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GUN BLAST FROM NAVAL GUNS

by

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Test and Evaluation Department



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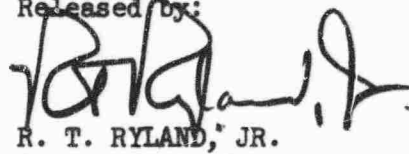
FOREWORD

The principal gun blast effort during the period covered by this report was concerned with the development of computer programs for curve fitting and data handling. This work included a mathematical model of the free-air gun blast field and a compilation of blast data for most calibers of naval guns. The computer programs developed are presently being used at the Naval Weapons Laboratory in connection with the reduction of all gun blast data.

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This report was reviewed by Messrs. F. F. Churchill, D. C. Ross, J. J. Yagla and Dr. G. R. Moore of the Instrumentation and Environments Division.

Released by:



R. T. RYLAND, JR.

Acting Head, Test and
Evaluation Department

ABSTRACT

The available data on gun blasts from naval guns are compiled utilizing computer curve fitting techniques. Curves of peak free-air pressure are presented for all naval guns, ranging in size from 20 mm to 16"/50. In addition, curves of arrival time, duration and impulse are given for three of these guns. Development of the computer programs and data reduction methods which were used to model the free-air gun blast field are described.

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INTRODUCTION

Gun blasts cause damage to ship and aircraft structures near the gun muzzle. In the past, parameters of the blast field near most Naval guns were measured, but the data had not been compiled in a systematic manner. The current work was undertaken to supply the information available on gun blast in a form that satisfies a long standing need. These data, when furnished to designers, should contribute to improvements in the design of structures to resist gun blast damage.

Individual readings of blast data must be organized into regular groupings such as blast curves. The collection of blast data was begun in 1905 with the introduction of a mechanical gauge called the Williams Blast Meter. These data were furnished in the form of blast curves which were widely distributed to shipyards and design activities. The Williams gauge 7 pound curve was formerly considered the limiting blast factor for structural and personnel damage, although the rationale for either use had not been well documented. The present effort provides the best available set of data on blast from naval guns. Some revision to the curves will be required when additional data are obtained.

The blast field around a gun is very similar to the shock field around explosives. However, the gun blast wave is produced by a large quantity of high pressure propellant gas having a high velocity along the axis of the gun. The large momentum component of the propellant gas along the gun axis leads to a pressure field that is asymmetrical about the muzzle plane.

Gun blasts sometimes exhibit other characteristics such as secondary blast. The secondary blast causes a second shock wave which follows the primary wave. Secondary blast is caused by certain powder formulations, the unburned propellant and gaseous products of which are ignited upon mixing with air. The newer, non-flashing propellants have significantly reduced the occurrence of secondary blast. The data supplied in this report neglect any secondary shocks and are only concerned with the primary free-air blast wave. Reflections of shock waves with decks or other surfaces are not analyzed or presented.

OBJECTIVE

The objective of this project was to develop a method for compiling gun blast data and presenting them in the form of pressure contours. The parameters considered most important to present were peak free-air pressure, arrival time, duration and impulse. These parameters describe the free-air blast field about the muzzle of a gun. Such knowledge is necessary before the reflected blast field about an actual gun installation may be determined.

PROCEDURES

The compilation of gun blast data began with a search of Naval Weapons Laboratory files for all available gun blast data and with the selection of those data which could be used. The principal effort was an attempt to mathematically model the blast field and to then generate the blast contours by using a computer. The final step in the compilation of data for each gun was the plotting of the contours, giving the blast field around the gun muzzle. The description of the process of developing the contours from the experimental data is detailed in the following paragraphs.

The data on gun blast which were available in the files included isolated measurements which were made for various purposes, often as secondary objectives on other tests. For most of these tests, the data were part of such an incomplete set they were usually bypassed in favor of more complete studies in which a large sector of the blast field was measured. These blast tests were usually conducted with the gun firing horizontally and the gauges mounted in the horizontal plane containing the gun. The data were usually taken at regular angles around the muzzle, such as 15, 30, 45, etc. degrees measured from the extended bore axis and muzzle of the gun.

For some guns it was not economical to fire at 0 degree elevation for the sole purpose of obtaining free-air gun blast data (the 16"/50 gun for example). In these cases, the gun was usually fired at a high angle of elevation. To be useful, the data measurement locations had to be transformed from ground coordinates to coordinates around the gun muzzle and bore axis extended. This procedure was considered valid since the free-air blast is assumed symmetrical about the gun axis.

The data for some guns were acquired recently and the oscillograph traces were still available. To prepare these data for subsequent tabulation, the records for each round were measured at several identifiable points on the record. Figure 1 shows a typical gun blast pressure trace and the idealized pressure wave as represented by the average wave.

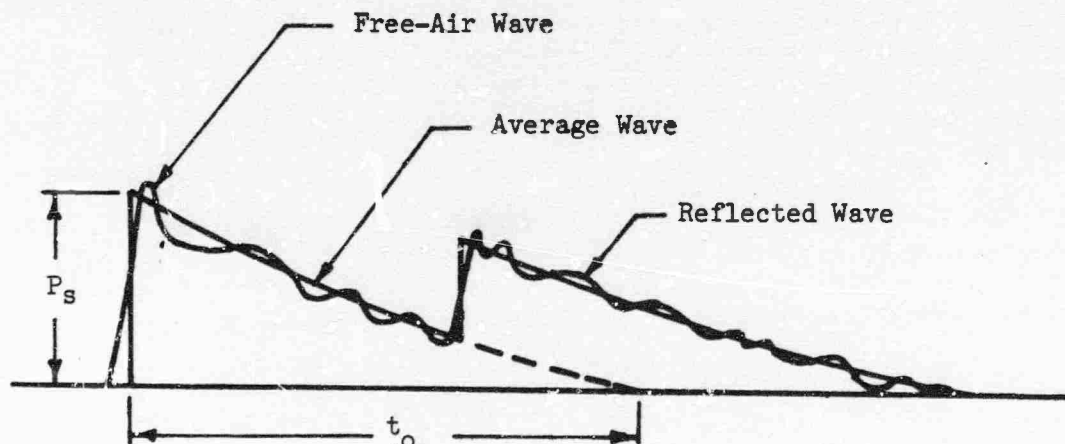


Figure 1. Typical Gun Blast Pressure Trace

The average wave can be represented by the Friedlander equation

$$P(t) = P_s (1 - t/t_0) e^{(-t/t_0)}$$

Where,¹

- $P(t)$ = Pressure at time t (psi)
- P_s = Peak pressure (psi)
- t = Time from the instant of shock arrival at the gauge (msec)
- t_0 = Duration of the pressure above ambient (msec)
- e = 2.7183

¹In this report the term "pressure" means the pressure in excess of one atmosphere.

A computer program was used to assist in the data reduction and tabulation. This program was particularly useful in estimating the free-air duration in those cases in which the reflected wave partially obscured the free-air wave as shown in Figure 1. This was accomplished by measuring the free-air pressure just before the reflected wave occurred, and then having the program vary the duration in small increments until the Friedlander curve was found which best fit the average free-air wave. This method served to describe the wave completely since the impulse could be easily calculated from the fitted Friedlander equation. The balance of this discussion will outline the methods developed to use the data to obtain blast pressure contours.

The first step in modeling the free-air blast field was to assume the pressure followed an inverse power law along radial lines from the muzzle. This assumption was previously used in references 1 and 2 and has been found to closely approximate experimental data.

It was desired to describe the complete field of interest from the bore axis extended (0 degrees) to directly aft of the muzzle (180 degrees). This required that the experimental data be extrapolated to include regions where the experimental data coverage was incomplete.

The assumption that the pressure follows an inverse power law along radial lines from the muzzle implies that plotted values of experimental pressure vs distance on a log-log graph should appear as straight lines. The slope and intercept of each straight line is dependent upon the angle from the line of fire at which the measurements were made. Finding analytical expressions for the angular dependence of the slopes and intercepts is the essence of the mathematical modeling of the blast field.

Pressure vs distance was plotted on log-log graphs as shown in Figure 2. Straight lines were constructed which best fit the experimental data for each angle for which data existed.

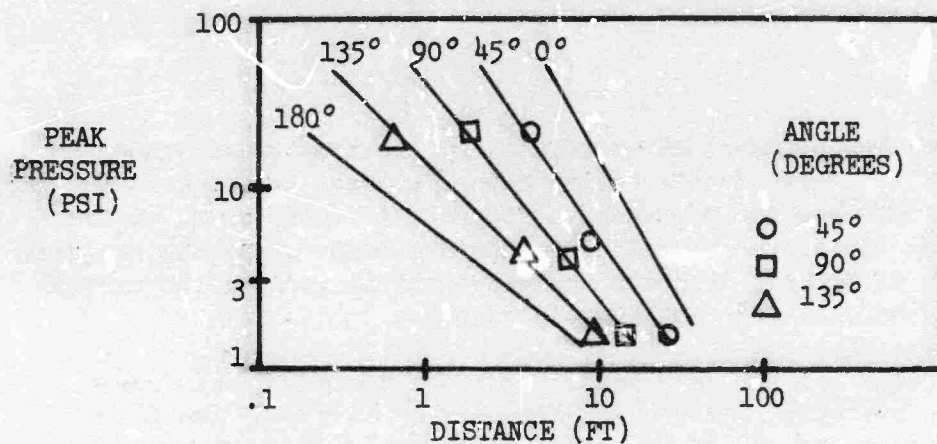


Figure 2. Typical Log-Log Graph of Pressure vs Distance

Additional lines, corresponding to angles for which experimental data did not exist, were drawn on the graph based on trends of the other lines and from scaling other caliber guns where data existed in these regions. The locations of some of the lines could be established from a single data point if adjacent lines were well defined. The log-log graph was then used to determine the radial distances from the muzzle at which 3 and 10 psi pressures existed for each of the thirteen radials that were chosen. The distances corresponding to the 3 and 10 psi pressures for the 13 angles were then plotted as shown in Figure 3. These contours were smoothed, as shown, to compensate for scatter in the data. The smoothed values of distance at the 13 chosen angles were then used as input to the curve fitting computer program, listed in Appendix B.

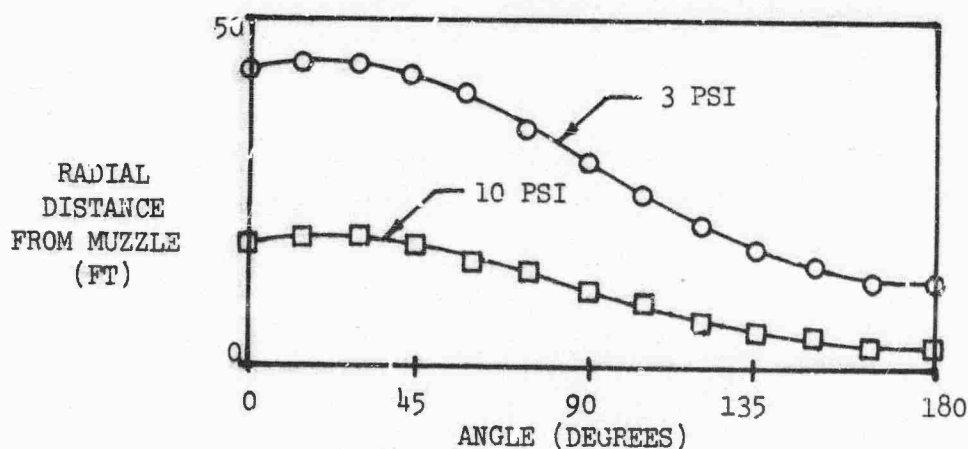


Figure 3. Typical 3 and 10 PSI Contours

The resulting contours as calculated by the program are shown in Figures 4 to 14. These smooth curves have also been modified to include experimental data and are repeated in Appendix A. Also shown on the curves in Appendix A are the calculated points computed by the program. The following paragraphs describe the mathematical formulation and computer program used in preparing the contours.

The computer program developed to compute the gun blast free-air peak pressure contours is listed in Appendix B along with its flow chart. It uses a standard orthonormal polynomial fit subroutine which has also been listed in Appendix B. A description of the computer program follows.

The first step in the computer program was to curve fit the 3 and 10 psi contours which were entered at 13 angles around the muzzle. This was done in an attempt to further smooth the contours.

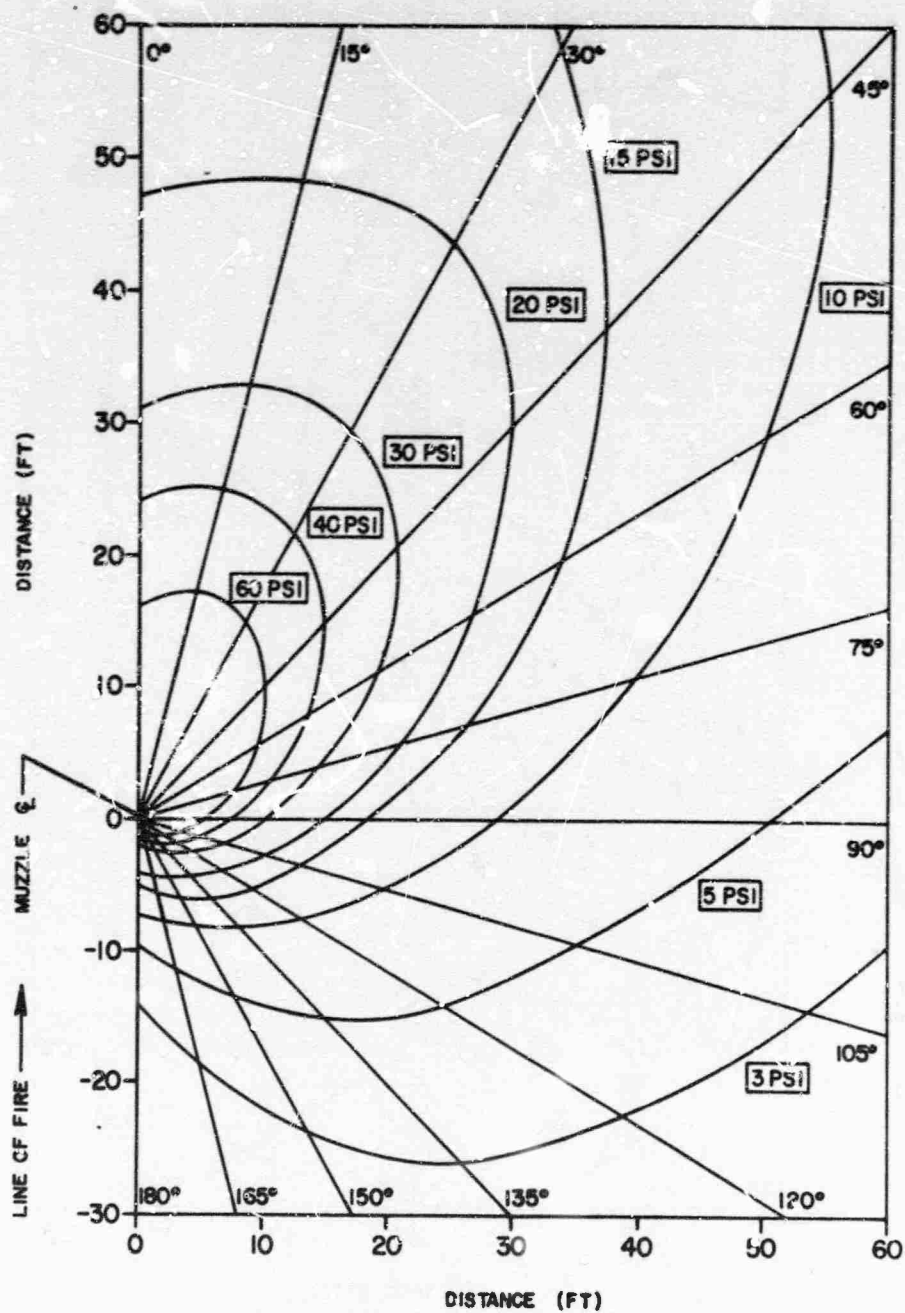
As noted earlier, the peak pressure was assumed to decrease as the inverse power of distance. This can be written as follows for each angle:

$$P_s = AD^{-N} \quad (1)$$

where

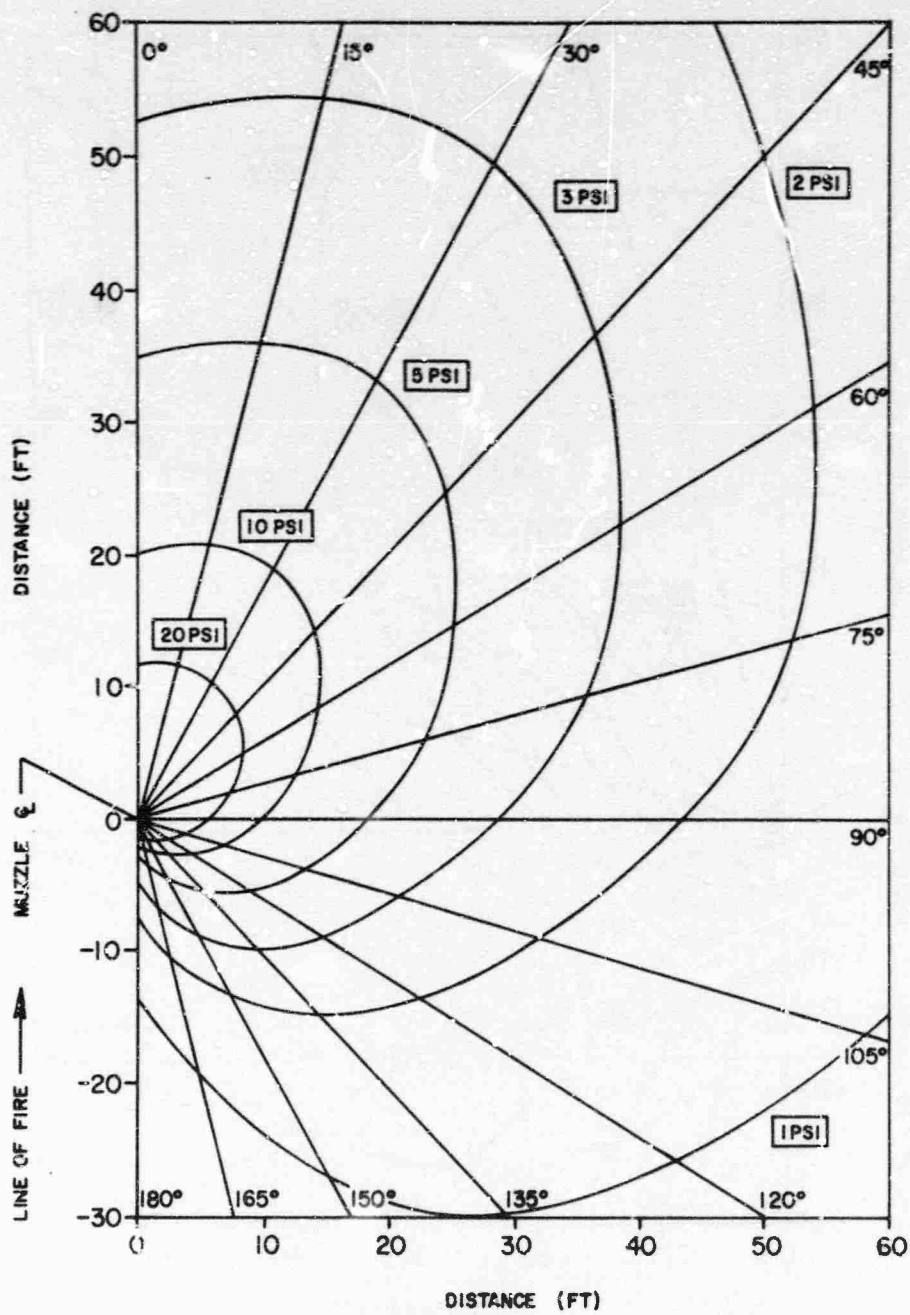
- P_s = peak pressure (psi)
- D = distance (ft)
- A = constant
- N = constant

The constant, $-N$, is the slope of the pressure vs distance curve when plotted on a log-log graph as shown in Figure 15.



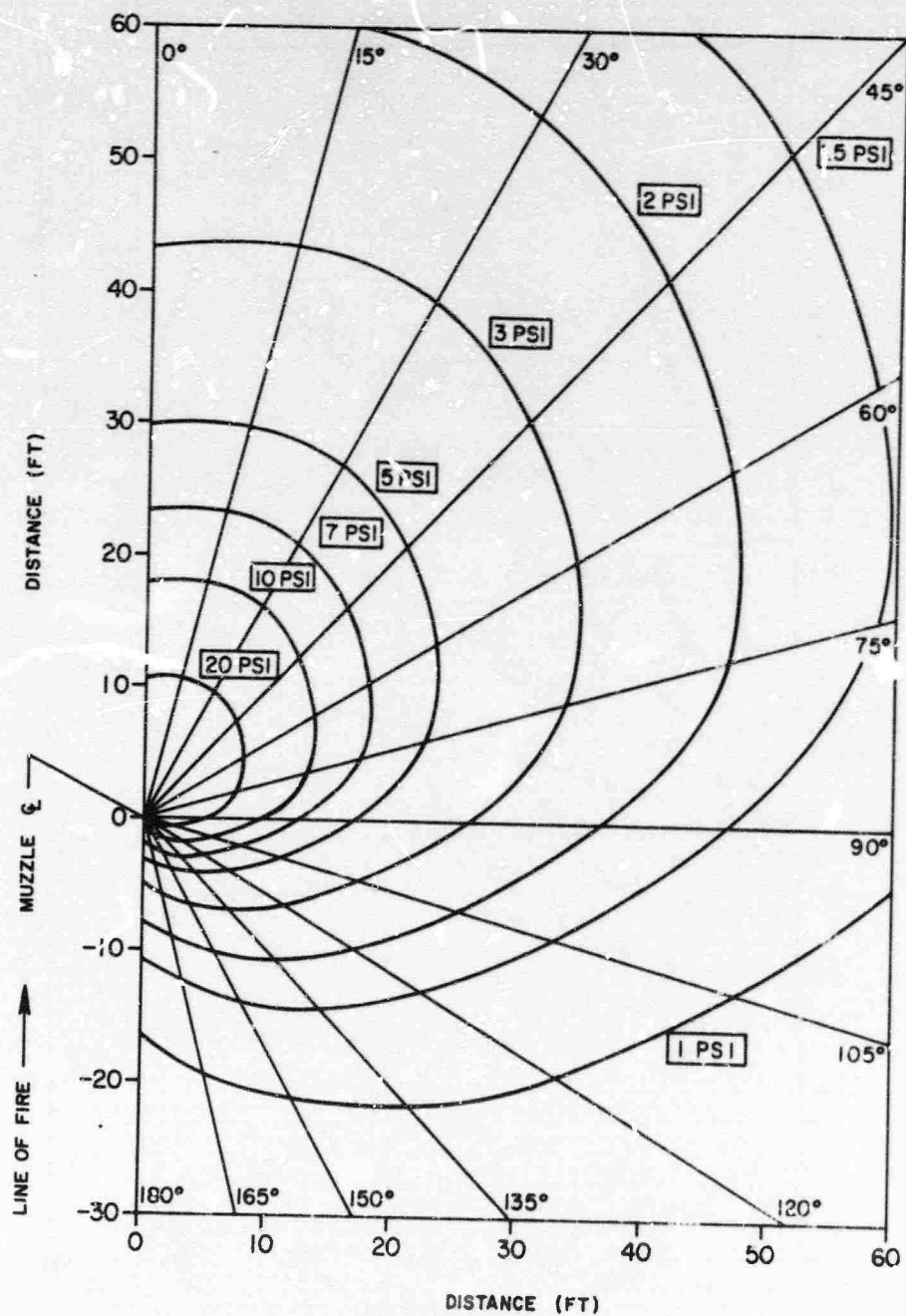
FREE-AIR PEAK PRESSURE CURVES FOR 16"/50 GUN

FIGURE 4

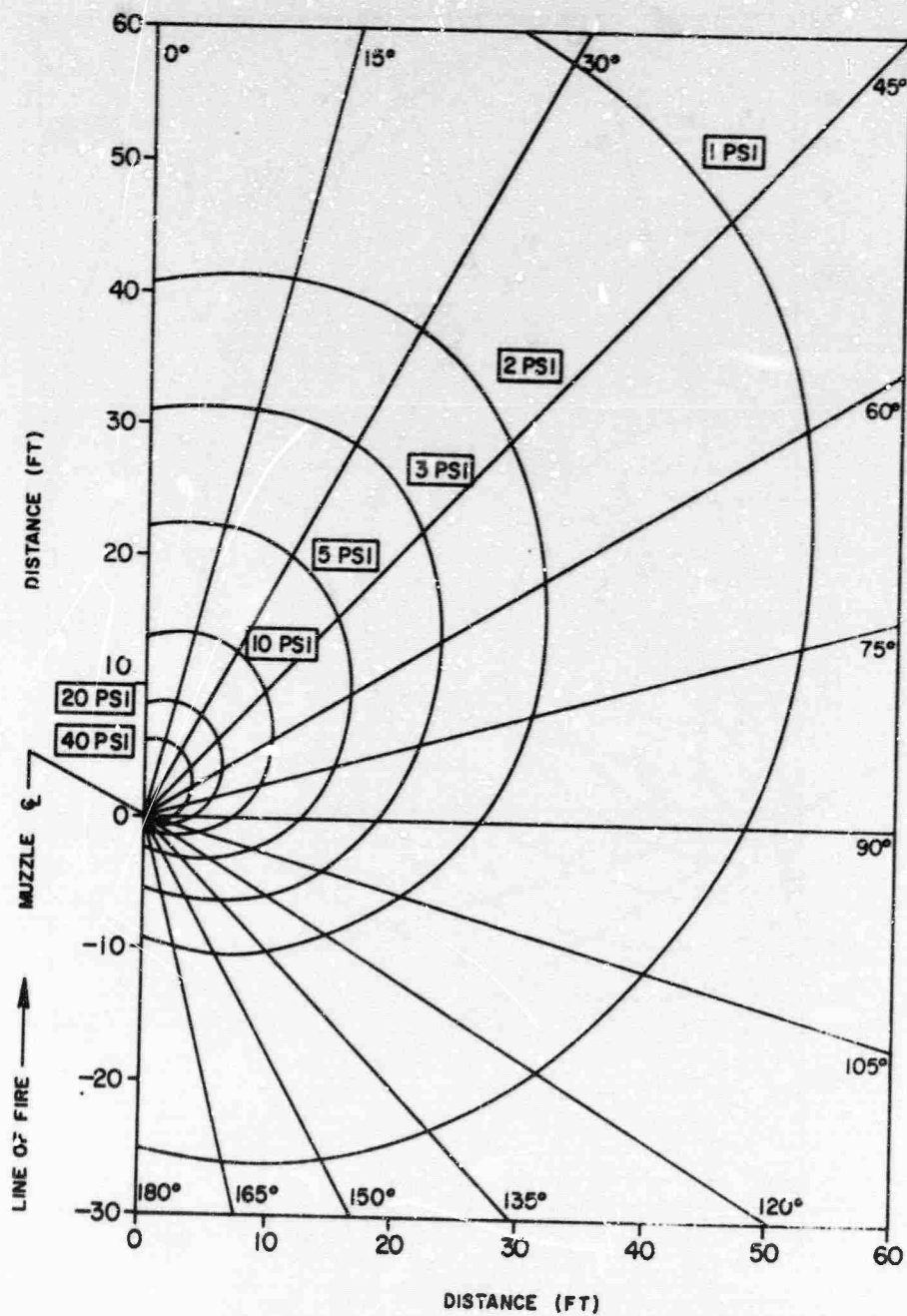


FREE-AIR PEAK PRESSURE CURVES FOR 8"/55 GUN

FIGURE 5

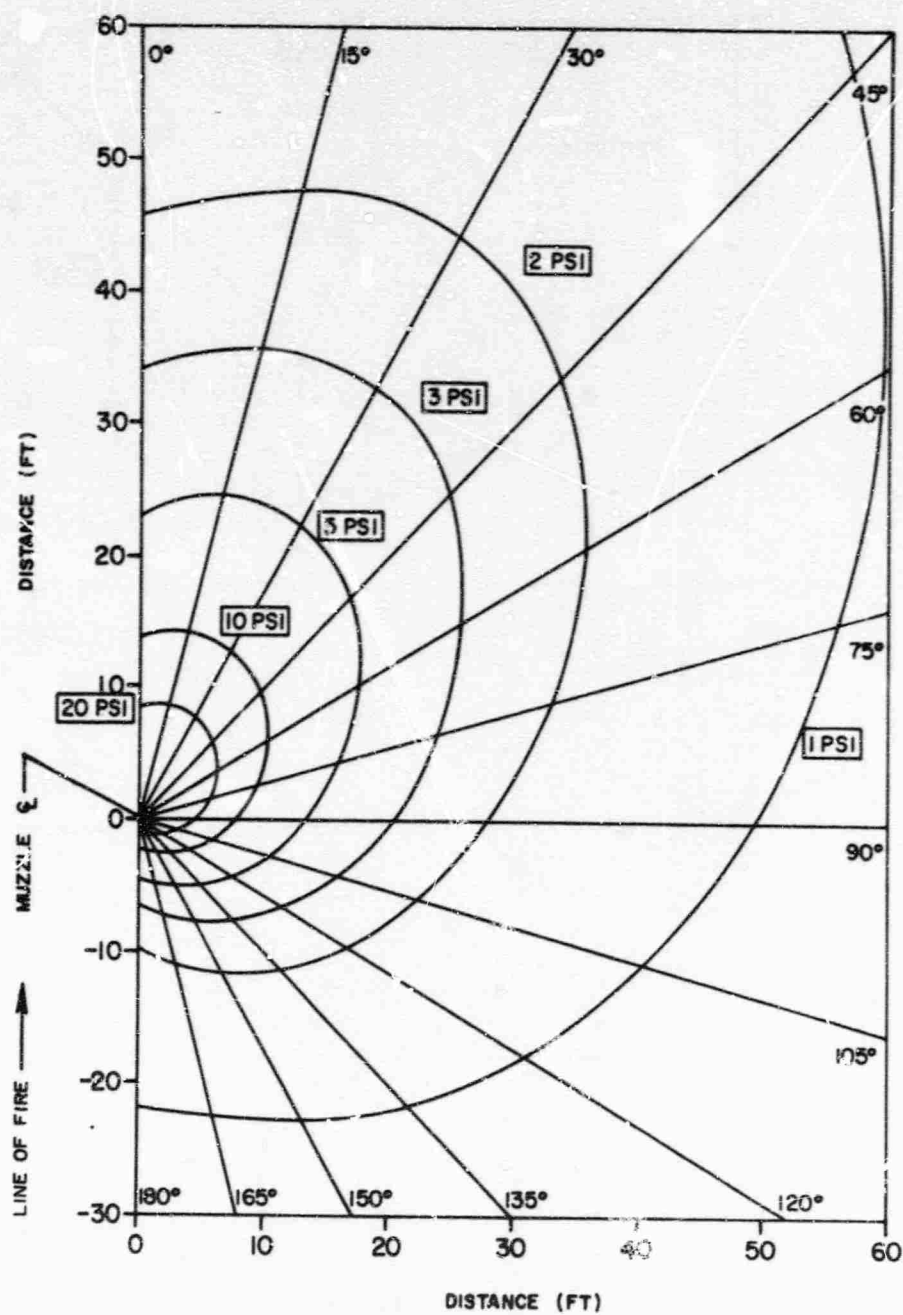


FREE-AIR PEAK PRESSURE CURVES FOR 6"/47 GUN
FIGURE 6



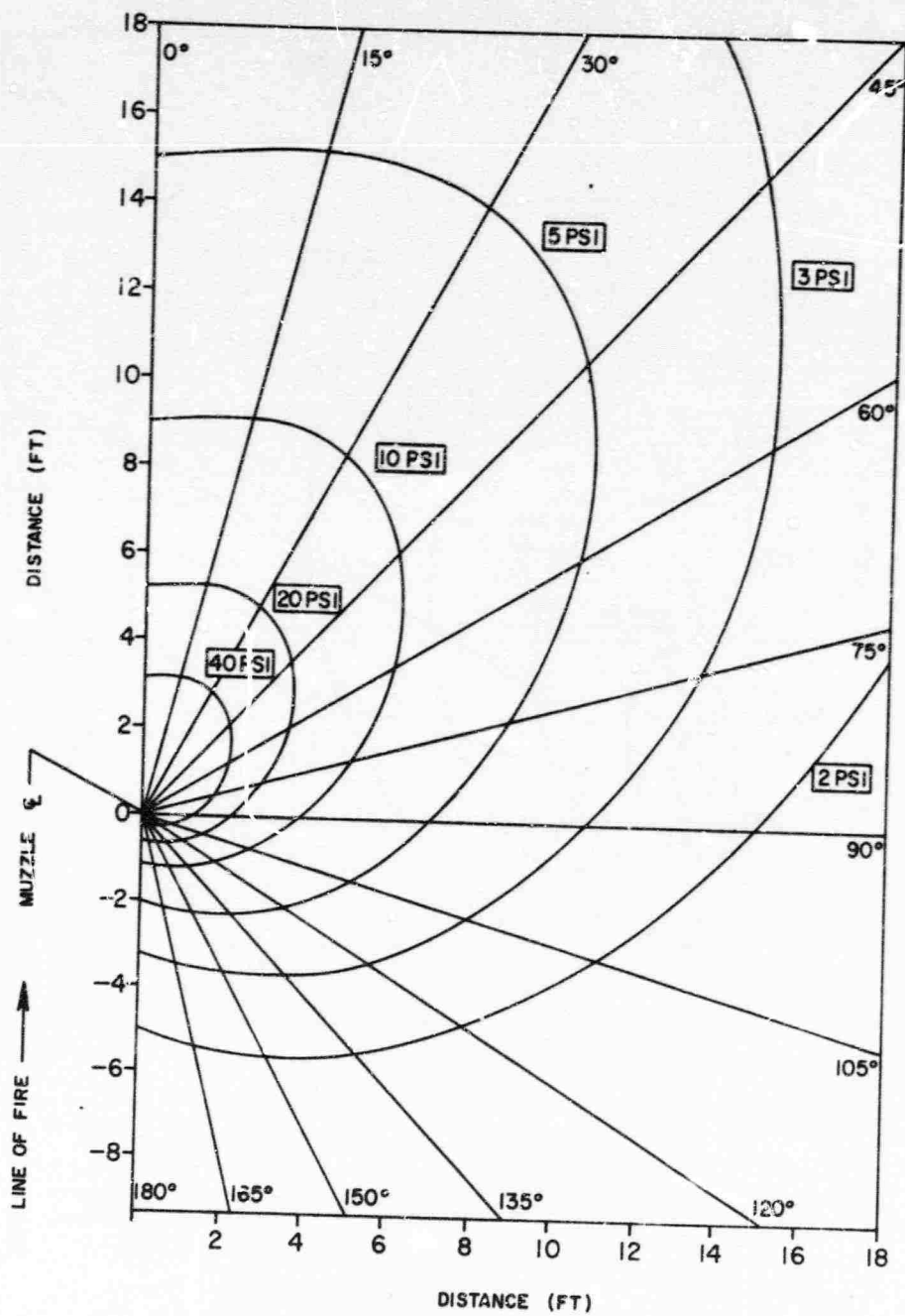
FREE-AIR PEAK PRESSURE CURVES FOR 5"/54 GUN

FIGURE 7



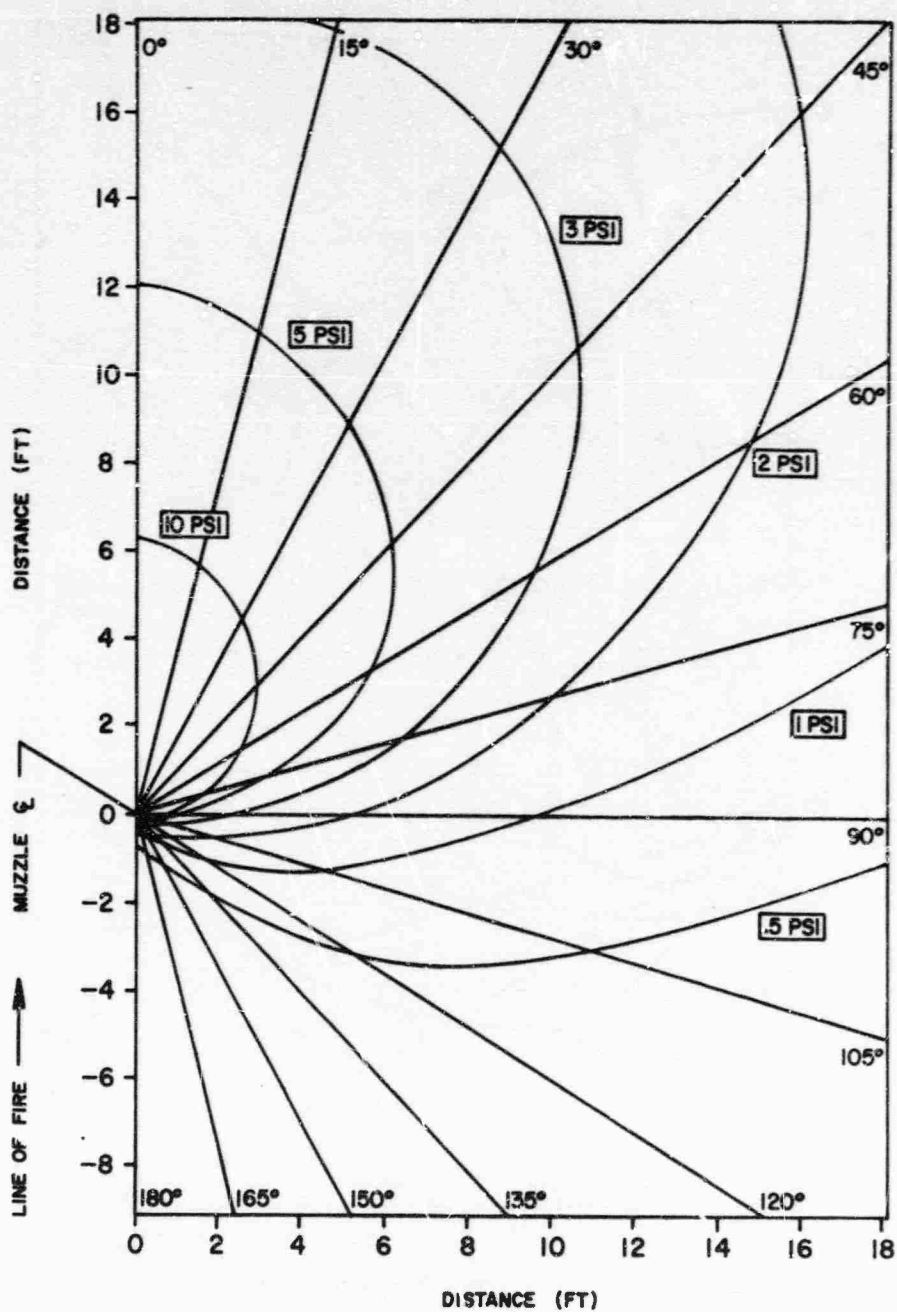
FREE-AIR PEAK PRESSURE CURVES FOR 5"/38 GUN

FIGURE 8



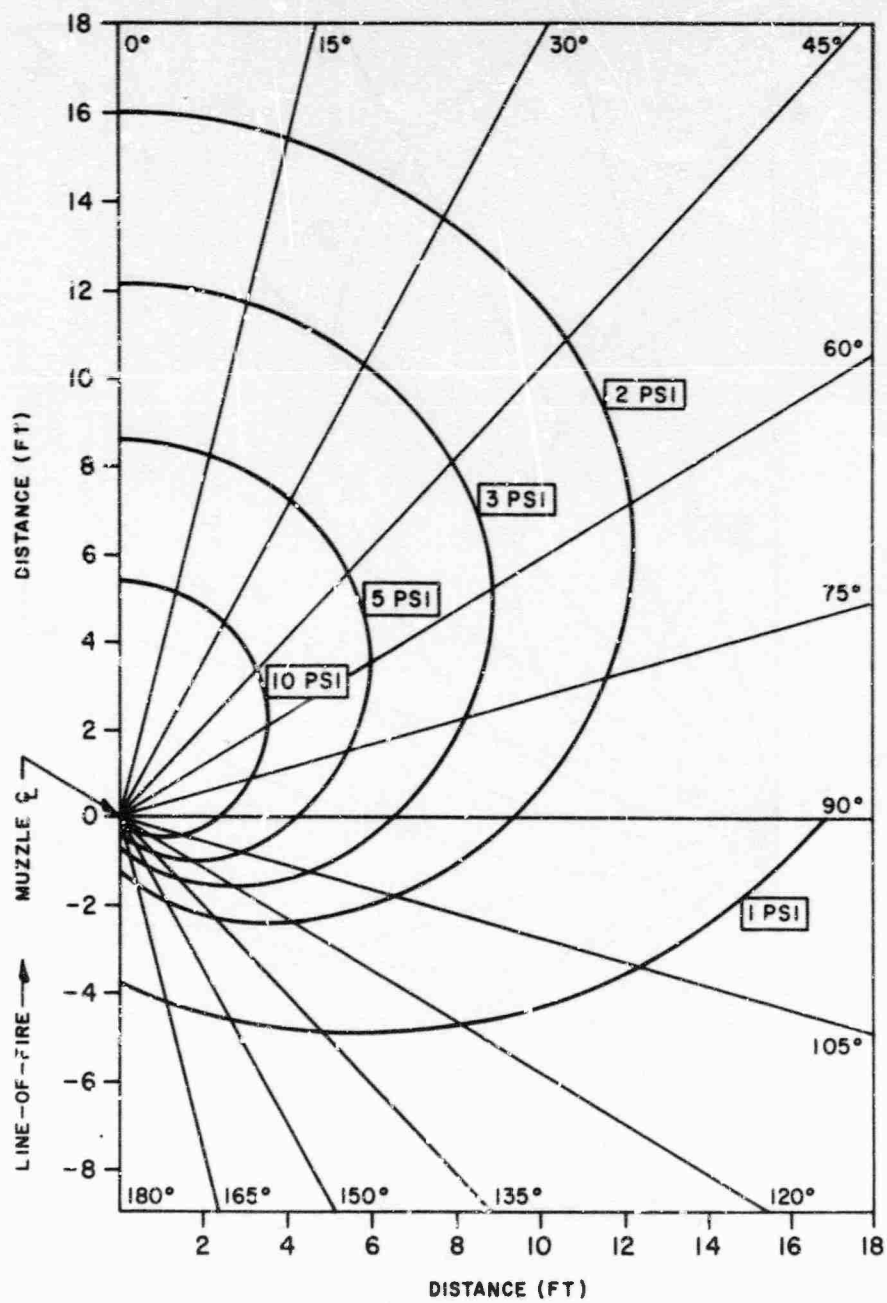
FREE-AIR PEAK PRESSURE CURVES FOR 3"/50 GUN

FIGURE 9



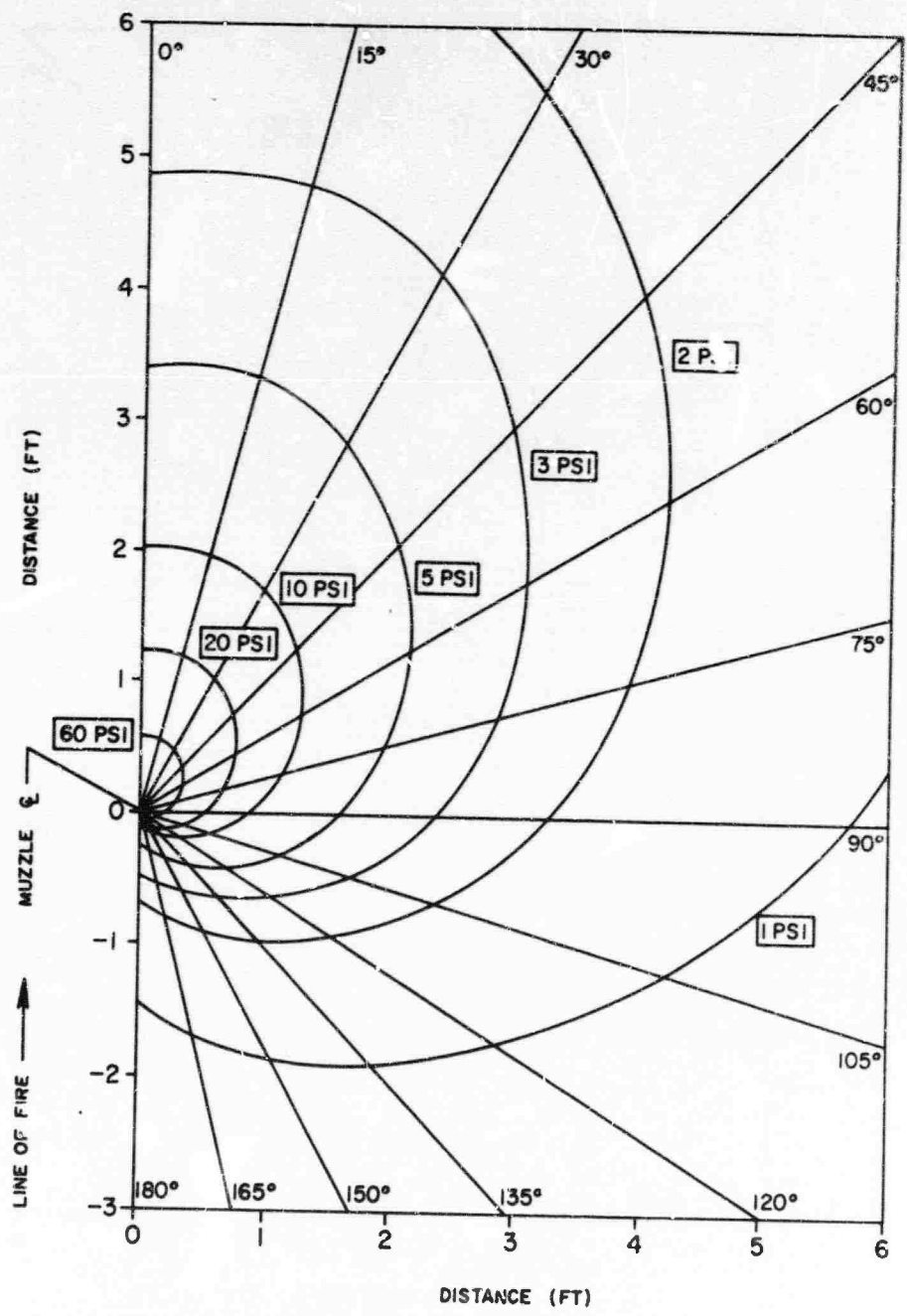
FREE-AIR PEAK PRESSURE CURVES FOR
40 MM GUN WITH FLASH HIDER

FIGURE 10



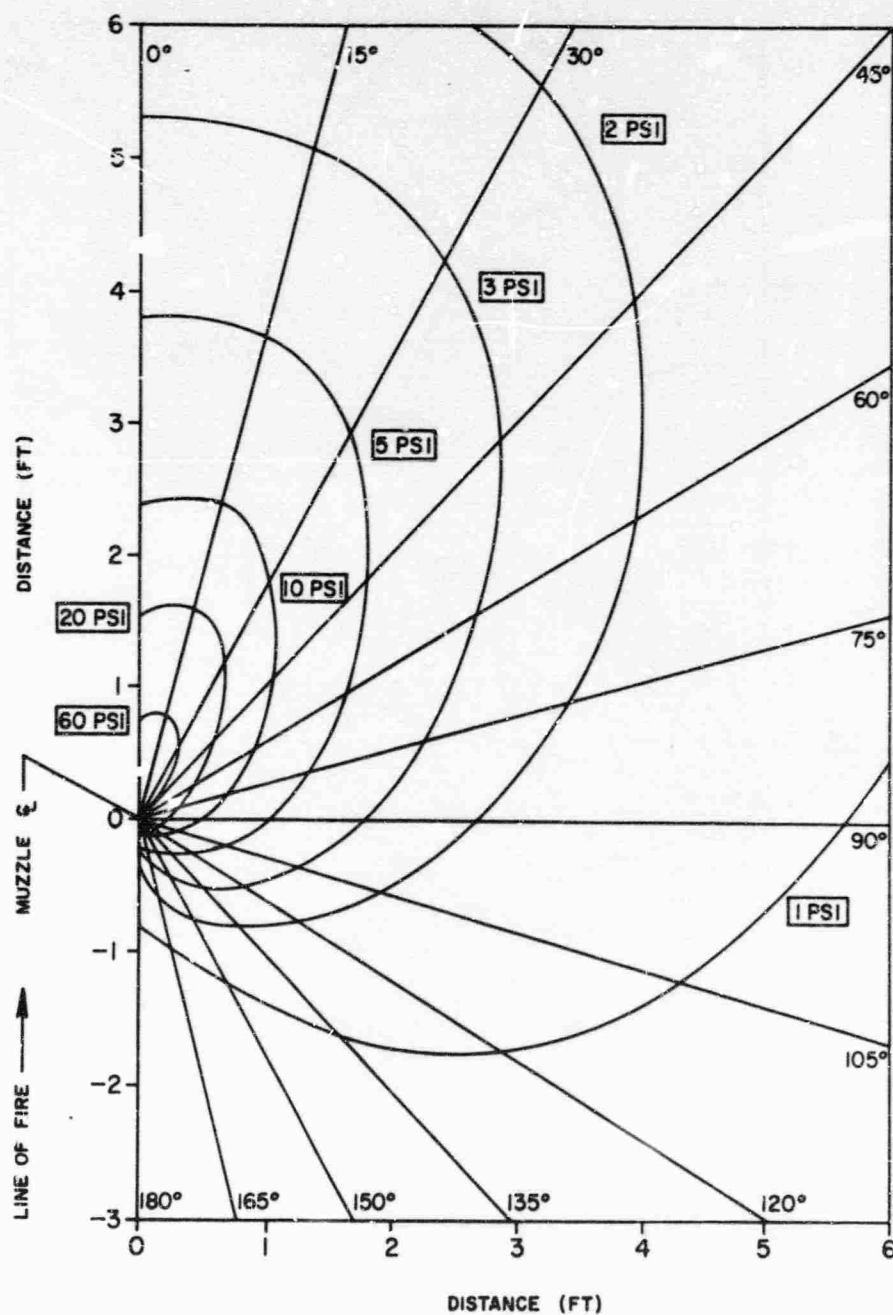
FREE-AIR PEAK PRESSURE CURVES FOR
40 MM GUN WITHOUT FLASH HIDER

FIGURE 11



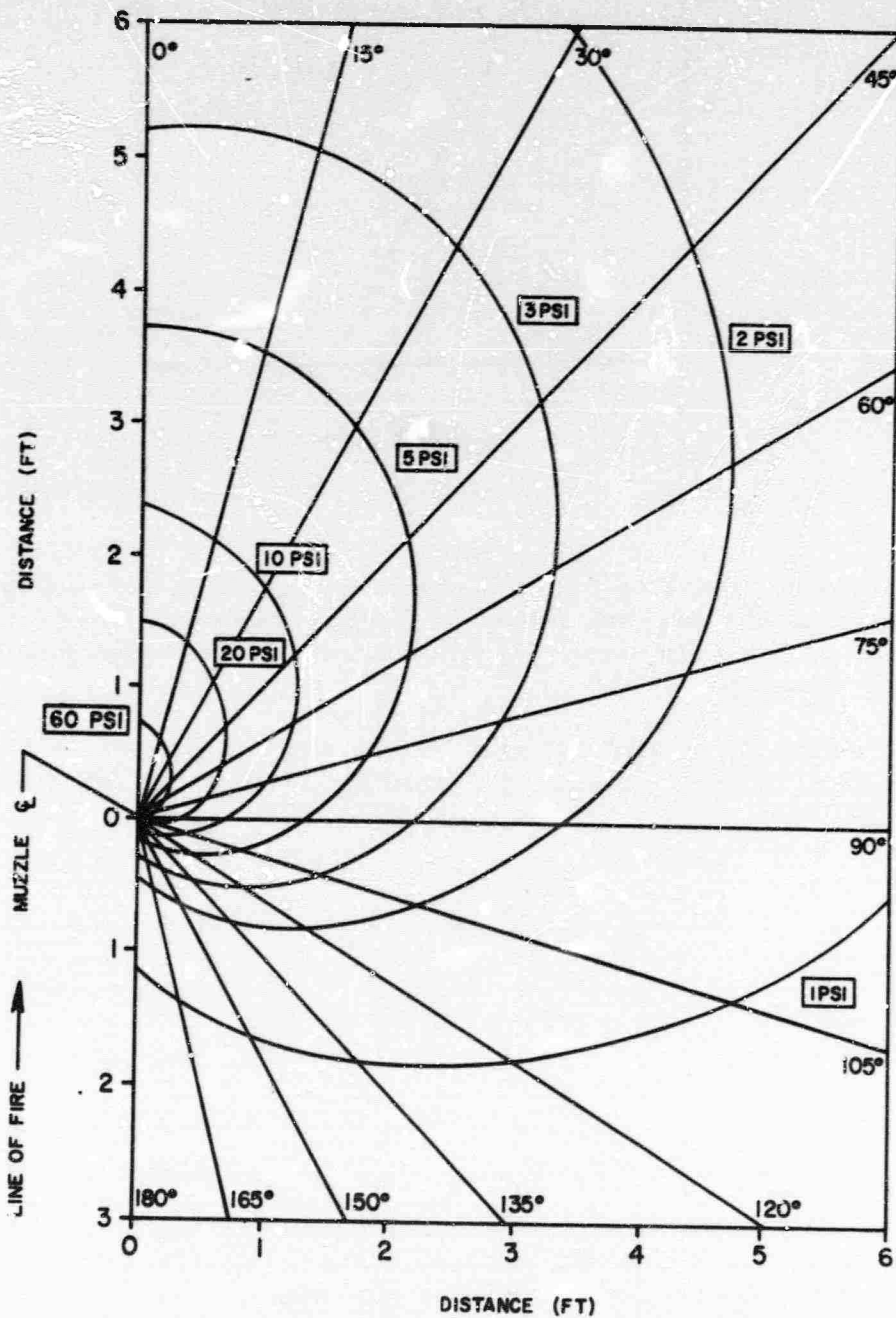
FREE-AIR PEAK PRESSURE CURVES FOR 20 MM M3 GUN

FIGURE 12



FREE-AIR PEAK PRESSURE CURVES FOR 20 MM XM 197 GUN

FIGURE 13



FREE-AIR PEAK PRESSURE CURVES FOR 20 MM MK 12 GUN

FIGURE 14

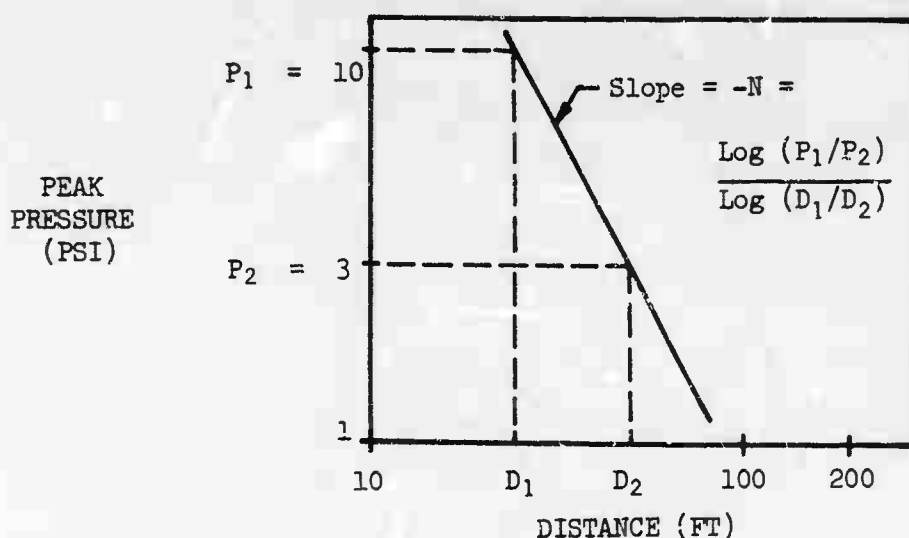


Figure 15. Log-Log Graph of Peak Pressure vs Distance and Definition of N

The values of the constants N are then calculated for each of the 13 angles from the smoothed values of distance corresponding to the 3 and 10 psi pressure contours. Next, equation (1) is solved for A, giving 13 values for A.

The constants A and N are next fitted with polynomials in terms of the angle, χ , measured from the extended bore axis and muzzle, giving

$$A = A_1 + A_2 X + A_3 X^2 + \dots + A_9 X^8 \quad (2)$$

$$N = N_1 + N_2 X + N_3 X^2 + \dots + N_9 X^8 \quad (3)$$

where $A_1, A_2, \dots, A_9$ and $N_1, N_2, \dots, N_9$ are the coefficients of the polynomial fits of the constants A and N. Substitution of the polynomials given by equations (2) and (3) into equation (1) completely describes the free-air peak pressure field about the gun muzzle.

$$P(D, \psi) = \left(\sum_{i=1}^9 A_i \psi^{i-1} \right) \left(D \sum_{i=1}^9 N_i \psi^{i-1} \right) \quad (4)$$

In Figures 16 and 17, typical graphs of the constants N and A have been shown as functions of muzzle angle. X.

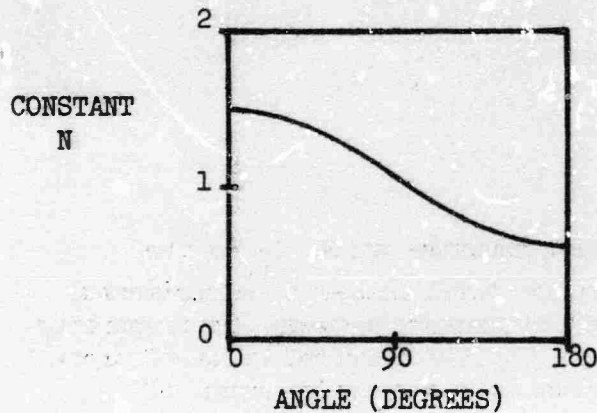


Figure 16. Typical Graph of Constant N vs Angle

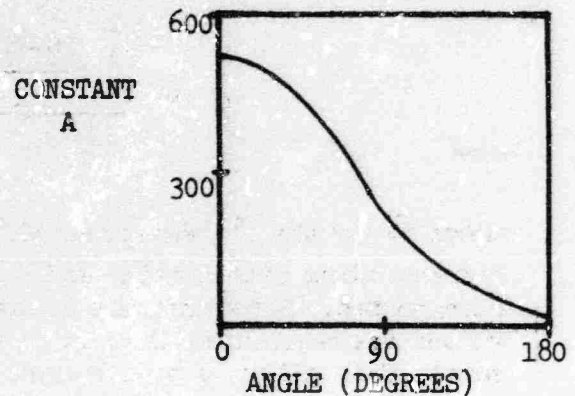


Figure 17. Typical Graph of Constant A vs Angle

Graphs of the constants A and N were constructed for all of the guns investigated in this report. They were used as a further check on the consistency between guns in regions around the gun muzzle where insufficient data existed.

After the computer program has calculated the coefficients for equations (2) and (3), the distances to the 3 and 10 psi pressures at the 13 regular angles are calculated using equation (4). This provides a direct comparison between the original values which were put into the computer program and the calculated values.

Next the program computes 21 contours ranging from .1 to 2000 psi pressure. These are provided as distances from the muzzle to each contour along each of the 13 angles.

Next all the experimental data are introduced. Each experimental pressure reading together with its free-air angle and distance are provided as input. Using the coefficients previously calculated, the program computes a pressure at the same location and compares it with the corresponding experimental value. Two statistical values are calculated for comparison purposes.

A normalized first moment, v_1 , is calculated as given by

$$v_1 = \frac{\sum_{i=1}^K \frac{P_i - \bar{P}_i}{P_i}}{K}, \quad (5)$$

where $\bar{P}_i$ is the i^{th} experimental peak pressure value, P_i is the corresponding fitted value and K is the total number of experimental data points. Note that the pressure difference between corresponding values has been normalized by dividing by the computed value of pressure. This allows a statistical check over the entire range of pressures.

The square root of the normalized second moment, v_2 , given by,

$$v_2 = \frac{\sum_{i=1}^K \frac{(P_i - \bar{P}_i)^2}{P_i}}{K}^{\frac{1}{2}}, \quad (6)$$

is also computed. The statistical computations for each gun are listed in Appendix E. The experimental data used in calculating the statistical values also included round-to-round variations in the experimental data. Therefore, the statistical values as given in Appendix E are not completely indicative of the accuracy of the fitting method since they also include variations in the experimental data.

The method developed to provide pressure contours was also used for arrival time, duration and impulse with no changes in the program, even though the slopes were positive in some cases.

RESULTS

The free-air gun blast curves presented in this report represent an accumulation of data taken over many years at the Naval Weapons Laboratory. Firing test data including date; Mark-Mod; propellant

type, index and weight; and projectile Mark and weight are listed in Appendix F. On tests where this information was not recorded or was not to be found, it has been indicated as "not available".

The small caliber guns such as the 20 mm have many configurations. Three 20 mm guns are presented in this report. Detailed records of small caliber gun tests are not permanently filed at NWL. Therefore, the firing test data for these guns are listed in Appendix F.

The free-air peak pressure curves are given in the body of this report as Figures 4 to 14 and a copy of each of these curves containing additional information is provided in Appendix A. For the 8"/55, 5"/54 and 3"/50 guns, preliminary curves giving the other parameters of arrival time, duration and impulse are also included in Appendix A. The dashed lines on the graphs in Appendix A enclose the areas in which experimental data were available. The experimental data points are shown by the square symbols to indicate the location of the measurement. The value of the experimental measurement is placed beside the symbol. The round symbols on the curves indicate the fitted data point locations as computed by the curve fitting program.

The experimental data which were used in constructing the log-log graph and in the statistical calculations are listed in Appendix C. Digital values for the contours which were generated by the curve fitting program are provided in Appendix D. This list is included since it contains a greater range of pressures than is shown on the graphs.

DISCUSSION OF RESULTS

The contour fitting technique described in this report was found to work well for determining the gun blast contours of peak pressure using experimental data. This technique allows a systematic determination of the complete gun blast pressure field with a limited amount of experimental data. The assumption that the peak pressure decays as an inverse power law along radial lines from the muzzle agrees well with experimental data over the ranges of pressure listed in Appendix C.

The shock wave arrival time data were also found to closely approximate the assumed radial decay. However, a common ejection or reference time has not been used in most gun blast tests. Thus the data presented may be shifted in time depending upon the method used to measure ejection time of the projectile. For this reason curves of arrival time have been marked "preliminary" although the discrepancy does not effect the accuracy of the shape of these curves, but will only shift the time increments slightly (less than 1 millisecond).

The contour fitting technique was also applied to duration and impulse gun blast data from the 8"/55, 5"/54 and 3"/50 guns. Both duration and impulse gun blast data contain considerable scatter due primarily to the method by which the data were taken. Reflections of the blast wave from the ground, gun mount and other structures are superimposed on the free-air wave making it difficult to determine the precise duration or impulse of the free-air blast wave. For this reason it was not possible to completely evaluate the assumption that duration and impulse follow an inverse power law along radial lines from the muzzle. Therefore the contour graphs of duration and impulse have also been labeled "preliminary".

The statistical comparison between the computed contours and experimental data is given in Appendix E. Although these values also include round-to-round variations in the experimental data, the fit is in general quite good for both peak pressure and arrival time. The 16"/50, 20 mm M3 and 20 mm XM197 guns show somewhat more variation, but this is primarily due to scatter in the experimental data and particularly the lack of data in the case of the 16"/50 gun.

CONCLUSIONS

A large body of experimental gun blast data have been systematically analyzed and presented. The contour fitting computer program and methods of data handling which were developed under this research project provide a means of translating experimental data readings into useful graphs and tables.

The free-air gun blast curves presented were computed from the best currently available gun blast data. As new and more extensive experimental data become available, the techniques presented in this report may be used to compute new and more accurate free-air gun blast contours.

REFERENCES

- (1) M. Walther "Gun Blast From A 5"/54 Gun" Naval Proving Ground, Dahlgren, Virginia, Report No. 1608 dated 30 July 1958.
- (2) M. Walther "Blast Studies; Gun Blast From a 5"/38 Gun" Naval Proving Ground, Dahlgren, Virginia, Report No. 1307 dated 26 Nov 1954.

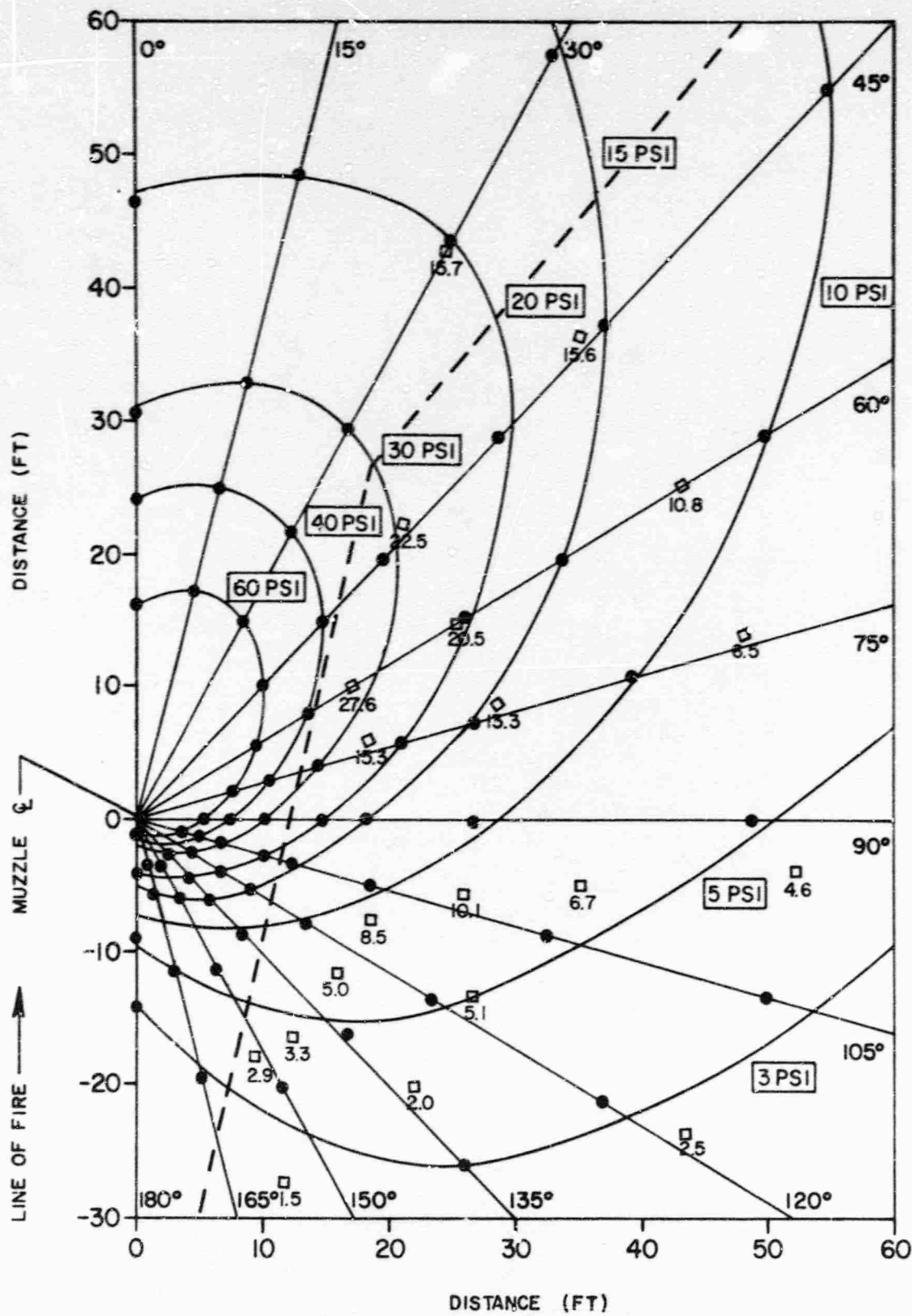
APPENDIX A

GUN BLAST CURVES WITH EXPERIMENTAL
DATA AND COMPUTER GENERATED POINTS

APPENDIX A

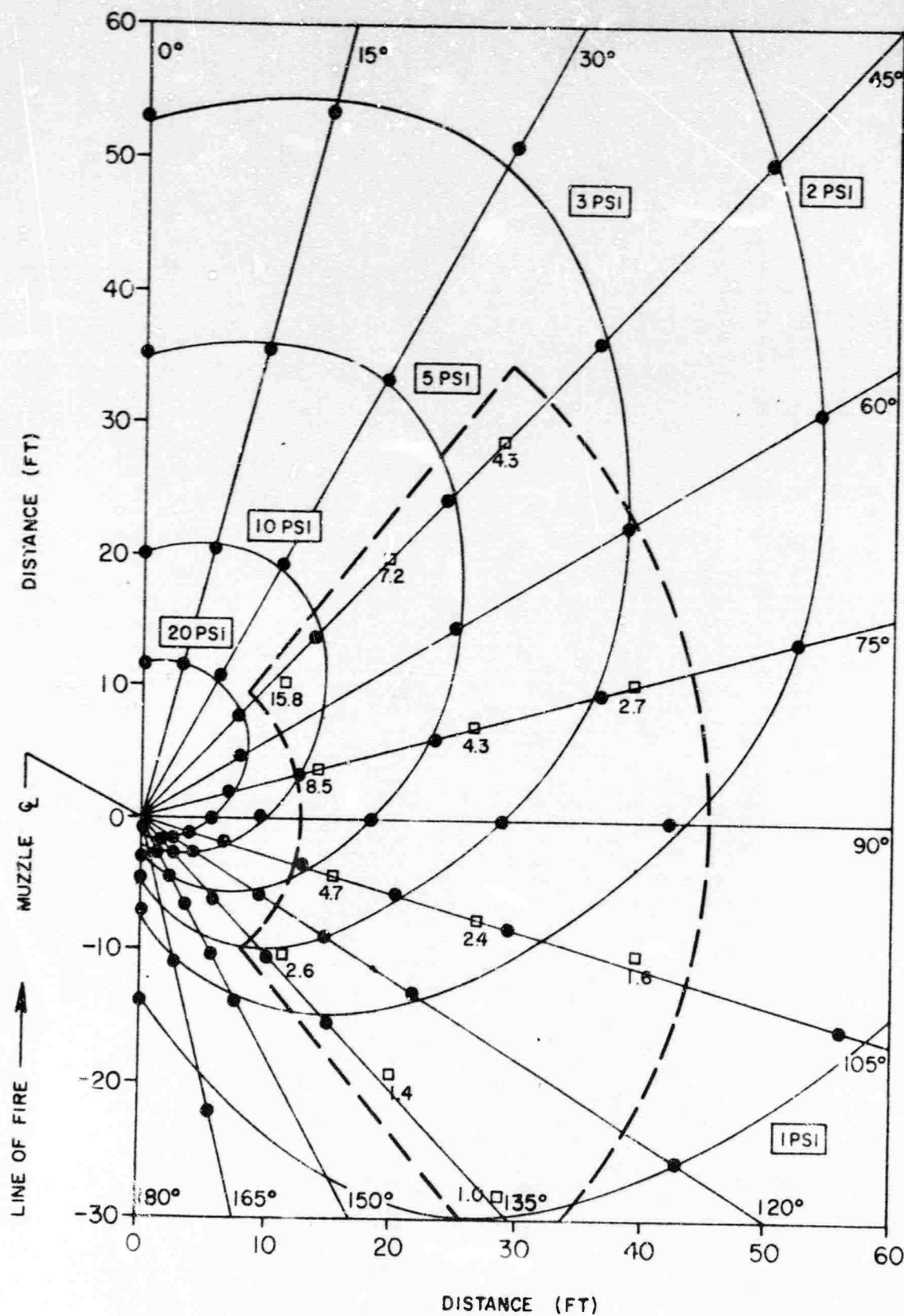
GUN BLAST CURVES WITH EXPERIMENTAL DATA AND COMPUTER GENERATED POINTS

- Figure A-1 Free-Air Peak Pressure Curves for 16"/50 Gun
- A-2 Free-Air Peak Pressure Curves for 8"/55 Gun
 - A-3 Free-Air Arrival Time Curves for 8"/55 Gun (preliminary)
 - A-4 Free-Air Duration Curves for 8"/55 Gun (preliminary)
 - A-5 Free-Air Impulse Curves for 8"/55 Gun (preliminary)
 - A-6 Free-Air Pressure Curves for 6"/47 Gun
 - A-7 Free-Air Pressure Curves for 5"/54 Gun
 - A-8 Free-Air Arrival Time Curves for 5"/54 Gun (preliminary)
 - A-9 Free-Air Duration Curves for 5"/54 Gun (preliminary)
 - A-10 Free-Air Impulse Curves for 5"/54 Gun (preliminary)
 - A-11 Free-Air Pressure Curves for 5"/38 Gun
 - A-12 Free-Air Peak Pressure Curves for 3"/50 Gun
 - A-13 Free-Air Arrival Time Curves for 3"/50 Gun (preliminary)
 - A-14 Free-Air Duration Curves for 3"/50 Gun (preliminary)
 - A-15 Free-Air Impulse Curves for 3"/50 Gun (preliminary)
 - A-16 Free-Air Peak Pressure Curves for 40 mm Gun With Flash Hider
 - A-17 Free-Air Peak Pressure Curves for 40 mm Gun Without Flash Hide
 - A-18 Free-Air Peak Pressure Curves for 20 mm M3 Gun
 - A-19 Free-Air Peak Pressure Curves for 20 mm XM 197 Gun
 - A-20 Free-Air Peak Pressure Curves for 20 mm MK 12 Gun



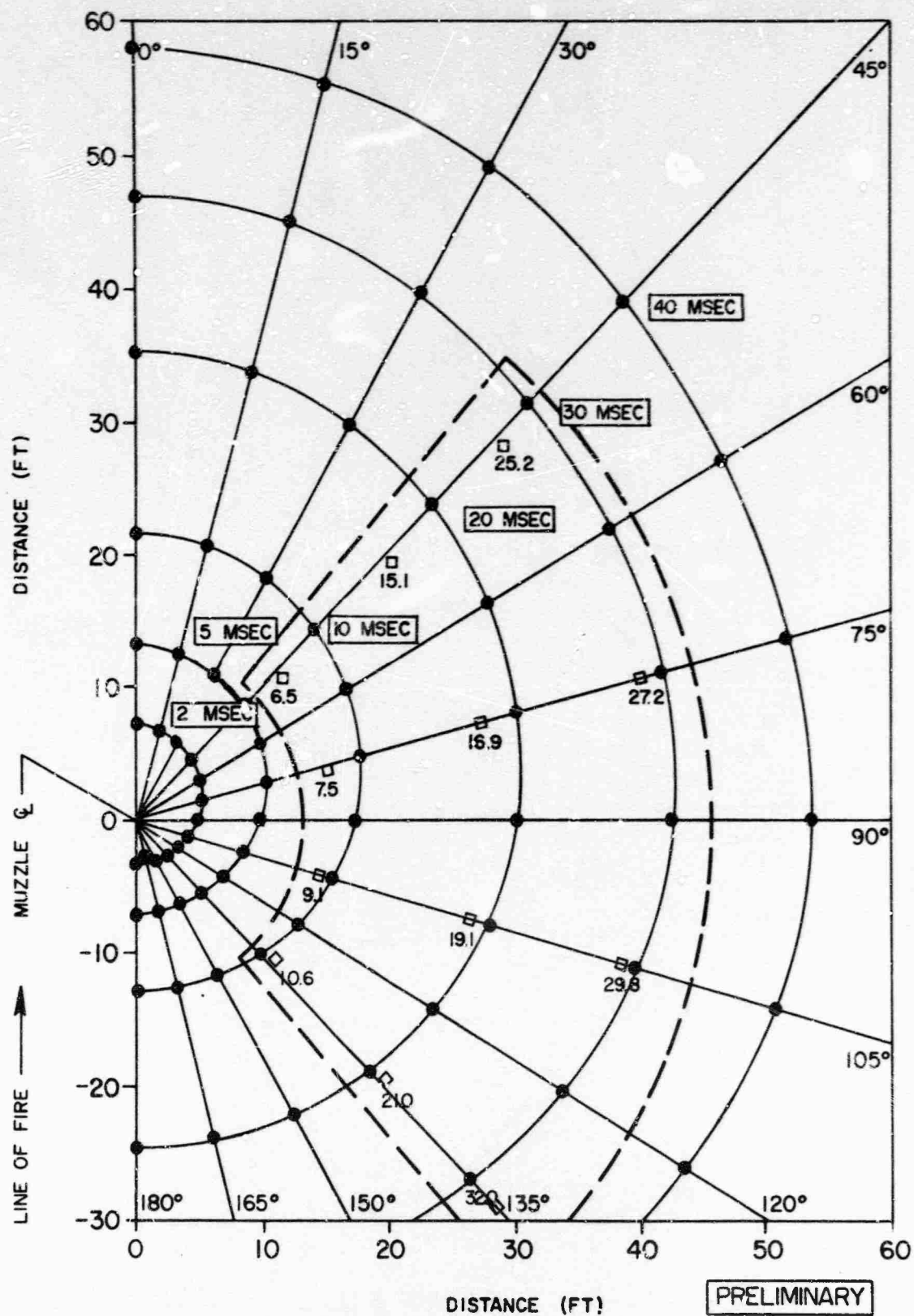
FREE-AIR PEAK PRESSURE CURVES FOR 16"/50 GUN

FIGURE A-1



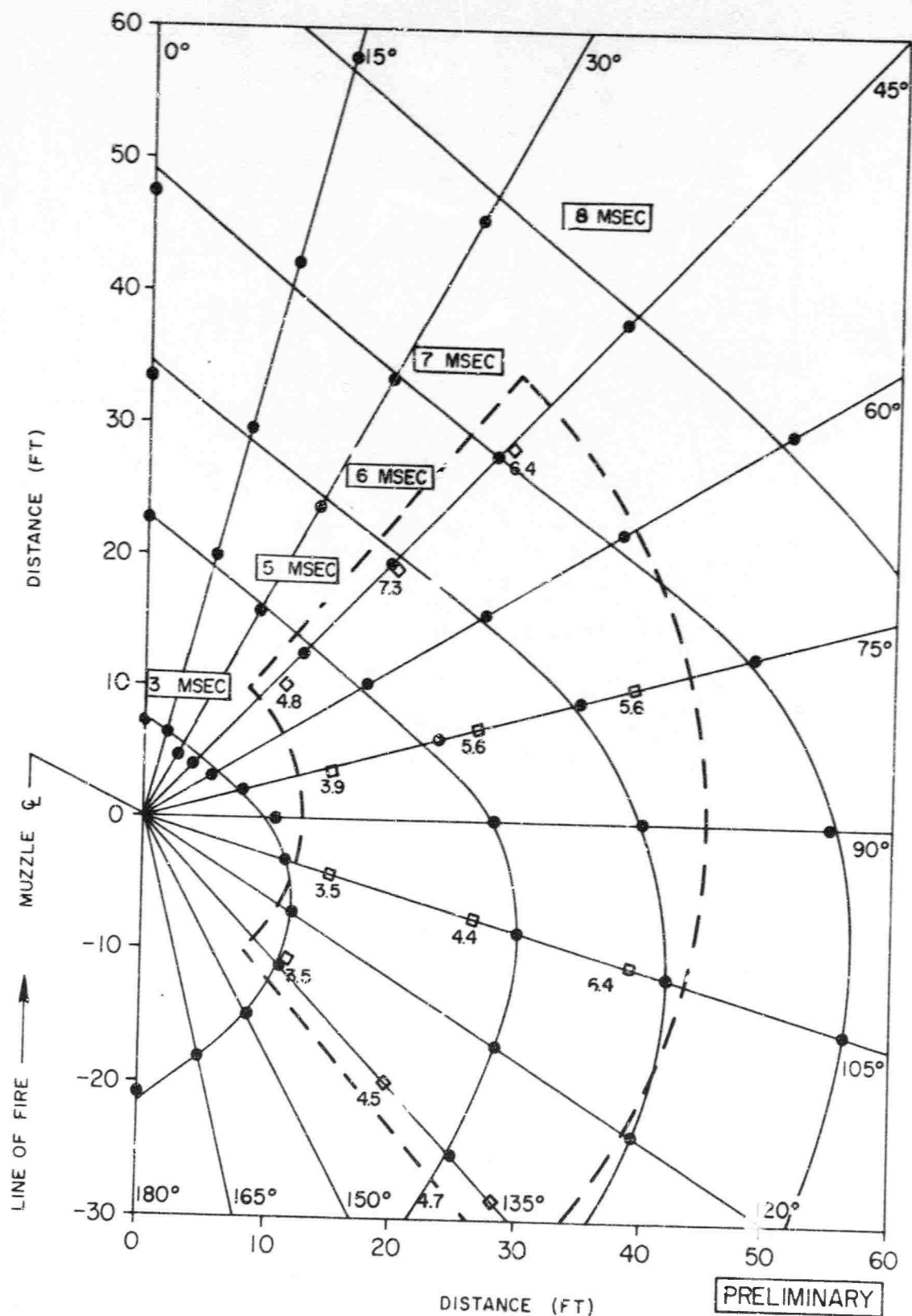
FREE-AIR PEAK PRESSURE CURVES FOR 8"/55 GUN

FIGURE A-2



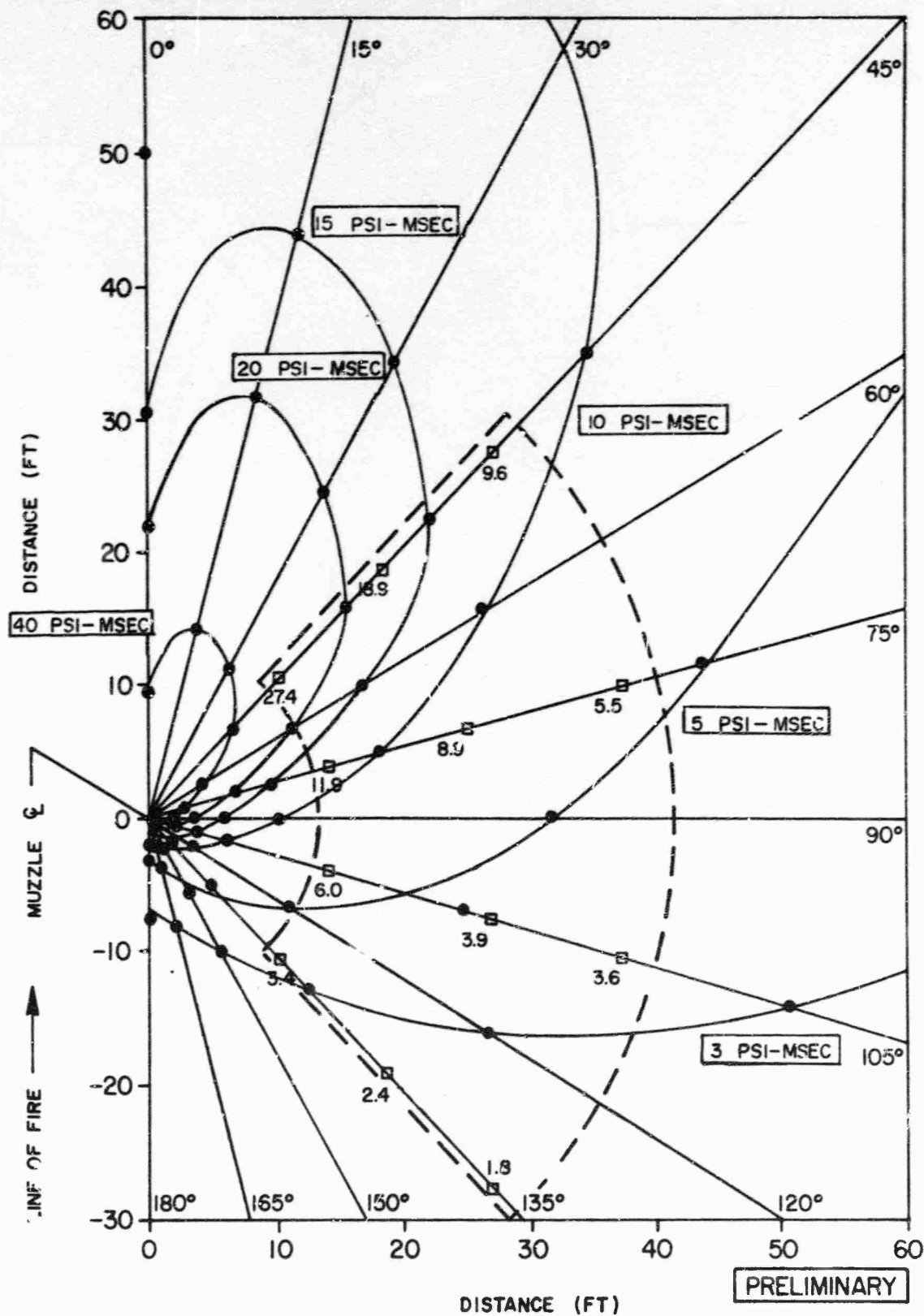
FREE-AIR ARRIVAL TIME CURVES FOR 8"/55 GUN

FIGURE A - 3



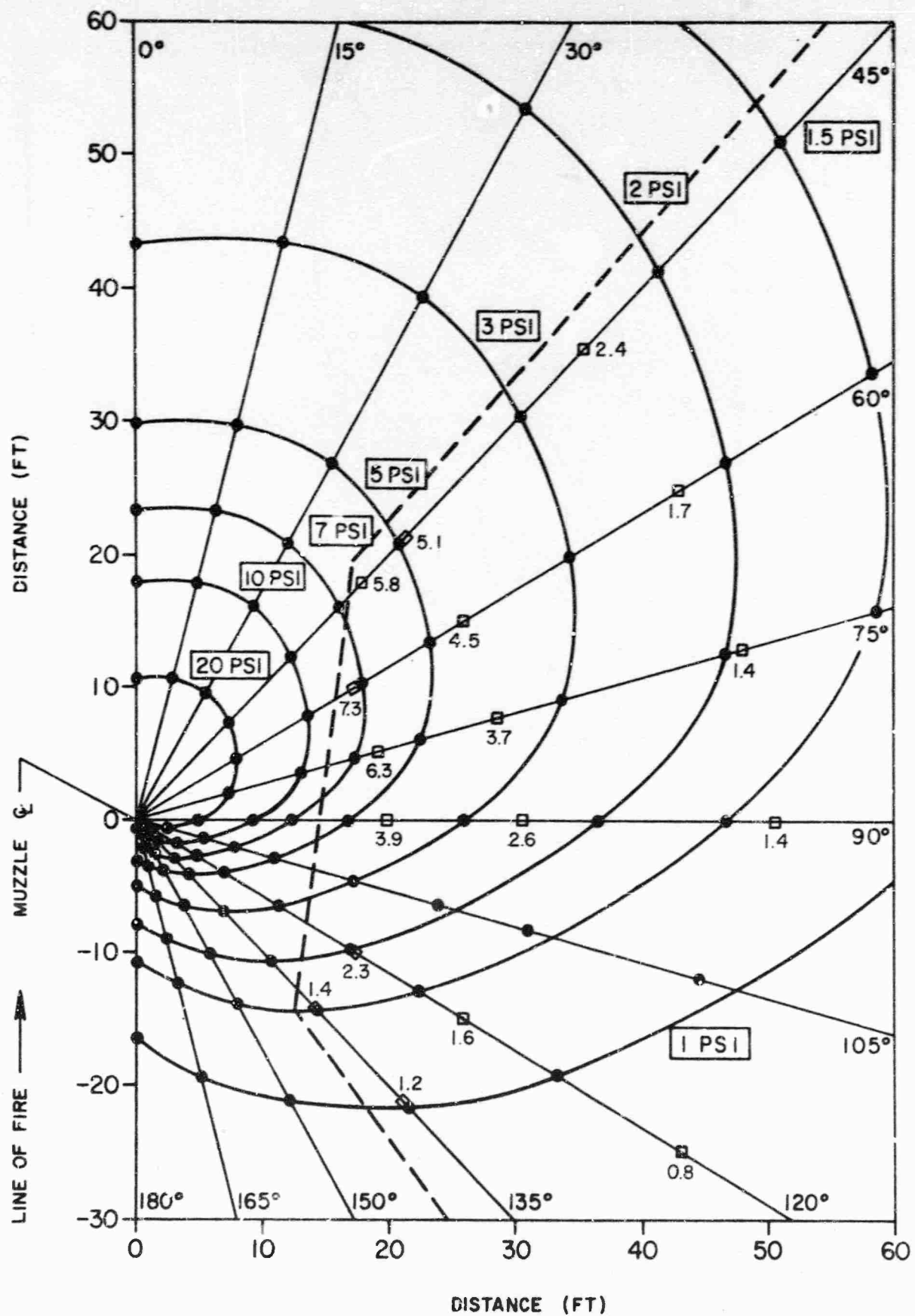
FREE-AIR DURATION CURVES FOR 8"/55 GUN

FIGURE A-4



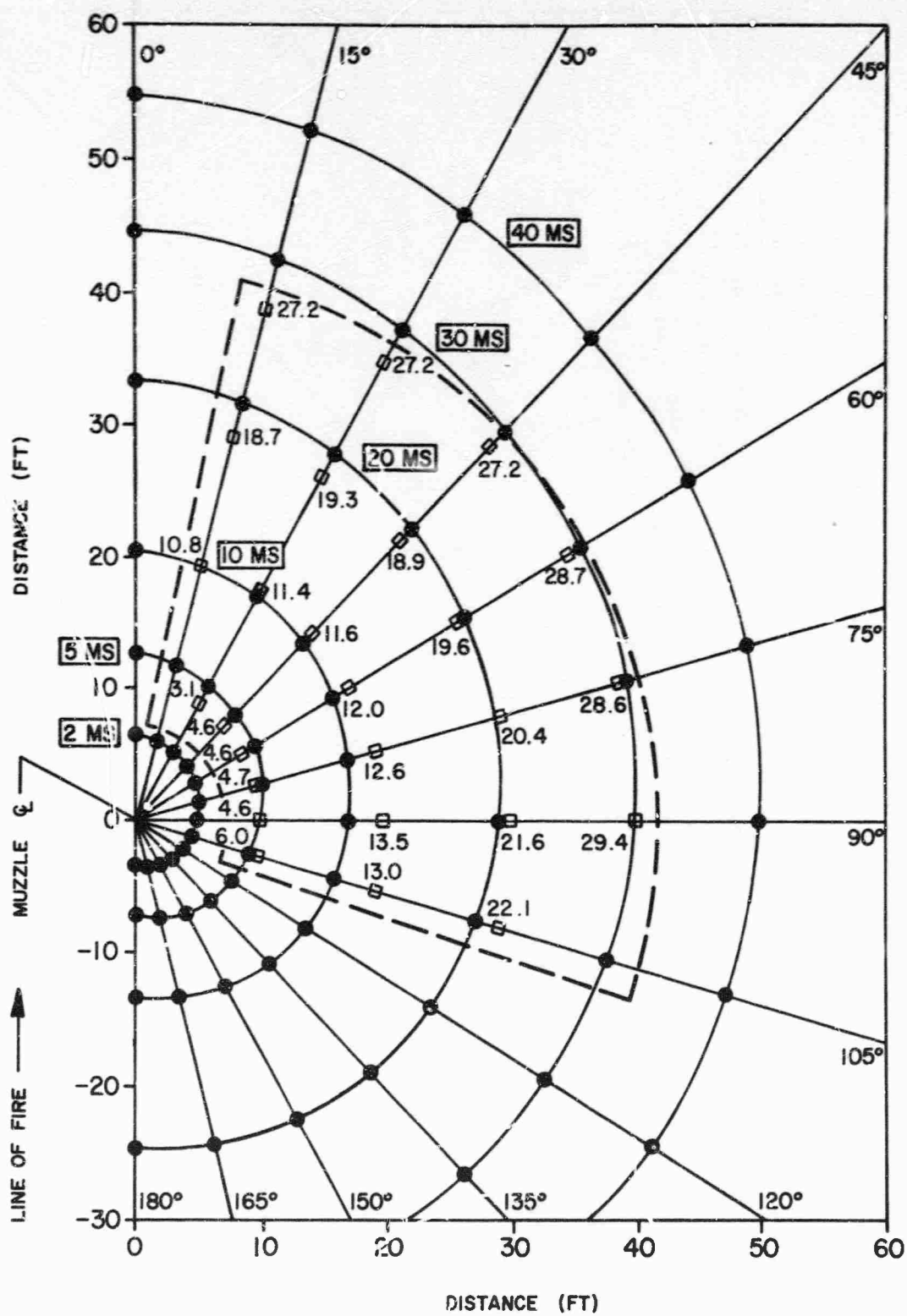
FREE-AIR IMPULSE CURVES FOR 8"55 GUN

FIGURE A-5



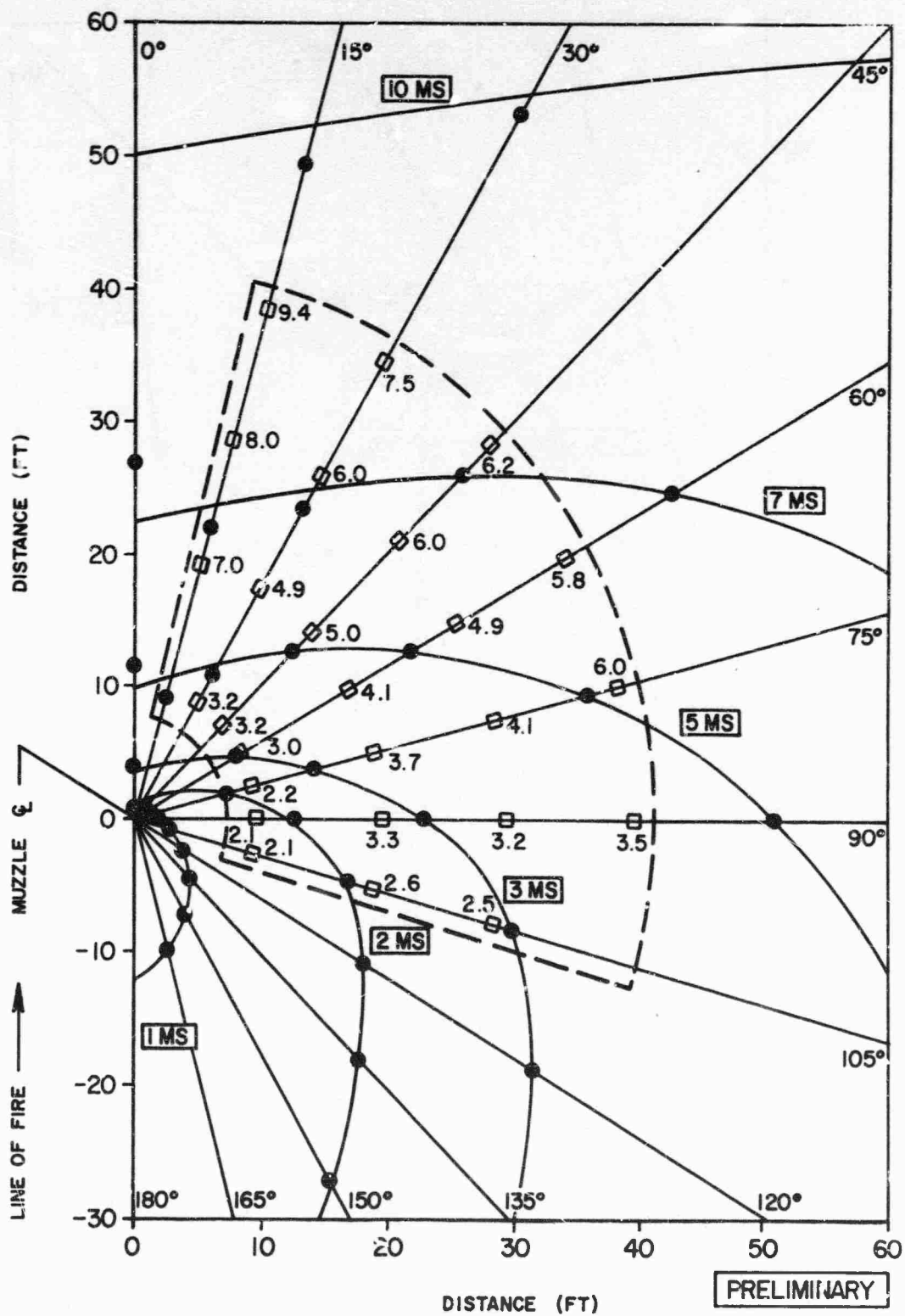
FREE-AIR PEAK PRESSURE CURVES FOR 6"/47 GUN

FIGURE A-6



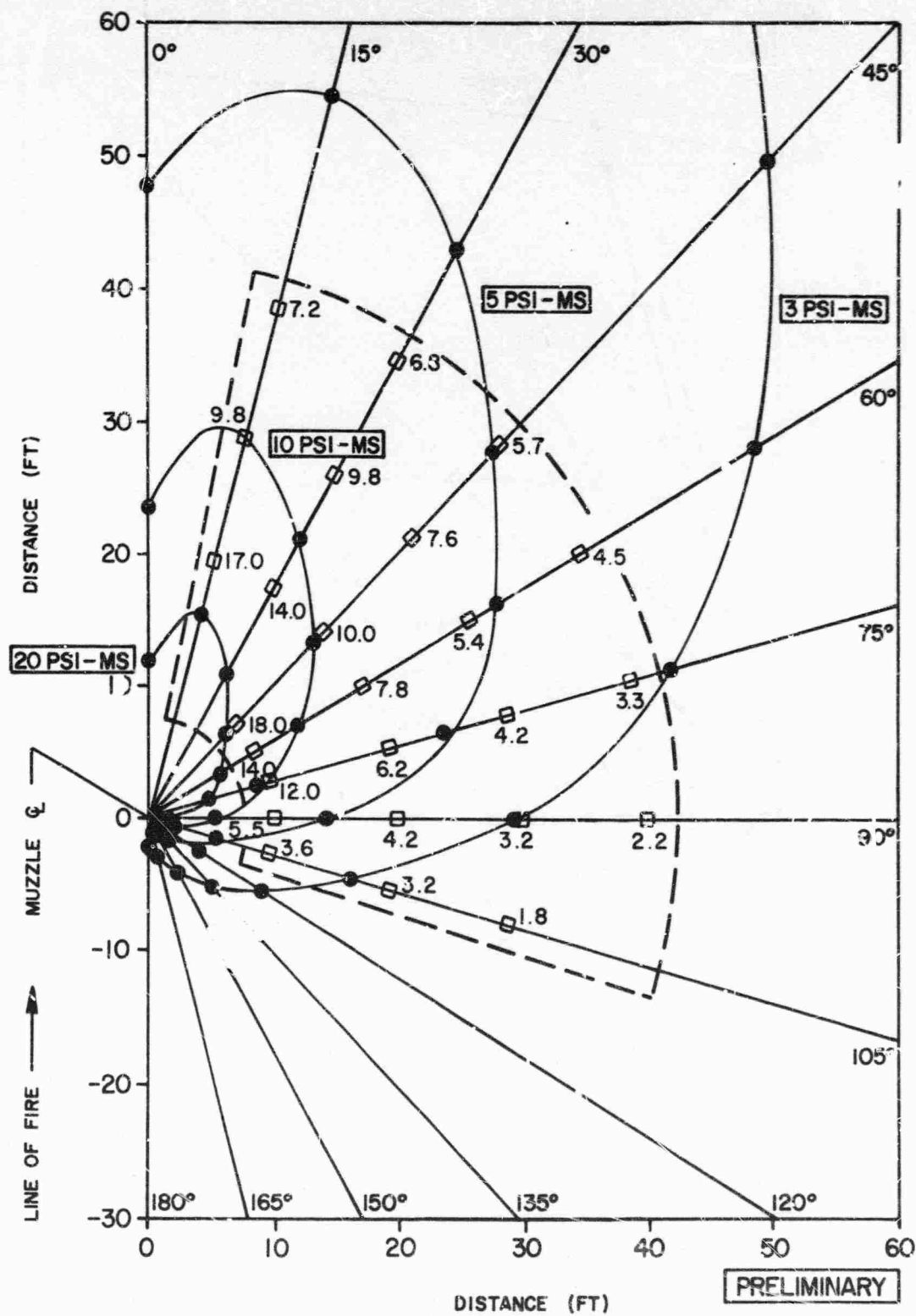
FREE-AIR ARRIVAL TIMES FOR 5" /54 GUN

FIGURE A - 8



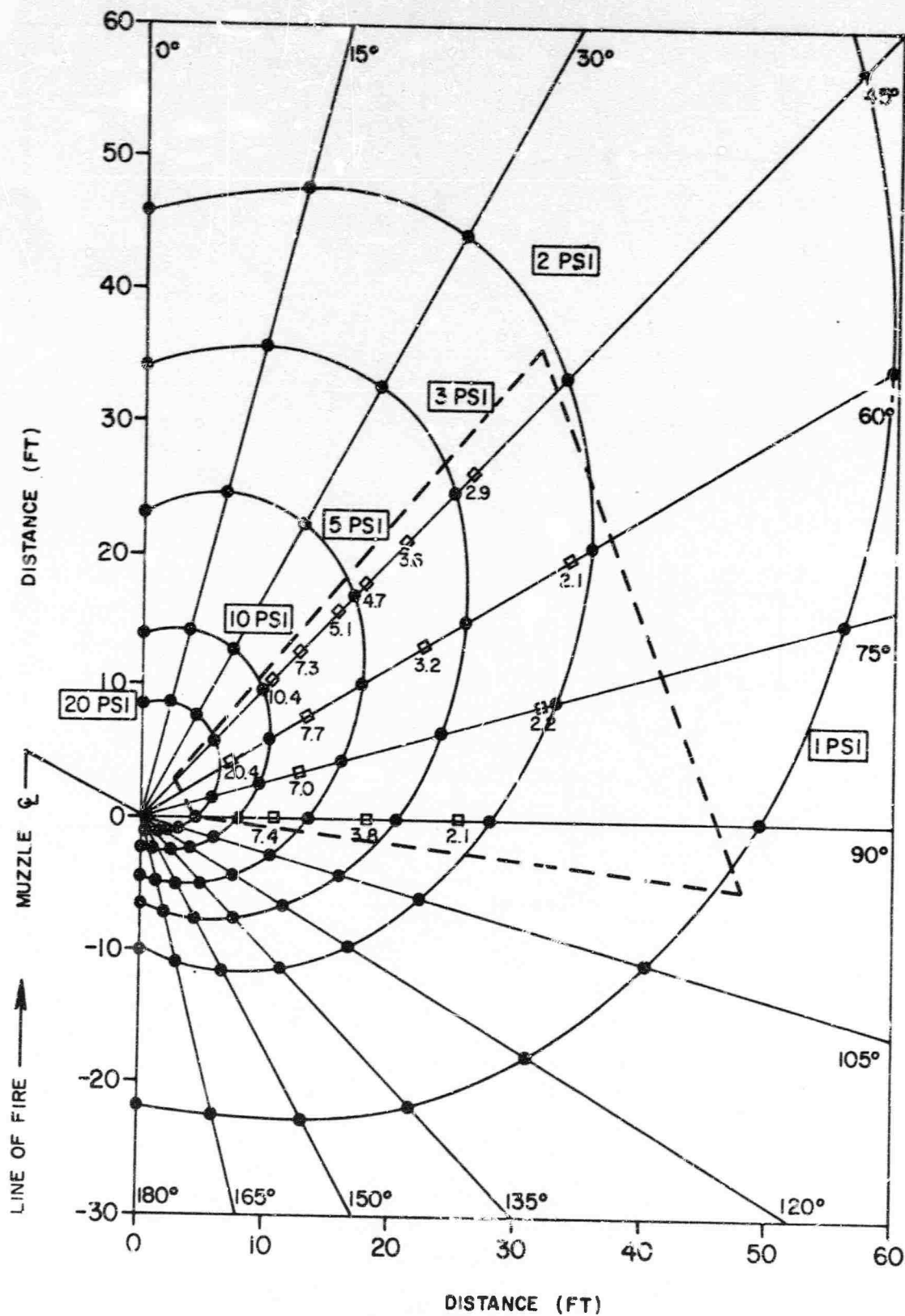
FREE-AIR DURATION FOR 5"/54 GUN

FIGURE A-9



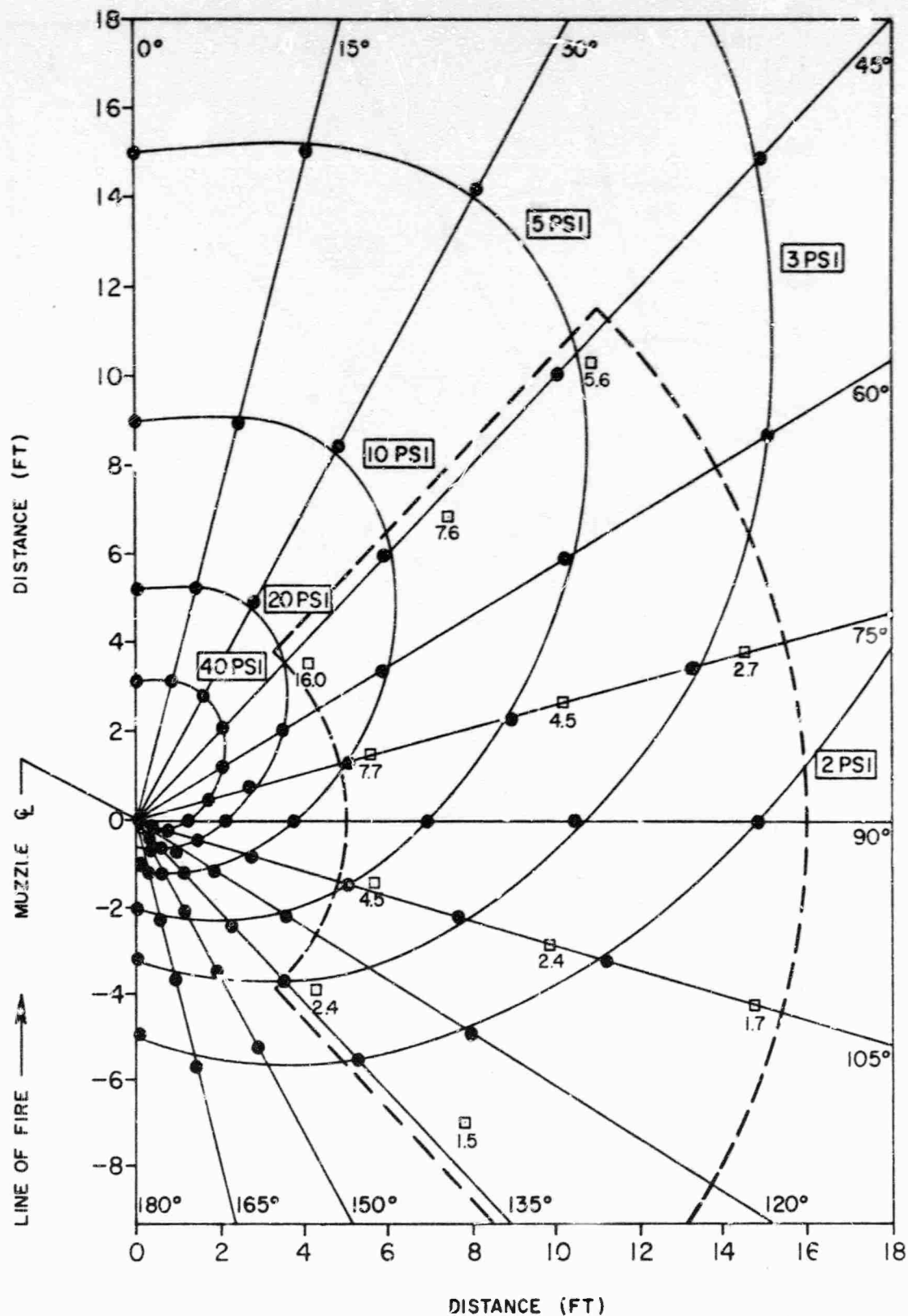
FREE-AIR IMPULSE FOR 5"/54 GUN

FIGURE A-10



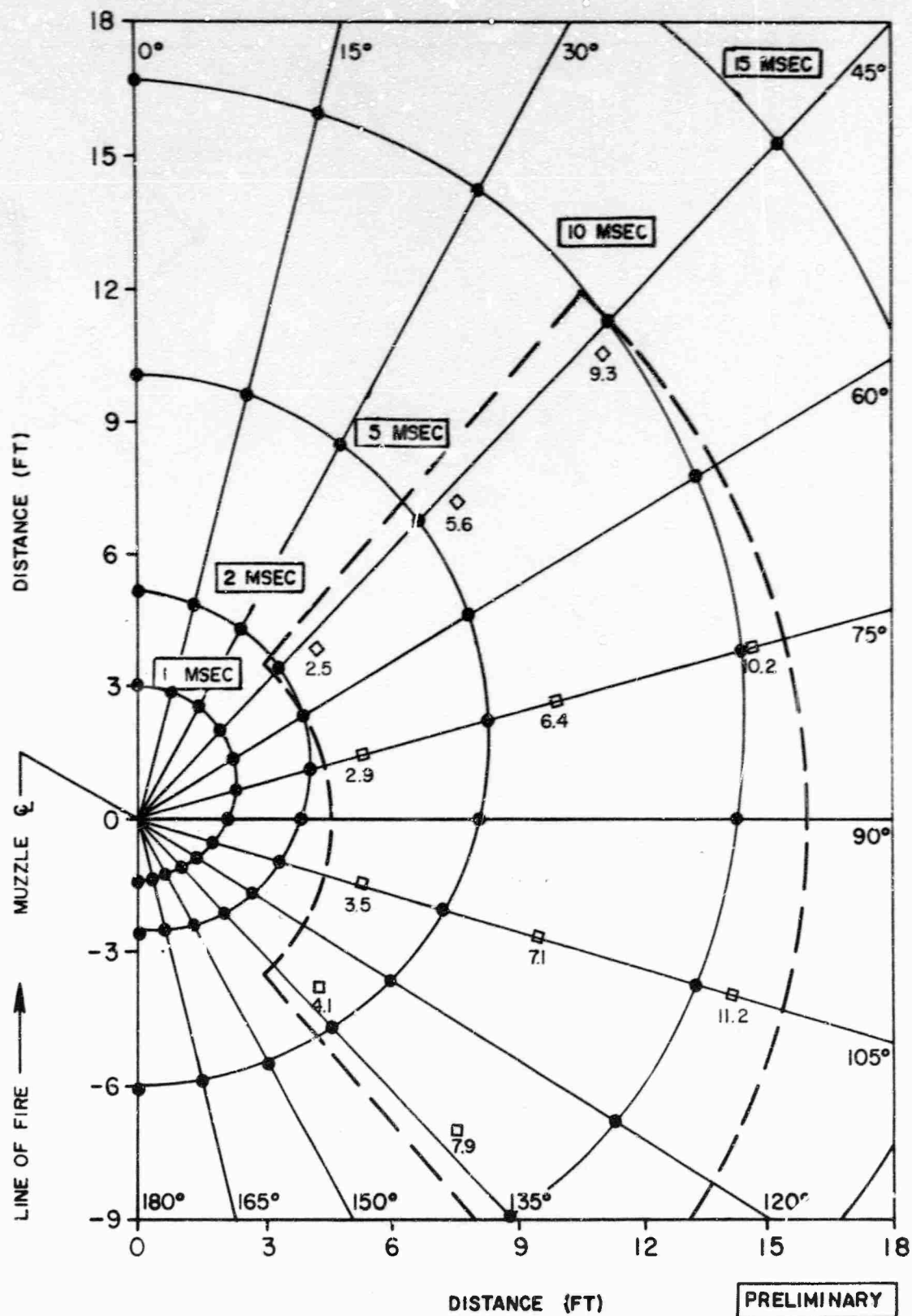
PREC-AIR PEAK PRESSURE CURVES FOR 5"/38 GUN

FIGURE A-II



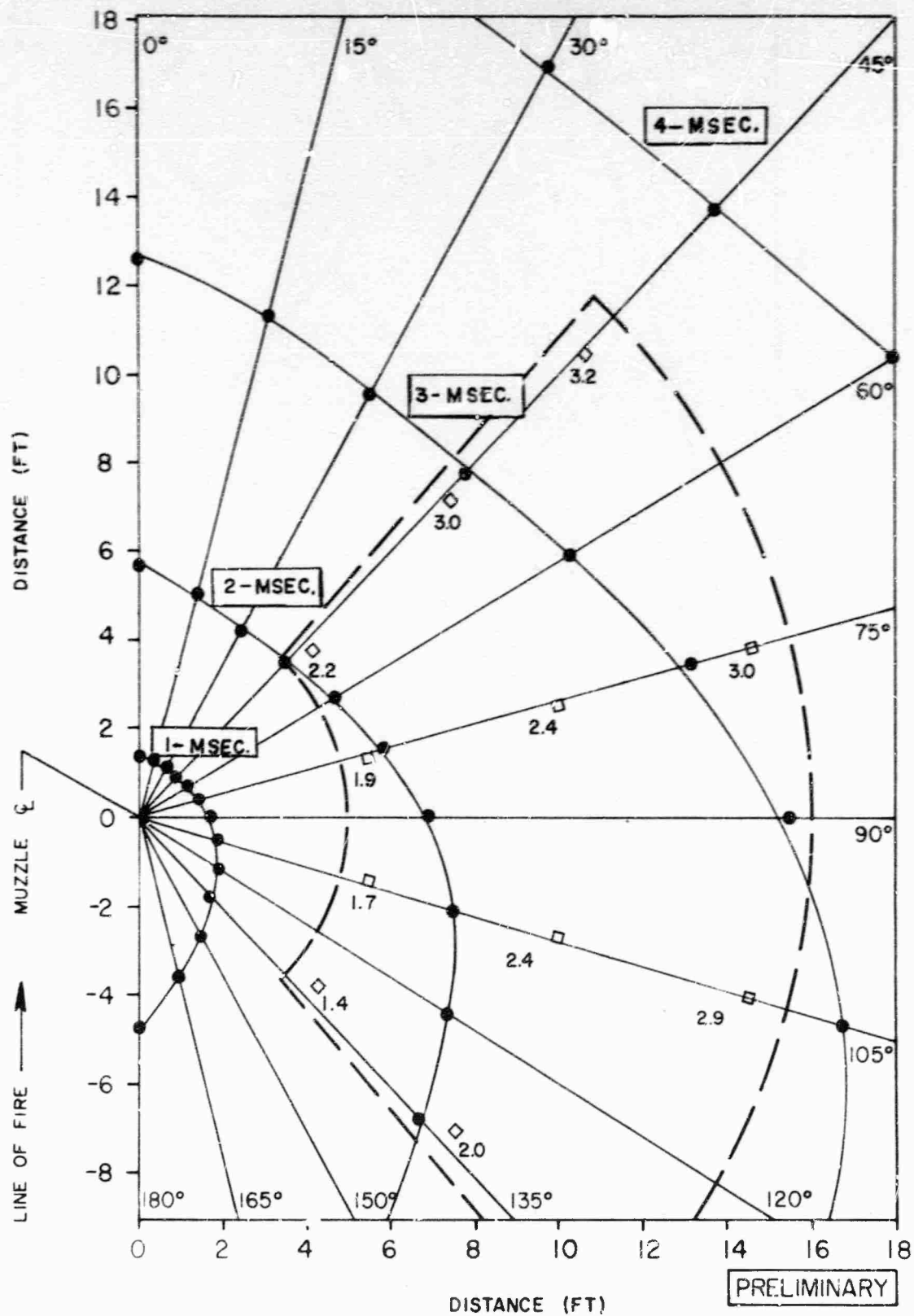
FREE-AIR PEAK PRESSURE CURVES FOR 3"/50 GUN

FIGURE A-12



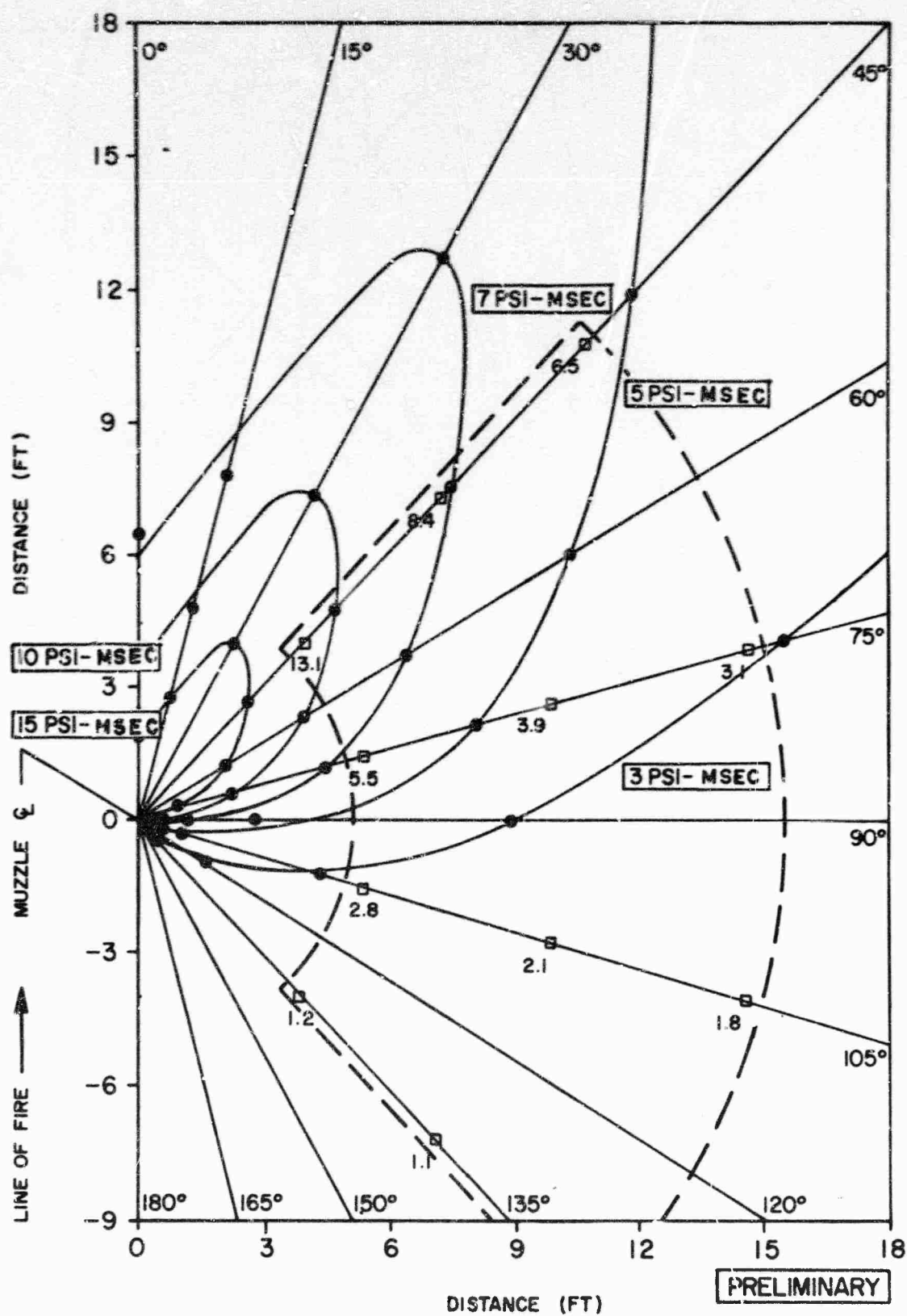
FREE-AIR ARRIVAL TIME CURVES FOR 3"/50 GUN

FIGURE A-13



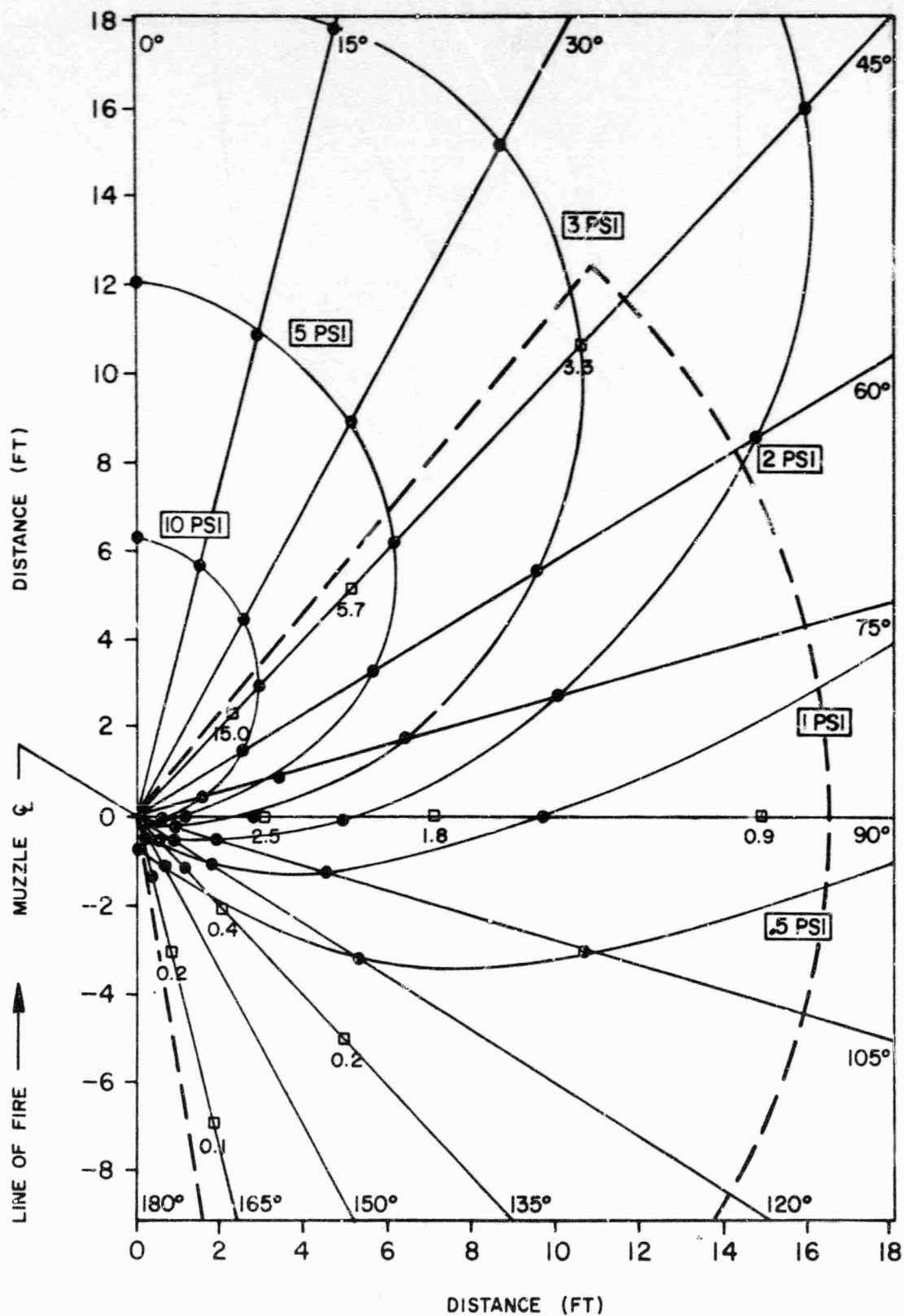
FREE-AIR DURATION CURVES FOR 3 1/2" 50 GUN

FIGURE A-14



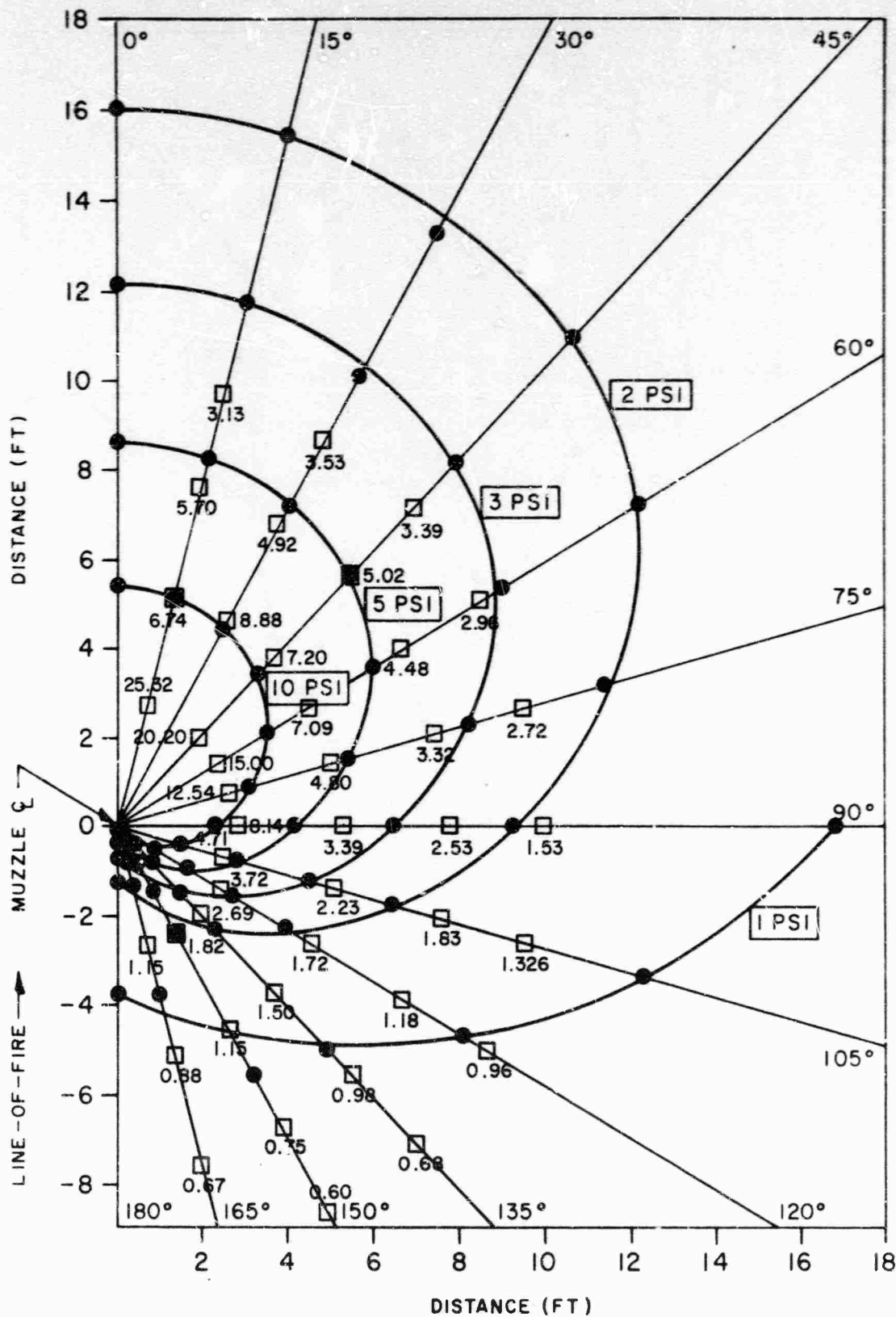
FREE-AIR IMPULSE CURVES FOR 3"/50 GUN

FIGURE A-15



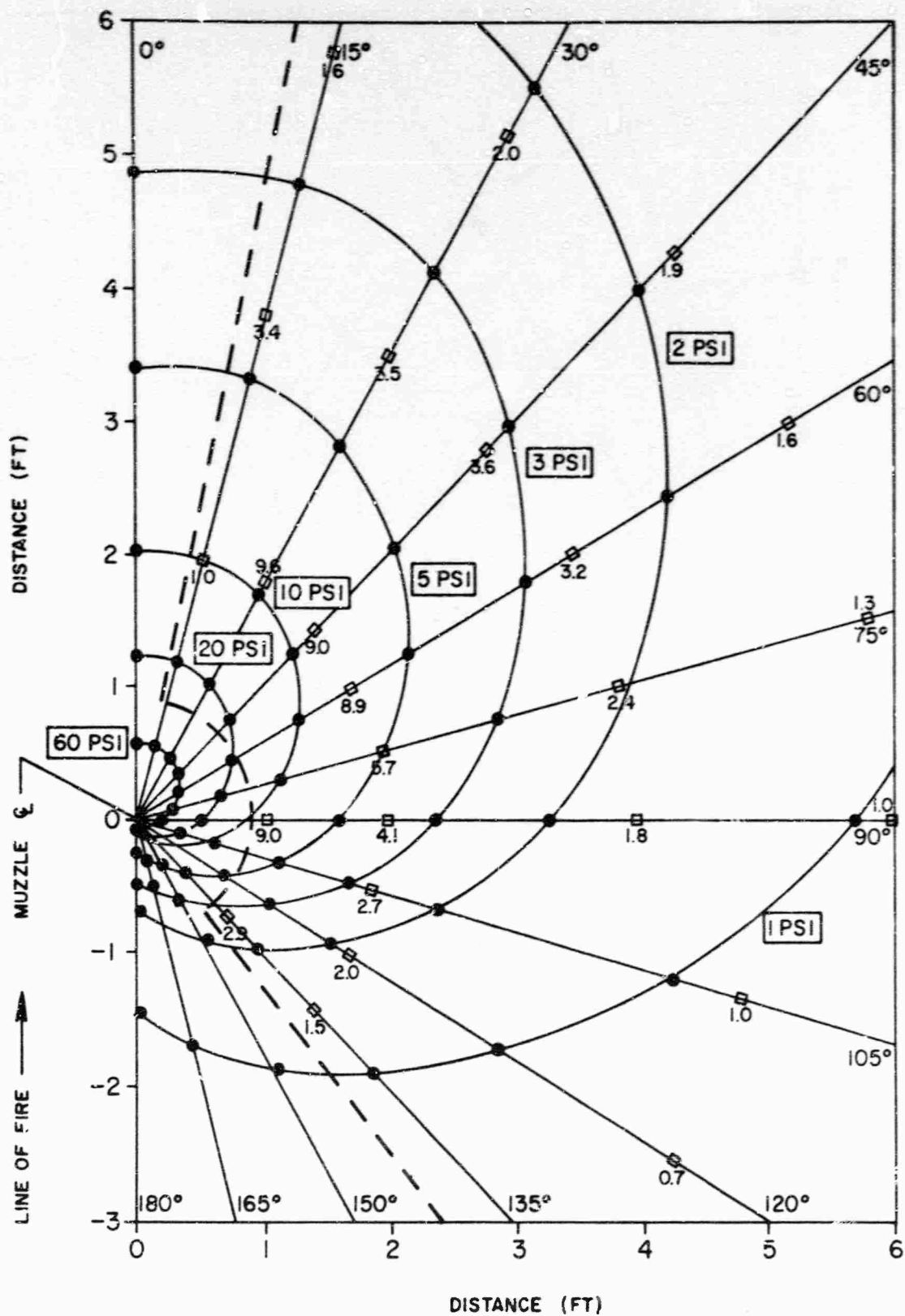
FREE-AIR PEAK PRESSURE CURVES FOR
40 MM GUN WITH FLASH HIDER

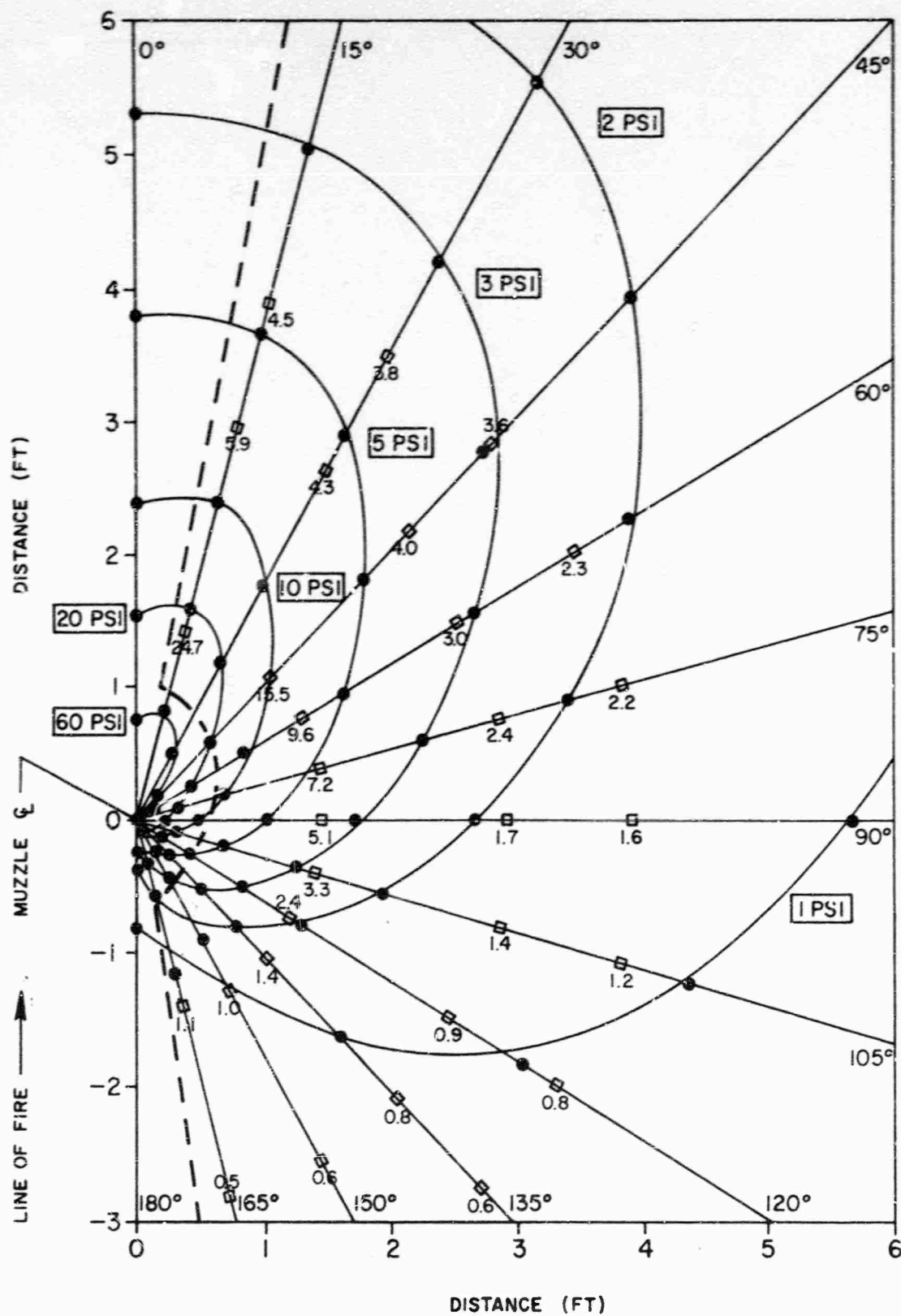
FIGURE A-16



FREE-AIR PEAK PRESSURE CURVES FOR
40 MM GUN WITHOUT FLASH HIDER

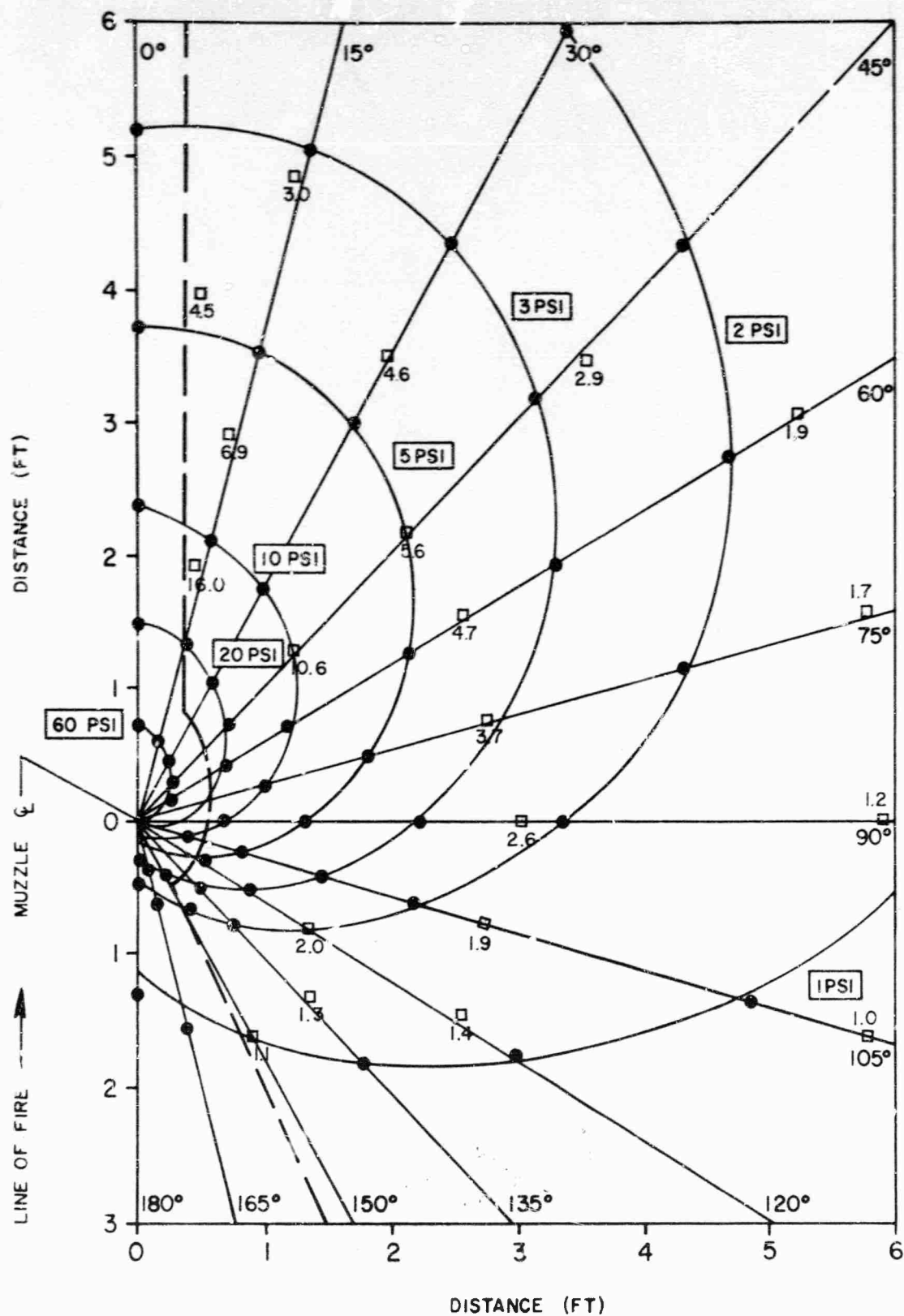
FIGURE A-17





FREE-AIR PEAK PRESSURE CURVES FOR 20 MM XM 197 GUN

FIGURE A-19



FREE-AIR PEAK PRESSURE CURVES FOR 20 MM MK 12 GUN

FIGURE A-20

APPENDIX B

CURVE FITTING COMPUTER PROGRAM LISTING

APPENDIX B

CURVE FITTING COMPUTER PROGRAM LISTINGS

- B-1 Listing of Program
- B-2 Listing of Subroutine
- B-3 Flow Chart of Program

LIST B-1 LISTING OF PROGRAM

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PROGRAM MAIN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
DIMENSION X(13),Y(13),W(13),D(25),S(25)
DIMENSION A(9),B(9),C(13),F(13),PHIX(39)
DIMENSION D1(13),D2(13),U3(13),U10(13)
DIMENSION GA(13),GN(13),XA(13),XN(13)
5 READ 950,A1,A2,A3,A4,A5,A6,A7
950 FORMAT(7A10)
PRINT 955,A1,A2,A3,A4,A5,A6,A7
955 FORMAT(1H1,//////////,6X,7A10)
10 KD=8
KN=17
DC 5 I=1,13
C(I)=0.
5 F(I)=0.
15 READ 10,(X(I),Y(I),W(I),I=1,13)
10 FORMAT(F5.0,F6.0,F10.0)
C
C COMPUTE COEFFICIENTS FOR ORTHONORMAL POLYNOMIAL FIT OF Y
C
20 CALL RTHN (KD,KN,X,Y,A,PHIX,IERR)
IF(IERR)999,101,999
101 PRINT 994,A1,A2,A3,A4,A5,A6,A7
994 FORMAT(1H1,6X,7A10)
PRINT 850
25 850 FORMAT(1H0,////////,30X,22H3 PSI PRESSURE CONTOUR)
PRINT 103
103 FORMAT(//,14X,5HANGLE,11X,5HINPUT,12X,8HSMOOTHED)
PRINT 104
104 FORMAT(12X,9H(DEGREES),5X,13HDISTANCE (FT),5X,13HDISTANCE (FT),/)
30 C
C COMPUTE FITTED VALUES OF Y, D2(K)
C
DO108 K=1,13
D2(K)=A(1)+A(2)*X(K)+A(3)*X(K)**2+A(4)*X(K)**3+A(5)*X(K)**4+
35 1A(6)*X(K)**5+A(7)*X(K)**6+A(8)*X(K)**7+A(9)*X(K)**8
PRINT 106,X(K),Y(K),D2(K)
106 FORMAT(13X,F6.2,10X,F7.2,11X,F7.2)
108 CONTINUE
C
C COMPUTE COEFFICIENTS FOR ORTHONORMAL POLYNOMIAL FIT OF W
C
40 CALL RTHN (KD,KN,X,W,B,PHIX,IERR)
IF(IERR)999,107,999
107 PRINT 855
45 855 FORMAT(////////,30X,23H10 PSI PRESSURE CONTOUR)
PRINT 103
PRINT 104
C
C COMPUTE FITTED VALUES OF W, D1(K)
C
50 DO 115 K=1,13
D1(K)=B(1)+B(2)*X(K)+B(3)*X(K)**2+B(4)*X(K)**3+B(5)*X(K)**4+
1B(6)*X(K)**5+B(7)*X(K)**6+B(8)*X(K)**7+B(9)*X(K)**8
PRINT 106,X(K),W(K),D1(K)
55 115 CONTINUE

```

```

C
C      COMPUTE COEFFICIENTS XA(K) AND EXPONENTS XN(K)
C      USING P=XA*D**XN
C
60      P1=10.
      P2=3.
      PRINT 994,A1,A2,A3,A4,A5,A6,A7
      PRINT 121
121     FORMAT(1H0,/////,15X,1HW,10X,1H7-7X,1HX,12X,2HXX,12X,2HXA,/)
65     DO 127 K=1,13
      XN(K)=(ALOG(P1)-ALOG(P2))/(ALOG(D1(K))-ALOG(D2(K)))
      XA(K)=P1/(D1(K)**XN(K))
      PRINT 122,D1(K),D2(K),X(K),XN(K),XA(K)
122     FORMAT (11X,F8.4,3X,F8.4,3X,F5.1,3X,F11.5,3X,F11.5)
70     127 CONTINUE
C
C      COMPUTE COEFFICIENTS FOR ORTHONORMAL POLYNOMIAL FIT OF XN
C
      CALL RTHN (KD,KN,X,XN,C,PHIX,IERR)
75     IF(IERR)999,125,999
125     PRINT 128
128     FORMAT(///,15X,1HX,14X,2HXX,17X,1HC,/)
      DO 129 K=1,13
      PRINT 126,X(K),XN(K),C(K)
80     126     FORMAT(13X,F5.1,4X,F12.5,4X,E20.12)
      129 CONTINUE
C
C      COMPUTE COEFFICIENTS FOR ORTHONORMAL POLYNOMIAL FIT OF XA
C
85     CALL RTHN (KD,KN,X,XA,F,PHIX,IERR)
      IF(IERR)999,401,999
401     PRINT 400
400     FORMAT(///,15X,1HX,14X,2HXA,17X,1HF,/)
90     DO131 K=1,13
      PRINT 126,X(K),XA(K),F(K)
131     CONTINUE
C
C      COMPUTE FITTED VALUES OF XN AND XA,
C      GN(K) AND GA(K) RESPECTIVELY
C
95     PRINT 994,A1,A2,A3,A4,A5,A6,A7
      PRINT 151
151     FORMAT(1H0,////////,7X,2HGN,14X,2HGA,9X,1HX,10X,2H02,13X,2HU3,/)
100     DO 155 K=1,13
      GN(K)=C(1)+C(2)*X(K)+C(3)*X(K)**2+C(4)*X(K)**3+C(5)*X(K)**4+
      1C(6)*X(K)**5+C(7)*X(K)**6+C(8)*X(K)**7+C(9)*X(K)**8
      GA(K)=F(1)+F(2)*X(K)+F(3)*X(K)**2+F(4)*X(K)**3+F(5)*X(K)**4+
      1F(6)*X(K)**5+F(7)*X(K)**6+F(8)*X(K)**7+F(9)*X(K)**8
      U3(K)=GA(K)*D2(K)**GN(K)
105     PRINT 152,GN(K),GA(K),X(K),D2(K),U3(K)
152     FORMAT (F12.5,5X,F12.5,5X,F5.1,5X,F9.5,5X,F9.5)
155     CONTINUE
      PRINT 157
110     157     FORMAT(///,7X,2HGN,14X,2HGA,9X,1HX,10X,2H01,13X,3HU10,/)
      DO 158 K=1,13

```

```

      U10(K)=GA(K)*D1(K)**GN(K)
      PRINT 152,GN(K),GA(K),X(K),D1(K),U10(K)
158 CONTINUE
C
115 C      COMPUTE D(KK) USING SPECIFIED S(KK) VALUES
C
      PRINT 994,A1,A2,A3,A4,A5,A6,A7
      PRINT 159
159 FORMAT(1H0,/////,14X,5HANGLE,9X,8HDISTANCE,7X,5HPRESSURE:
      PRINT 160
160 FORMAT(12X,9H(DEGREES),4X,6H(FEET),10X,5H(PSI),/)
      S(1)=2000.0
      S(2)=1000.0
      S(3)= 200.0
125 S(4)= 100.0
      S(5)= 60.0
      S(6)= 40.0
      S(7)= 30.0
      S(8)= 20.0
130 S(9)= 15.0
      S(10)= 10.0
      S(11)= 9.0
      S(12)= 8.0
      S(13)= 7.0
135 S(14)= 6.0
      S(15)= 5.0
      S(16)= 4.0
      S(17)= 3.0
      S(18)= 2.0
140 S(19)= 1.0
      S(20)= 0.5
      S(21)= 0.1
      DO 250 J=1,7
      DO 240 I=1,2
145 K=2*J+I-2
      IF(K-14)163,250,250
163 CONTINUE
      DO 165 KK=1,21
      D(KK)=(S(KK)/GA(K))**(1./GN(K))
150 PRINT 168,X(K),D(KK),S(KK)
168 FORMAT(13X,F7.2,7X,F9.4,6X,F9.3)
      PRINT 169
169 FORMAT(/)
170 CONTINUE
155 PRINT 994,A1,A2,A3,A4,A5,A6,A7
      PRINT 159
      PRINT 160
250 CONTINUE
C
160 C      COMPUTE FIRST AND SECOND MOMENTS FOR STATISTICAL COMPARISON
C      BETWEEN COMPUTED AND EXPERIMENTAL VALUES
C
      T=0
      C12=0
165 M=1

```

```

      PRINT 994,A1,A2,A3,A4,A5,A6,A7
      PRINT 897
170 897 FORMAT(1H0,//////,8X,14HEXPER. DATA PT,25X,8HPRESSURE,4X,
      15HPRESSURE)
      PRINT 898
      898 FORMAT(8X,14HIDENTIFICATION,4X,5HANGLE,4X,9HDISTANCE,2X,
      112HEXPERIMENTAL,3X,6HFITTED)
      PRINT 899
175 899 FORMAT(12X,6HNUMBER,6X,9H(DEGREES),3X,6H(FEET),7X,5H(PSI),
      16X,5H(PSI),/)
299 READ(5,300)L,Q,F,P3
      IF(EOF(5))510,305
305 CONTINUE
180 300 FORMAT(I5,1X,3(F6.2,1X))
      JH=100*M
      JN=JH/45
      GN1=C(1)+C(2)*Q+C(3)*Q**2+C(4)*Q**3+C(5)*Q**4+
      1C(6)*Q**5+C(7)*Q**6+C(8)*Q**7+C(9)*Q**8
      GA1=F(1)+F(2)*Q+F(3)*Q**2+F(4)*Q**3+F(5)*Q**4+
185 1F(6)*Q**5+F(7)*Q**6+F(8)*Q**7+F(9)*Q**8
      P=GA1*E**GN1
      C10=P-P3
      C11=C10/P
      C12=C12+C11
190 C13=C12/M
      C1=ABS(C10)
      C2=C1/P
      C3=C2**2
      T=T+C3
195 T5=T/M
      N0=M
      M=M+1
      T1=SQRT(T5)
      IF(JN-100)470,500,410
200 410 IF(JN-200)470,500,420
      420 IF(JN-300)470,500,430
      430 IF(JN-400)470,500,440
      440 IF(JN-500)470,500,450
      450 IF(JN-600)470,500,451
205 451 IF(JN-700)470,500,452
      452 IF(JN-800)470,500,453
      453 IF(JN-900)470,500,454
      454 IF(JN-1000)470,500,455
      455 IF(JN-1100)470,500,456
210 456 IF(JN-1200)470,500,457
      457 IF(JN-1300)470,500,460
      460 IF(JN-1400)470,500,510
      500 PRINT 994,A1,A2,A3,A4,A5,A6,A7
      PRINT 897
215 PRINT 898
      PRINT 899
      470 PRINT 900,L,Q,E,F3,P
      900 FORMAT(12X,I5,8X,F6.2,3(4X,F8.3))
      GO TO 299
220 510 PRINT 901,C13

```

225

```
901 FORMAT(//,5X,14HFIRST MOMENT =,F8.2)
    PRINT 902,T1
902 FORMAT(//,5X,15HSECOND MOMENT =,F7.2)
999 CONTINUE
    END
```

LIST B-2 LISTING OF SUBROUTINE

		SUBROUTINE RTHN(KD,KN,X,Y,A,PHIX,IERR)	RTH	0
		DIMENSION X(100),Y(100),A(20),PHI(5,20),PHIX(3,100)	RTH	10
	C		RTH	20
	C	ERROR LIST	RTH	30
5	C	IERR=5021 - DEGREE OF FIT GREATER THAN 19.	RTH	40
	C	IERR=5022 - DEGREE OF FIT EQUAL TO, OR GREATER	RTH	50
	C	THAN, NUMBER OF POINTS.	RTH	60
	C		RTH	70
	C	CONSISTENCY CHECK	RTH	80
10	C		RTH	90
		IF(KD-19)2,2,1	RTH	100
	1	IERR=5021	RTH	110
		RETURN	RTH	120
	2	IF(KN-KD)3,3,4	RTH	130
15	3	IERR=5022	RTH	140
		RETURN	RTH	150
	4	IERR=0	RTH	160
	C		RTH	170
	C	INITIALIZATION	RTH	180
20	C		RTH	190
		KDA=KD+1	RTH	200
		DO 7 K=1,KDA	RTH	210
		A(K)=0.0	RTH	220
		DO 7 J=1,5	RTH	230
25	7	PHI(J,K)=0.0	RTH	240
	C		RTH	250
	C	MAP ABSCISSAS ONTO THE CLOSED INTERVAL -1.0 TO +1.0	RTH	260
	C	USING Z=A+IX	RTH	270
	C		RTH	280
30		XMAX=-1.0E+307	RTH	290
		XMIN=+1.0E+307	RTH	300
		DO 107 K=1,KN	RTH	310
		IF(XMAX-X(K))101,103,103	RTH	320
	101	XMAX=X(K)	RTH	330
35	103	IF(XMIN-X(K))107,107,105	RTH	340
	105	XMIN=X(K)	RTH	350
	107	CONTINUE	RTH	360
		ZB=2.0/(XMAX-XMIN)	RTH	370
		ZA=-XMIN*ZB-1.0	RTH	380
40		DO 12 K=1,KN	RTH	390
	12	PHIX(1,K)=ZA+ZB*X(K)	RTH	400
	C		RTH	410
	C	COMPUTE FIRST ORTHONORMAL POLYNOMIAL	RTH	420
	C	AND DETERMINE ITS COEFFICIENT	RTH	430
45	C		RTH	440
		PHI(1,1)=1.0/SQRT(FLOAT(KN))	RTH	450
		C=0.0	RTH	460
		ALP=0.0	RTH	470
		DUMA=PHI(1,1)**2	RTH	480
50		DO 21 K=1,KN	RTH	490
		ALP=ALP+PHIX(1,K)*DUMA	RTH	500
	21	C=C+PHI(1,1)*Y(K)	RTH	510
		PHI(4,1)=PHI(1,1)*C	RTH	520
	C		RTH	530
55	C	COMPUTE SECOND ORTHONORMAL POLYNOMIAL	RTH	540

	C	AND DETERMINE ITS COEFFICIENT	RTH	550
	C		RTH	560
	C		RTH	570
50		PHI(2,1)=-ALP*PHI(1,1)	RTH	580
		PHI(2,2)=PHI(1,1)	RTH	590
		ALAM=0.0	RTH	600
		DO 25 K=1,KN	RTH	610
		PHIX(2,K)=PHI(2,1)+PHI(2,2)*PHIX(1,K)	RTH	620
65	25	ALAM=ALAM+PHIX(2,K)**2	RTH	630
		ALAM=SQRT (ALAM)	RTH	640
		PHI(2,1)=PHI(2,1)/ALAM	RTH	650
		PHI(2,2)=PHI(2,2)/ALAM	RTH	660
		C=0.0	RTH	670
		DO 27 K=1,KN	RTH	680
70		PHIX(2,K)=PHIX(2,K)/ALAM	RTH	690
	27	C=C+PHIX(2,K)*(Y(K)-PHI(4,1))	RTH	700
		PHI(4,1)=PHI(4,1)+PHI(2,1)*C	RTH	710
		PHI(4,2)=PHI(2,2)*C	RTH	720
75	C		RTH	730
	C	COMPUTE RESIDUALS	RTH	740
	C		RTH	750
		DO 28 K=1,KN	RTH	760
	28	PHIX(3,K)=Y(K)-PHI(4,1)-PHI(4,2)*PHIX(1,K)	RTH	770
80	C		RTH	780
	C	ARE POLYNOMIALS HIGHER THAN FIRST	RTH	790
	C	DEGREE REQUIRED. NO,NO,YES	RTH	800
	C		RTH	810
		IF(KD-1)81,81,31	RTH	820
85	C		RTH	830
	C	COMPUTE HIGHER DEGREE ORTHONORMAL POLYNOMIALS	RTH	840
	C	AND DETERMINE THEIR COEFFICIENTS	RTH	850
	C		RTH	860
	31	LA=1	RTH	870
		LB=2	RTH	880
90		LC=3	RTH	890
		DO 79 KT=2,KD	RTH	900
		KTA=KT+1	RTH	910
95	C		RTH	920
	C	COMPUTE ALPHA(T)	RTH	930
	C		RTH	940
		ALP=0.0	RTH	950
		DO 32 K=1,KN	RTH	960
	32	ALP=ALP+PHIX(1,K)*PHIX(2,K)**2	RTH	970
100	C		RTH	980
	C	COMPUTE LAMDA(T+1)*PHI(T+1)	RTH	990
	C		RTH	1000
		PHI(LC,1)=0.0	RTH	1010
		DO 33 K=1,KT	RTH	1020
		PHI(LC,K)=PHI(LC,K)-ALP*PHI(LA,K)-ALAM*PHI(LB,K)	RTH	1030
105	33	PHI(LC,K+1)=PHI(LA,K)	RTH	1040
	C		RTH	1050
	C	COMPUTE LAMDA(T+1)*PHI(T+1) OF Z	RTH	1060
	C		RTH	1070
		DO 34 I=1,KN	RTH	1080
110		PHIX(2,I)=PHI(LC,KTA)	RTH	1090

	DO 34 JA=1,KT	RTH 110
	JB=KTA-JA	RTH 111
	34 PHIX(2,I)=PHIX(2,I)*PHIX(1,I)+PHI(LC,JB)	RTH 112
115	C	RTH 1130
	C	RTH 1140
	C	RTH 1150
	ALAM=0.0	RTH 1160
	DO 35 K=1,KN	RTH 1170
120	35 ALAM=ALAM+PHIX(2,K)**2	RTH 1180
	ALAM=SQRT (ALAM)	RTH 1190
	C	RTH 1200
	C	RTH 1210
	C	RTH 1220
	DO 36 K=1,KN	RTH 1230
125	36 PHIX(2,K)=PHIX(2,K)/ALAM	RTH 1240
	C	RTH 1250
	C	RTH 1260
	C	RTH 1270
	DO 37 K=1,KTA	RTH 1280
130	37 PHI(LC,K)=PHI(LC,K)/ALAM	RTH 1290
	C	RTH 1300
	C	RTH 1310
	C	RTH 1320
	COMPUTE COEFFICIENT OF ORTHONORMAL POLYNOMIAL	RTH 1330
	C=0.0	RTH 1340
135	DO 41 K=1,KN	RTH 1350
	41 C=C+PHIX(2,K)*PHIX(3,K)	RTH 1360
	C	RTH 1370
	C	RTH 1380
	C	RTH 1390
140	ACCUMULATE CONTRIBUTION OF THIS POLYNOMIAL IN THE FORM OF POWERS OF Z	RTH 1400
	DO 42 K=1,KTA	RTH 1410
	42 PHI(4,K)=PHI(4,K)+PHI(LC,K)*C	RTH 1420
	C	RTH 1430
145	C	RTH 1440
	C	RTH 1450
	DO 52 J=1,KN	RTH 1460
	PHIX(3,J)=PHI(4,KTA)	RTH 1470
	DO 51 K=1,KT	RTH 1480
	KT=KTA-K	RTH 1490
150	51 PHIX(3,J)=PHIX(3,J)*PHIX(1,J)+PHI(4,KT)	RTH 1500
	52 PHIX(3,J)=Y(J)-PHIX(3,J)	RTH 1510
	C	RTH 1520
	C	RTH 1530
	C	RTH 1540
155	SHIFT VECTORS FOR THE NEXT RECURSION	RTH 1550
	LS=LA	RTH 1560
	LA=LB	RTH 1570
	LB=LC	RTH 1580
	LC=LS	RTH 1590
	79 CONTINUE	RTH 1600
160	C	RTH 1610
	C	RTH 1620
	C	RTH 1630
	TRANSFORM COEFFICIENTS FROM Z TO X	RTH 1640
	81 PHI(5,1)=ZA	
	PHI(5,2)=ZB	
165	A(1)=PHI(4,1)+Z1*PHI(4,2)	

```

      A(2)=ZB*PHI(4,2)
      KDX(2)=2
      IF(KD-2) 111,111,109
109  KDXQ=KD
111  DO 87 K=2,KDXQ
      KB=K+1
      ZZ=0.0
      DO 83 KA=1,KB
      ZY=PHI(5,K/)*ZB
175  PHI(5,KA)=PHI(5,KA)+ZA+ZZ
      83 ZZ=ZY
      PHI(5,KB)=ZZ
      DO 85 KA=1,KB
180  A(KA)=A(KA)+PHI(4,KB)*PHI(5,KA)
      85 CONTINUE
      87 RETURN
      END

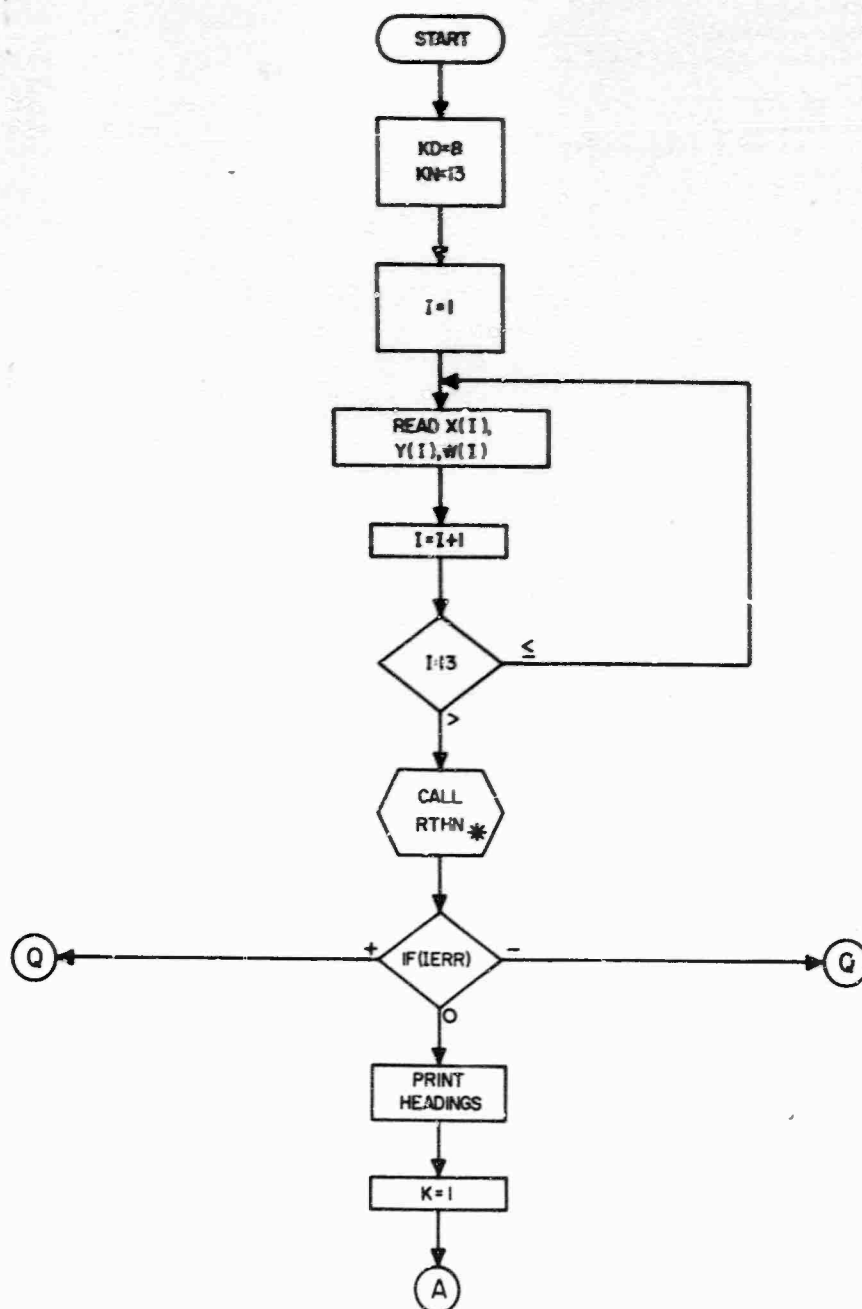
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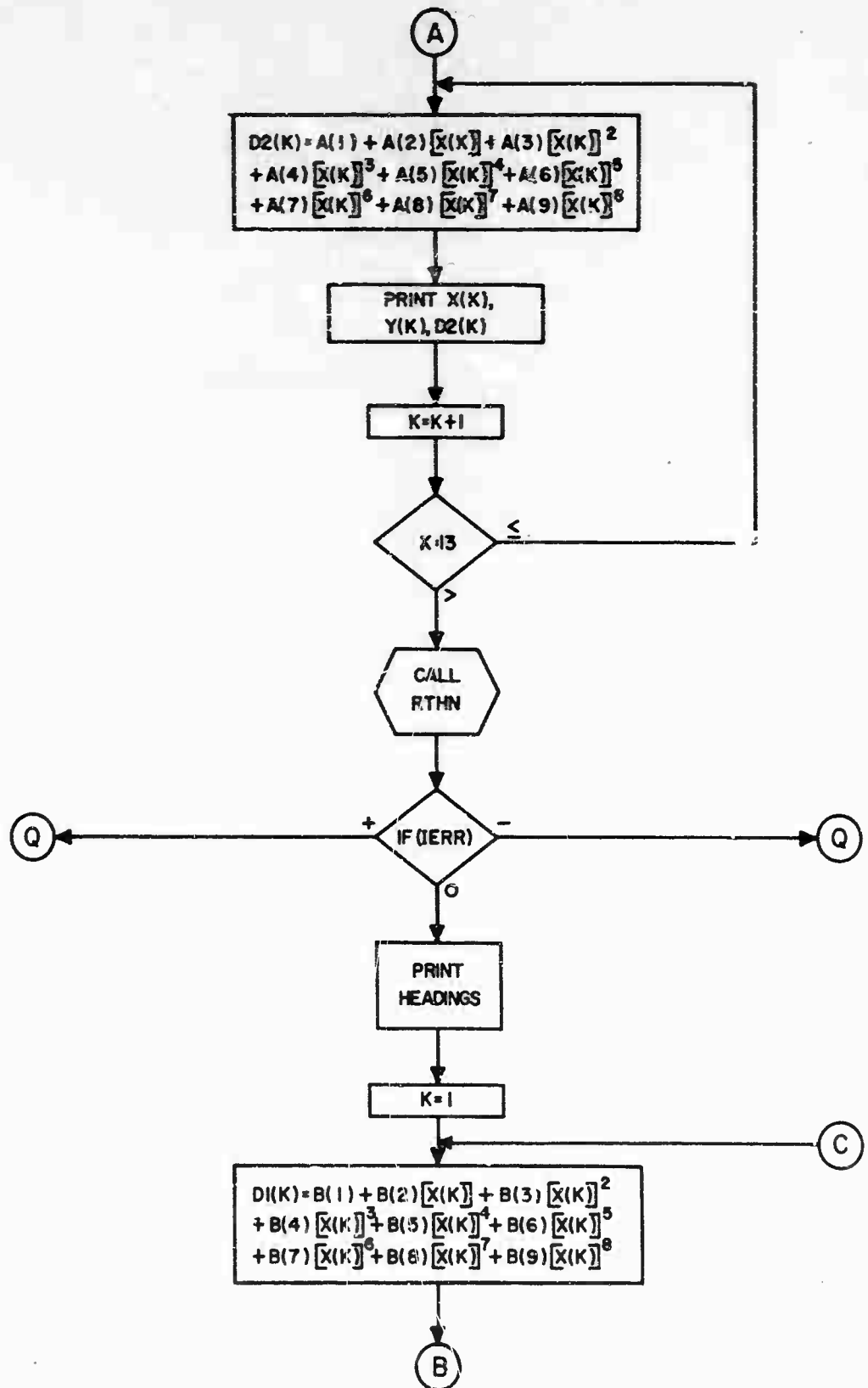
RTH 1650
RTH 1660
RTH 1670
RTH 1680
RTH 1690
RTH 1710
RTH 1710
RTH 1720
RTH 1730
RTH 1740
RTH 1750
RTH 1760
RTH 1770
RTH 1780
RTH 1790
RTH 1800
RTH 1810

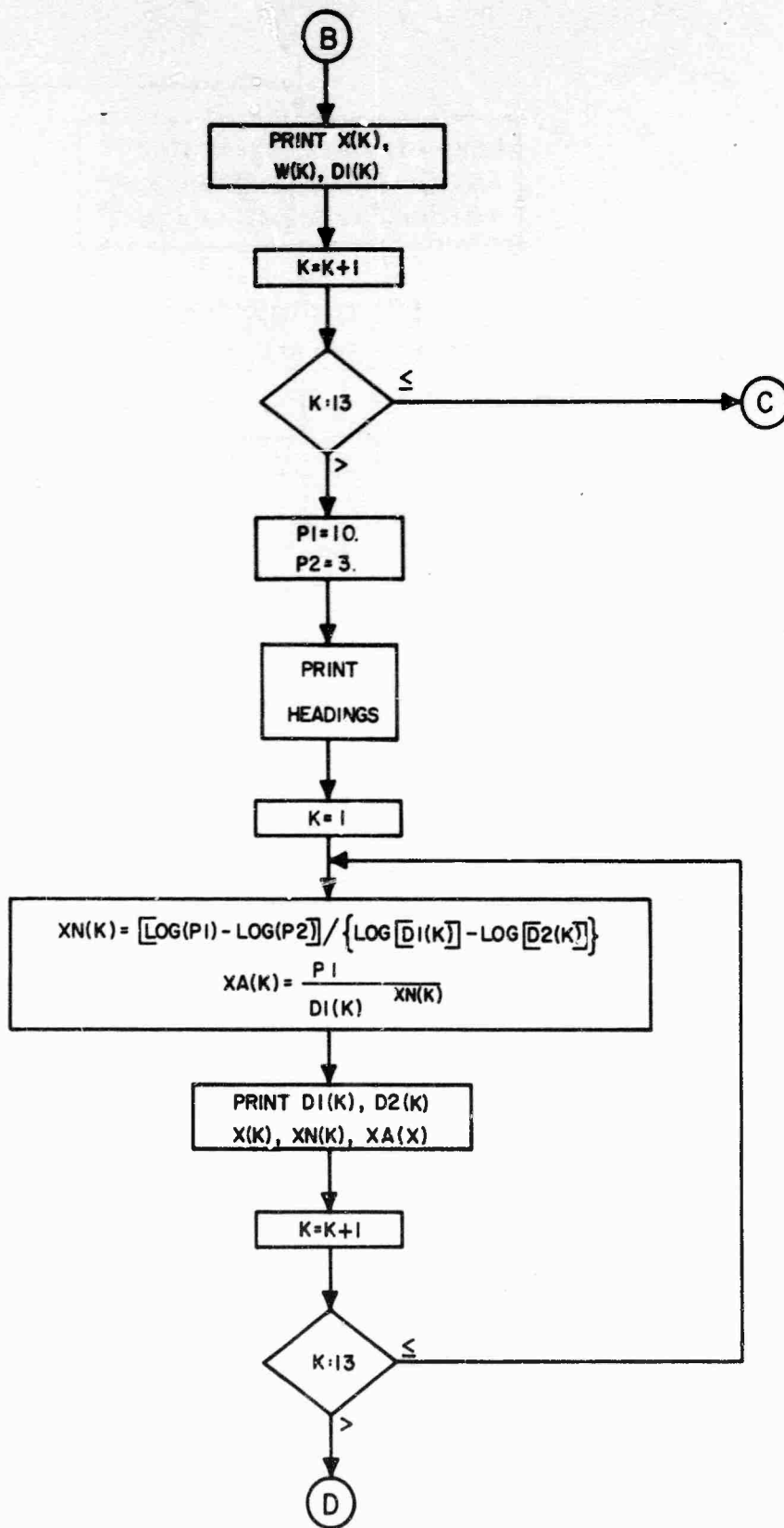
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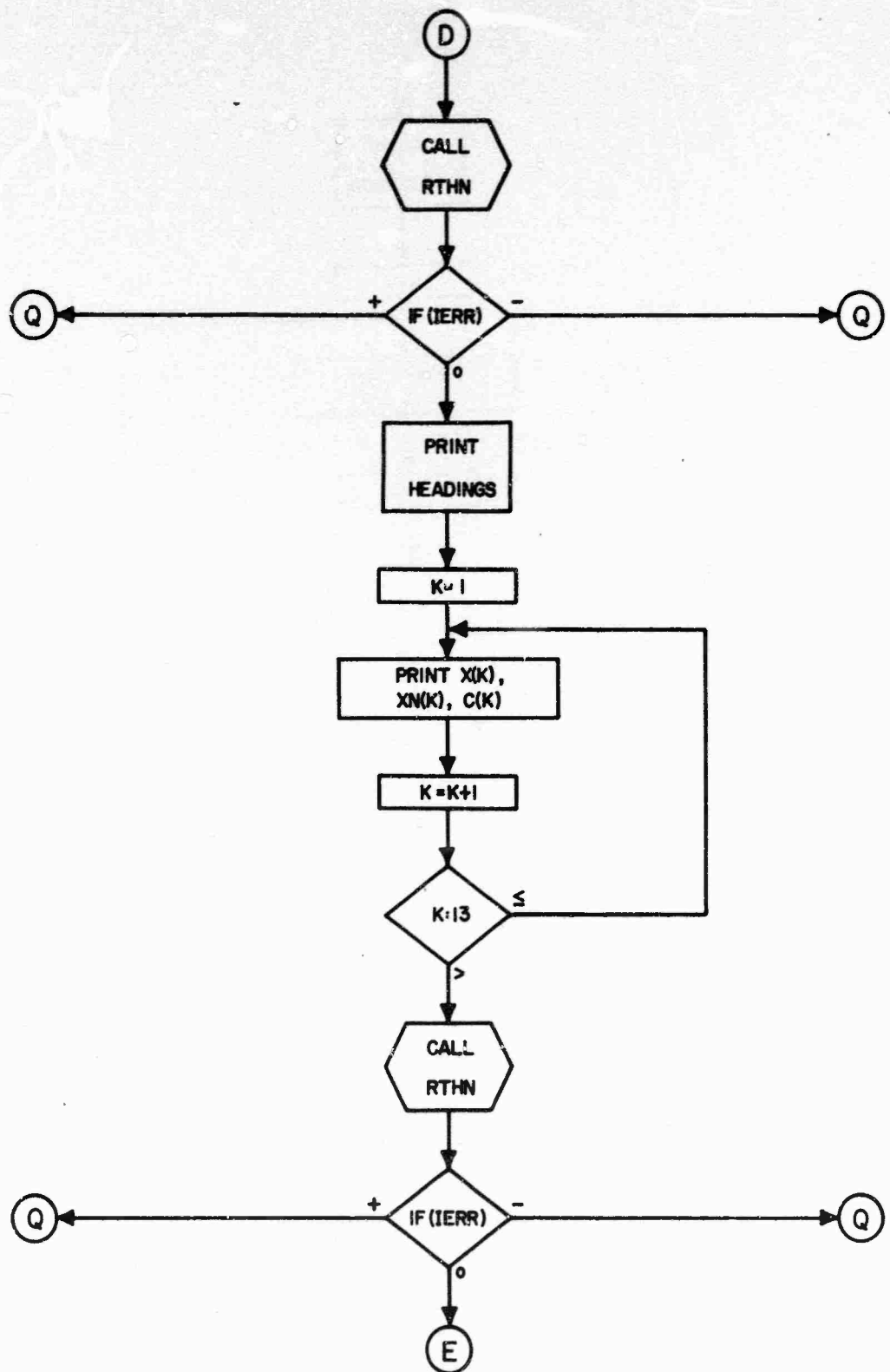
CHART B-3 FLOW CHART OF PROGRAM

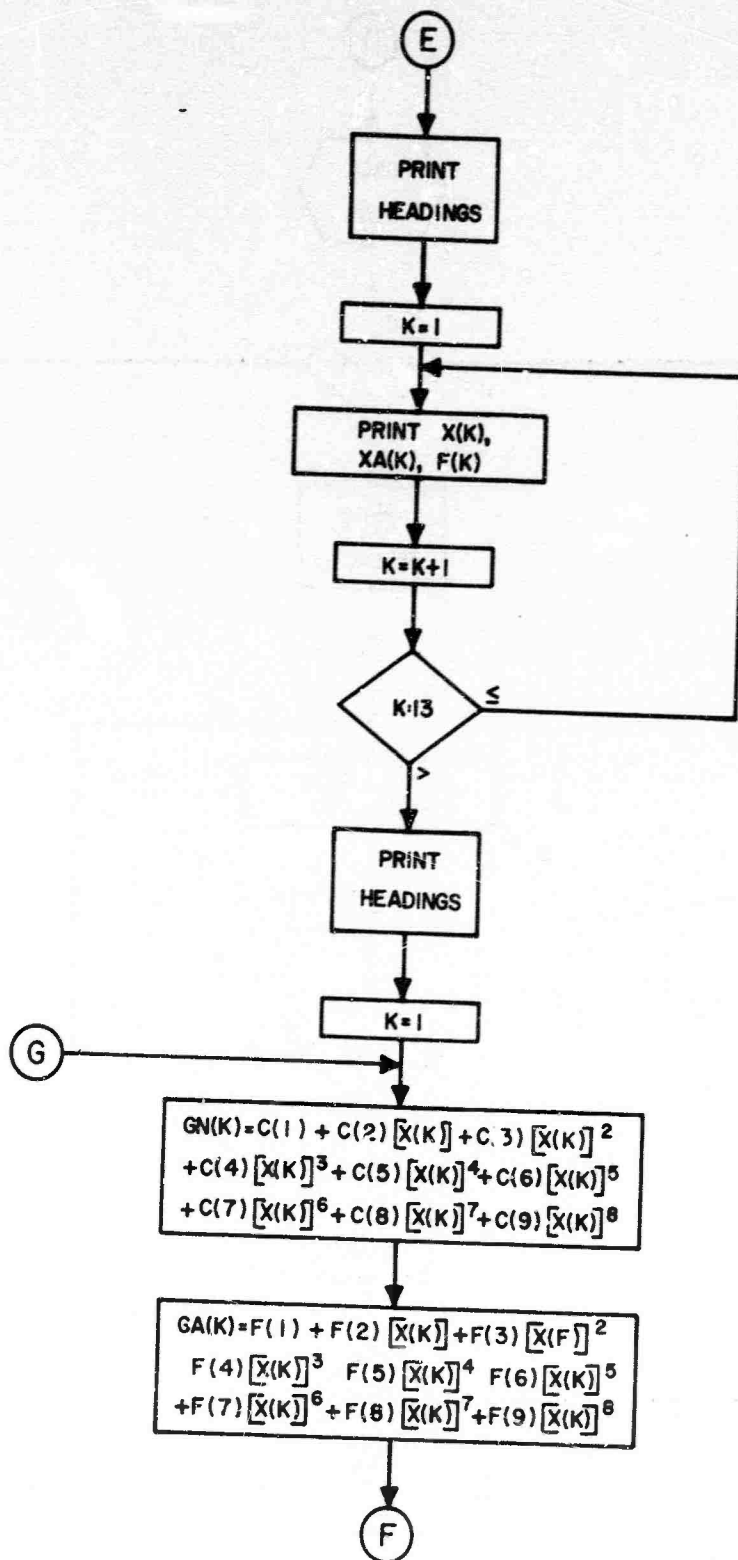


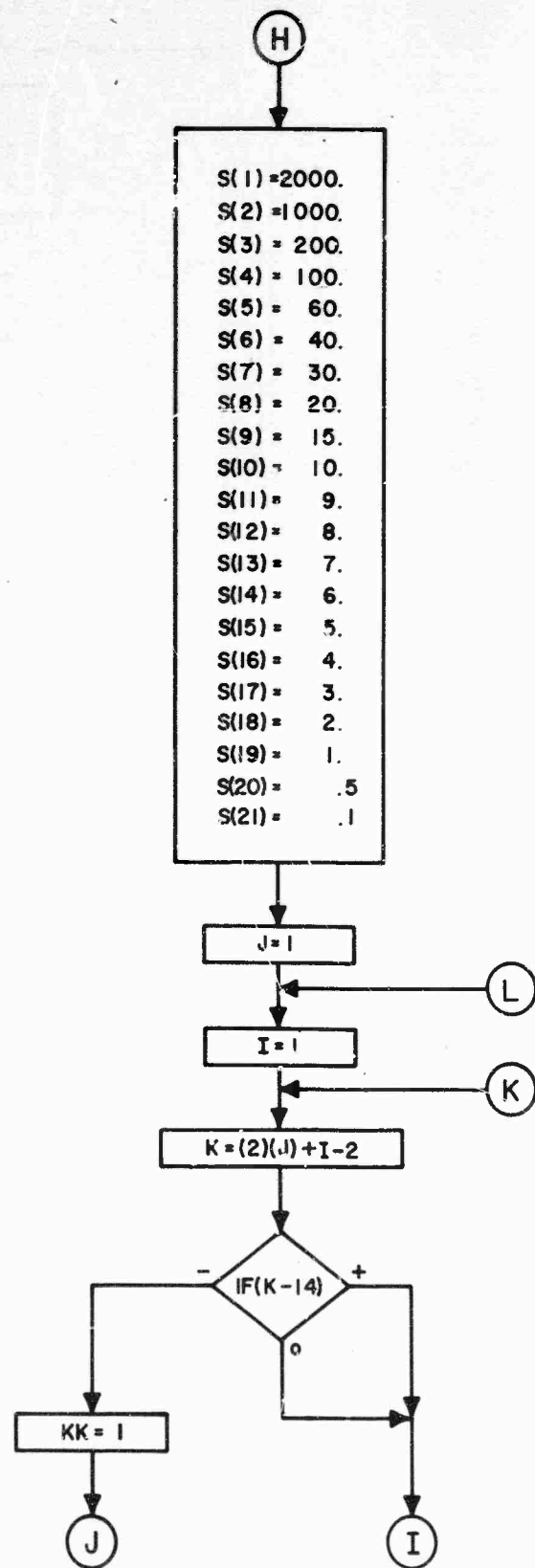
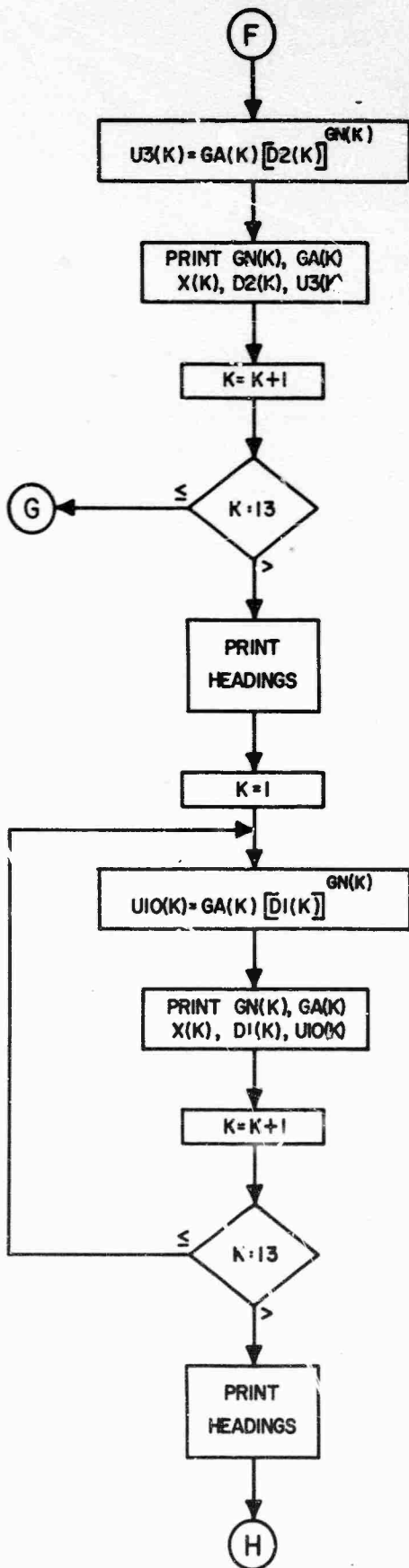
FORSYTHE, G. E. (1957) "GENERATION AND USE OF ORTHOGONAL POLYNOMIALS FOR DATA FITTING WITH A DIGITAL COMPUTER," J. SOC. FOR INDUST. AND APPL. MATH., VOL. 5, P 74.

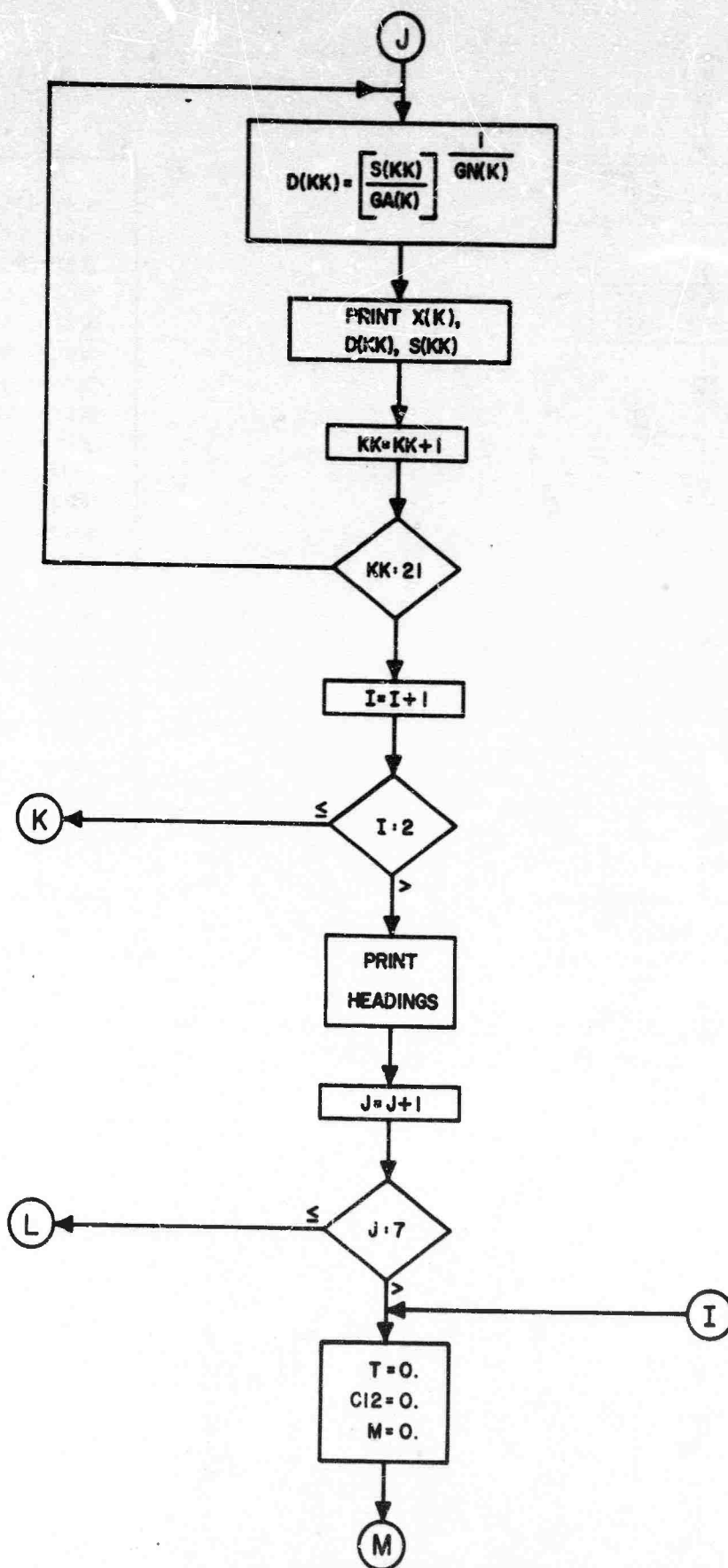


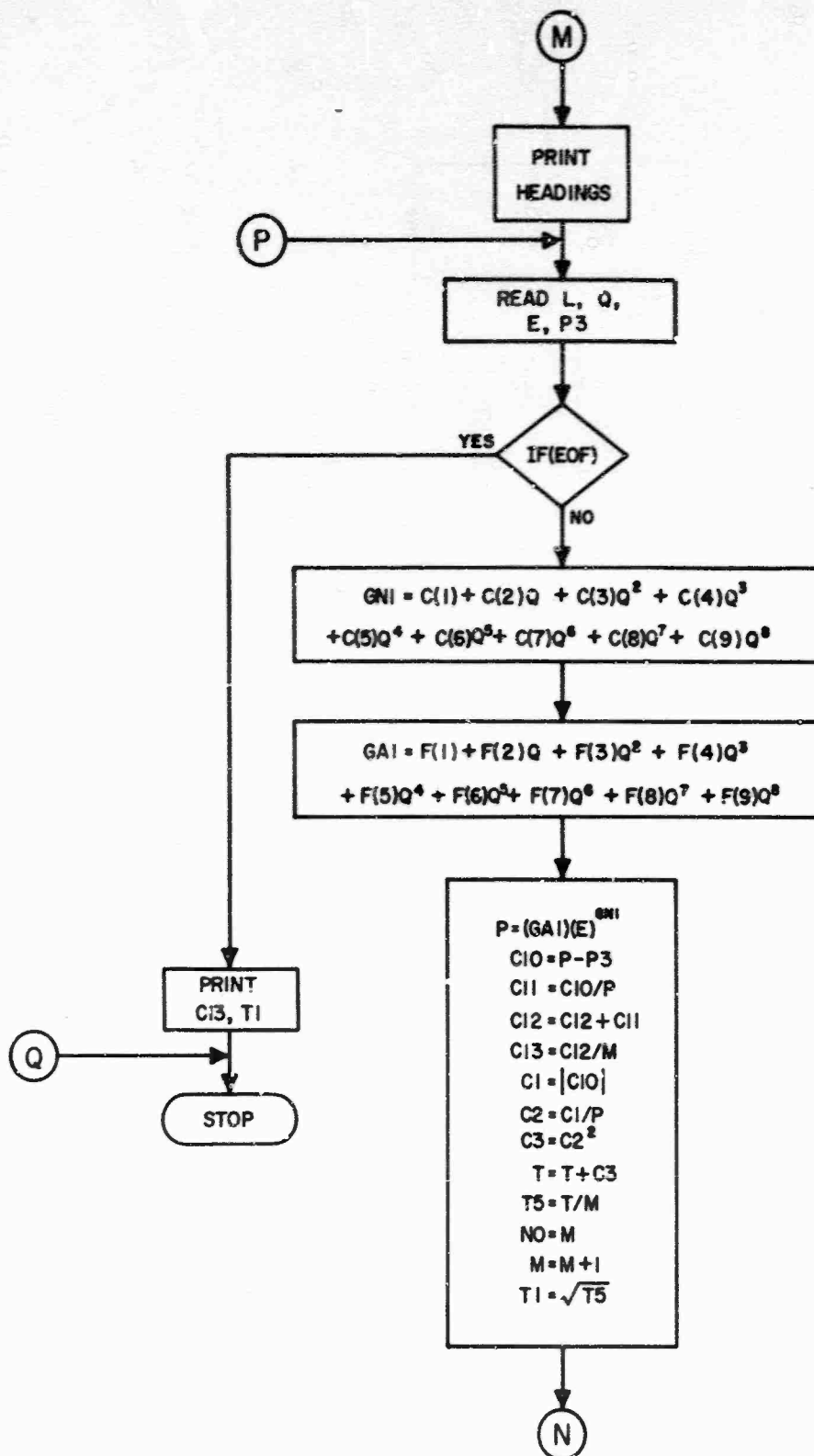


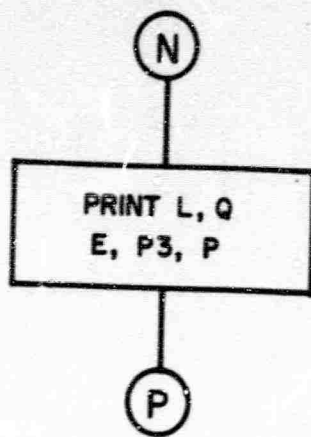












APPENDIX C
EXPERIMENTAL DATA

APPENDIX C

EXPERIMENTAL DATA

Table

C-1	Experimental Data for 16"/50 Gun
C-2	Experimental Data for 8"/55 Gun
C-3	Experimental Data for 6"/47 Gun
C-4	Experimental Data for 5"/54 Gun
C-5	Experimental Data for 5"/38 Gun
C-6	Experimental Data for 3"/50 Gun
C-7	Experimental Data for 40 mm Gun With Flash Hider
C-8	Experimental Data for 40 mm Gun Without Flash Hider
C-9	Experimental Data for 20 mm M3 Gun
C-10	Experimental Data for 20 mm XM197 Gun
C-11	Experimental Data for 20 mm MARK 12 Gun

TABLE-C-1

EXPERIMENTAL DATA FOR 16"/50 GUN

ANGLE (DEGS.)	DISTANCE (FEET)	PRESSURE (PSI)
29.90	50.0	15.7
29.90	80.0	6.5
44.50	30.0	22.5
44.70	50.0	15.6
44.80	80.0	8.5
58.60	20.0	27.6
59.00	30.0	20.5
59.50	50.0	10.8
59.70	80.0	4.7
72.10	20.0	15.3
73.50	30.0	13.3
74.40	50.0	6.5
98.50	34.5	6.7
95.10	52.8	4.6
102.40	26.2	10.1
112.30	20.0	8.5
117.00	30.0	5.1
119.00	50.0	2.5
125.00	20.0	5.0
131.20	30.0	2.0
133.80	50.0	1.2
146.70	20.0	3.3
152.50	20.0	2.9
157.70	30.0	1.5
163.20	50.0	1.0

TABLE C-2

EXPERIMENTAL DATA FOR 8"/55 GUN

<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>	<u>ARRIVAL TIME (MSEC)</u>	<u>DURATION (MSEC)</u>	<u>IMPULSE (PSI-MSEC)</u>
47.9	15.1	15.93	6.50	4.83	28.17
46.2	27.7	7.17	15.09	7.28	18.95
45.8	40.5	4.32	25.82	6.38	9.60
75.8	15.1	8.12	7.55	3.92	11.74
75.4	27.7	4.34	16.91	5.58	8.69
75.3	40.5	2.70	27.20	5.63	5.54
104.4	15.1	4.68	9.06	3.51	6.05
105.0	27.6	2.39	19.10	4.44	3.89
105.0	40.5	1.56	29.82	6.38	3.64
132.0	15.2	2.60	10.65	3.51	3.38
134.0	27.6	1.42	21.03	4.55	2.38
134.5	40.5	1.44	25.44	4.74	1.78

TABLE C-3

EXPERIMENTAL DATA FOR 6"/47

<u>ANGLE</u> <u>(DEGREES)</u>	<u>DISTANCE</u> <u>(FEET)</u>	<u>PRESSURE</u> <u>(PSI)</u>
45.0	25.0	5.84
45.0	30.0	5.08
45.0	50.0	2.38
45.0	100.0	.71
60.0	20.0	7.33
60.0	30.0	4.50
60.0	50.0	1.68
60.0	100.0	.61
75.0	20.0	6.25
75.0	50.0	1.44
75.0	100.0	.60
90.0	20.0	3.91
90.0	30.0	2.60
90.0	50.0	1.39
90.0	100.0	.59
120.0	20.0	2.27
120.0	30.0	1.55
120.0	50.0	.84
120.0	100.0	.35
135.0	20.0	1.37
135.0	30.0	1.16
135.0	50.0	.61
135.0	100.0	.30

TABLE C-4

EXPERIMENTAL DATA FOR 5"/54 GUN

<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>	<u>ARRIVAL TIME (MSEC)</u>	<u>DURATION (MSEC)</u>	<u>IMPULSE (PSI-MSEC)</u>
15.0	20	7.2	10.8	7.0	17.0
	30	3.5	18.7	8.0	9.8
	40	2.2	27.2	9.4	7.2
30.0	10	17.0	3.1	3.2	-
	20	6.2	11.4	4.9	14.0
	30	3.4	19.3	6.0	9.8
	40	2.3	27.2	7.5	6.8
45.0	10	14.0	4.64	3.2	18.0
	20	5.5	11.6	5.0	10.0
	30	3.3	18.9	6.0	7.6
	40	2.2	27.2	6.2	5.7
60.0	10	12.0	4.64	3.0	14.0
	20	4.6	12.0	4.1	7.8
	30	2.7	19.6	4.9	5.4
	40	1.9	28.7	5.8	4.5
75.0	10	9.0	4.66	2.2	12.0
	20	3.8	12.6	3.7	6.2
	30	2.2	20.4	4.1	4.2
	40	1.6	28.6	6.0	3.3
90.0	10	6.5	4.64	2.1	5.5
	20	2.8	13.5	3.3	4.2
	30	1.7	21.6	3.2	3.2
	40	1.3	29.4	3.5	2.2
105.0	10	4.1	6.0	2.1	3.6
	20	2.2	13.0	2.6	3.2
	30	1.4	22.1	2.5	1.8

TABLE C-5

EXPERIMENTAL DATA FOR 5"/38 GUN

<u>ANGLE</u> <u>(DEGREES)</u>	<u>DISTANCE</u> <u>(FEET)</u>	<u>PRESSURE</u> <u>(PSI)</u>
45.0	13.5	10.30
	17.5	7.27
	22.0	5.43
	25.5	4.67
	30.0	3.65
	37.0	2.59
	39.0	2.10
	8.5	20.43
60.0	12.0	10.07
	14.2	7.70
	15.2	7.90
	18.5	6.07
	21.5	4.60
	22.5	5.00
	26.5	3.20
	8.5	13.05
75.0	10.0	10.65
	13.0	7.05
	14.0	6.10
	33.5	2.20
	4.5	16.35
	6.1	13.50
	7.0	10.03
	10.0	7.40
90.0	14.0	5.08
	18.0	3.53
	25.5	2.00
	27.5	2.10

TABLE C-6

EXPERIMENTAL DATA FOR 3"/50 GUN

<u>ANGLE</u> <u>(DEGREES)</u>	<u>DISTANCE</u> <u>(FEET)</u>	<u>PRESSURE</u> <u>(PSI)</u>	<u>ARRIVAL TIME</u> <u>(MSEC)</u>	<u>DURATION</u> <u>(MSEC)</u>	<u>IMPULSE</u> <u>(PSI-MSEC)</u>
48.0	5.7	16.04	2.50	2.18	13.05
46.4	10.4	7.62	5.60	2.99	8.39
46.0	15.2	5.60	9.32	3.16	6.54
75.9	5.7	7.71	2.91	1.95	5.52
75.4	10.4	4.52	6.36	2.36	3.92
75.3	15.2	2.80	10.16	3.00	3.10
104.0	5.7	4.47	3.52	1.68	2.78
105.0	10.4	2.36	7.12	2.43	2.10
105.0	15.2	1.76	11.24	2.90	1.80
131.0	5.8	2.36	4.15	1.43	1.24
133.0	10.4	1.49	7.95	2.05	1.13
134.0	15.2	0.92	12.20	4.14	1.44

TABLE C-7

EXPERIMENTAL DATA FOR 40 MM GUN WITH FLASH HIDER

<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>
45.0	3.0	14.96
	7.0	5.70
	15.0	3.28
90.0	3.0	2.52
	7.0	1.82
	15.0	0.92
135.0	3.0	0.38
	7.0	0.20
	15.0	0.10
165.0	3.0	0.18
	7.0	0.10
	15.0	0.06

TABLE C-8

EXPERIMENTAL DATA FOR 40 MM GUN WITHOUT FLASH HIDER

<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>
15.0	2.83	25.32
	5.35	6.74
	7.87	5.70
	10.40	3.13
30.0	5.35	8.88
	7.87	4.92
	10.40	3.53
	2.83	20.20
45.0	5.35	7.20
	7.87	5.02
	10.40	3.39
	2.83	15.00
60.0	5.35	7.09
	7.87	4.48
	10.40	2.96
	2.83	12.54
75.0	5.35	4.80
	7.87	3.32
	10.40	2.72
	2.83	8.14
90.0	5.35	3.39
	7.87	2.53
	10.40	1.53
	2.83	4.71
105.0	5.35	2.23
	7.87	1.83
	10.40	1.33
	2.83	3.72
120.0	5.35	1.72
	7.87	1.18
	10.40	0.96
	2.83	2.69
135.0	5.35	1.50
	7.87	0.98
	10.40	0.68
	2.83	1.82
150.0	5.35	1.15
	7.87	0.75
	10.40	0.60
	2.83	1.15
165.0	5.35	0.88
	7.87	0.67
	10.40	0.50
	2.83	

TABLE C-9

EXPERIMENTAL DATA FOR 20 MM M3 GUN

ANGLE (DEGS.)	DISTANCE (FEET)	PRESSURE (PSI)	ANGLE (DEGS.)	DISTANCE (FEET)	PRESSURE (PSI)
15.0	1.0	28.90	105.0	8.0	0.50
	2.0	10.10		10.0	0.40
	4.0	3.40		20.0	0.20
	6.0	1.60		1.0	3.60
	8.0	1.10		2.0	2.00
30.0	20.0	0.40	120.0	5.0	0.70
	1.0	23.60		8.0	0.40
	2.0	9.60		10.0	0.40
	4.0	3.50		20.0	0.20
	6.0	2.00		1.0	2.50
45.0	8.0	1.50	135.0	2.0	1.50
	20.0	0.50		5.0	0.50
	1.0	20.20		8.0	0.30
	2.0	9.00		10.0	0.30
	4.0	3.60		20.0	0.10
60.0	6.0	1.90			
	8.0	1.30			
	20.0	0.50			
	1.0	16.80			
	2.0	8.90			
75.0	4.0	3.20			
	6.0	1.60			
	8.0	1.20			
	20.0	0.40			
	1.0	11.30			
90.0	2.0	5.70			
	4.0	2.40			
	6.0	1.30			
	8.0	1.00			
	20.0	0.40			
105.0	1.0	7.80			
	2.0	4.10			
	4.0	1.80			
	6.0	1.00			
	8.0	0.80			
	20.0	0.30			
	1.0	4.90			
	2.0	2.70			
	5.0	1.00			

TABLE C-10

EXPERIMENTAL DATA FOR 20 MM XM 197 GUN

<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>	<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>
15.0	1.0	34.56	135.0	0.5	3.44
	1.5	24.73		1.5	1.44
	3.0	5.86		3.0	0.78
	10.0	0.94		4.0	0.60
30.0	1.0	23.57	150.0	10.0	0.20
	1.5	14.28		0.5	2.53
	3.0	4.25		1.5	1.03
	4.0	3.80		3.0	0.60
45.0	10.0	0.93	165.0	4.0	0.60
	1.0	24.12		10.0	0.20
	1.5	15.46		0.5	2.00
	3.0	4.02		1.5	1.12
60.0	4.0	3.56		3.0	0.50
	10.0	1.00		4.0	0.60
	0.5	22.22		10.0	0.20
	1.5	9.60			
75.0	3.0	2.98			
	4.0	2.32			
	10.0	0.84			
	0.5	15.34			
90.0	1.5	7.24			
	3.0	2.40			
	4.0	2.18			
	10.0	0.78			
105.0	0.5	10.42			
	1.5	5.08			
	3.0	1.74			
	4.0	1.64			
120.0	10.0	0.40			
	0.5	6.00			
	1.5	3.32			
	3.0	1.37			
	4.0	1.25			
	10.0	0.30			
	0.5	5.60			
	1.5	2.42			
	3.0	0.90			
	4.0	0.82			
	10.0	0.20			

TABLE C-11

EXPERIMENTAL DATA FOR 20 MM MARK 12 GUN

ANGLE (DEGS.)	DISTANCE (FEET)	PRESSURE (PSI)	ANGLE (DEGS.)	DISTANCE (FEET)	PRESSURE (PSI)
0	1.00	30.00	90.0	6.00	1.20
	2.00	16.00		12.00	0.60
	4.00	4.50		20.00	0.30
	6.00	2.10		0.50	7.30
	8.00	1.20		1.50	2.70
	20.00	0.40		3.00	1.90
15.0	3.00	6.90	120.0	6.00	1.00
	5.00	3.00		12.00	0.40
	7.00	1.90		20.00	0.20
	10.00	1.00		0.50	5.10
	15.00	0.70		1.66	2.00
	20.00	0.50		3.00	1.40
30.0	1.00	25.40	135.0	6.00	0.60
	2.00	10.80		12.00	0.30
	4.00	4.60		20.00	0.20
	6.00	2.00		0.50	4.20
	8.00	0.90		2.00	1.30
	20.00	0.50		4.50	0.60
45.0	0.75	23.40	150.00	6.00	0.50
	1.75	10.60		10.00	0.30
	3.00	5.60		15.00	0.20
	5.00	2.90		0.50	3.10
	12.00	0.90		2.00	1.10
	20.00	0.50			
60.0	0.50	22.90			
	1.50	8.00			
	3.00	4.70			
	6.00	1.90			
	12.00	0.30			
	20.00	0.50			
75.0	0.50	14.90			
	1.50	6.00			
	3.00	3.50			
	6.00	1.70			
	12.00	0.60			
	20.00	0.40			
90.0	0.50	11.50			
	1.50	3.80			
	3.00	2.60			

APPENDIX D

COMPUTER GENERATED DATA
FOR CONSTRUCTING CURVES

APPENDIX D

COMPUTER GENERATED DATA FOR CONSTRUCTING CURVES

Table

D-1	Free-Air Peak Pressure Data For 16"/50 Gun From Curve Fitting Program
D-2	Free-Air Peak Pressure Data For 8"/55 Gun From Curve Fitting Program
D-3	Free-Air Arrival Time Data For 8"/55 Gun From Curve Fitting Program (preliminary)
D-4	Free-Air Duration Data For 8"/55 Gun From Curve Fitting Program (preliminary)
D-5	Free-Air Impulse Data For 8"/55 Gun From Curve Fitting Program (preliminary)
D-6	Free-Air Peak Pressure Data For 6"/47 Gun From Curve Fitting Program
D-7	Free-Air Peak Pressure Data For 5"/54 Gun From Curve Fitting Program
D-8	Free-Air Arrival Time Data For 5"/54 Gun From Curve Fitting Program (preliminary)
D-9	Free-Air Duration Data For 5"/54 Gun From Curve Fitting Program (preliminary)
D-10	Free-Air Impulse Data For 5"/54 Gun From Curve Fitting Program (preliminary)
D-11	Free-Air Peak Pressure Data For 5"/38 Gun From Curve Fitting Program
D-12	Free-Air Peak Pressure Data For 3"/50 Gun From Curve Fitting Program
D-13	Free-Air Arrival Time Data For 3"/50 Gun From Curve Fitting Program (preliminary)
D-14	Free-Air Duration Data For 3"/50 Gun From Curve Fitting Program (preliminary)
D-15	Free-Air Impulse Data For 3"/50 Gun From Curve Fitting Program (preliminary)
D-16	Free-Air Peak Pressure Data For 40 mm Gun With Flash Hider From Curve Fitting Program
D-17	Free-Air Peak Pressure Data For 40 mm Gun Without Flash Hider From Curve Fitting Program
D-18	Free-Air Peak Pressure Data For 20 mm M3 Gun From Curve Fitting Program
D-19	Free-Air Peak Pressure Data For 20 mm XM197 Gun From Curve Fitting Program
D-20	Free-Air Peak Pressure Data For 20 mm MK 12 Gun From Curve Fitting Program

TABLE D-1

FREE-AIR PEAK PRESSURE FOR 16"/50 GUN FROM CURVE FITTING PROGRAM

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Pressure (PSI)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.52	0.67	0.62	0.55	0.45	0.34	0.24	0.19	0.16	0.09	0.03	0.03	0.02
1000	1.03	1.28	1.20	1.05	0.85	0.63	0.45	0.35	0.28	0.18	0.06	0.05	0.03
200	4.90	5.80	5.58	4.72	3.71	2.70	1.87	1.40	1.14	0.78	0.31	0.27	0.18
100	9.61	11.10	10.80	9.02	7.00	5.04	3.45	2.54	2.07	1.47	0.63	0.56	0.36
60	15.80	17.90	17.60	14.50	11.20	8.00	5.42	3.94	3.21	2.36	1.05	0.94	0.61
40	23.40	26.30	26.00	21.20	16.20	11.50	7.75	5.59	4.56	3.42	1.58	1.43	0.93
30	31.00	34.40	34.20	27.80	21.10	15.00	10.00	7.16	5.84	4.45	2.11	1.92	1.26
20	46.00	50.30	50.30	40.60	30.50	21.60	14.30	10.10	8.29	6.46	3.17	2.91	1.92
15	60.80	65.90	66.30	53.10	39.70	28.00	18.50	13.00	10.60	8.41	4.24	3.91	2.59
10	90.20	96.40	97.70	77.50	57.60	40.40	26.40	18.40	15.10	12.20	6.37	5.92	3.94
9	100.00	106.00	108.00	85.50	63.40	44.40	29.00	20.20	16.50	13.50	7.09	6.60	4.40
8	112.00	119.00	121.00	95.50	70.60	49.40	32.20	22.30	18.30	15.00	7.98	7.44	4.97
7	128.00	135.00	137.00	108.00	79.80	55.80	36.20	25.00	20.50	16.90	9.13	8.54	5.71
6	148.00	156.00	159.00	125.00	91.80	64.10	41.50	28.60	23.40	19.50	10.70	10.00	6.70
5	177.00	185.00	189.00	148.00	109.00	75.60	48.80	33.40	27.40	23.10	12.80	12.10	8.10
4	220.00	228.00	234.00	182.00	132.00	92.50	59.40	40.50	33.20	28.30	16.10	15.20	10.20
3	291.00	298.00	309.00	239.00	173.00	120.00	76.60	51.90	42.60	36.90	21.50	20.40	13.80
2	432.00	437.00	455.00	349.00	251.00	173.00	110.00	73.50	60.40	53.50	32.30	30.90	21.00
1	847.00	837.00	882.00	666.00	473.00	324.00	202.00	133.00	110.00	101.00	65.00	62.90	43.10
0.5	1660.00	1600.00	1710.00	1270.00	892.00	606.00	374.00	242.00	199.00	191.00	131.00	128.00	88.70
0.1	7950.00	7260.00	7960.00	5730.00	3890.00	2590.00	1550.00	968.00	799.00	838.00	662.00	667.00	472.00

TABLE D-2

FREE-AIR PEAK PRESSURE DATA FOR 6"/55 GUN FROM CURVE FITTING PROGRAM

DISTANCES FROM MUZZLE — ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Pressure (PSI)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.31	0.32	0.32	0.29	0.23	0.14	0.08	0.05	0.04	0.02	0.01	0.01	0.00
1000	0.54	0.55	0.55	0.51	0.40	0.26	0.15	0.10	0.07	0.04	0.01	0.02	0.01
200	1.93	1.98	2.02	1.82	1.47	1.03	0.65	0.44	0.33	0.20	0.07	0.08	0.05
100	3.34	3.44	3.53	3.16	2.58	1.88	1.22	0.83	0.63	0.40	0.15	0.17	0.10
60	5.00	5.15	5.32	4.75	3.91	2.91	1.93	1.33	1.03	0.67	0.27	0.30	0.18
40	6.88	7.11	7.38	6.56	5.45	4.13	2.79	1.94	1.51	1.02	0.43	0.46	0.27
30	8.64	8.94	9.30	8.25	6.89	5.30	3.62	2.53	1.98	1.36	0.59	0.62	0.37
20	11.90	12.30	12.90	11.40	9.58	7.51	5.23	3.67	2.92	2.07	0.92	0.45	0.56
15	14.90	15.50	16.30	14.30	12.10	9.62	6.78	4.80	3.83	2.77	1.27	1.29	0.76
10	20.50	21.40	22.50	19.80	16.80	13.70	9.78	6.97	5.63	4.20	1.99	1.98	1.16
9	22.30	23.20	24.50	21.50	18.40	14.90	10.80	7.69	6.23	4.68	2.24	2.21	1.30
8	24.50	25.50	27.00	23.60	20.20	16.50	12.00	8.57	6.97	5.28	2.55	2.51	1.47
7	27.20	28.40	30.00	26.30	22.50	18.60	13.50	9.70	7.91	6.06	2.96	2.89	1.69
6	30.80	32.10	34.00	29.70	25.50	21.20	15.50	11.20	9.16	7.10	3.51	3.40	1.99
5	35.50	37.00	39.40	34.30	29.60	24.80	18.30	13.20	10.90	8.55	4.29	4.13	2.40
4	43.30	44.20	47.10	41.00	35.50	30.10	22.40	16.30	13.50	10.70	5.50	5.23	3.03
3	53.10	55.60	59.40	51.60	44.90	38.50	29.10	21.20	17.70	14.40	7.57	7.09	4.10
2	73.20	76.70	82.40	71.20	62.50	54.70	42.00	30.90	26.00	21.90	11.90	10.90	6.26
1	126.00	133.00	144.00	124.00	110.00	99.30	78.60	58.60	50.30	44.50	25.60	22.70	12.90
0.5	218.00	230.00	252.00	215.00	193.00	181.00	147.00	111.00	97.20	90.50	55.30	47.40	26.70
0.1	778.00	826.00	920.00	773.00	717.00	723.00	631.00	492.00	449.00	471.00	330.00	261.00	144.00

TABLE D-3

FREE-AIR ARRIVAL TIME DATA FOR 8"/55 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Arrival Time (MSEC)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	913.00	932.00	923.00	915.00	966.00	1090.00	1280.00	1470.00	1590.00	1650.00	1710.00	1750.00	1820.00
1000	560.00	570.00	563.00	556.00	579.00	642.00	731.00	816.00	865.00	887.00	907.00	921.00	950.00
200	180.00	182.00	178.00	174.00	177.00	186.00	198.00	208.00	210.00	209.00	209.00	208.00	212.00
100	111.00	111.00	109.00	106.00	106.00	109.00	113.00	115.00	114.00	112.00	111.00	110.00	111.00
60	77.20	77.20	75.40	73.30	72.80	73.50	74.60	74.60	72.90	70.80	69.50	68.40	66.50
40	58.00	57.90	56.40	54.80	54.00	53.80	53.60	52.80	51.10	49.20	48.00	47.00	47.10
30	47.30	47.20	46.00	44.50	43.70	43.10	42.50	41.30	39.60	38.00	36.90	36.00	36.00
20	35.60	35.40	34.40	33.30	32.40	31.50	30.60	29.30	27.80	26.40	25.50	24.80	24.70
15	29.10	28.90	28.00	27.00	26.20	25.30	24.20	22.90	21.60	20.40	19.60	19.00	18.90
10	21.80	21.60	21.00	20.20	19.40	18.50	17.40	16.20	15.10	14.20	13.50	13.10	12.90
9	20.30	20.10	19.40	18.70	18.00	17.00	16.00	14.80	13.80	12.90	12.30	11.80	11.70
8	18.70	18.50	17.90	17.20	16.50	15.60	14.50	13.40	12.40	11.60	11.00	10.60	10.50
7	17.00	16.80	16.30	15.60	14.90	14.00	13.00	12.00	11.00	10.30	9.78	9.39	9.26
6	15.20	15.10	14.60	14.00	13.30	12.50	11.50	10.50	9.63	8.95	8.50	8.15	8.02
5	13.40	13.20	12.80	12.30	11.60	10.80	9.92	9.01	8.20	7.60	7.19	6.88	6.77
4	11.40	11.30	10.90	10.40	9.88	9.13	8.28	7.45	6.74	6.22	5.87	5.60	5.50
3	9.35	9.20	8.87	8.49	7.99	7.31	6.55	5.83	5.23	4.80	4.51	4.29	4.28
2	7.03	6.90	6.64	6.34	5.93	5.35	4.72	4.13	3.66	3.34	3.12	2.95	2.88
1	4.31	4.22	4.05	3.85	3.56	3.14	2.69	2.29	1.99	1.79	1.66	1.56	1.51
0.5	2.65	2.58	2.47	2.34	2.13	1.84	1.53	1.27	1.08	0.96	0.88	0.82	0.79
0.1	0.85	0.82	0.78	0.73	0.65	0.53	0.41	0.32	0.26	0.23	0.20	0.19	0.18

TABLE D-4

FREE-AIR DURATION DATA FOR 8"/55 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Duration Time (MSEC)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
40	2350.00	2360.00	2310.00	2420.00	2420.00	2180.00	1850.00	1520.00	1290.00	1150.00	1040.00	916.00	877.00
30	1230.00	1230.00	1180.00	1230.00	1250.00	1170.00	1030.00	885.00	780.00	713.00	661.00	596.00	577.00
25	821.00	810.00	767.00	798.00	822.00	789.00	712.00	630.00	566.00	526.00	495.00	453.00	442.00
20	498.00	487.00	455.00	471.00	492.00	487.00	455.00	415.00	382.00	362.00	348.00	325.00	319.00
15	262.00	253.00	231.00	238.00	254.00	261.00	255.00	242.00	230.00	224.00	220.00	211.00	210.00
14	225.00	216.00	197.00	202.00	217.00	225.00	222.00	213.00	204.00	199.00	198.00	190.00	190.00
13	190.00	183.00	165.00	170.00	183.00	192.00	192.00	185.00	179.00	176.00	176.00	170.00	170.00
12	159.00	152.00	137.00	141.00	152.00	161.00	163.00	160.00	155.00	154.00	155.00	151.00	151.00
11	131.00	125.00	112.00	114.00	125.00	134.00	137.00	136.00	133.00	133.00	135.00	133.00	133.00
10	106.00	100.00	89.40	91.40	100.00	109.00	113.00	114.00	113.00	114.00	116.00	115.00	116.00
9	83.70	79.00	69.80	71.20	78.60	86.50	91.60	93.20	93.60	95.30	98.10	98.10	99.50
8	64.30	60.40	53.00	53.90	59.90	67.10	72.30	74.80	76.10	78.30	81.40	82.30	83.80
7	47.70	44.60	38.70	39.30	44.10	50.20	55.30	58.30	60.10	62.60	65.90	67.40	68.90
6	33.80	31.40	27.00	27.30	30.90	36.00	40.60	43.70	45.80	48.40	51.60	53.50	55.00
5	22.50	20.70	17.60	17.70	20.40	24.30	28.10	31.10	33.30	35.70	38.60	40.70	42.20
4	13.70	12.50	10.40	10.50	12.20	15.00	18.00	20.50	22.40	24.60	27.10	29.10	30.50
3	7.19	6.47	5.31	5.30	6.29	8.04	10.10	12.00	13.50	15.20	17.20	18.90	20.00
2	2.91	2.57	2.05	2.03	2.48	3.34	4.47	5.60	6.62	7.71	9.05	10.30	11.10
1	0.62	0.53	0.40	0.39	0.50	0.75	1.11	1.53	1.95	2.42	3.02	3.65	4.03
0.5	0.13	0.11	0.08	0.08	0.10	0.17	0.28	0.42	0.58	0.76	1.01	1.29	1.46
0.1	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.05	0.08	0.12	0.14

TABLE D-5
FREE-AIR IMPULSE DATA FOR 8"/55 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)
DISTANCES FROM MUZZLE — ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Impulse (PGI-MSEC)	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
400	0.53	1.03	0.93	0.56	0.25	0.09	0.03	0.011	0.004	0.006	0.015	0.007	0.003
300	0.76	1.43	1.29	0.80	0.37	0.14	0.05	0.018	0.007	0.010	0.022	0.011	0.004
200	1.25	2.29	2.05	1.32	0.62	0.25	0.10	0.036	0.015	0.019	0.038	0.020	0.008
100	2.93	5.12	4.53	3.11	1.56	0.66	0.29	0.123	0.055	0.056	0.098	0.052	0.025
60	5.50	9.25	8.13	5.83	3.07	1.36	0.65	0.306	0.139	0.127	0.197	0.109	0.057
40	9.05	14.80	12.90	9.60	5.25	2.43	1.23	0.630	0.292	0.243	0.342	0.194	0.109
30	12.90	20.60	18.00	13.70	7.69	3.65	1.93	1.050	0.495	0.385	0.507	0.292	0.173
20	21.20	33.00	28.60	22.50	13.20	6.49	3.65	2.160	1.040	0.737	0.883	0.521	0.333
15	30.20	46.10	39.80	32.10	19.30	9.77	5.73	3.600	1.760	1.170	1.310	0.786	0.528
10	49.80	73.60	63.40	52.80	33.00	17.40	10.80	7.410	3.710	2.230	2.280	1.400	1.010
9	56.60	83.20	71.50	60.10	37.90	20.20	12.80	8.930	4.500	2.640	2.630	1.630	1.200
8	65.50	95.40	81.80	69.50	44.30	23.80	15.40	11.000	5.580	3.190	3.090	1.930	1.450
7	77.10	111.00	95.30	81.90	52.90	28.80	19.00	14.000	7.130	3.940	3.710	2.330	1.800
6	93.20	133.00	114.00	99.10	64.90	35.90	24.20	18.400	9.460	5.050	4.580	2.910	2.310
5	117.00	164.00	140.00	124.00	82.60	46.50	32.30	25.400	13.200	6.750	5.880	3.770	3.090
4	153.00	213.00	181.00	163.00	111.00	63.80	45.90	37.800	19.900	9.650	7.970	5.180	4.430
3	219.00	297.00	252.00	232.00	163.00	96.00	72.10	63.000	33.700	15.300	11.800	7.820	7.030
2	60.00	475.00	400.00	383.00	278.00	171.00	136.00	130.000	70.900	29.200	20.600	13.900	13.500
1	844.00	1060.00	886.00	898.00	697.00	457.00	406.00	445.000	253.000	88.500	53.100	37.500	41.100
0.5	1980.00	2370.00	1960.00	2110.00	1750.00	1220.00	1210.00	1520.000	900.000	268.000	137.000	101.000	125.000
0.1	14300.00	15300.00	12400.00	15300.00	14700.00	12000.00	15200.00	26700.000	17200.000	3510.000	1240.000	1000.000	1670.000

TABLE D-6

FREE-AIR PEAK PRESSURE DATA FOR 6"/47 GUN FITTING PROGRAM

DISTANCE FROM MUZZLE -- ANGLE FROM MUZZLE AND BORE AXIS EXTENDED

PRESSURE (PSI)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.35	0.36	0.35	0.31	0.27	0.20	0.11	0.04	0.02	0.01	0.01	0.01	0.00
1000	0.59	0.61	0.59	0.53	0.46	0.34	0.19	0.08	0.04	0.03	0.02	0.01	0.01
200	1.94	2.00	1.96	1.80	1.57	1.24	0.74	0.36	0.21	0.14	0.10	0.07	0.05
100	3.25	3.35	3.29	3.03	2.67	2.15	1.33	0.68	0.42	0.28	0.20	0.14	0.11
60	4.74	4.89	4.82	4.47	3.95	3.23	2.05	1.09	0.69	0.47	0.34	0.25	0.19
40	6.39	6.60	6.53	6.07	5.40	4.46	2.89	1.58	1.03	0.71	0.52	0.38	0.30
30	7.91	8.17	8.10	7.54	6.73	5.61	3.69	2.06	1.37	0.95	0.71	0.52	0.41
20	10.77	11.03	10.98	10.25	9.19	7.75	5.20	2.98	2.04	1.45	1.08	0.81	0.64
15	13.21	13.65	13.62	12.74	11.47	9.75	6.64	3.88	2.70	1.94	1.45	1.10	0.87
10	17.82	18.43	18.46	17.32	15.66	13.46	9.36	5.62	4.02	2.94	2.22	1.70	1.35
5	19.27	19.93	19.97	18.76	16.98	10.23	10.23	6.19	4.46	3.27	2.48	1.90	1.52
8	21.02	21.74	21.81	20.50	18.59	16.07	11.30	6.90	5.01	3.69	2.80	2.16	1.72
7	23.21	24.01	24.11	22.68	20.66	17.88	12.65	7.80	5.71	4.23	3.22	2.49	1.99
6	26.01	26.91	27.06	25.49	23.18	20.21	14.42	8.98	6.64	4.95	3.78	2.94	2.36
5	29.77	30.80	31.02	29.26	26.67	23.37	16.82	10.61	7.95	5.96	4.57	3.58	2.87
4	35.11	36.34	36.67	34.64	31.66	27.91	20.32	13.01	9.89	7.49	5.77	4.54	3.66
3	43.44	44.97	45.49	43.06	39.49	35.09	25.93	16.93	13.12	10.05	7.78	6.19	5.01
2	58.63	60.73	61.64	58.52	53.92	48.46	36.55	24.54	19.53	15.21	11.87	9.56	7.78
1	97.91	101.50	103.60	98.86	91.85	84.14	65.72	46.28	38.56	30.88	24.45	20.12	16.51
.5	163.50	169.64	174.15	167.02	156.44	146.09	118.18	87.29	76.14	62.72	50.35	42.33	35.07
.1	537.79	559.00	581.58	564.37	538.71	525.99	461.72	380.86	369.55	324.95	269.35	238.19	201.55

TABLE D-7

FREE-AIR PRESSURE DATA FOR 5"/54 GUN FROM CURVE FITTING PROGRAM

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Pressure (PSI)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.38	0.52	0.43	0.32	0.25	0.17	0.09	0.03	0.01	0.00	0.00	0.00	0.00
1000	0.60	0.81	0.68	0.52	0.41	0.29	0.17	0.06	0.02	0.01	0.01	0.00	0.00
200	1.79	2.29	1.96	1.61	1.31	0.99	0.62	0.28	0.10	0.06	0.04	0.01	0.01
100	2.87	3.57	3.10	2.62	2.16	1.67	1.09	0.53	0.22	0.14	0.09	0.04	0.02
60	4.06	4.96	4.35	3.75	3.14	2.45	1.66	0.86	0.38	0.26	0.17	0.08	0.04
40	5.35	6.44	5.68	4.98	4.21	3.32	2.32	1.26	0.60	0.42	0.28	0.14	0.08
30	6.50	7.75	6.87	6.09	5.19	4.13	2.93	1.66	0.83	0.59	0.39	0.21	0.13
20	8.55	10.10	8.99	8.08	6.96	5.60	4.09	2.44	1.29	0.97	0.65	0.38	0.25
15	10.40	12.10	10.90	9.89	8.58	6.96	5.18	3.20	1.77	1.36	0.93	0.58	0.38
10	13.70	15.70	14.20	13.10	11.50	9.45	7.22	4.69	2.77	2.21	1.55	1.04	0.72
9	14.70	16.80	15.20	14.10	12.40	10.20	7.87	5.19	3.11	2.51	1.76	1.21	0.85
8	15.90	18.10	16.50	15.30	13.50	11.20	8.67	5.80	3.54	2.89	2.04	1.43	1.02
7	17.40	19.70	18.00	16.90	14.90	12.40	9.67	6.58	4.10	3.39	2.41	1.73	1.25
6	19.40	21.80	19.90	18.80	16.70	13.90	11.00	7.61	4.86	4.08	2.92	2.16	1.59
5	21.90	24.50	22.50	21.30	19.00	15.90	12.70	9.04	5.95	5.07	3.66	2.81	2.11
4	25.50	28.30	26.00	24.90	22.40	18.90	15.30	11.20	7.60	6.62	4.83	3.68	2.99
3	31.00	34.00	31.50	30.50	27.60	23.40	19.40	14.70	10.40	9.35	6.91	5.87	4.68
2	40.80	44.20	41.20	40.50	37.00	31.80	27.00	21.50	16.30	15.20	11.40	10.50	8.78
1	65.20	63.90	65.10	65.70	61.30	53.60	47.70	41.50	35.00	34.80	27.10	28.60	25.80
0.5	104.00	108.00	103.00	107.00	101.00	90.40	84.20	79.90	75.10	79.70	64.10	77.60	75.70
0.1	311.00	303.00	298.00	329.00	326.00	304.00	315.00	366.00	442.00	547.00	474.00	788.00	923.00

TABLE D-8

FREE-AIR ARRIVAL TIME DATA FOR 5"/54 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Arrival Time (MSEC)	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
2000	898.00	914.00	898.00	910.00	957.00	1020.00	1070.00	1100.00	1150.00	1250.00	1360.00	1360.00	1630.00
1000	543.00	554.00	543.00	548.00	570.00	599.00	621.00	633.00	654.00	701.00	749.00	747.00	872.00
200	173.00	174.00	169.00	169.00	171.00	175.00	177.00	177.00	175.00	175.00	189.00	185.00	203.00
100	106.00	105.00	103.00	102.00	102.00	103.00	103.00	102.00	102.00	103.00	104.00	101.00	108.00
60	73.40	72.90	70.90	69.80	69.50	69.50	69.10	68.00	67.10	67.30	67.40	65.20	58.00
40	55.00	54.40	52.90	51.90	51.30	50.90	50.30	49.30	48.40	48.00	47.60	45.90	47.10
30	44.80	44.20	42.90	42.00	41.40	40.90	40.20	39.20	38.30	37.80	37.20	35.70	36.30
20	33.60	33.00	32.00	31.20	30.60	30.00	29.30	28.50	27.60	26.90	26.30	25.10	25.10
15	27.40	26.80	26.00	25.30	24.60	24.00	23.40	22.60	21.90	21.20	20.60	19.60	19.40
10	20.50	20.00	19.40	18.80	18.20	17.60	17.10	16.40	15.70	15.10	14.50	13.80	13.40
9	19.00	18.50	18.00	17.40	16.80	16.30	15.70	15.10	14.50	13.90	13.30	12.60	12.20
8	17.50	17.00	16.50	16.00	15.40	14.90	14.30	13.80	13.10	12.60	12.00	11.40	10.90
7	15.90	15.50	15.00	14.50	13.90	13.40	12.90	12.40	11.80	11.20	10.70	10.10	9.70
6	14.20	13.80	13.40	12.90	12.40	11.90	11.40	11.00	10.40	9.89	9.39	8.85	8.43
5	12.50	12.10	11.70	11.30	10.80	10.40	9.92	9.48	8.99	8.49	8.04	7.56	7.15
4	10.70	10.30	9.98	9.62	9.17	8.73	8.34	7.94	7.50	7.05	6.64	6.23	5.84
3	8.70	8.40	8.10	7.79	7.40	7.01	6.66	6.32	5.94	5.55	5.19	4.86	4.50
2	6.52	6.27	6.04	5.79	5.46	5.14	4.85	4.58	4.28	3.96	3.67	3.42	3.12
1	3.98	3.80	3.66	3.49	3.25	3.02	2.82	2.64	2.44	2.22	2.03	1.87	1.66
0.5	2.43	2.31	2.22	2.10	1.94	1.78	1.64	1.53	1.39	1.25	1.12	1.03	0.89
0.1	0.77	0.72	0.69	0.65	0.58	0.52	0.47	0.43	0.38	0.33	0.28	0.25	0.21

TABLE D-9
FREE-AIR DURATION DATA FOR 5"/54 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)
DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Duration Time (MSEC)	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
40	1410.00	1260.00	1440.00	1600.00	1510.00	1350.00	1310.00	1310.00	1260.00	1330.00	1600.00	1470.00	1540.00
30	735.00	646.00	748.00	862.00	858.00	819.00	837.00	865.00	851.00	906.00	1100.00	1030.00	1100.00
25	486.00	424.00	494.00	581.00	600.00	596.00	630.00	665.00	663.00	712.00	873.00	822.00	887.00
20	293.00	253.00	297.00	359.00	387.00	404.00	444.00	482.00	489.00	530.00	655.00	624.00	683.00
15	153.00	130.00	155.00	143.00	220.00	245.00	284.00	319.00	330.00	362.00	453.00	437.00	487.00
14	131.00	111.00	132.00	166.00	192.00	217.00	255.00	289.00	300.00	331.00	415.00	401.00	449.00
13	111.00	93.20	112.00	141.00	166.00	191.00	227.00	260.00	271.00	300.00	377.00	366.00	412.00
12	92.20	77.40	93.00	119.00	142.00	166.00	200.00	231.00	243.00	270.00	340.00	331.00	375.00
11	75.70	63.30	76.30	98.50	120.00	143.00	175.00	204.00	216.00	240.00	304.00	297.00	339.00
10	61.00	50.70	61.50	80.20	99.30	121.00	151.00	178.00	189.00	212.00	269.00	264.00	303.00
9	48.10	39.80	48.40	63.80	80.80	101.00	128.00	153.00	164.00	184.00	235.00	232.00	268.00
8	36.80	30.30	37.00	49.50	64.10	82.10	106.00	129.00	140.00	158.00	202.00	200.00	233.00
7	27.20	22.20	27.30	37.10	49.30	65.00	86.40	106.00	116.00	132.00	170.00	170.00	199.00
6	19.20	15.50	19.20	26.60	36.50	49.70	68.00	85.30	94.10	108.00	140.00	140.00	166.00
5	12.70	10.20	12.70	17.90	25.50	36.20	51.10	65.60	73.40	84.80	111.00	112.00	134.00
4	7.66	6.08	7.64	11.10	16.40	24.60	36.10	47.60	54.10	63.10	83.10	84.80	103.00
3	3.99	3.12	3.97	5.94	9.35	14.90	23.10	31.40	36.50	43.10	57.50	59.40	73.70
2	1.99	1.22	1.58	2.47	4.22	7.35	12.20	17.50	20.90	25.20	34.20	35.90	45.80
1	0.33	0.25	0.33	0.55	1.08	2.20	4.15	6.47	8.12	10.10	14.00	15.20	20.30
0.5	0.07	0.05	0.07	0.12	0.28	0.66	1.41	2.38	3.14	4.03	5.77	6.45	9.00
0.1	0.00	0.00	0.00	0.00	0.01	0.04	0.11	0.24	0.35	0.48	0.73	0.88	1.36

TABLE D-10
FREE-AIR IMPULSE DATA FOR 5"/54 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Impulse (PSI-MSEC)	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
400	0.56	1.03	0.58	0.32	0.23	0.14	0.04	0.004	0.001	0.001	0.000	0.000	0.090
300	0.75	1.34	0.78	0.43	0.31	0.19	0.06	0.006	0.002	0.001	0.000	0.000	0.000
200	1.13	1.94	1.18	0.68	0.50	0.31	0.10	0.011	0.004	0.002	0.000	0.000	0.000
100	2.29	3.65	2.39	1.45	1.09	0.72	0.25	0.035	0.015	0.010	0.000	0.000	0.000
60	3.84	5.83	4.01	2.54	1.95	1.31	0.50	0.082	0.042	0.031	0.000	0.001	0.000
40	5.79	8.45	6.06	3.98	3.09	2.13	0.87	0.159	0.093	0.074	0.000	0.004	0.001
30	7.75	11.00	8.11	5.46	4.28	3.00	1.28	0.255	0.165	0.137	0.001	0.010	0.002
20	11.70	15.90	12.20	8.53	6.78	4.85	2.20	0.496	0.367	0.328	0.002	0.034	0.006
15	15.70	20.70	16.40	11.70	9.39	6.83	3.25	0.796	0.648	0.608	0.004	0.080	0.013
10	23.60	30.10	24.70	18.30	14.90	11.10	5.61	1.550	1.440	1.450	0.009	0.274	0.043
9	26.30	33.10	27.50	20.60	16.80	12.50	6.47	1.840	1.780	1.820	0.012	0.378	0.058
8	29.60	36.90	31.00	23.40	19.10	14.40	7.58	2.240	2.240	2.340	0.016	0.539	0.082
7	33.90	41.70	35.50	27.10	22.30	16.90	9.08	2.780	2.920	3.120	0.021	0.808	0.121
6	39.60	48.00	41.60	32.10	26.50	20.30	11.20	3.590	3.960	4.340	0.030	1.290	0.189
5	47.70	56.70	50.00	39.30	32.60	25.20	14.30	4.840	5.680	6.420	0.046	2.240	0.321
4	59.80	69.60	62.70	50.20	42.00	32.90	19.30	6.980	8.820	10.400	0.077	4.400	0.615
3	80.00	90.50	84.00	68.90	58.20	46.30	28.50	11.200	15.600	19.200	0.148	10.500	1.420
2	121.00	131.00	127.00	108.00	92.10	75.60	49.20	21.800	34.100	45.900	0.377	35.900	4.630
1	244.00	247.00	256.00	231.00	202.00	171.00	125.00	68.100	137.000	203.000	1.860	293.000	34.900
0.5	492.00	467.00	518.00	496.00	443.00	390.00	319.00	213.000	538.000	898.000	9.150	2390.000	263.000
0.1	2510.00	2040.00	2650.00	2920.00	2750.00	2640.00	2790.00	3000.000	12900.000	20400.000	371.000	2630.000	28500.000

TABLE D-11

FREE-AIR PEAK PRESSURE DATA FOR 5"/38 GUN FROM CURVE FITTING PROGRAM

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Pressure (PSI)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.26	0.34	0.31	0.26	0.21	0.16	0.10	0.06	0.04	0.03	0.02	0.01	0.01
1000	0.44	0.57	0.51	0.44	0.36	0.27	0.18	0.11	0.08	0.05	0.03	0.02	0.01
200	1.48	1.80	1.69	1.48	1.23	0.96	0.68	0.45	0.32	0.24	0.16	0.10	0.07
100	2.49	2.97	2.83	2.50	2.09	1.64	1.19	0.82	0.59	0.45	0.31	0.21	0.14
60	3.65	4.29	4.13	3.67	3.08	2.44	1.80	1.27	0.93	0.72	0.51	0.36	0.25
40	4.95	5.74	5.58	4.98	4.19	3.34	2.50	1.79	1.33	1.04	0.76	0.54	0.39
30	6.14	7.06	6.90	6.19	5.22	4.18	3.16	2.29	1.72	1.36	1.00	0.73	0.53
20	8.32	9.46	9.32	8.40	7.11	5.74	4.39	3.24	2.48	1.98	1.48	1.11	0.82
15	10.30	11.60	11.50	10.40	8.85	7.18	5.55	4.14	3.20	2.58	1.94	1.49	1.12
10	14.00	15.60	15.60	14.20	12.10	9.84	7.71	5.86	4.60	3.75	2.87	2.26	1.74
9	15.10	16.80	16.80	15.30	13.10	10.70	8.40	6.41	5.05	4.13	3.17	2.52	1.96
8	16.50	18.30	18.40	16.80	14.30	11.70	9.24	7.09	5.61	4.60	3.55	2.85	2.23
7	18.30	20.10	20.30	18.50	15.80	13.00	10.30	7.94	6.32	5.21	4.04	3.27	2.58
6	20.50	22.50	22.70	20.80	17.80	14.70	11.70	9.06	7.25	6.00	4.68	3.83	3.05
5	23.50	25.70	26.00	23.90	20.40	16.90	13.50	10.60	8.53	7.10	5.58	4.62	3.72
4	27.80	30.10	30.70	28.30	24.20	20.10	16.20	12.80	10.40	8.73	6.91	5.81	4.74
3	34.50	37.10	38.00	35.10	30.20	25.10	20.50	16.40	13.50	11.40	9.11	7.80	6.48
2	46.70	49.70	51.30	47.70	41.10	34.50	28.50	23.20	19.30	16.50	13.40	11.80	10.10
1	78.60	81.80	85.80	80.50	69.60	59.10	50.00	41.90	35.90	31.40	26.10	24.20	21.40
0.5	132.00	135.00	143.00	136.00	118.00	101.00	87.70	75.70	66.70	59.40	50.80	49.30	45.50
0.1	441.00	429.00	473.00	457.00	402.00	355.00	324.00	299.00	281.00	262.00	238.00	258.00	263.00

TABLE D-12

FREE-AIR PEAK PRESSURE DATA FOR 3"/50 GUN FROM CURVE FITTING PROGRAM

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Pressure (PSI)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.18	0.18	0.19	0.17	0.12	0.07	0.04	0.03	0.02	0.01	0.01	0.01	0.00
1000	0.30	0.30	0.32	0.29	0.21	0.12	0.07	0.05	0.04	0.02	0.01	0.01	0.01
200	0.98	1.00	1.07	0.94	0.71	0.46	0.29	0.21	0.16	0.11	0.06	0.06	0.04
100	1.63	1.68	1.78	1.58	1.20	0.80	0.52	0.38	0.30	0.20	0.12	0.11	0.08
60	2.38	2.45	2.61	2.30	1.78	1.22	0.80	0.59	0.47	0.32	0.20	0.19	0.13
40	3.22	3.31	3.53	3.11	2.42	1.69	1.14	0.84	0.67	0.47	0.30	0.28	0.20
30	3.99	4.10	4.37	3.85	3.02	2.14	1.45	1.08	0.84	0.61	0.40	0.37	0.28
20	5.39	5.55	5.91	5.20	4.12	2.98	2.06	1.54	1.23	0.89	0.60	0.56	0.42
15	6.67	6.87	7.32	6.44	5.14	3.77	2.63	1.98	1.59	1.17	0.80	0.75	0.57
10	9.02	9.28	9.90	8.69	7.01	5.24	3.73	2.82	2.27	1.70	1.19	1.12	0.87
9	9.75	10.00	10.70	9.40	7.60	5.71	4.08	3.10	2.49	1.87	1.32	1.25	0.97
8	10.60	11.00	11.70	10.30	8.32	6.29	4.51	3.43	2.76	2.09	1.49	1.40	1.10
7	11.80	12.10	12.90	11.30	9.21	7.01	5.06	3.85	3.11	2.36	1.70	1.60	1.27
6	13.20	13.60	14.50	12.70	10.40	7.95	5.77	4.41	3.56	2.73	1.98	1.87	1.49
5	15.10	15.50	16.60	14.50	11.90	9.22	6.74	5.17	4.19	3.23	2.37	2.25	1.80
4	17.80	18.30	19.60	17.10	14.10	11.10	8.16	6.27	5.10	3.97	2.96	2.81	2.28
3	22.00	22.70	24.30	21.20	17.60	14.00	10.40	8.06	6.57	5.18	3.93	3.75	3.08
2	29.80	30.70	32.80	28.60	24.00	19.40	14.80	11.53	9.40	7.55	5.88	5.62	4.70
1	49.80	51.40	55.00	47.90	40.90	34.20	26.80	21.00	17.30	14.30	11.70	11.20	9.72
0.5	83.40	86.00	92.10	80.00	69.50	60.20	48.40	38.40	32.00	27.30	23.30	22.50	20.10
0.1	275.00	284.00	305.00	264.00	239.00	223.00	192.00	156.00	133.00	121.00	115.00	113.00	109.00

TABLE D-13
FREE-AIR ARRIVAL TIME DATA FOR 3"/50 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)
DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Arrival Time (MSEC)	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
2000	841.00	853.00	845.00	842.00	871.00	948.00	1090.00	1310.00	1520.00	1610.00	1620.00	1740.00	1730.00
1000	504.00	509.00	505.00	501.00	514.00	551.00	620.00	720.00	816.00	854.00	855.00	905.00	899.00
200	153.00	154.00	153.00	150.00	151.00	156.00	166.00	181.00	194.00	196.00	193.00	199.00	197.00
100	91.90	92.10	91.20	89.40	89.00	90.60	94.20	99.60	104.00	104.00	102.00	104.00	103.00
60	63.00	63.00	62.40	61.00	60.30	60.70	62.00	64.20	66.00	65.40	63.70	64.00	63.30
40	46.70	46.60	46.10	45.00	44.30	44.20	44.50	45.30	45.90	45.20	43.80	43.70	43.20
30	37.70	37.60	37.20	36.30	35.60	35.20	35.20	35.40	35.50	34.70	33.60	33.40	33.00
20	28.00	27.80	27.60	26.80	26.10	25.60	25.20	25.00	24.70	24.00	23.10	22.80	22.50
15	22.60	22.50	22.20	21.60	21.00	20.50	19.90	19.50	19.10	18.40	17.70	17.40	17.10
10	16.80	16.60	16.50	15.90	15.40	14.90	14.30	13.80	13.30	12.70	12.20	11.90	11.70
9	15.50	15.40	15.20	14.70	14.20	13.70	13.10	12.50	12.10	11.60	11.00	10.70	10.60
8	14.20	14.10	13.90	13.50	13.00	12.50	11.90	11.40	10.90	10.40	9.91	9.61	9.48
7	12.90	12.80	12.60	12.20	11.80	11.30	10.70	10.10	9.66	9.19	8.76	8.48	8.36
6	11.50	11.40	11.30	10.90	10.50	9.98	9.43	8.89	8.42	7.98	7.60	7.33	7.23
5	10.00	9.94	9.83	9.48	9.10	8.65	8.12	7.60	7.15	6.76	6.42	6.17	6.09
4	8.51	8.42	8.33	8.02	7.68	7.26	6.77	6.27	5.86	5.51	5.23	5.00	4.93
3	6.88	6.80	6.72	6.47	6.17	5.80	5.35	4.90	4.53	4.24	4.01	3.82	3.76
2	5.10	5.03	4.97	4.77	4.53	4.22	3.84	3.46	3.15	2.93	2.76	2.61	2.57
1	3.06	3.01	2.97	2.84	2.67	2.45	2.18	1.91	1.70	1.55	1.45	1.36	1.33
0.5	1.83	1.80	1.77	1.69	1.58	1.42	1.23	1.05	0.91	0.83	0.77	0.71	0.69
0.1	0.56	0.54	0.54	0.51	0.46	0.40	0.33	0.26	0.22	0.19	0.17	0.16	0.15

TABLE D-14

FREE-AIR DURATION DATA FOR 3"/50 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)

DISTANCES FROM MUZZLE --- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Duration Time (MSEC)	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
40	2150.00	2080.00	1900.00	1900.00	2040.00	2270.00	2510.00	2750.00	3000.00	3290.00	3560.00	3670.00	4000.00
30	1220.00	1170.00	1070.00	1070.00	1150.00	1280.00	1430.00	1570.00	1710.00	1880.00	2050.00	2150.00	2370.00
25	846.00	814.00	748.00	745.00	802.00	895.00	998.00	1100.00	1190.00	1320.00	1450.00	1530.00	1700.00
20	543.00	521.00	480.00	478.00	515.00	576.00	644.00	707.00	771.00	851.00	943.00	1010.00	1130.00
15	307.00	294.00	271.00	270.00	290.00	326.00	366.00	403.00	439.00	486.00	543.00	590.00	669.00
14	267.00	256.00	236.00	235.00	253.00	284.00	320.00	352.00	383.00	424.00	476.00	519.00	590.00
13	231.00	221.00	204.00	203.00	218.00	246.00	276.00	304.00	331.00	367.00	413.00	452.00	515.00
12	197.00	188.00	174.00	173.00	186.00	210.00	236.00	260.00	283.00	314.00	354.00	389.00	445.00
11	165.00	158.00	146.00	145.00	157.00	177.00	199.00	219.00	239.00	265.00	300.00	331.00	380.00
10	137.00	131.00	121.00	120.00	130.00	146.00	165.00	182.00	198.00	220.00	250.00	277.00	319.00
9	111.00	106.00	98.20	97.50	105.00	119.00	134.00	148.00	161.00	179.00	204.00	228.00	263.00
8	87.80	83.70	77.70	77.10	83.10	94.10	107.00	118.00	128.00	142.00	163.00	183.00	212.00
7	67.40	64.20	59.60	59.10	63.70	72.20	82.00	90.50	98.50	110.00	126.00	143.00	167.00
6	49.60	47.20	43.90	43.50	46.90	53.30	60.60	66.90	72.80	81.20	93.80	107.00	126.00
5	34.50	32.80	30.60	30.20	32.60	37.10	42.40	46.80	50.90	56.90	66.10	76.10	90.10
4	22.10	21.00	19.60	19.40	20.90	23.90	27.30	30.20	32.90	36.80	43.10	50.20	60.00
3	12.50	11.80	11.10	10.90	11.80	13.50	13.50	17.20	18.70	21.00	24.80	29.40	35.50
2	5.58	5.27	4.95	4.88	5.27	6.07	6.07	7.78	8.44	9.51	11.40	13.80	16.90
1	1.41	1.32	1.25	1.23	1.33	1.54	1.54	2.00	2.17	2.46	3.02	3.79	4.78
0.5	0.35	0.33	0.32	0.31	0.33	0.39	0.39	0.51	0.56	0.63	0.80	1.04	1.35
0.1	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.04	0.05	0.07

TABLE D-15

FREE-AIR IMPULSE DATA FOR 3"/50 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Impulse (PSI-MSEC)	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
2000	0.013	0.033	0.033	0.044	0.026	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1000	0.020	0.049	0.051	0.066	0.038	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000
200	0.037	0.085	0.094	0.114	0.067	0.011	0.000	0.000	0.001	0.001	0.000	0.000	0.000
100	0.108	0.219	0.267	0.291	0.178	0.037	0.002	0.001	0.003	0.002	0.000	0.000	0.000
60	0.235	0.439	0.577	0.581	0.365	0.094	0.007	0.003	0.008	0.006	0.001	0.001	0.001
40	0.438	0.762	1.060	1.010	0.645	0.195	0.019	0.008	0.018	0.012	0.003	0.003	0.003
30	0.680	1.130	1.640	1.490	0.965	0.328	0.039	0.016	0.031	0.020	0.005	0.005	0.011
20	1.270	1.960	3.030	2.580	1.700	0.684	0.102	0.041	0.068	0.042	0.011	0.011	0.019
15	1.970	2.890	4.670	3.800	2.550	1.150	0.203	0.080	0.118	0.070	0.019	0.019	0.044
10	3.660	5.030	8.610	6.590	4.510	2.400	0.536	0.206	0.254	0.146	0.044	0.044	0.054
9	4.300	5.800	10.100	7.600	5.220	2.900	0.690	0.264	0.311	0.177	0.054	0.054	0.069
8	5.140	6.810	12.000	8.920	6.160	3.600	0.915	0.347	0.389	0.219	0.069	0.069	0.090
7	6.310	8.170	14.700	10.700	7.430	4.600	1.260	0.474	0.502	0.278	0.090	0.090	0.122
6	7.990	10.100	18.600	13.200	9.230	6.050	1.820	0.679	0.673	0.368	0.122	0.122	0.177
5	10.600	12.900	24.500	16.900	11.900	8.420	2.820	1.040	0.953	0.511	0.177	0.177	0.277
4	14.900	17.500	34.300	22.800	16.300	12.600	4.810	1.750	1.460	0.765	0.277	0.277	0.494
3	23.100	25.900	52.900	33.700	24.400	21.200	9.580	3.420	2.520	1.290	0.494	0.494	1.120
2	42.900	44.900	97.500	58.400	43.100	44.300	25.300	8.810	5.460	2.680	1.120	1.120	4.500
1	124.000	115.000	277.000	149.000	114.000	155.000	133.000	44.400	20.400	9.350	4.500	4.500	18.200
0.5	358.000	246.000	788.000	382.000	301.000	545.000	699.000	224.000	76.500	32.700	18.200	18.200	464.000
0.1	4210.000	2650.000	8930.000	3340.000	2800.000	10000.000	33000.000	9550.000	1640.000	599.000	464.000	464.000	

TABLE D-16

FREE-AIR PEAK PRESSURE FOR 40 MM GUN WITH FLASH HIDER FROM CURVE FITTING PROGRAM

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Pressure (PSI)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.04	0.04	0.023	0.017	0.011	0.006	0.002	0.0006	0.0002	0.0001	0.0000	0.0000	0.0000
1000	0.08	0.07	0.047	0.035	0.023	0.012	0.004	0.0014	0.0005	0.0002	0.0001	0.0001	0.0000
200	0.36	0.32	0.240	0.185	0.129	0.087	0.024	0.0090	0.0037	0.0015	0.0004	0.0007	0.0000
100	0.70	0.63	0.488	0.383	0.269	0.144	0.053	0.0202	0.0086	0.0035	0.0008	0.0016	0.0000
60	1.14	1.03	0.821	0.652	0.453	0.251	0.094	0.0365	0.0161	0.0064	0.0014	0.0030	0.0001
40	1.67	1.52	1.240	0.996	0.712	0.391	0.148	0.0584	0.0265	0.0103	0.0023	0.0049	0.0001
30	2.19	2.00	1.660	1.350	0.966	0.535	0.205	0.0815	0.0377	0.0144	0.0032	0.0070	0.0002
20	3.22	2.95	2.520	2.060	1.490	0.833	0.325	0.1310	0.0621	0.0233	0.0051	0.0115	0.0004
15	4.23	3.69	3.370	2.780	2.010	1.140	0.450	0.1820	0.0886	0.0327	0.0070	0.0164	0.0007
10	6.21	5.75	5.100	4.240	3.100	1.780	0.712	0.2920	0.1460	0.0528	0.0111	0.0270	0.0015
9	6.86	6.36	5.680	4.730	3.460	1.990	0.803	0.3300	0.1660	0.0598	0.0125	0.0307	0.0018
8	7.67	7.13	6.400	5.350	3.930	2.270	0.917	0.3780	0.1920	0.0687	0.0143	0.0355	0.0022
7	8.71	8.10	7.340	6.160	4.520	2.620	1.070	0.4420	0.2260	0.0805	0.0166	0.0419	0.0027
6	10.10	9.40	8.590	7.230	5.330	3.100	1.270	0.5280	0.2740	0.0966	0.0198	0.0507	0.0036
5	12.00	11.20	10.300	8.750	6.460	3.790	1.560	0.6530	0.3420	0.1200	0.0244	0.0635	0.0049
4	14.80	13.90	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314	0.0836	0.0073
3	19.40	18.30	17.400	14.900	11.100	6.610	2.790	1.1800	0.6420	0.2190	0.0436	0.1190	0.0121
2	28.50	27.00	26.300	22.800	17.100	10.300	4.410	1.8900	1.0600	0.3530	0.0691	0.1970	0.0247
1	55.10	52.60	53.000	47.000	35.600	21.900	9.670	4.2300	2.4800	0.8010	0.1520	0.4620	0.3836
0.5	106.00	102.00	108.000	97.000	74.400	46.800	21.200	9.4600	5.8300	1.8200	0.3340	1.0900	0.2830
0.1	488.00	481.00	558.000	521.000	410.000	271.000	131.000	61.3000	42.2000	12.2000	2.0800	7.9200	4.7800

TABLE D-17
FREE-AIR PEAK PRESSURE FOR 40 MM GUN WITHOUT FLASH HIDER FROM CURVE FITTING PROGRAM

PRESSURE (PSI)	DISTANCES FROM MUZZLE --- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED												
	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.15	0.14	0.12	0.10	0.08	0.05	0.03	0.01	0.01	0.00	0.00	0.00	0.00
1000	0.24	0.23	0.20	0.17	0.13	0.09	0.05	0.02	0.01	0.00	0.00	0.00	0.00
200	0.71	0.68	0.62	0.54	0.43	0.31	0.18	0.10	0.05	0.02	0.01	0.00	0.00
100	1.14	1.10	1.01	0.89	0.73	0.53	0.33	0.19	0.10	0.05	0.02	0.01	0.00
60	1.61	1.56	1.44	1.29	1.08	0.80	0.51	0.30	0.17	0.09	0.04	0.02	0.01
40	2.12	2.05	1.92	1.73	1.46	1.11	0.72	0.43	0.25	0.14	0.07	0.03	0.02
30	2.57	2.50	2.35	2.13	1.82	1.39	0.92	0.56	0.33	0.19	0.10	0.05	0.03
20	3.39	3.30	3.12	2.86	2.47	1.92	1.30	0.81	0.49	0.29	0.16	0.08	0.05
15	4.11	4.02	3.82	3.52	3.07	2.42	1.65	1.06	0.66	0.40	0.22	0.11	0.07
10	5.41	5.30	5.07	4.72	4.16	3.34	2.34	1.53	0.99	0.62	0.37	0.19	0.12
9	5.81	5.70	5.46	5.09	4.51	3.63	2.56	1.69	1.09	0.69	0.41	0.22	0.14
8	6.29	6.18	5.93	5.54	4.93	3.99	2.83	1.88	1.23	0.79	0.48	0.26	0.17
7	6.88	6.77	6.52	6.11	5.45	4.44	3.17	2.13	1.41	0.91	0.56	0.31	0.21
6	7.64	7.53	7.26	6.83	6.12	5.02	3.61	2.45	1.64	1.08	0.67	0.38	0.26
5	8.64	8.53	8.25	7.79	7.03	5.81	4.22	2.90	1.96	1.31	0.84	0.49	0.34
4	10.04	9.94	9.64	9.15	8.32	6.94	5.10	3.55	2.45	1.68	1.10	0.66	0.47
3	12.20	12.10	11.80	11.27	10.33	8.73	6.51	4.53	3.26	2.29	1.55	0.96	0.71
2	16.05	15.97	15.68	15.11	14.03	12.05	9.20	6.71	4.89	3.56	2.52	1.65	1.27
1	25.63	25.67	25.49	24.95	23.67	20.95	16.59	12.67	9.74	7.57	5.79	4.13	3.46
.5	40.94	41.27	41.44	41.20	39.94	36.39	29.94	23.93	19.41	16.09	13.29	10.37	9.42
.1	121.46	124.26	128.05	131.97	134.55	131.27	117.80	104.67	96.27	92.67	91.62	87.69	96.37

TABLE D-18

FREE-AIR PEAK PRESSURE DATA FOR 20 MM M3 GUN FROM CURVE FITTING PROGRAM

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Pressure (PSI)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.049	0.046	0.040	0.034	0.029	0.022	0.014	0.008	0.0045	0.0025	0.0013	0.0006	0.0004
1000	0.079	0.076	0.066	0.057	0.048	0.037	0.025	0.015	0.0083	0.0047	0.0026	0.0013	0.0008
200	0.247	0.242	0.215	0.188	0.159	0.124	0.087	0.056	0.0337	0.0206	0.0125	0.0071	0.0047
100	0.403	0.399	0.358	0.314	0.266	0.210	0.151	0.099	0.0616	0.0389	0.0246	0.0145	0.0100
60	0.578	0.577	0.521	0.458	0.388	0.309	0.225	0.151	0.0961	0.0622	0.0404	0.0247	0.0174
40	0.770	0.773	0.702	0.618	0.525	0.420	0.310	0.210	0.1370	0.0901	0.0599	0.0377	0.0269
30	0.943	0.951	0.868	0.764	0.649	0.522	0.389	0.267	0.1760	0.1170	0.0792	0.0509	0.0367
20	1.260	1.270	1.170	1.030	0.877	0.710	0.535	0.373	0.2500	0.1700	0.1180	0.0776	0.0568
15	1.540	1.570	1.450	1.270	1.090	0.883	0.671	0.474	0.3210	0.2210	0.1550	0.1050	0.0775
10	2.050	2.100	1.950	1.720	1.470	1.200	0.924	0.662	0.4570	0.3210	0.2310	0.1600	0.1200
9	2.210	2.270	2.110	1.860	1.590	1.300	1.000	0.723	0.5010	0.3530	0.2550	0.1780	0.1350
8	2.400	2.470	2.300	2.030	1.730	1.420	1.100	0.797	0.5550	0.3940	0.2860	0.2010	0.1530
7	2.640	2.720	2.530	2.240	1.910	1.570	1.220	0.890	0.6230	0.4450	0.3260	0.2310	0.1770
6	2.940	3.040	2.840	2.510	2.140	1.770	1.380	1.010	0.7130	0.5120	0.3790	0.2720	0.2080
5	3.350	3.460	3.250	2.870	2.450	2.030	1.590	1.180	0.8350	0.6050	0.4520	0.3280	0.2540
4	3.920	4.070	3.830	3.380	2.900	2.410	1.900	1.410	1.0100	0.7730	0.5620	0.4140	0.3230
3	4.800	5.010	4.730	4.180	3.580	2.990	2.390	1.790	1.3000	0.9670	0.7430	0.5590	0.4400
2	6.390	6.710	6.370	5.640	4.840	4.070	3.280	2.510	1.8500	1.4000	1.1000	0.8520	0.6820
1	10.400	11.100	10.600	9.410	8.100	6.880	5.670	4.450	3.3900	2.6400	2.1600	1.7500	1.4400
0.5	17.000	18.200	17.700	15.700	13.500	11.600	9.790	7.900	6.1900	4.9900	4.2400	3.6000	3.0400
0.1	53.000	58.300	57.800	51.500	44.700	39.400	34.800	29.900	25.1000	21.8000	20.3000	19.2000	17.3000

TABLE D-19

FREE-AIR PEAK PRESSURE DATA FOR 20 MM XML97 GUN FROM CURVE FITTING PROGRAM

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Pressure (PSI)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.070	0.098	0.045	0.015	0.007	0.004	0.002	0.001	0.0006	0.0006	0.0004	0.0002	0.0001
1000	0.112	0.150	0.014	0.027	0.013	0.008	0.004	0.002	0.0013	0.0014	0.0008	0.0004	0.0003
200	0.326	0.400	0.235	0.108	0.058	0.037	0.021	0.011	0.0083	0.0077	0.0044	0.0027	0.0020
100	0.517	0.611	0.388	0.196	0.112	0.074	0.044	0.025	0.0183	0.0163	0.0090	0.0061	0.0043
60	0.727	0.834	0.560	0.304	0.182	0.122	0.075	0.044	0.0329	0.0283	0.0152	0.0109	0.0077
40	0.952	1.070	0.749	0.430	0.267	0.183	0.115	0.069	0.0524	0.0438	0.0232	0.0175	0.0122
30	1.150	1.270	0.921	0.549	0.350	0.244	0.155	0.096	0.0730	0.0598	0.0313	0.0244	0.0169
20	1.510	1.630	1.230	0.777	0.513	0.364	0.239	0.152	0.1160	0.0926	0.0476	0.0390	0.0268
15	1.830	1.950	1.520	0.995	0.673	0.485	0.324	0.210	0.1620	0.1260	0.0642	0.0544	0.0372
10	2.400	2.490	2.030	1.410	0.987	0.726	0.497	0.332	0.2576	0.1960	0.0978	0.0869	0.0590
9	2.570	2.660	2.190	1.540	1.090	0.806	0.556	0.374	0.2910	0.2190	0.1090	0.0981	0.0666
8	2.780	2.860	2.380	1.700	1.220	0.906	0.629	0.428	0.3330	0.2490	0.1230	0.1120	0.0761
7	3.040	3.100	2.620	1.910	1.380	1.030	0.725	0.498	0.3880	0.2870	0.1420	0.1310	0.0886
6	3.370	3.410	2.930	2.180	1.600	1.210	0.853	0.593	0.4630	0.3390	0.1660	0.1570	0.1060
5	3.810	3.810	3.340	2.550	1.900	1.450	1.030	0.729	0.5700	0.4130	0.2010	0.1940	0.1300
4	4.420	4.360	3.920	3.080	2.340	1.800	1.310	0.939	0.7370	0.5250	0.2530	0.2510	0.1670
3	5.350	5.200	4.820	3.940	3.070	2.400	1.780	1.300	1.0300	0.7160	0.3420	0.3490	0.2320
2	7.010	6.670	6.450	5.580	4.500	3.590	2.730	2.060	1.6300	1.1100	0.5200	0.5580	0.3680
1	11.100	10.200	10.600	10.100	8.660	7.200	5.680	4.510	3.6200	2.3400	1.0700	1.2400	0.8110
0.5	17.700	15.500	17.500	18.300	16.700	14.300	11.800	9.900	8.0100	4.9500	2.1900	2.7700	1.7800
00.1	51.600	41.600	55.600	72.500	76.100	70.600	65.000	61.300	50.8000	28.1000	11.7000	17.8000	11.1000

TABLE D-20

FREE-AIR PEAK PRESSURE DATA FOR 20 MM MK 12 GUN FROM CURVE FITTING PROGRAM

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND JORE AXIS EXTENDED

Pressure (PSI)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.08	0.05	0.036	0.027	0.016	0.007	0.003	0.0014	0.0009	0.0003	0.0002	0.0001	0.0000
1000	0.12	0.08	0.060	0.046	0.029	0.013	0.006	0.0030	0.0019	0.0011	0.0005	0.0002	0.0001
200	0.35	0.25	0.206	0.164	0.111	0.060	0.030	0.0168	0.0111	0.0068	0.0033	0.0017	0.0007
100	0.55	0.41	0.349	0.283	0.199	0.116	0.061	0.0355	0.0236	0.0148	0.0077	0.0041	0.0020
60	0.76	0.60	0.515	0.424	0.306	0.187	0.104	0.0616	0.0411	0.0262	0.0143	0.0080	0.0040
40	0.99	0.81	0.701	0.583	0.430	0.273	0.157	0.0953	0.0640	0.0414	0.0233	0.0136	0.0071
30	1.19	0.99	0.873	0.731	0.548	0.357	0.211	0.1300	0.0876	0.0571	0.0329	0.0198	0.0106
20	1.54	1.33	1.190	1.010	0.772	0.522	0.321	0.2010	0.1360	0.0901	0.0537	0.0335	0.0187
15	1.85	1.64	1.480	1.260	0.984	0.684	0.431	0.2740	0.1870	0.1250	0.0760	0.0487	0.0281
10	2.40	2.20	2.020	1.730	1.390	1.000	0.654	0.4240	0.2900	0.1960	0.1240	0.0825	0.0496
8	2.57	2.38	2.190	1.880	1.510	1.100	0.729	0.4750	0.3260	0.2210	0.1410	0.0945	0.0575
7	2.77	2.59	2.390	2.070	1.670	1.230	0.823	0.5400	0.3700	0.2520	0.1620	0.1100	0.0679
6	3.02	2.85	2.650	2.300	1.870	1.400	0.944	0.6230	0.4280	0.2930	0.1910	0.1310	0.0819
5	3.33	3.19	2.980	2.590	2.130	1.610	1.110	0.7360	0.5070	0.3480	0.2300	0.1600	0.1020
4	3.75	3.64	3.420	2.990	2.490	1.910	1.340	0.8950	0.6180	0.4280	0.2860	0.2030	0.1310
3	4.33	4.28	4.050	3.560	3.000	2.360	1.680	1.1400	0.7880	0.5490	0.3740	0.2710	0.1800
2	5.20	5.28	5.050	4.470	3.830	3.090	2.260	1.5500	1.0800	0.7590	0.5300	0.3940	0.2690
1	6.75	7.08	6.880	6.150	5.390	4.510	3.430	2.4000	1.6800	1.2000	0.8640	0.6680	0.4760
0.5	10.50	11.70	11.700	10.600	9.670	8.640	6.990	5.0700	3.5800	2.6100	1.9900	1.6400	1.2600
0.1	16.40	19.40	19.800	18.300	17.300	16.500	14.300	10.7000	7.6100	5.6800	4.6000	4.0400	3.3400
	46.20	62.30	67.400	64.900	67.400	74.700	74.800	60.5000	44.0000	34.6000	32.1030	32.7000	32.1000

APPENDIX E
STATISTICAL DATA

APPENDIX E

STATISTICAL DATA

Table

E-1 Statistical Data Comparing Experimental And Computer Generated
Values

TABLE E-1

STATISTICAL DATA COMPARING EXPERIMENTAL AND COMPUTER GENERATED VALUES

Table shows first and square root of the second moment in percent

GUN	PRESSURE		ARRIVAL		DURATION		IMPULSE	
	FIRST (%)	SECOND (%)	FIRST (%)	SECOND (%)	FIRST (%)	SECOND (%)	FIRST (%)	SECOND (%)
16"/50	11	24	-	-	-	-	-	-
8"/55	- 3	15	2	6	- 3	17	- 3	19
6"/47	+ 3	15	-	-	-	-	-	-
5"/54	0	4	- 5	6	7	9	- 4	16
5"/38	0	11	-	-	-	-	-	-
3"/50	0	15	1	1	- 1	21	-10	29
40 MM *	-	-	-	-	-	-	-	-
40 MM **	5	14	-	-	-	-	-	-
20 MM M 3	- 8	21	-	-	-	-	-	-
20 MM								
XM197	- 9	33	-	-	-	-	-	-
20 MM								
MK 12	2	14	-	-	-	-	-	-

* 40 MM WITH FLASH HIDER (NOT AVAILABLE)

** 40 MM WITHOUT FLASH HIDER

APPENDIX F

FIRING TEST DATA

Table

F-1 Firing Test Data for Enclosed Guns

TABLE F-1

FIRING TEST DATA

GUN	16"/50	16"/55	6"/47	5"/54	5"/38	3"/50	40 mm	20 mm M3*	20 mm XM197	20 mm MK 12*
BARREL										
MARK-MOD	N.A.	15-7	16-0	18-0	12-1	N.A.	1-0	3-0	197-0	12-0
PROJECTILE										
MARK-MOD	N.A.	25	36	41	49	33	2	99	55A2	11
WEIGHT (LBS)	N.A.	335	130	70.0	55.18	13.0	1.985	.271	.214	.243
PROPELLANT										
TYPE	N.A.	NACO	M-1	PYRO	M-1	M-1	M-6	N.A.	N.A.	PYRO(DMT COATED)
INDEX	N.A.	SPDF-11072	SPDN-9744	SPDF-9733	SPDN-7380	SPDN-9744	SPDN-8927	N.A.	N.A.	SPDN-10802
C. ARGE (LBS)	N.A.	98.17	33.79	18.36	15.83	4.06	.687	.07	.083	.0915
DATE	1967-68	Sept 69	July 68	May, June 58	Mar, Apr 54	Sept 69	Apr 71** May 71***	Nov, Dec 66	Oct 69	Nov, Dec 66

N.A. - Not Available

* - Fired Without Diffuser

** - With Flash Hider

*** - Without Flash Hider

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Nat Shot

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13. ABSTRACT

The available data on gun blasts from naval guns are compiled utilizing computer curve fitting techniques. Curves of peak free-air pressure are presented for all naval guns, ranging in size from 20mm to 16"/50. In addition, curves of arrival time, duration and impulse are given for three of these guns. Development of the computer programs and data reduction methods which were used to model the free-air gun blast field are described.