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THE USE OF OPAQUE LOUVRES AND SHIELDS TO REDUCE REFLECTIONS
WITHIN THE COCKPIT: COMPUTER PROGRAMS FOR TWO APPROACHES TO THE PROBLEM

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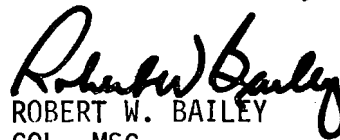
the computer programs (FORTRAN) for each approach for possible use by others.

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SUMMARY

Opaque shields can be used to channel light and thereby reduce reflections within the cockpit. These shielding devices range from the standard glare shield on top of the instrument panel to the more experimental use of Light Control Film^R and Micromesh^R for this purpose. Previous work in this series has demonstrated two mathematical approaches to a specific reflection problem in the AH-1 aircraft, namely, the reflections coming from the portion of canopy directly above the gunner's head. It was felt that it would be useful to demonstrate the compatibility of these two approaches and to publish the computer programs (FORTRAN) for each approach for possible use by others.



ROBERT W. BAILEY
COL, MSC
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INTRODUCTION

One technique of reducing the reflections of the instruments, dials, etc. from the transparent enclosures is the use of opaque louvres and shields. In using these screening materials, one wants to maximize the extent to which they block light from reaching the canopy but minimize the extent to which they block light from reaching the pilots' eyes. This is accomplished by choosing the proper values for the position, width, spacing, angle, etc. of these shields.

In a previous report¹ we showed a set of mathematical equations for the solution of this problem in terms of analytic geometry. Quite independently, the problem has also been investigated by a different mathematical method, namely a plane geometrical and trigonometrical method. The latter method will be documented elsewhere². Regardless of the different mathematical derivations, results from these two theoretical predictions of the reduction in interior cockpit reflections were essentially identical. The purposes of this report are to demonstrate the compatibility of these two theoretical predictions and to document these two FORTRAN computer programs.

ANALYSIS

Due to the nature of the problem, visibility has been classified

into three cases. We denoted the projected points of the lower and higher points of the louvre to the vertical axis of the pilot's position by h and H respectively. Case I concerns the visibility V_I above H . Visibility V_{II} (Case II) is the region between H and h . Below h , visibility V_{III} is classified as Case III. Since Case II is relatively trivial and since Case III is similar to Case I, we will show the equations for Case I by these two methods.

a. Analytical geometry method:

$$V_{IA} = 1 \frac{d_l \tan \theta - k_l}{c + k_l \tan \theta} \quad (A)$$

Where V_{IA} is visibility, c is the distance between louvres, d_l is the thickness of the louvre, θ is the decline angle of the instrument panel and k_l is constant. All the symbols were explained in the original paper and are shown in Appendix I (incorporated with notations in the computer programs).

b. Plane geometrical method:

$$V_{IB} = K \frac{1 (h-H) (\cot^\alpha \cos \theta + \sin \theta)}{h \sec (\alpha-\theta) - 1 - \alpha \sin \theta \sec (\alpha-\theta) - (h-H \cos \theta \sin \alpha)} \quad (B)$$

Where V_{I_B} is visibility, K is constant, h is the minimum height, H is the maximum height, θ is the decline angle of the instrument panel and α is the extended angle.

A detailed explanation of the symbols in this equation is also given in Appendix II.

SOLUTION

Computer programs for equations (A) and (B) are attached in Appendices III and IV respectively. Comments and notations used have been added in the programs except for the graphic portion of the programs, which required a few calls from standard subroutines, and were plotted through a hybrid computer plotter³.

Results from both methods have been represented by two graphs (Figures 1 and 2 correspond to methods (A) and (B) respectively.). They were indistinguishably identical. (The vertical axis showed the normalized visibility and the horizontal axis was the vertical distance with respect to a referenced ground point in the Cartesian coordinates system. There are six curves in each graph with each curve representing a different louvre width. These graphic representations enabled us to determine the amount of visibility of a pilot under a set of predetermined cockpit parameters.

In short, this study has presented two different mathematical formulations which produced identical solutions for the analysis of the use of opaque louvres and shields to reduce reflections within the cockpit. It has also documented two computational procedures with their respective computer programs for future analyses of cockpit light reflections.

CONCLUSION

Previous work in this series has demonstrated two mathematical approaches to a specific reflection problem, namely, the reflections coming from the portion of canopy directly above the gunner's head. Although these two studies addressed a specific reflection problem, they each represented the modulus of a general approach to the canopy reflection problem. Therefore, it was felt that it would be useful to demonstrate the compatibility of these two approaches and to publish the computer programs for each approach for possible use by others.

RECOMMENDATIONS

In future canopy design, it is recommended that an analysis of this sort be carried out prior to fabrication of the canopy and cockpit. In this way, some potential reflection problems could be prevented without having to initiate costly re-designs and product improvement programs.

REFERENCES

1. Chiou, W.C. and Holly, F.F., "The Use of Opaque Louvres and Shields to Reduce Reflections Within the Cockpit: A Mathematical Treatment", USAARL Report NO. 75-22, June 1975.
2. Park, C.K. and Holly, F.F., "The Use of Opaque Louvres and Shields To Reduce Reflections Within the Cockpit: A Trigonometrical and Plane Geometrical Approach," USAARL Report NO. 76-4, Sep 75.
3. We thank Dr. H.D. Jones of the Hybrid Computer and Analysis Branch, USAARL, for establishing the plot portion of the computer programs.

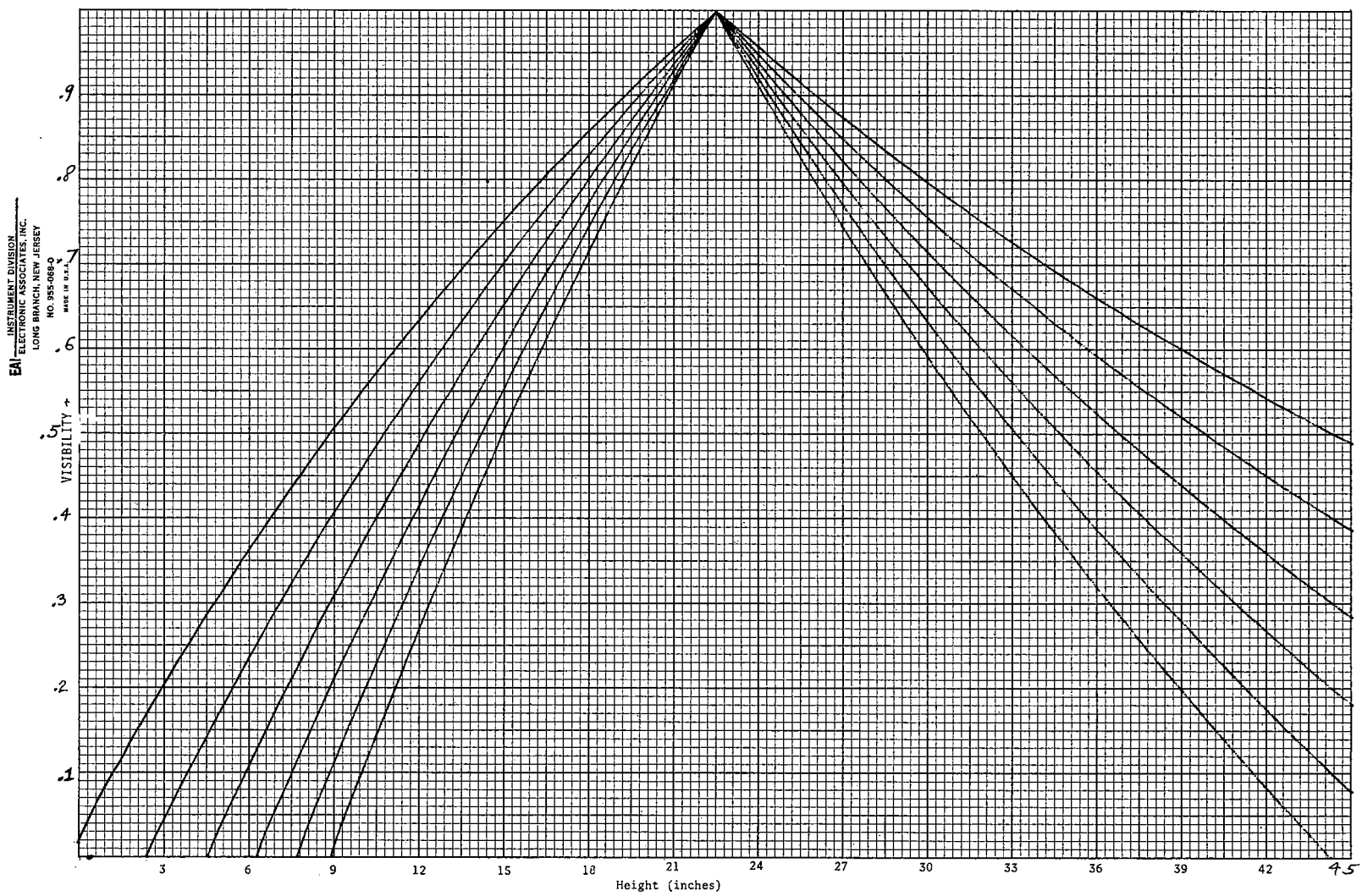


FIGURE 1. Visibility as a function of height in the plane of the gunner as determined by the method of analytic geometry.

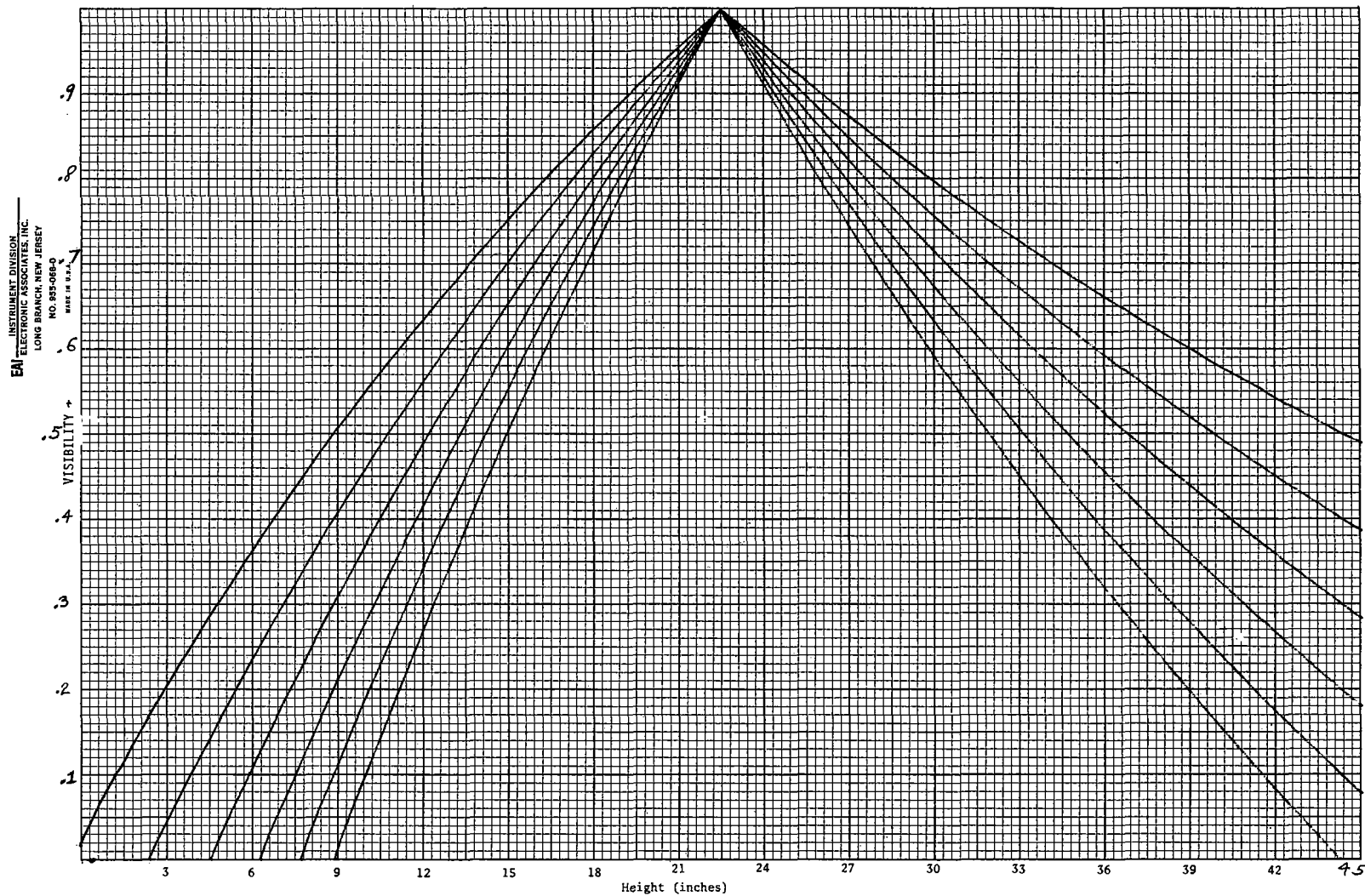


FIGURE 2. Visibility as a function of height in the plane of the gunner as determined by the method of plane geometry.

APPENDIX I

ANALYTICAL GEOMETRY METHOD

COL. (4 Decimal)	INPUT CODE	SYMBOLIC CODE	HEADER CODE	COMMENT
1-7	A	a	A	Distance from panel
8-14	B	b	B	Distance the louvre is up the panel
19-21	C	c	C	Distance between the louvres
22-28	D ₁	d ₁	D ₁	Width of louvre
29-35	D ₂	d ₂	D ₂	Width of louvre
36-42	E	θ	E	L θ
43-49	ORGN		ORGN	Beginning point

APPENDIX II
PLANE GEOMETRIC METHOD

COL (3 Decimal)	INPUT CODE	SYMBOLIC CODE	HEADER CODE	COMMENT
1-7	A	l	L	Starting width of louvre Program Increments dy .003
8-14	B	α	B	$L \alpha$
15-21	C	K	K	Distance between louvres
22-28	D	H	HF	Starting height to be varied ± 10 by .25
29-35	E	a	A	Height up the panel
36-42	F	θ	T	$L \theta$
43-49	G	M	M	Distance from panel

APPENDIX III

COMPUTER PROGRAM (a)

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75      VIV(I)=VII
76      GO TO 500
77      400 CONTINUE
78      IF (PY(I).GT.4Y)GO TO 500
79      GO TO 600
80      500 CONTINUE
81      KA=A+(B+C)*COS(EA)-D1*SIN(EA)
82      KB=PY(I)-((B+C)*SIN(EA)+D1*COS(EA))
83      KI=KA/KB
84      VI=1-D1/C*(SIN(EA)/COS(EA)-KI)/(1+KI*SIN(EA)/COS(EA))
85      VIV(I)=VI
86      600 CONTINUE
87      ORGN=ORGN+.01
88      700 CONTINUE
89      C*****
90      C*****
91      5 CONTINUE
92      C YS THIS IS PART OF SCALING
93      YS=ORGN-(ORGN)-.01
94      DO 23 M=1,2000
95      C I01 & I02 ARE X & Y IN SCALING EQUATION FOR E02 GRAPHING
96      I01=IC01V*(PY(M)-ORGN)/YS
97      I02=IC02V*VIV(M)
98      IF (VIV(M))9.51,51
99      51 CONTINUE
100     229 IF (.NOT.M.E0.1.OR..E0.2000)GO TO 232
101     WRITE (5,7)M,PY(M),VIV(M)
102     7 FORMAT(11.14,5X,F10.2,F12.6)
103     232 CONTINUE
104     C WRITING TO THE 581 & TO THE LINE PRINTED TAKES PLACE IN THE FOLLOWING
105     CALL LDDA(0.1,I01,(500)
106     IF (M.E0.1)PAUSE 000
107     23 CONTINUE
108     9 WRITE (5,7)M,PY(M),VIV(M)
109     PAUSE LABEL
110     GO TO 2
111     3 CONTINUE
112     STOP
113     END
114     $ASSIGN1 LIR=IVALL DIV=HYDRS
115     $ASSIGN2 5=SYC
116     $ASSIGN2 6=SL0.7000
117     $ALLOCATE 10000
118     $OPTION NOMAP
119     $EXECUTE GO
120     27.0,5.0,.01,.015,.015,55.0,0.0
121     27.0,5.0,.01,.018,.018,55.0,0.0
122     27.0,5.0,.01,.021,.021,55.0,0.0
123     27.0,5.0,.01,.024,.024,55.0,0.0
124     27.0,5.0,.01,.027,.027,55.0,0.0
125     27.0,5.0,.01,.030,.030,55.0,0.0
126     -000001
127     $EOJ
128     $*

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APPENDIX IV
COMPUTER PROGRAM (b)

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1  $JOB ALAF 1505 AAH1 DR. HOLLY AND E5 PARK
2  $OPTION 5
3  $OPTION NOMAP
4  $EXECUTE FORTRAN
5  C YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
6  C THIS PROGRAM CALCULATES VISIBILITY BETWEEN LOUVRES
7  C STARTING WHERE VISIBILITY IS GREATEST AND GOING
8  C UP FOR 20 INCHES ALSO GIVES GRAPH THROUGH THE
9  C 681. ALSO IT GIVES # THAT CORRESPOND TO CURVE..
10 C PAUSES ARE SET UP THAT WE MAY SET SCALE & SET PEN
11 C THIS USES DR. HOLLY AND E4 PARK FORMULAS.....
12 C YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
13 C ID1 & IV1 ARE MY X & Y IN SCALE FRACTION FORM FOR GRAPHING
14 C COMMON ID1,IV1
15 C ICONV IS MAX SCALE FRACTION
16 C ICONV=2**31-1
17 C XYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
18 C THIS PART OF THE PROGRAM SETS UP THE GRAPHING
19 C CALL INIT
20 C CALL SACN(1,IERR)
21 C CALL PENUP
22 C ID1=ICONV
23 C IV1=ICONV
24 C CALL LRQA(0,1,ID1,IERR)
25 C PAUSE FULLSC
26 C ID1=IV1=0
27 C CALL LRQA(0,1,ID1,IERR)
28 C PAUSE ORIGIN
29 C XYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
30 C WRITE(6,240)
31 C 240 FORMAT(1H1)
32 C ABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDAB
33 C EACH OF THESE HAVE 3 DECIMAL PLACES
34 C A = STARTING WIDTH OF LOUVRE PROGRAM INCREMENTS BY .003
35 C B = THE ANGLE OF THE LOUVRE
36 C C = DISTANCE BETWEEN LOUVRE
37 C D = HEIGHT OF PERSON TO BE VIEWED FOR 20 INCHES BY .01
38 C BUT H IS THE CALCULATED LITTLE H
39 C E = THE HEIGHT UP THE PANEL WHERE THE LOUVRE IS
40 C F = THE ANGLE OF THE PANEL
41 C G = THE DISTANCE FROM THE PANEL
42 C ABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDAB
43 C 2 READ(5,1)A,B,C,D,E,F,G
44 C 1 FORMAT(7F7.3)
45 C USED TO CONVERT DEGREES TO RADIANS
46 C B=B/57.2957795
47 C F=F/57.2957795
48 C N IS USED AS THE STARTING POINT
49 C N=-2000
50 C IF(A)3,4,4
51 C 4 CONTINUE
52 C *****
53 C *****
54 C * THE BIG DO LOUVE INCREMENTS "A" THE WIDTH OF *
55 C * THE LOUVRE.. THIS WILL DRAW THE DIFFERENT *
56 C * CURVES..THE LITTLE DO LOUVE DRAWS THE *
57 C * CURVE IT SELF.. TOGETHER THEY WILL DRAW 6. *
58 C *****
59 C 99 DO 20 J=1,6
60 C K=0
61 C PLUS=(C+E)*SIN(F)+A*SIN(B-F)
62 C TAN=SIN(B-F)/COS(B-F)*(G+(C+E)*COS(F)-A*COS(B-F))
63 C H=THE HEIGHT AT WHICH VISIBILITY IS 100%
64 C H=PLUS*TAN
65 C D=H-20
66 C D1=D
67 C *****
68 C DO 23 M=N,2000
69 C IF (M)33,55,55
70 C 33 CONTINUE
71 C THESE ARE SET UP IN MY EQUATION FOR "W"
72 C DIV=A*(H-D)*(COS(B)/SIN(B)*COS(F)+SIN(F))
73 C DIVER=H*1/SIN(B-F)-A-E*SIN(F)*1/SIN(B-F)
74 C DIVER2=(D-H)*COS(F)*SIN(B)

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