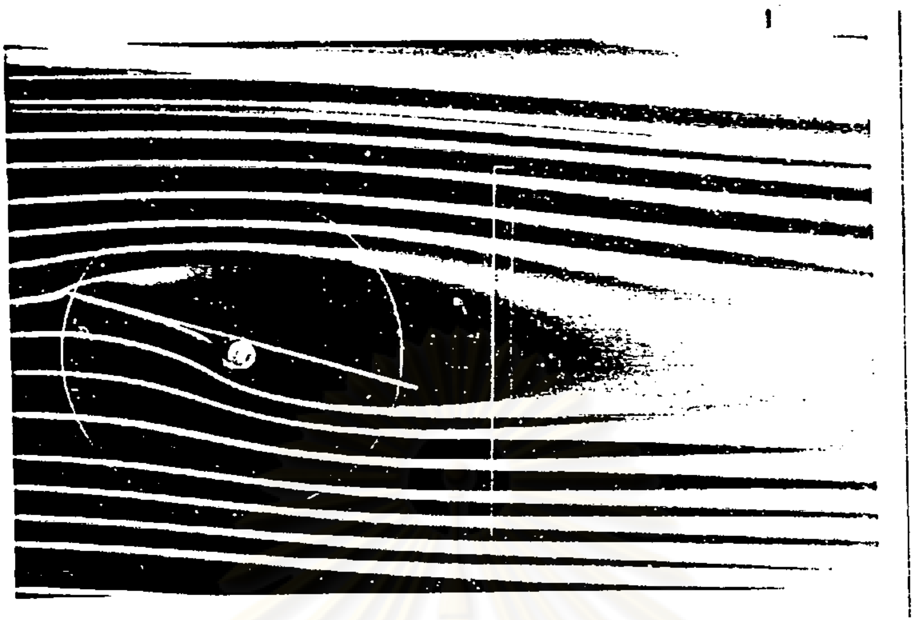

Fig. C.31 Attack angle = 15 degrees

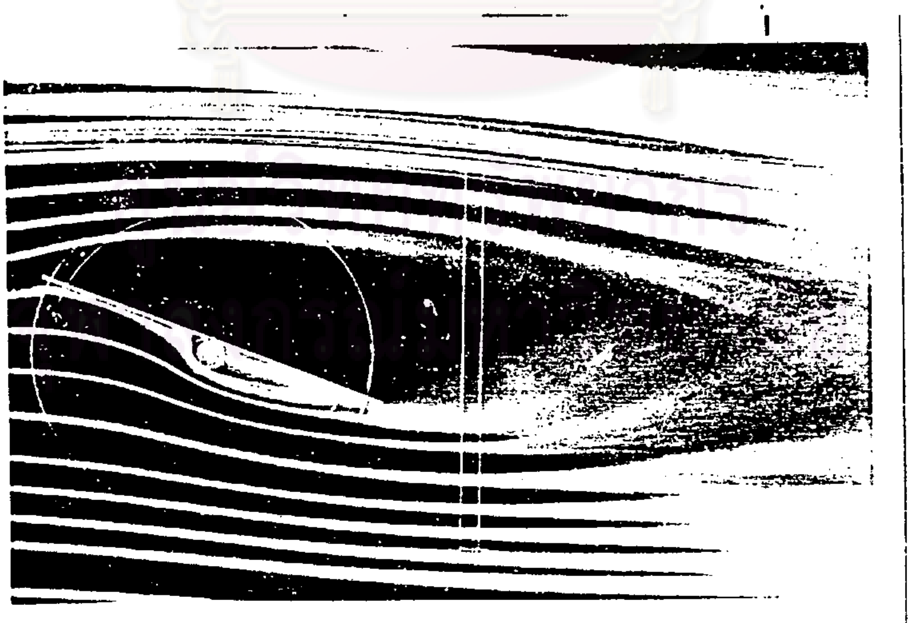

Fig. C.32 Attack angle = 20 degrees

Fig. C.33 Attack angle = 25 degrees

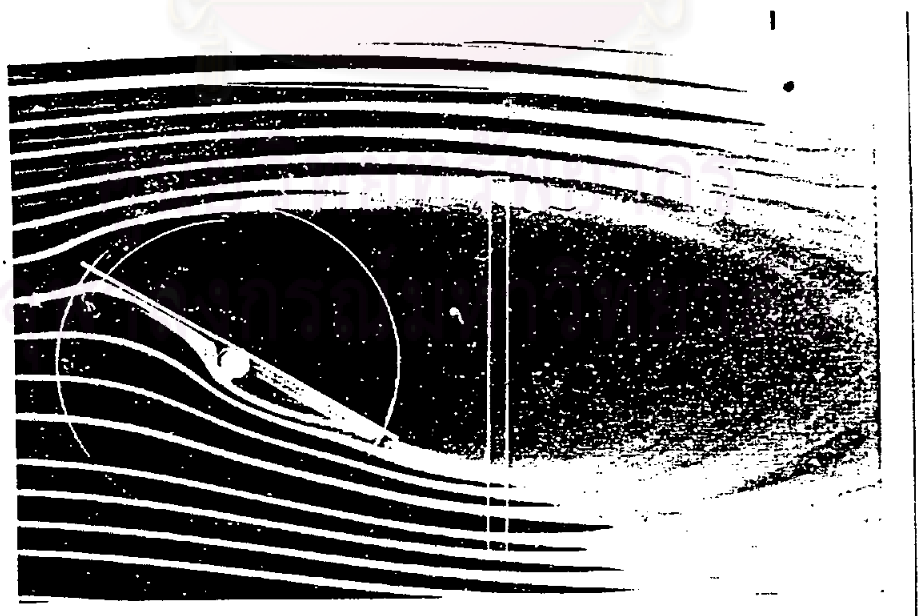

Fig. C.34 Attack angle = 30 degrees

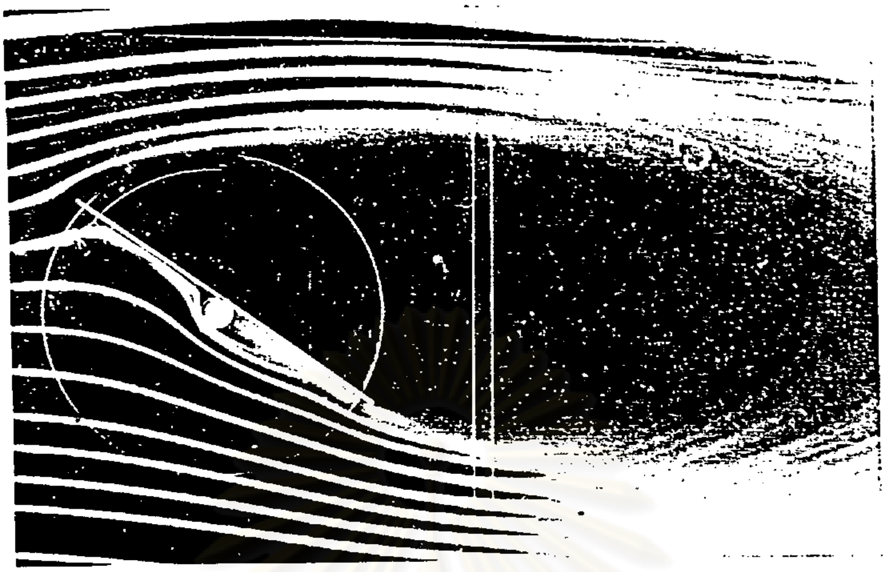

Fig. C.35 Attack angle = 35 degrees

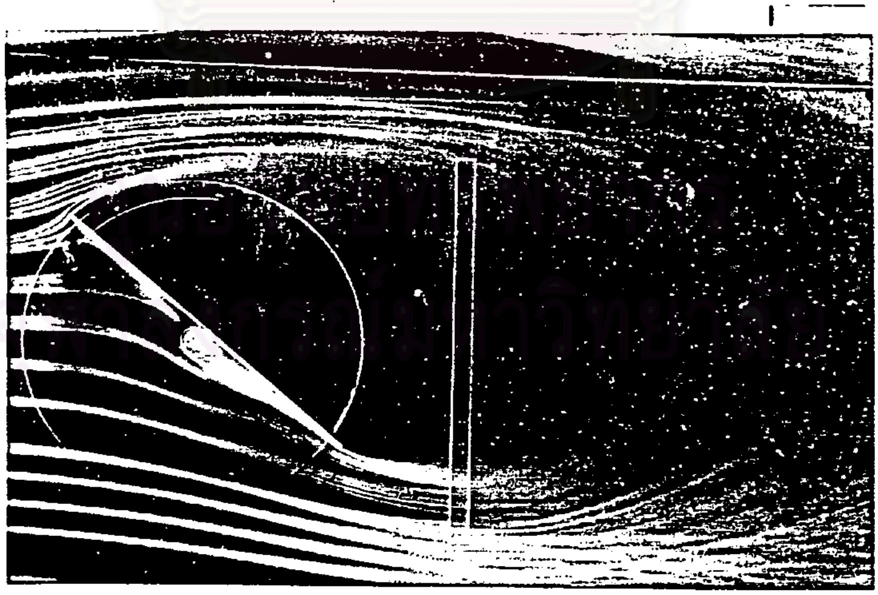

Fig. C.36 Attack angle = 40 degrees

ARCHED PLATE WITH STICK 6mm (NO SPACE)

RE = 64000

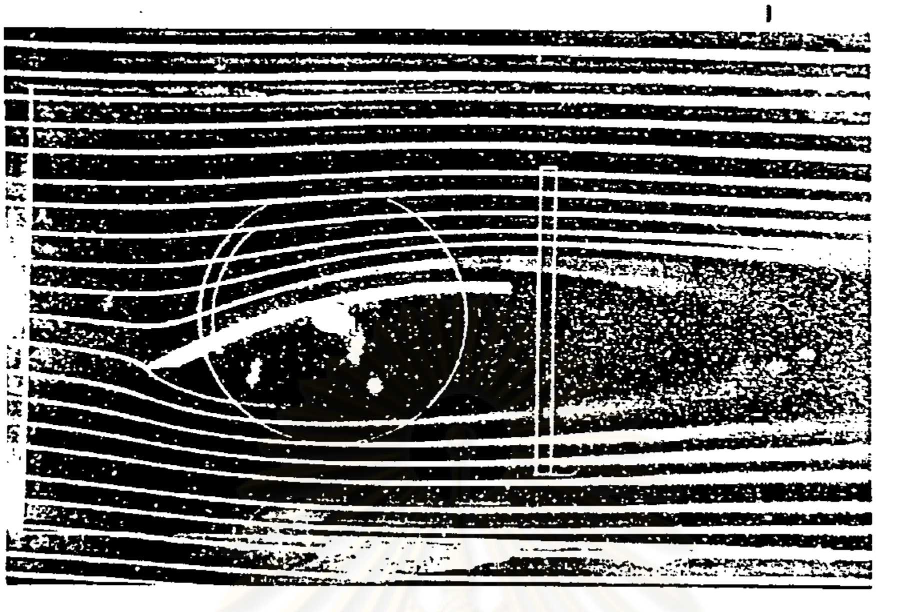

Fig.C.37 Attack angle = -15 degrees

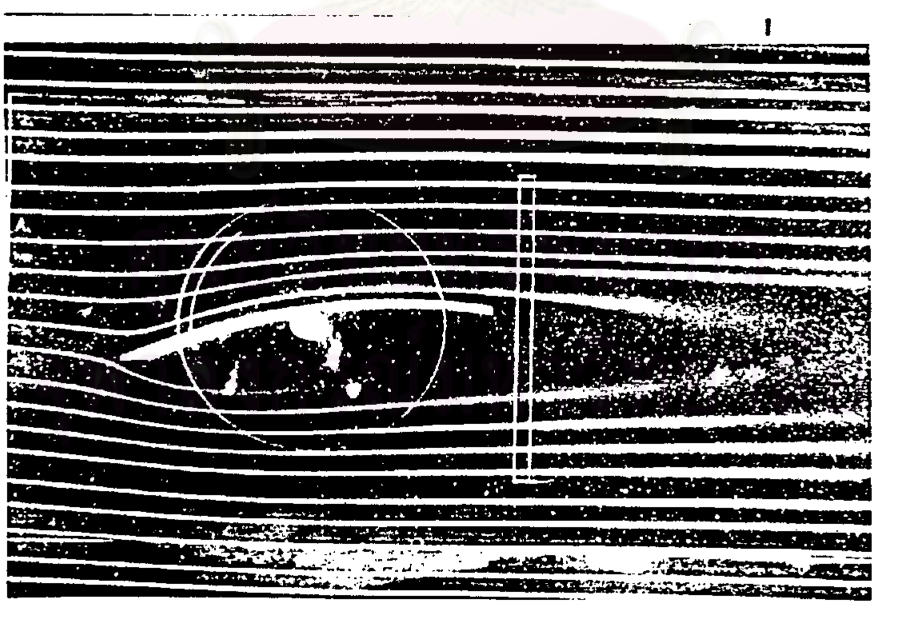

Fig.C.38 Attack angle = -10 degrees

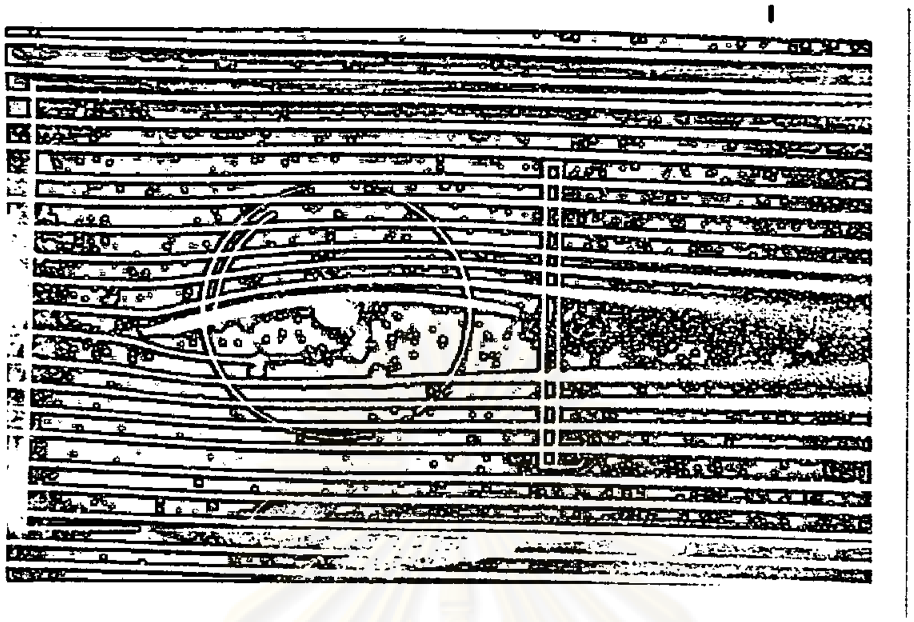

Fig. C.39 Attack angle = - 5 degrees

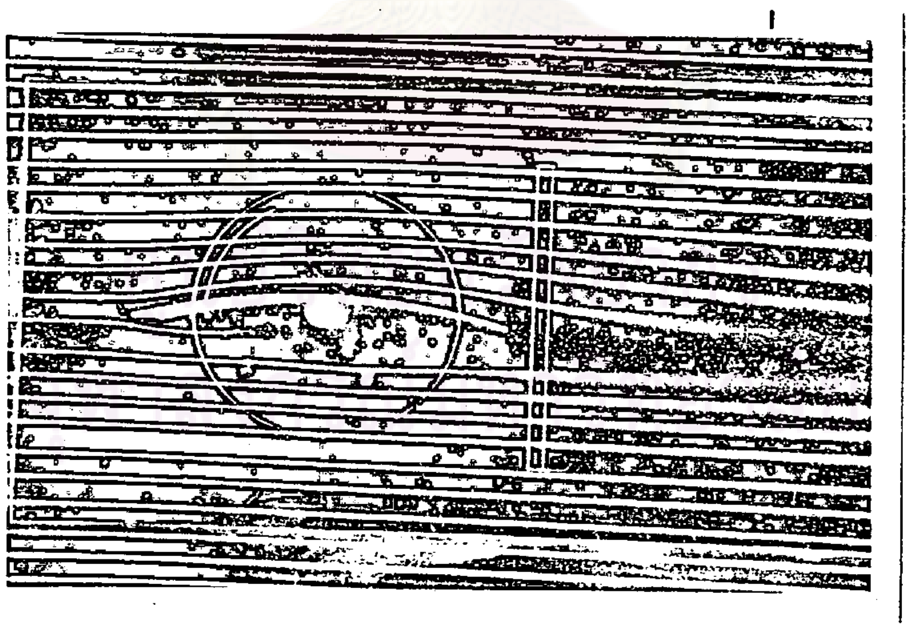

Fig. C.40 Attack angle = 0 degrees

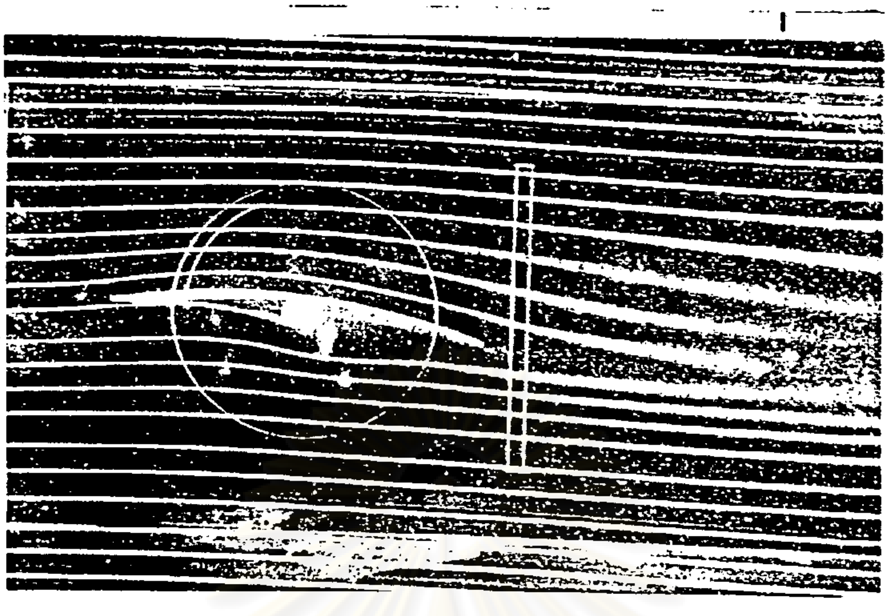

Fig.C.41 Attack angle = 5 degrees

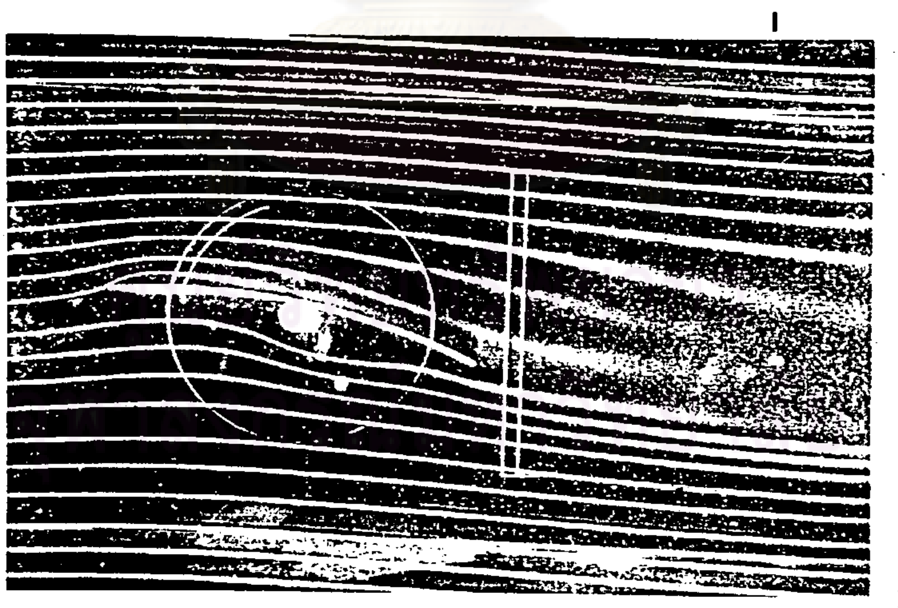

Fig.C.42 Attack angle = 10 degrees

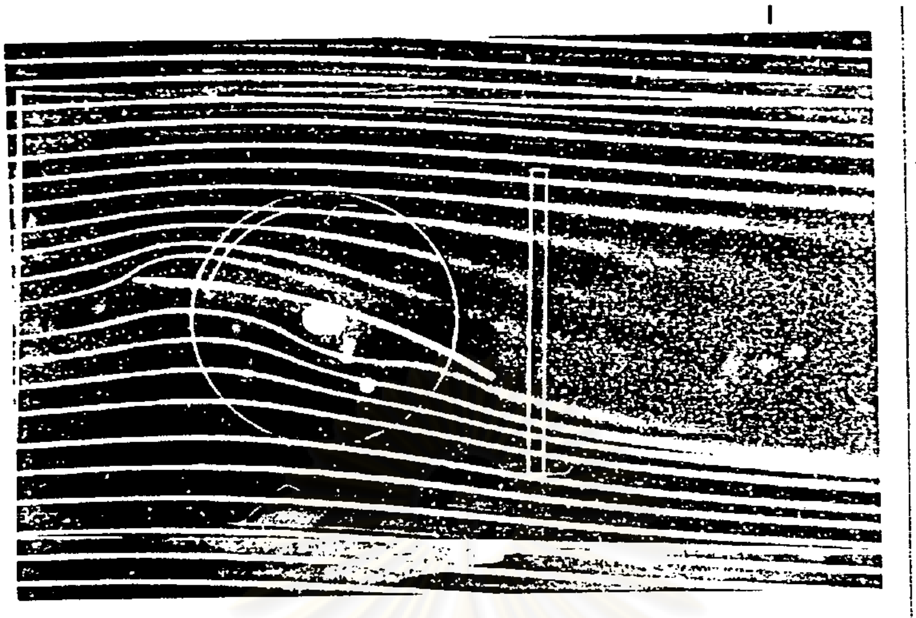

Fig. C.43 Attack angle = 15 degrees

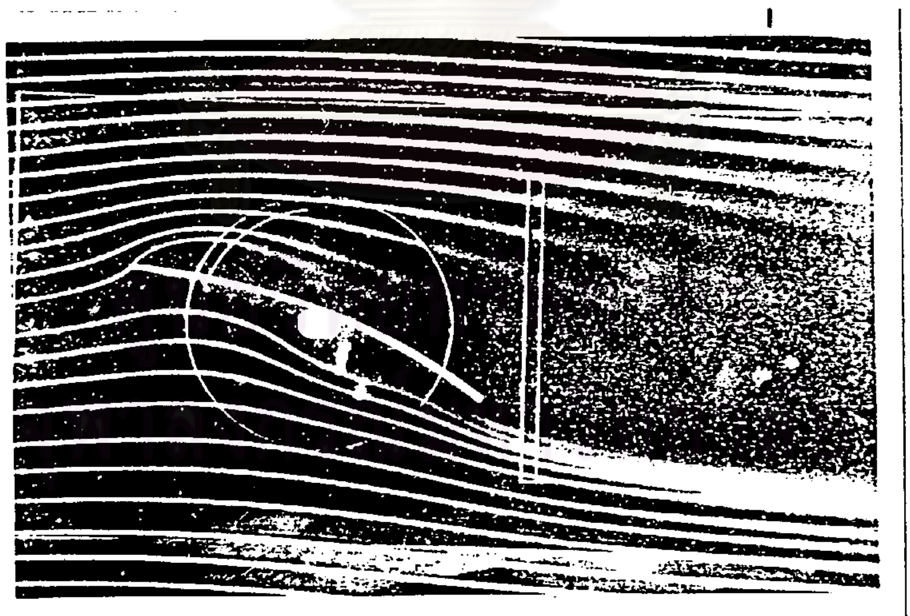

Fig. C.44 Attack angle = 20 degrees

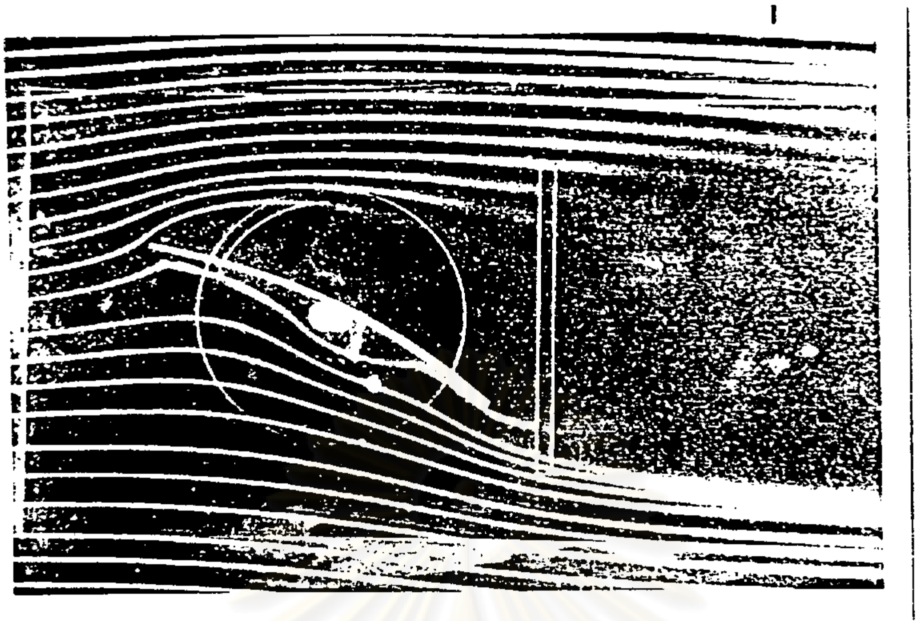

Fig. C.45 Attack angle = 25 degrees

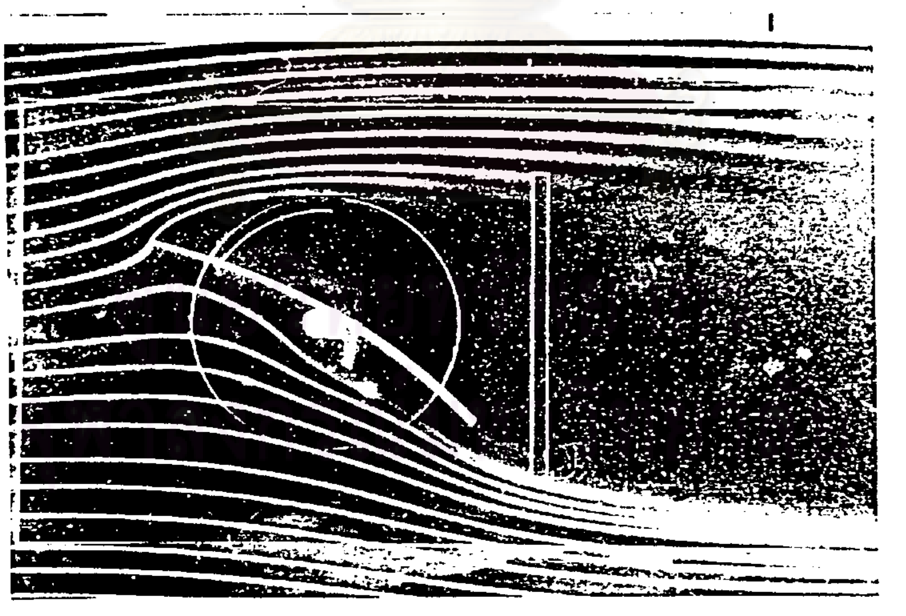

Fig. C.46 Attack angle = 30 degrees

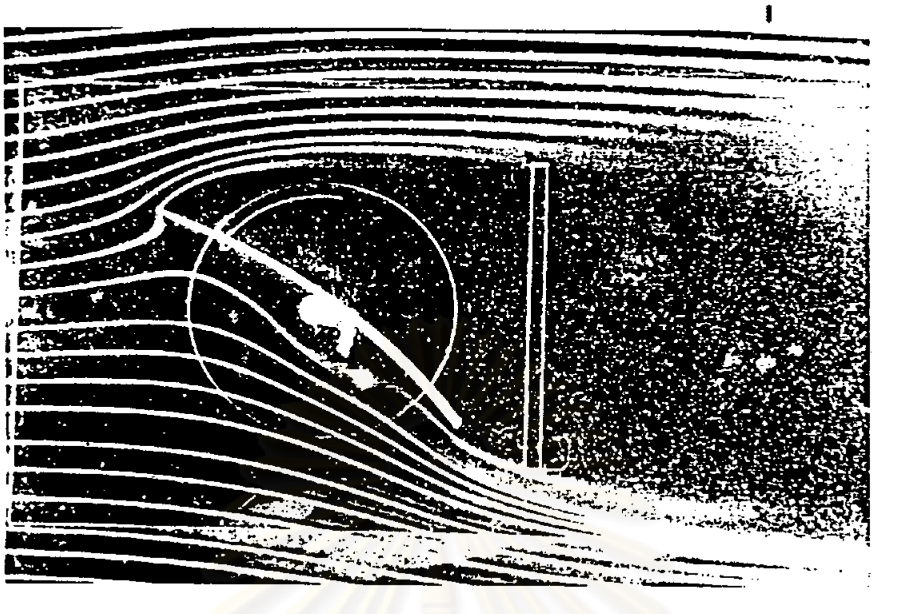

Fig.C.47 Attack angle = 35 degrees

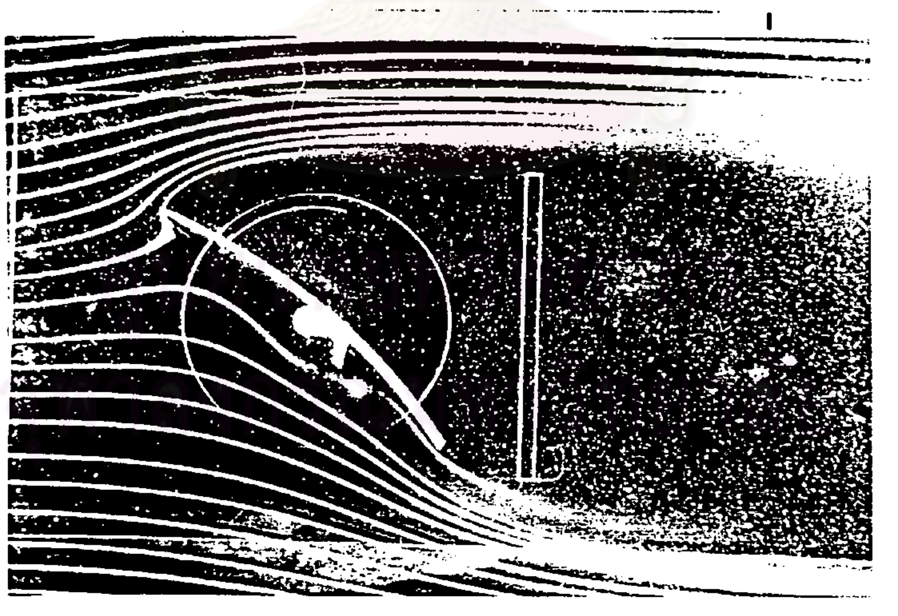

Fig. C.48 Attack angle = 40 degrees

ARCHED PLATE WITH STICK 6 mm (SPACE)

RE = 64000

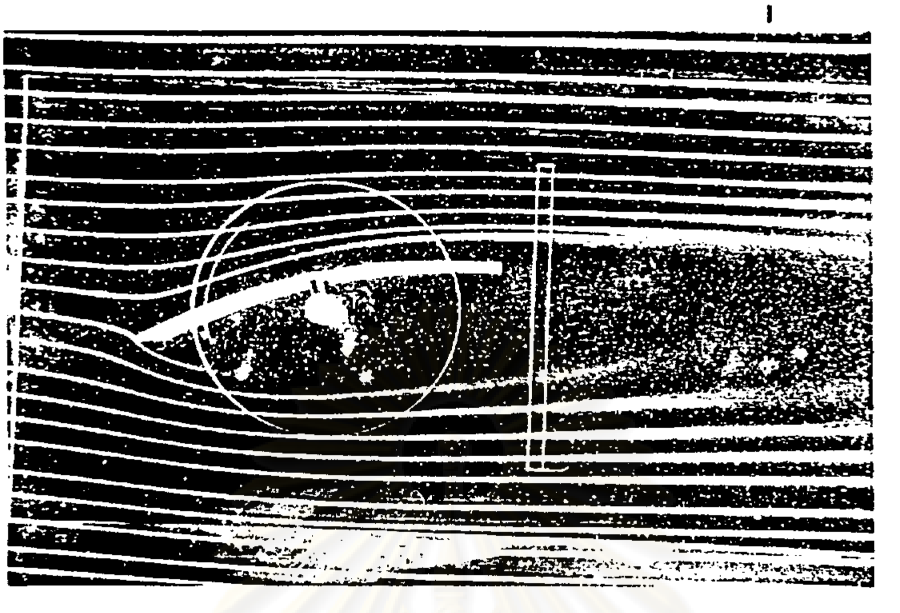

Fig. C.49 Attack angle = -15 degrees

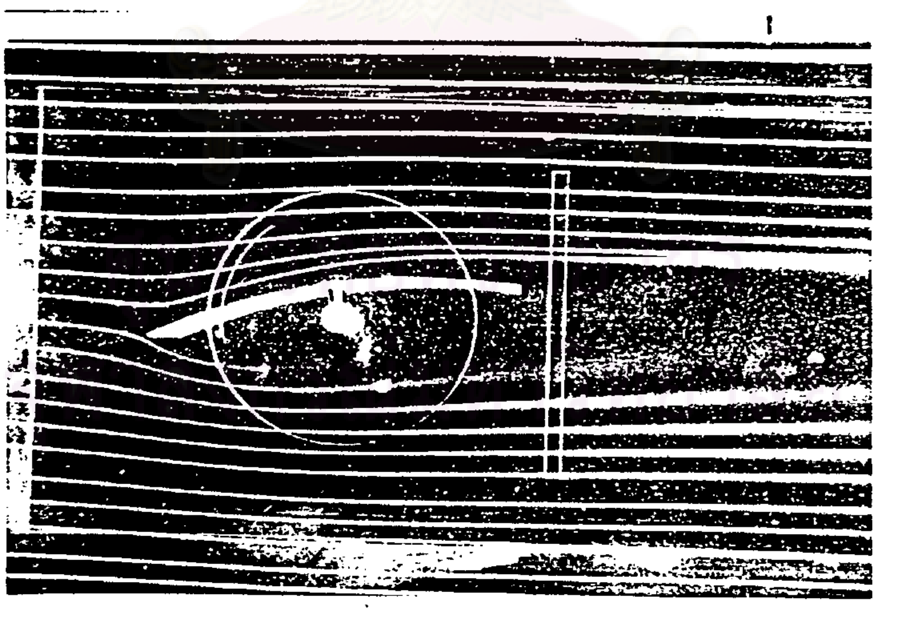

Fig.C.50 Attack angle = -10 degrees

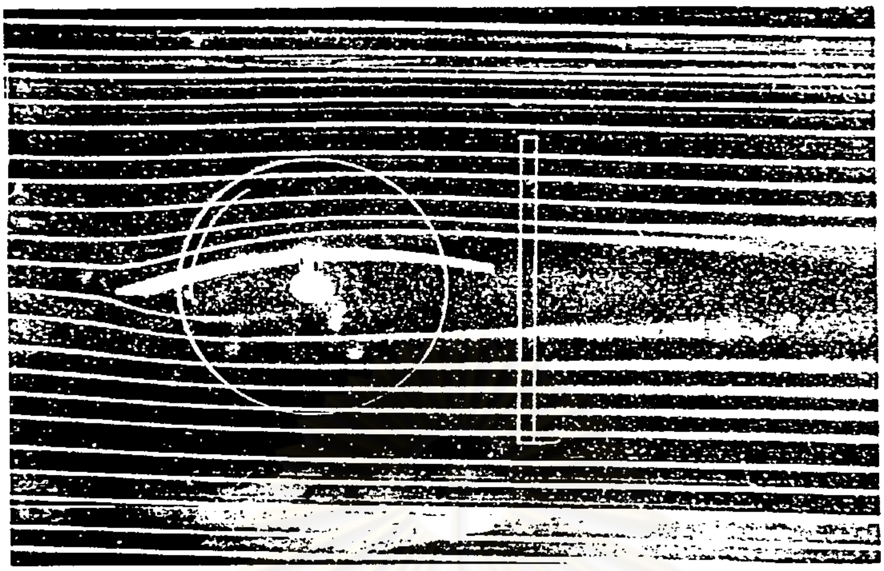

Fig. C.51 Attack angle = - 5 degrees

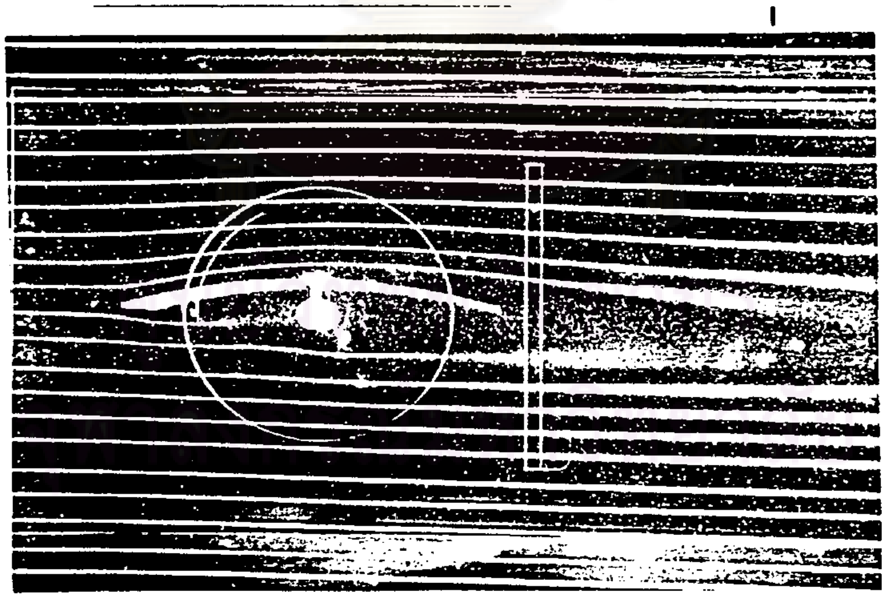

Fig. C.52 Attack angle = 0 degrees

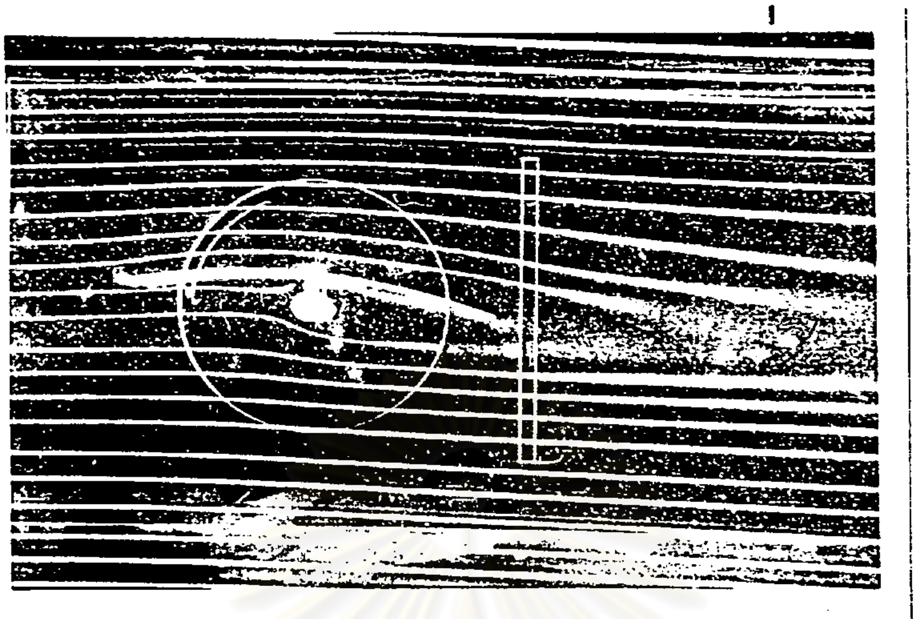

Fig. C.53 Attack angle = 5 degrees

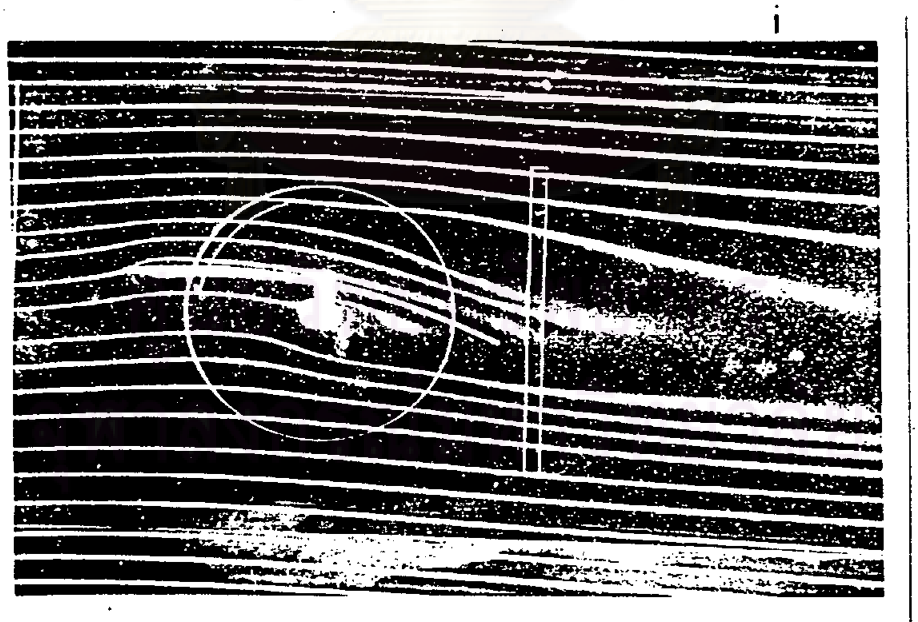

Fig. C.54 Attack angle = 10 degrees

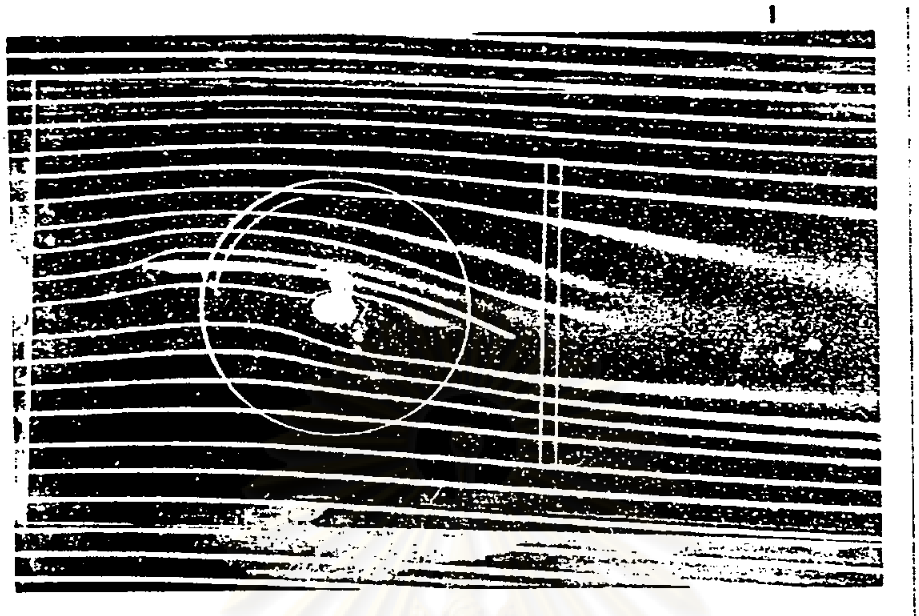

Fig. C.55 Attack angle = 15 degrees

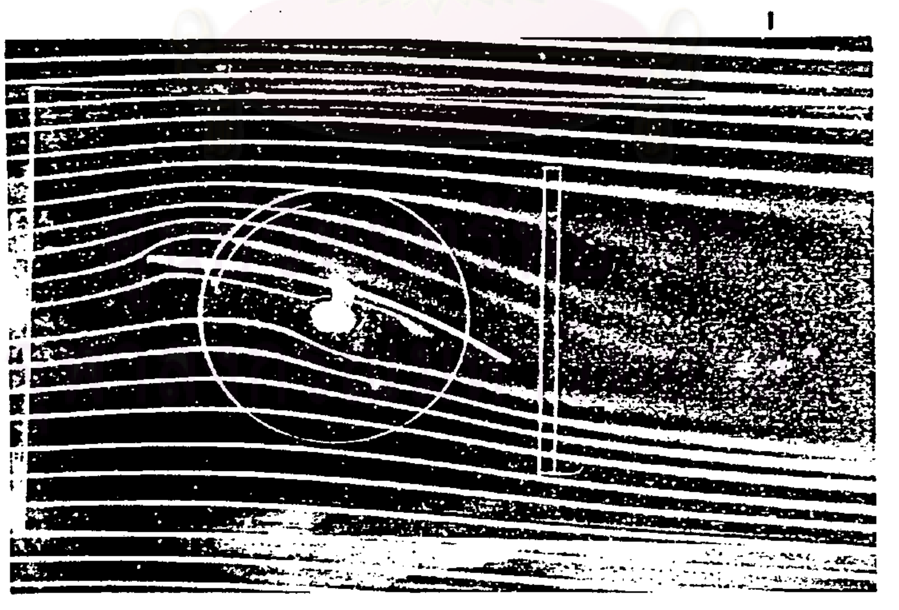

Fig. C.56 Attack angle = 20 degrees

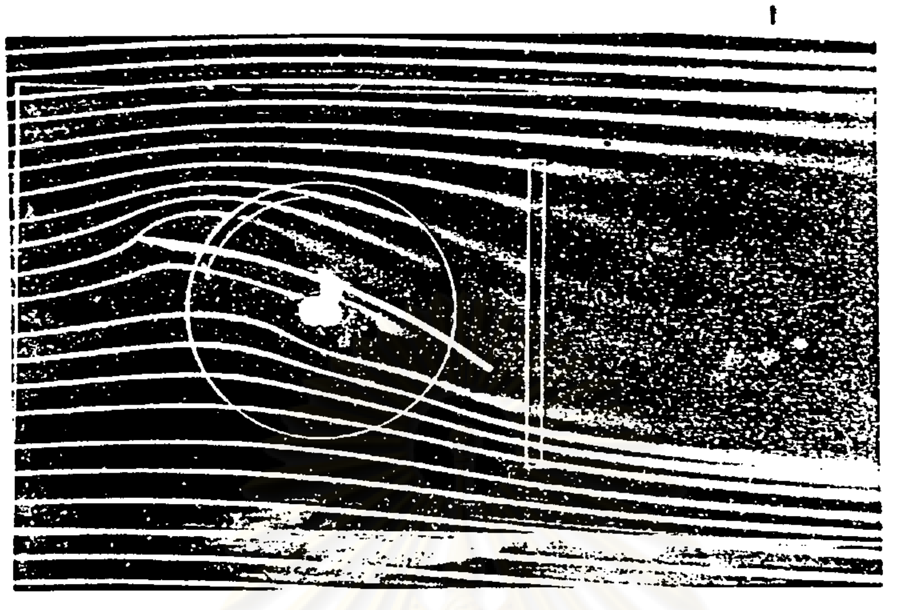

Fig. C.57 Attack angle = 25 degrees

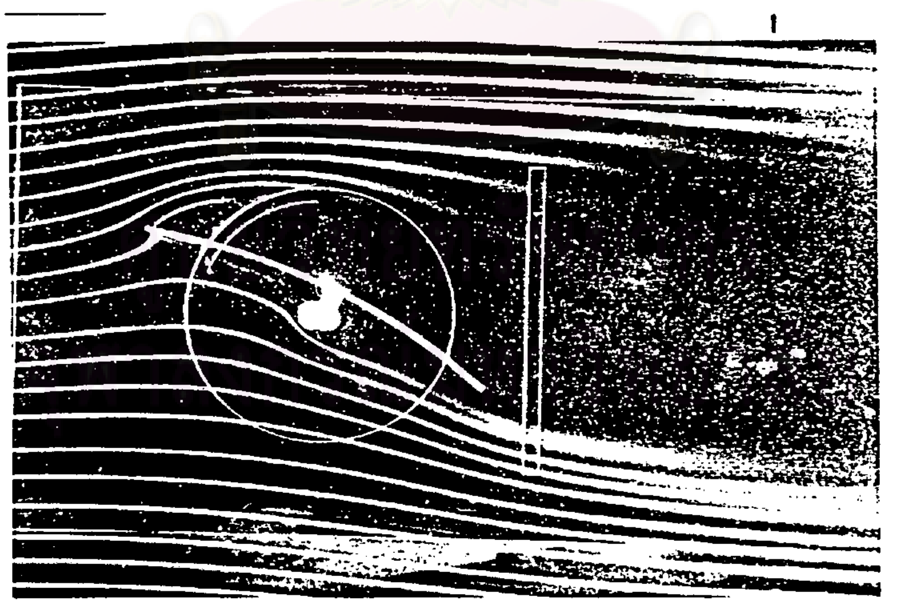

Fig.C.58 Attack angle = 30 degrees

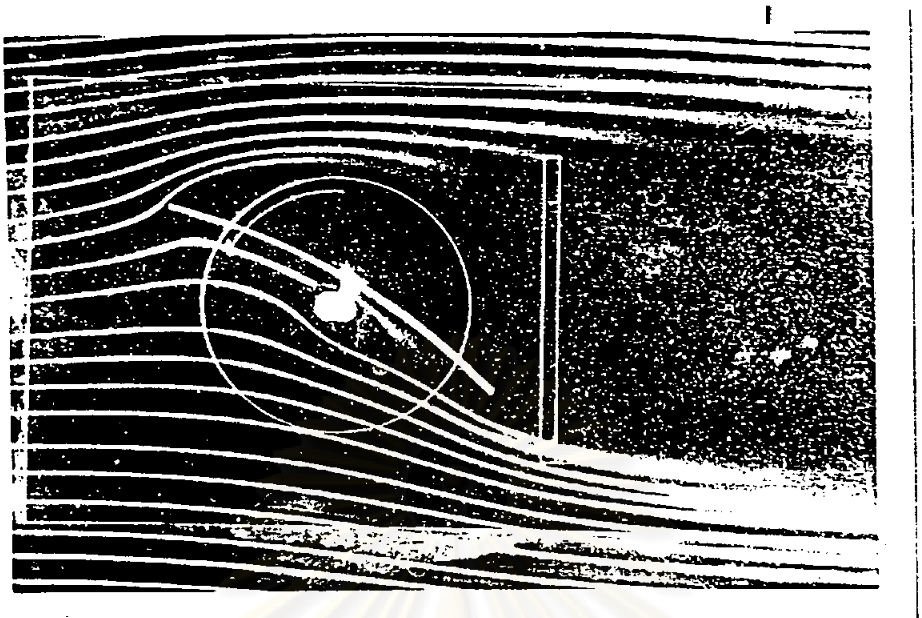

Fig.C.59 Attack angle = 35 degrees

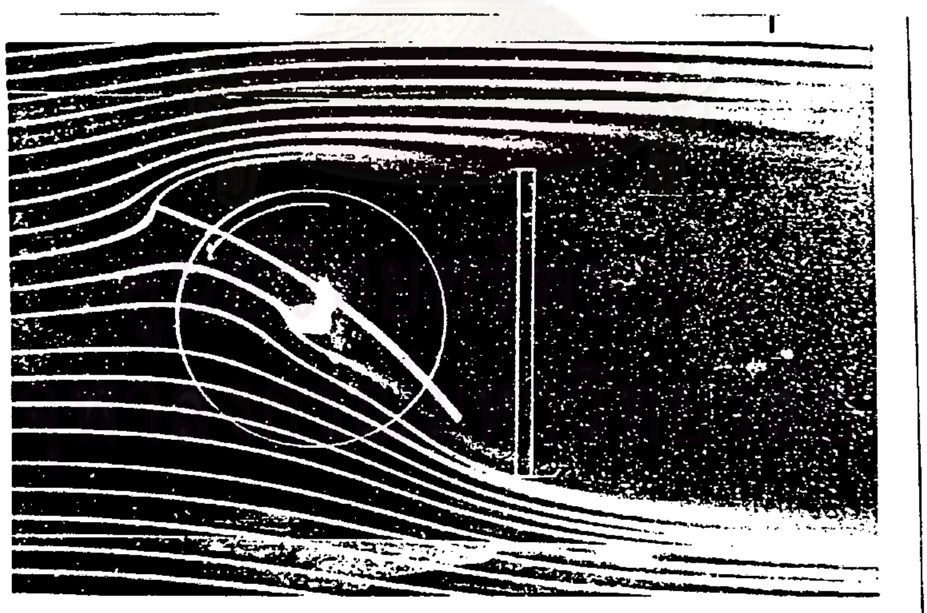

Fig.C.60 Attack angle = 40 degrees

ARCHED PLATE WITH STICK AT FRONT

RE = 64000

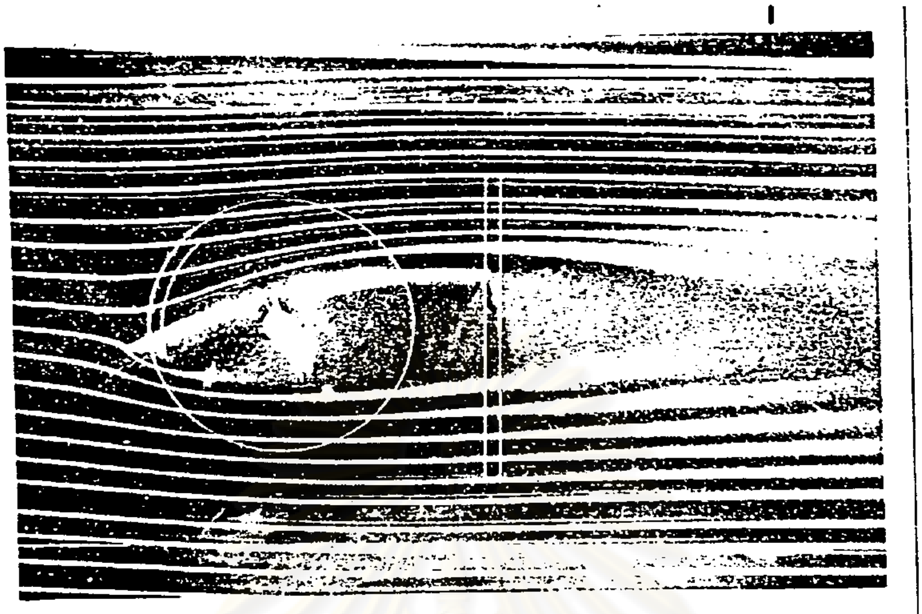

Fig. C.61 Attack angle = -15 degrees

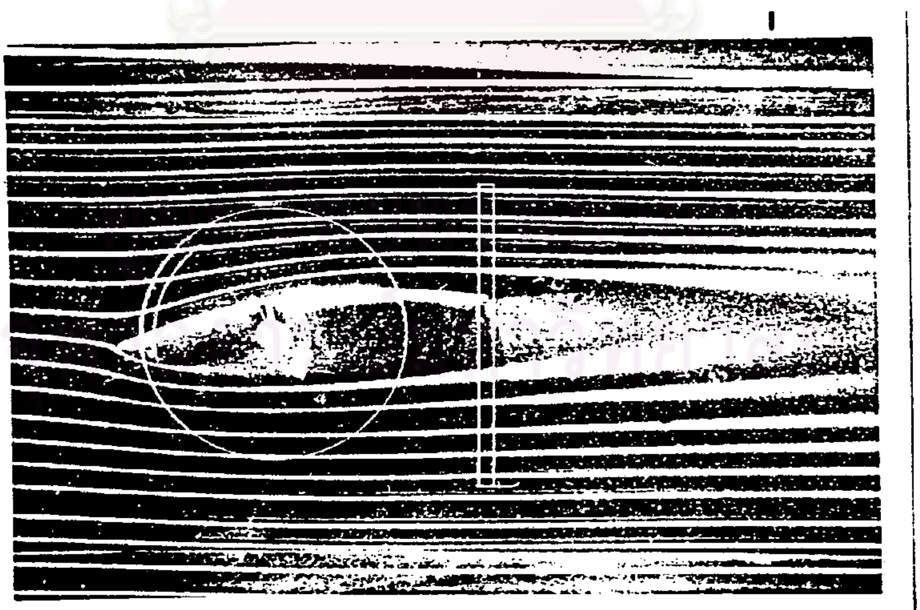

Fig. C.62 Attack angle = -10 degrees

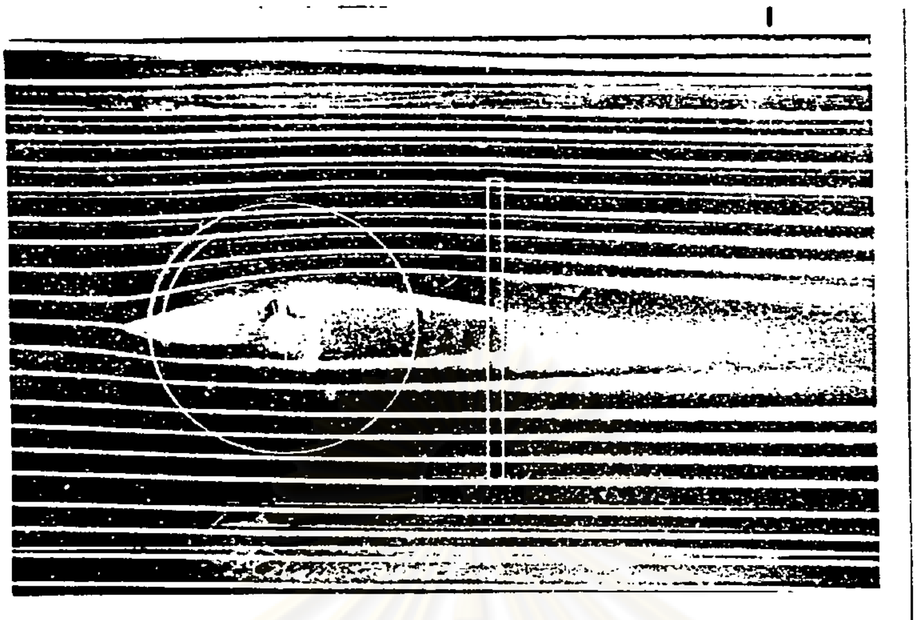

Fig. C.63 Attack angle = -5 degrees

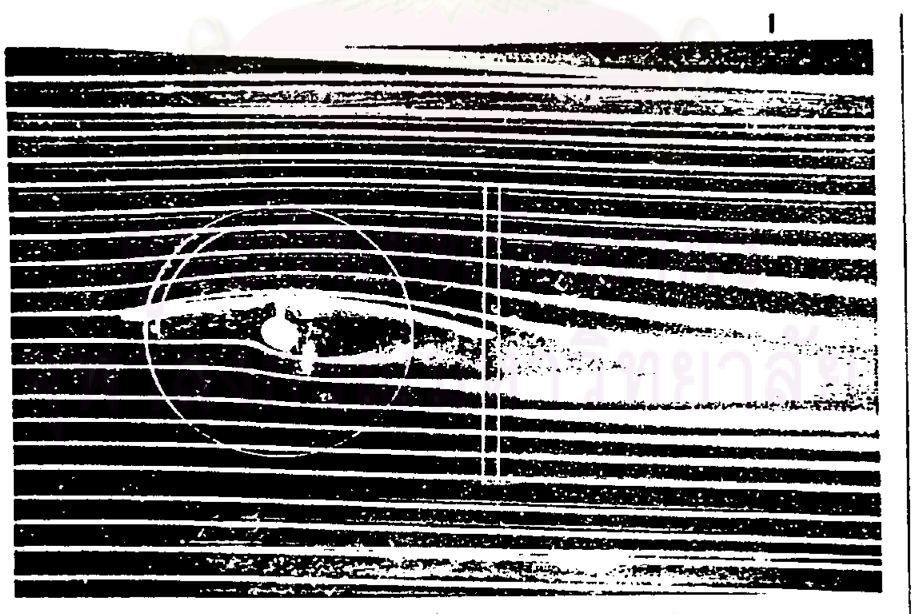

Fig. C.64 Attack angle = 0 degrees

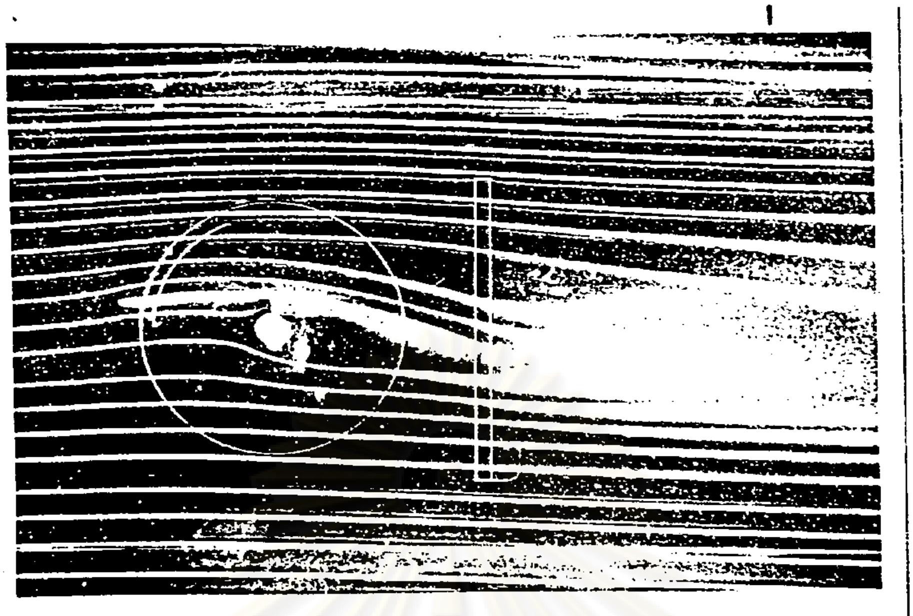

Fig. C.65 Attack angle = 5 degrees

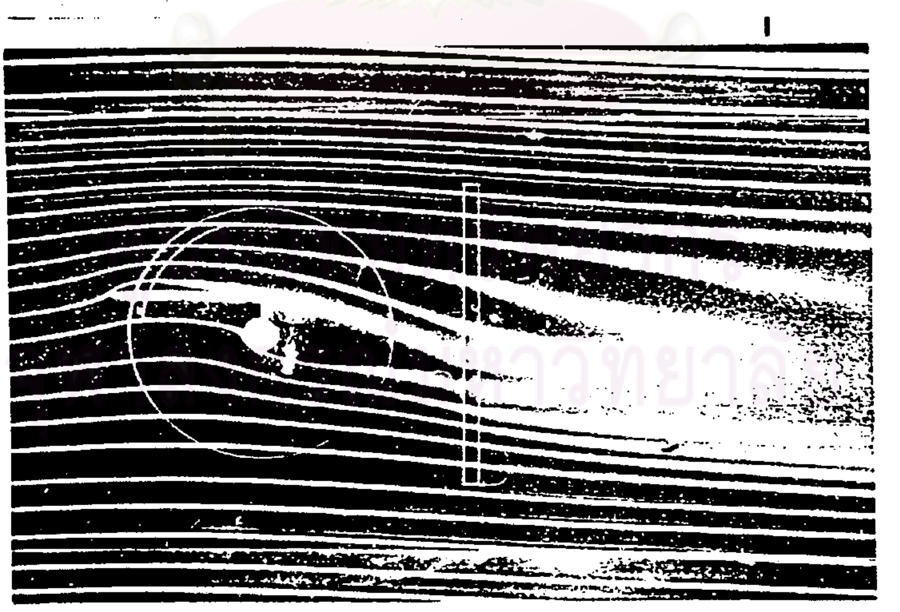

Fig. C.66 Attack angle = 10 degrees

Fig. C.67 Attack angle = 15 degrees

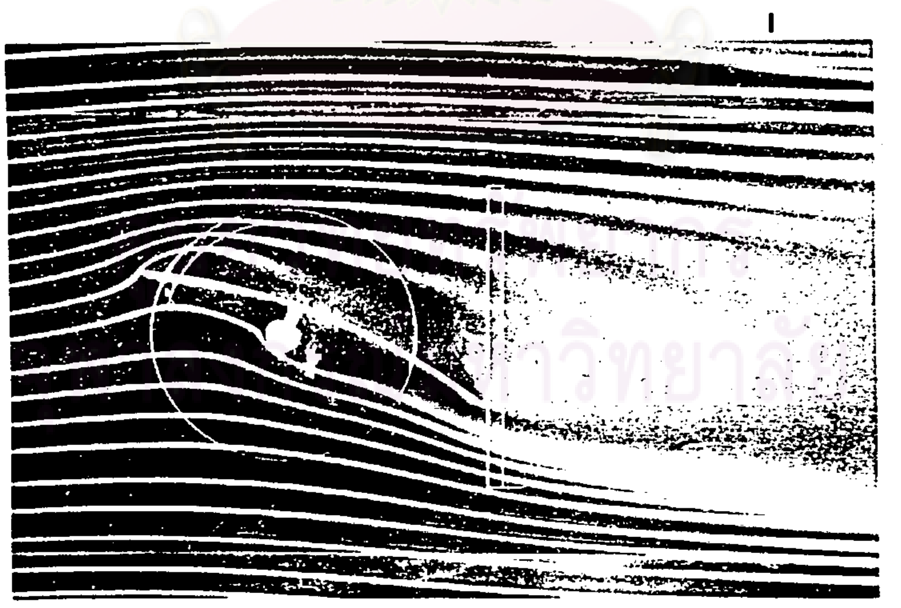

Fig. C.68 Attack angle = 20 degrees

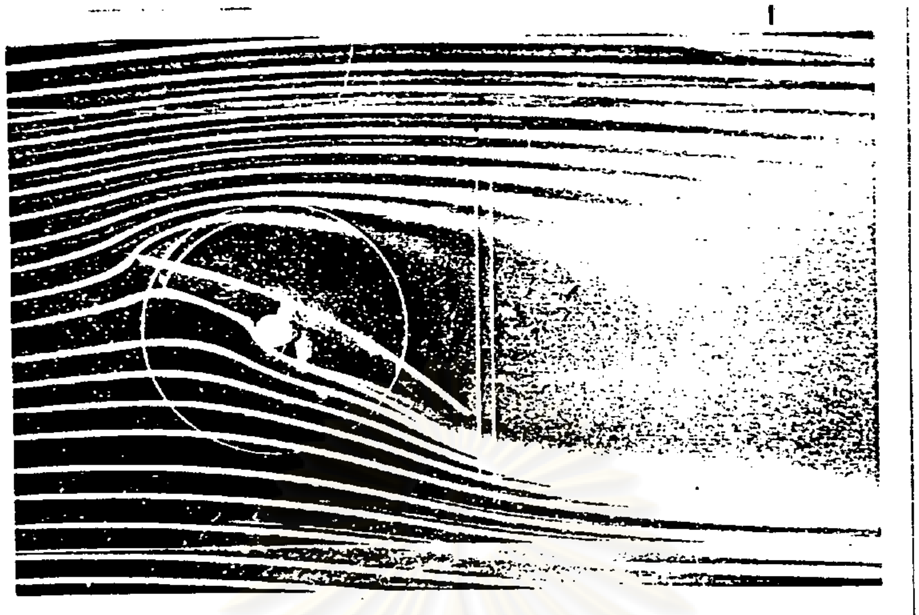

Fig. C.69 Attack angle = 25 degrees

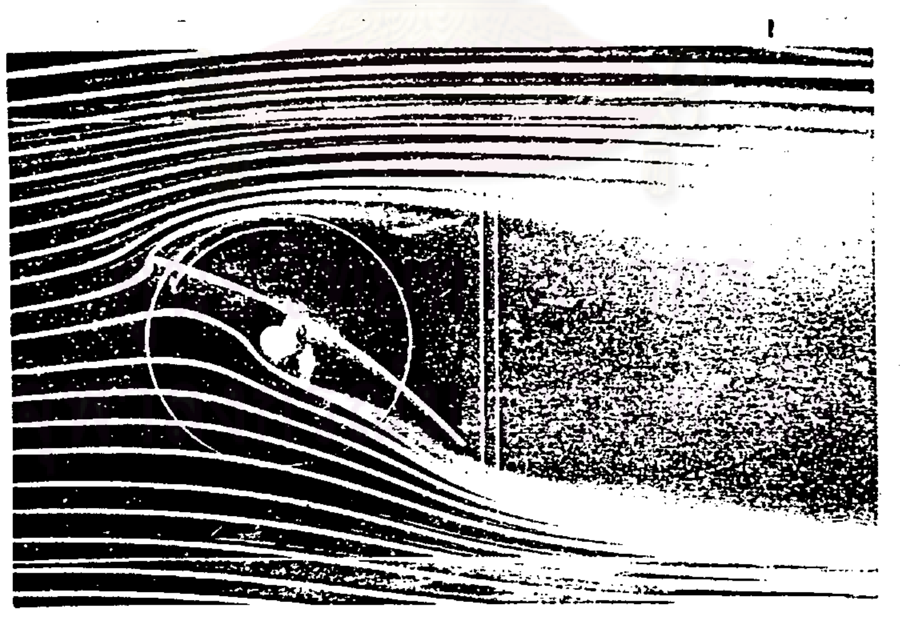

Fig. C.70 Attack angle = 30 degrees

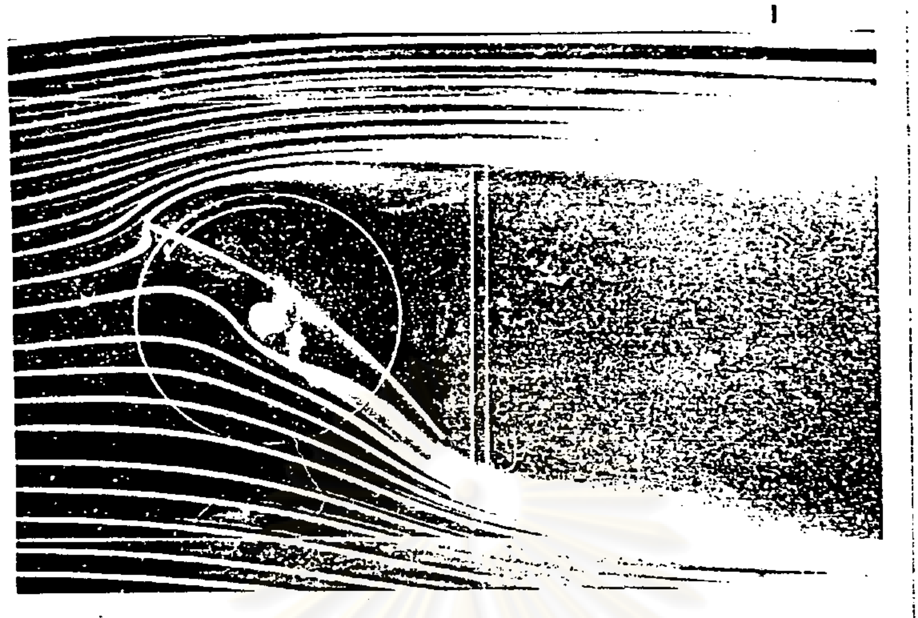

Fig. C.71 Attack angle = 35 degrees

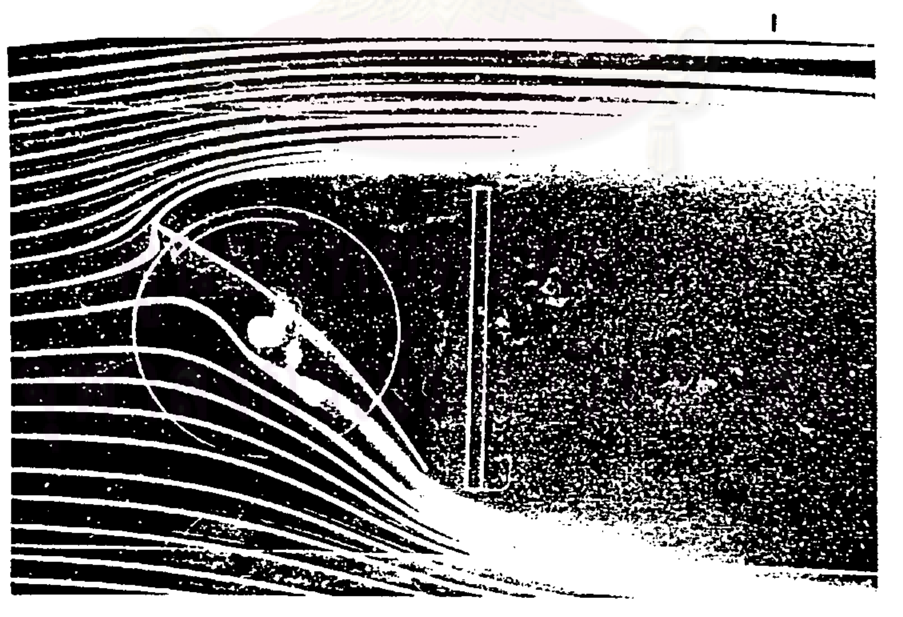

Fig. C.72 Attack angle = 40 degrees

ARCHED PLATE WITH STICK AT BACK

RE = 64000

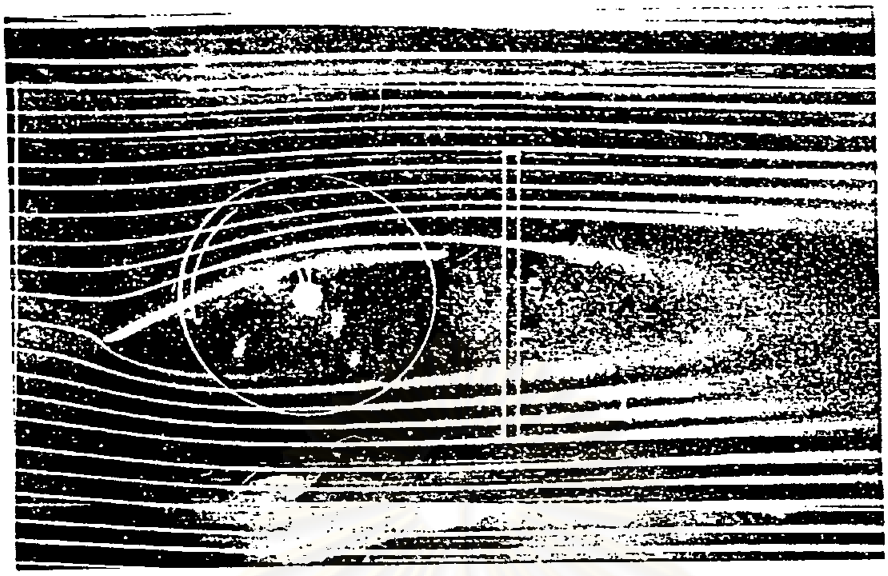

Fig. C.73 Attack angle = -15 degrees

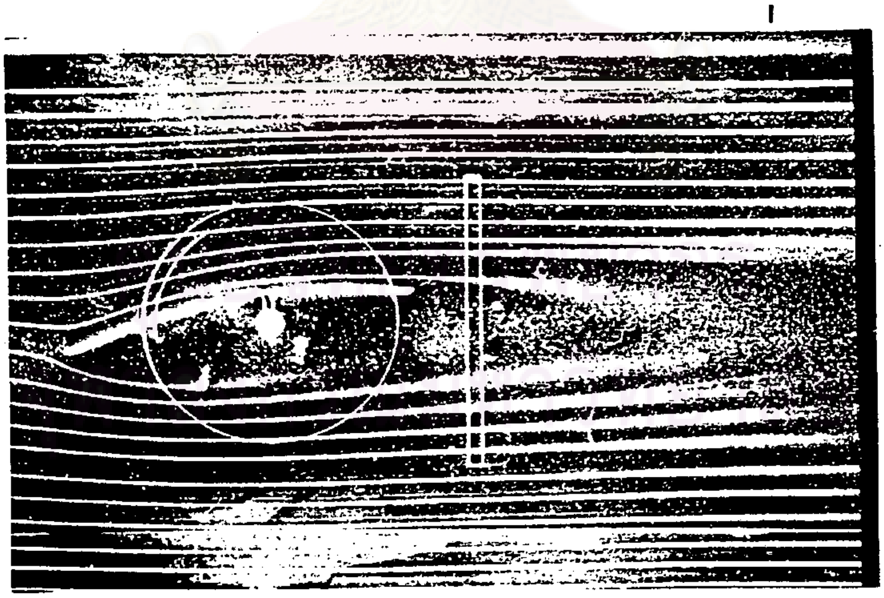

Fig. C.74 Attack angle = -10 degrees

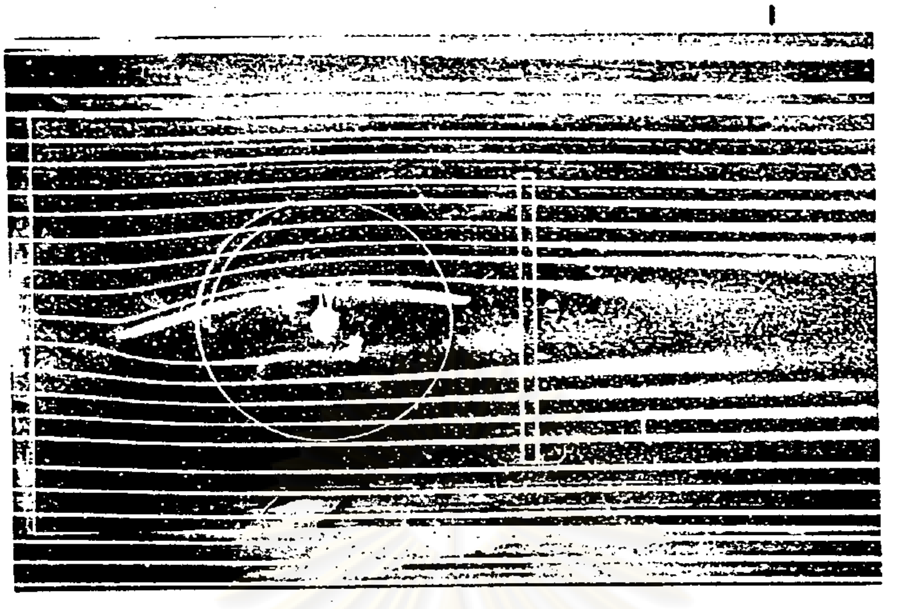

Fig. C.75 Attack angle = -5 degrees

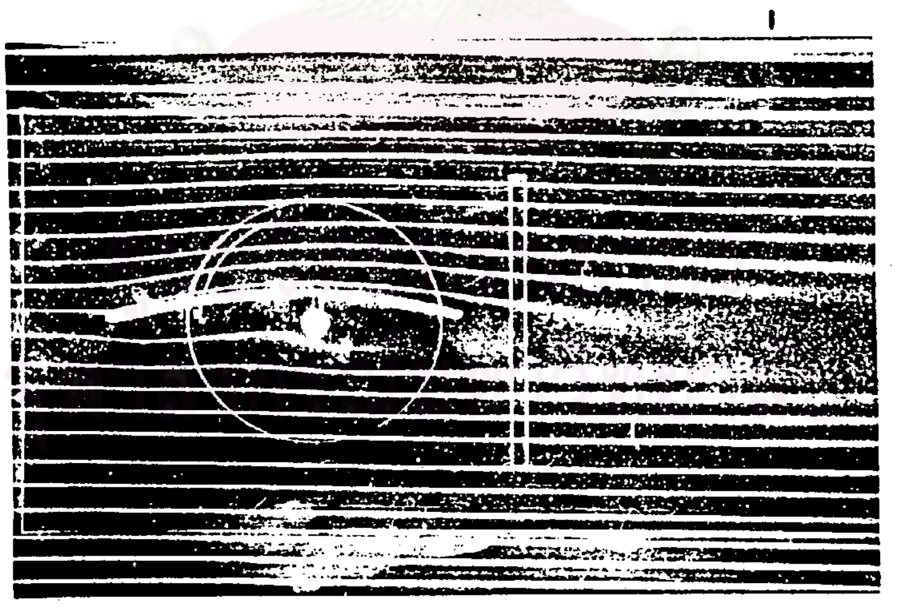

Fig. C.76 Attack angle = 0 degrees

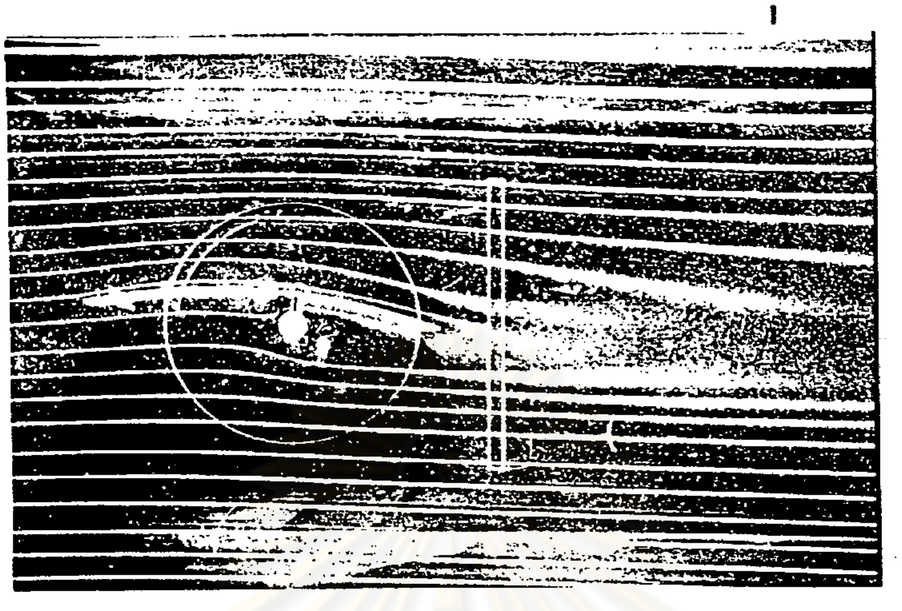

Fig. C .77 Attack angle = 5 degrees

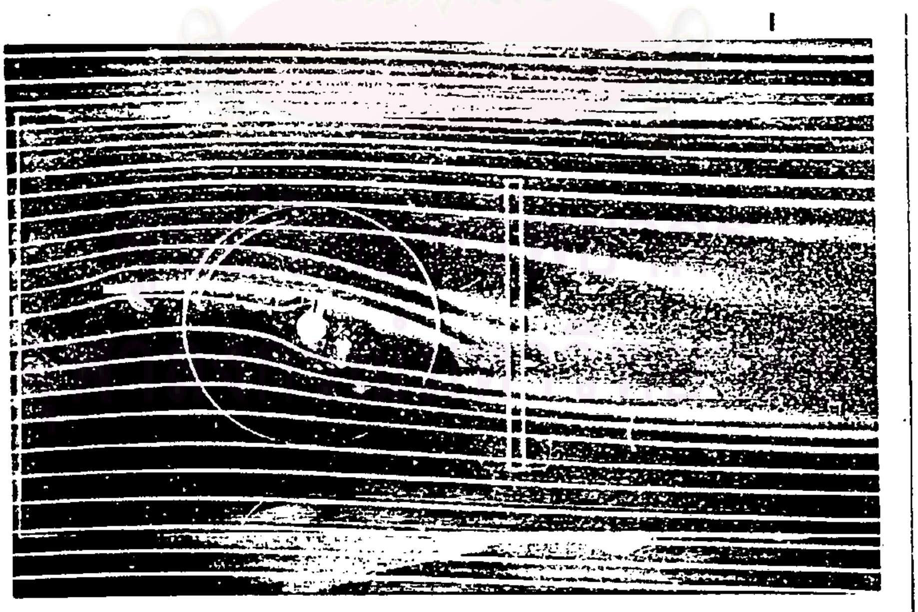

Fig. C .78 Attack angle = 10 degrees

Fig. C.79 Attack angle = 15 degrees

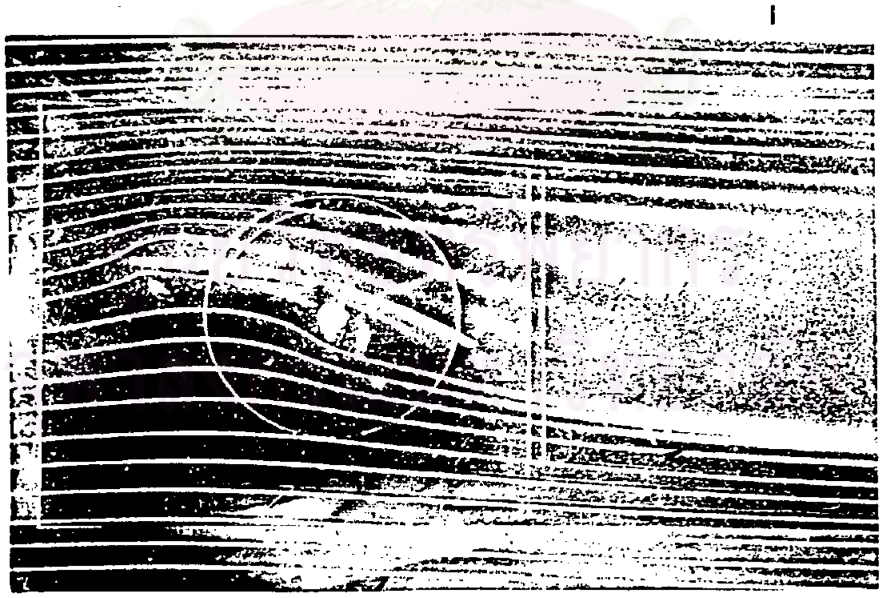

Fig. C.80 Attack angle = 20 degrees

Fig. C.81 Attack angle = 25 degrees

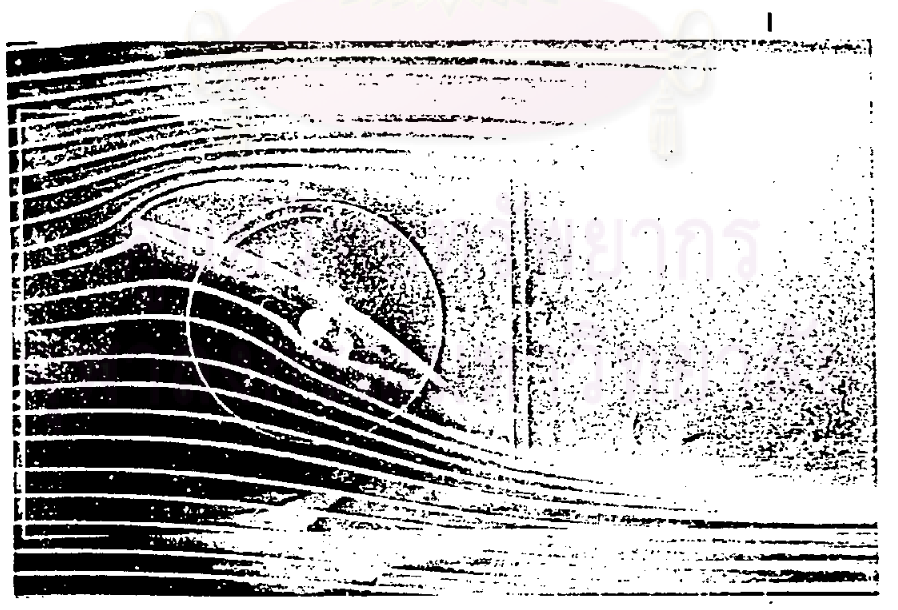

Fig. C.82 Attack angle = 30 degrees

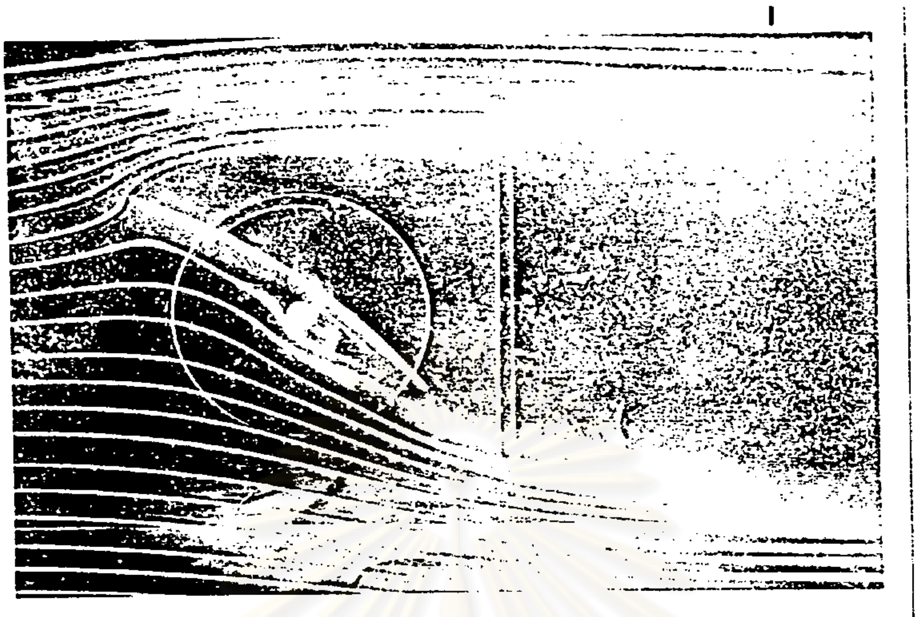

Fig. C.83 Attack angle = 35 degrees

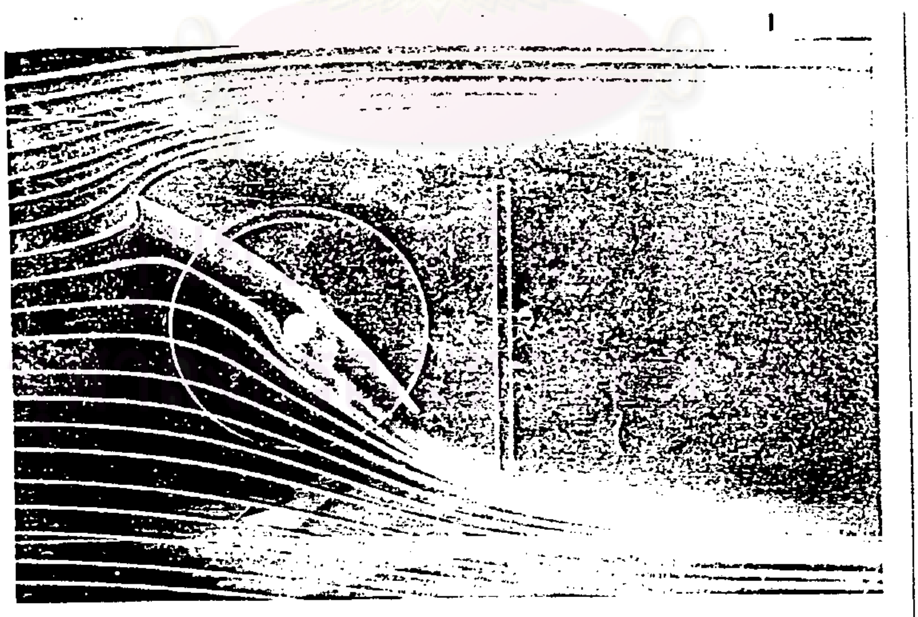

Fig.C.84 Attack angle = 40 degrees

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