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ANALYSIS OF A 105MM CLOSED BREECH  
GUN DESIGN WITH RECOIL CANCELLATION  
AND A 105MM DAVIS TYPE GUN DESIGN



## TECHNICAL REPORT

THOMAS J. REDLING

AUGUST 1973

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AIRCRAFT AND AIR DEFENSE WEAPON SYSTEMS DIRECTORATE

GENERAL THOMAS J. RODMAN LABORATORY

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GUN DESIGN WITH RECOIL CANCELLATION  
AND A 105MM DAVIS TYPE GUN DESIGN

BY

THOMAS J. REDLING

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## ABSTRACT

This report is a design study of large caliber weapons for helicopter application. The tables and graphs presented in this report provide a convenient tool for conducting trade-off evaluations.

Two weapon systems considered were a 105MM closed breech weapon with recoil cancellation and a 105MM Davis type gun. The results indicate that a greater combat load can be carried by a helicopter mounted 105MM closed breech gun design with recoil cancellation.

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## INTRODUCTION

Present requirements exist for arming light aircraft and helicopters with larger caliber weapon systems which will provide improved kill capability against armored vehicles, gun emplacements, hardened bunkers, small surface craft, and personnel. The major problem associated with mounting large caliber weapons to helicopters is the excessive recoil stresses encountered by the airframe. The proposed use of recoilless rifles has also proven unsatisfactory because of the damaging breech blast. Recoilless technology investigations to reduce or control the breech blast have been unsuccessful to date.

Other approaches which can be used to achieve non-damaging recoilless operation are a closed breech weapon with recoil cancellation (impulse generator) or a Davis type gun design. The impulse generator is a rocket motor which is used to accelerate the cannon's recoiling parts to a specific velocity when the gun is fired. The rocket continues to burn and balance the gun recoil forces until projectile exit. The Davis gun is basically two gun tubes pointing in opposite directions with a common propellant chamber at midpoint. An ammunition load consists of a case, propellant charge, projectile and a disintegrating reaction mass. The weapon is recoilless when the projectile and the reaction mass exit their respective barrels simultaneously with equal momentum.

The purpose of this study is to investigate 105MM closed breech gun designs with recoil cancellation and 105MM Davis type gun designs for helicopter application.

## DISCUSSION

The first step in this investigation was to select 105MM projectile weights of 25 and 30 pounds and determine gun weights, charge weights and muzzle velocities that could be obtained at different chamber pressures and tube lengths. A computer program developed at Watervliet Arsenal was used for this analysis and the results are shown in Table 1. Muzzle velocity versus gun chamber pressure at different tube lengths for 25 and 30 pound projectiles are shown in Figures 1 and 2 respectively.

The gun weights calculated by the program did not vary significantly with pressure for equal tube lengths since the computer program assumed a minimum wall thickness of 0.500 inches unless the pressures required greater thickness. The maximum pressures used for this analysis did not require wall thicknesses greater than the minimum.

Using the muzzle velocity results, exterior ballistic trajectories were calculated for firings from a helicopter at 1,000 feet and hover conditions. The range versus quadrant elevation and intersecting time of flight to range for various conditions are shown in Figures 3, 4, 5, and 6. These figures can be used in determining minimum muzzle velocity requirements for a specific range if the time-of-flight and maximum quadrant elevation are restrictive.

### Closed Breech Design with Impulse Generator

Having calculated the gun weights and gun propellant charge weights for various muzzle velocity, the next steps involved calculating cartridge case weights, impulse generator propellant and motor weights. The cartridge cases were assumed to be made from steel and an assumption (based on past designs) was used that the case weight equals twice the propellant charge weight.

$$W_{CA} \text{ (Case Weight)} = 2W_C \text{ (Gun Charge Weight)}$$

The impulse generator's rocket propellant weight required to cancel out the gun recoil forces was calculated by dividing total gun impulse by the propellant specific impulse. An Isp of 230 was assumed for these calculations.

$$MV \text{ (Gun)} = MV \text{ (Projectile)} + MV \text{ (Propellant Gases)}$$

$$W_p \text{ (Propellant Weight)} = \frac{MV}{I_{sp}}$$

Since the back blast associated with the rocket motor impulse generator is directly related to the mass rate of discharge and ignition rise rate, these parameters were held constant for each case even though the total impulse changed. This design parameter can be controlled by varying the propellant grain geometry and burn time. The back blast overpressure associated with each impulse generator would then be the same and based on previous testing would be about 1 to 2 psi 20" aft and 25" right or left of the nozzle exit cone.

The rocket motor inert metal parts weight was calculated from the relationship:

$$\frac{W_p \text{ (Weight Propellant)}}{W_{RM} \text{ (Weight Rocket Motor)}} = .75$$

This ratio is based upon previous experience in designing rocket motors and is fairly realistic since the rocket motors are expendable and are furnished one for one with each projectile.

Having made the necessary individual component weight calculation, the overall round weight can now be calculated.

$$\begin{aligned} W_{TR} \text{ (Total Round Weight)} = & W_{PJ} \text{ (Projectile Weight)} \\ & + W_{CA} \text{ (Gun Charge Weight)} \\ & + W_p \text{ (Rocket Propellant Weight)} \\ & + W_{RM} \text{ (Rocket Motor Weight)} \end{aligned}$$

The total gun system weight was calculated from the gun weight plus a constant weight of 250 pounds, which accounted for mount weight, adapter weight and feed system weight.

$$\begin{aligned} W_{GS} \text{ (Gun System Weight)} = & W_G \text{ (Gun Weight)} \\ & + W_{ADP} \text{ (Adapter Weight)} \\ & + W_{FS} \text{ (Feed System Weight)} \end{aligned}$$

To obtain total weapon system weight, it was necessary to add to the gun system weight, a constant weight of 300 pounds for the fire control.

$$W_{TWS} \text{ (Total Weapon System Weight)} = W_{GS} \text{ (Gun System Weight)} \\ + W_{FC} \text{ (Fire Control Weight)}$$

Assuming a helicopter payload capability of 2500 pounds, the weight available for an ammunition combat load can be calculated by subtracting total weapon system weight from 2500 pounds.

$$W_{AV} \text{ (Available Combat Load)} = 2500 - W_{TWS} \text{ (Total Weapon System Weight)}$$

The number of rounds that can then be carried by the helicopter will be equal to the available combat load divided by total round weight.

$$N \text{ (Rounds)} = \frac{W_{AV} \text{ (Available Combat Load)}}{W_T \text{ (Total Round Weight)}}$$

The results of these calculations are shown in Table 2 and the combat load versus muzzle velocity for a closed breech gun design with an impulse generator is shown in Figure 7.

Another important factor that must be considered in a closed breech gun design is the muzzle overpressures associated with these designs. Using the work of M. J. Salsbury<sup>1</sup>, the muzzle overpressures were calculated

1. Salsbury, M. J., Polar Blast Field of 105MM Howitzer, Measured and Predicted, RE TR71-11, Artillery Systems Laboratory, U. S. Army Weapons Command, Rock Island, Illinois, Jan 71.

at various distances from the muzzle for the different muzzle velocities. The results are shown in Table 3 and Figures 8 and 9 show plots of  $\Delta P$  overpressure versus muzzle velocity at two locations from muzzle. The location of the gun on the helicopter will be a key factor in determining the effects of muzzle blast overpressure.

These tables and figures represent some of the trade-offs that can be considered in selecting closed breech gun design with an impulse generator for helicopter application.

#### Davis Type Gun Design

The results obtained in Table 1 were considered applicable to a Davis type gun design and were used in calculating additional parameters.

The Davis gun weight was calculated by doubling the closed breech gun weight.

$$W_{DG} \text{ (Davis Gun Weight)} = 2W_G \text{ (Gun Weight)}$$

Since a weight equal to the projectile will be fired rearward to balance the recoil forces, the weight of gun propellant charge was doubled.

$$W_{DC} \text{ (Davis Charge Weight)} = 2W_C \text{ (Gun Charge Weight)}$$

Applying the previous assumption for steel cartridge cases, the Davis gun cartridge case weight would be equal to twice the Davis gun charge weight.

$$W_{DCA} \text{ (Davis Case Weight)} = 2W_{DC} \text{ (Davis Charge Weight)}$$

The total round weight would be equal to twice the projectile weight plus the Davis charge weight plus the Davis case weight.

$$\begin{aligned} W_{TDR} \text{ (Total Davis Round Weight)} &= 2W_{PJ} \text{ (Projectile Weight)} \\ &+ W_{DC} \text{ (Davis Charge Weight)} \\ &+ W_{DCA} \text{ (Davis Case Weight)} \end{aligned}$$

The total Davis gun system weight was calculated from the Davis gun weight plus a constant weight of 250 pounds, which accounted for mount weight, adapter weight and feed system weight.

$$\begin{aligned} W_{DGS} \text{ (Total Davis Gun System Weight)} &= W_{DG} \text{ (Davis Gun Weight)} \\ &+ W_{MO} \text{ (Mount Weight)} \\ &+ W_{ADP} \text{ (Adapter Weight)} \\ &+ W_{FS} \text{ (Feed System Weight)} \end{aligned}$$

To obtain total weapon system weight, it was necessary to add to the gun system weight a constant weight of 300 pounds for the fire control system.

$$W_{TDWS} \text{ (Total Davis Weapon System Weight)} = W_{DGS} \text{ (Davis Gun System Weight)} + W_{FC} \text{ (Fire Control Weight)}$$

Again, assuming a helicopter payload capability of 2500 pounds, the weight available for an ammunition combat load can be calculated by subtracting total Davis weapon system weight from 2500 pounds.

$$W_{AV} \text{ (Available Combat Load)} = 2500 - W_{TDWS} \text{ (Davis Weapon System Weight)}$$

The number of rounds that can then be carried by the helicopter will be equal to the available combat load divided by total round weight.

$$N \text{ (Rounds)} = \frac{W_{AV} \text{ (Available Combat Load)}}{W_{TDR}}$$

The results of these calculations are shown in Table 4 and the combat load versus muzzle velocity for a Davis type gun design is shown in Figure 10.

Since the same muzzle velocities as the closed breech gun system were considered in the Davis type gun design, the muzzle overpressures will be the same as those shown in Table 3 and plotted in Figures 8 and 9.

## CONCLUSIONS

The tables and figures presented in this report provide a tool for conducting trade-off evaluations of large caliber weapons systems in helicopter applications.

The results indicate that a greater combat load can be carried by a helicopter mounted 105MM closed breech gun design with recoil cancellation than one with a 105MM Davis type gun design.

The muzzle blast overpressure associated with both designs is considered a significant problem. By using the closed breech gun system, one half of the problem can be eliminated, since it does not appear that the blast from the impulse generator will be significant. Diffusers or barrel extensions will be required to reduce the peak muzzle blast overpressure or move it further away from the helicopter structure.

Additional trade-off design studies will be required once the overall weapon system requirements (range, time-of-flight, lethal effectiveness, accuracy, etc.) have been more adequately defined.

TABLE I

## 105MM CANNON DESIGN AND INTERIOR BALLISTIC DATA

| CONDITION<br>NO | PROJECTILE<br>WEIGHT W <sub>PJ</sub><br>POUNDS | CHAMBER<br>PRESSURE<br>P <sub>MAX</sub><br>PSI | MUZZLE<br>VELOCITY<br>V<br>FT/SEC | GUN CHARGE<br>WEIGHT W <sub>C</sub><br>POUNDS | CHAMBER<br>VOLUME V <sub>C</sub><br>CU. IN. | GUN<br>LENGTH L <sub>G</sub><br>INCHES | BREECH<br>WEIGHT W <sub>BR</sub><br>POUNDS | GUN<br>WEIGHT<br>W <sub>G</sub><br>POUNDS |
|-----------------|------------------------------------------------|------------------------------------------------|-----------------------------------|-----------------------------------------------|---------------------------------------------|----------------------------------------|--------------------------------------------|-------------------------------------------|
|                 |                                                |                                                |                                   |                                               |                                             |                                        |                                            |                                           |
| 1               | 25                                             | 10,000                                         | 1328                              | 1.36                                          | 58                                          | 110                                    | 76                                         | 314                                       |
| 2               | 25                                             | 15,000                                         | 1598                              | 1.97                                          | 84                                          | 110                                    | 78                                         | 311                                       |
| 3               | 25                                             | 20,000                                         | 1815                              | 2.55                                          | 108                                         | 110                                    | 79                                         | 313                                       |
| 4               | 25                                             | 25,000                                         | 1998                              | 3.09                                          | 131                                         | 110                                    | 80.5                                       | 320                                       |
| 5               | 25                                             | 30,000                                         | 2156                              | 3.59                                          | 153                                         | 110                                    | 82                                         | 332                                       |
| 6               | 25                                             | 10,000                                         | 1205                              | 1.12                                          | 48                                          | 90                                     | 76.5                                       | 271                                       |
| 7               | 25                                             | 15,000                                         | 1451                              | 1.63                                          | 69                                          | 90                                     | 78                                         | 269                                       |
| 8               | 25                                             | 20,000                                         | 1650                              | 2.10                                          | 90                                          | 90                                     | 79                                         | 272                                       |
| 9               | 25                                             | 25,000                                         | 1818                              | 2.55                                          | 109                                         | 90                                     | 80.5                                       | 277                                       |
| 10              | 25                                             | 30,000                                         | 1963                              | 2.98                                          | 127                                         | 90                                     | 82                                         | 288                                       |
| 11              | 30                                             | 10,000                                         | 1216                              | 1.37                                          | 58                                          | 110                                    | 76.5                                       | 314                                       |
| 12              | 30                                             | 15,000                                         | 1464                              | 1.99                                          | 85                                          | 110                                    | 78                                         | 312                                       |
| 13              | 30                                             | 20,000                                         | 1665                              | 2.57                                          | 109                                         | 110                                    | 79                                         | 314                                       |
| 14              | 30                                             | 25,000                                         | 1883                              | 3.12                                          | 133                                         | 110                                    | 80.5                                       | 321                                       |
| 15              | 30                                             | 30,000                                         | 1980                              | 3.64                                          | 155                                         | 110                                    | 82                                         | 333                                       |
| 16              | 30                                             | 10,000                                         | 1102                              | 1.13                                          | 48                                          | 90                                     | 76.5                                       | 271                                       |
| 17              | 30                                             | 15,000                                         | 1329                              | 1.64                                          | 70                                          | 90                                     | 78                                         | 269                                       |
| 18              | 30                                             | 20,000                                         | 1512                              | 2.12                                          | 90                                          | 90                                     | 79                                         | 272                                       |
| 19              | 30                                             | 25,000                                         | 1667                              | 2.58                                          | 110                                         | 90                                     | 80.5                                       | 278                                       |
| 20              | 30                                             | 30,000                                         | 1801                              | 3.01                                          | 128                                         | 90                                     | 82                                         | 289                                       |

TABLE 2

## 103MM CLOSED BREECH GUN DESIGN WITH IMPULSE GENERATOR

| CONDITION<br>NO | CASE<br>WEIGHT<br>W <sub>CA</sub><br>POUNDS | GUN<br>IMPULSE<br>MV<br>LB. SEC. | PROPELLANT<br>WEIGHT W <sub>P</sub><br>POUNDS | ROCKET<br>MOTOR<br>WEIGHT<br>W <sub>RM</sub><br>POUNDS | TOTAL<br>ROUND<br>WEIGHT<br>W <sub>TR</sub><br>POUNDS | GUN<br>SYSTEM<br>WEIGHT<br>W <sub>GS</sub><br>POUNDS | TOTAL<br>WEAPON SYSTEM<br>WEIGHT W <sub>TWS</sub><br>POUNDS | AVAILABLE<br>COMBAT<br>LOAD W <sub>AV</sub><br>POUNDS | NUMBER OF<br>ROUND<br>N |
|-----------------|---------------------------------------------|----------------------------------|-----------------------------------------------|--------------------------------------------------------|-------------------------------------------------------|------------------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------|-------------------------|
|                 |                                             |                                  |                                               |                                                        |                                                       |                                                      |                                                             |                                                       |                         |
| 1               | 2.72                                        | 1201                             | 5.25                                          | 7.00                                                   | 41.33                                                 | 564                                                  | 864                                                         | 1636                                                  | 39                      |
| 2               | 3.94                                        | 1528                             | 6.64                                          | 8.85                                                   | 46.40                                                 | 561                                                  | 861                                                         | 1639                                                  | 35                      |
| 3               | 5.10                                        | 1782                             | 7.75                                          | 10.35                                                  | 50.75                                                 | 563                                                  | 863                                                         | 1637                                                  | 32                      |
| 4               | 6.18                                        | 2001                             | 8.71                                          | 11.61                                                  | 53.59                                                 | 570                                                  | 870                                                         | 1630                                                  | 30                      |
| 5               | 7.18                                        | 2195                             | 9.55                                          | 12.73                                                  | 58.05                                                 | 582                                                  | 882                                                         | 1618                                                  | 27                      |
| 6               | 2.24                                        | 1097                             | 4.76                                          | 6.35                                                   | 39.47                                                 | 521                                                  | 821                                                         | 1679                                                  | 42                      |
| 7               | 3.26                                        | 1369                             | 5.95                                          | 7.94                                                   | 43.78                                                 | 519                                                  | 819                                                         | 1681                                                  | 38                      |
| 8               | 4.20                                        | 1587                             | 6.90                                          | 9.20                                                   | 47.40                                                 | 522                                                  | 822                                                         | 1678                                                  | 35                      |
| 9               | 5.10                                        | 1782                             | 7.75                                          | 10.35                                                  | 50.75                                                 | 527                                                  | 827                                                         | 1673                                                  | 32                      |
| 10              | 5.96                                        | 1960                             | 8.53                                          | 11.36                                                  | 53.83                                                 | 538                                                  | 838                                                         | 1662                                                  | 30                      |
| 11              | 2.74                                        | 1332                             | 5.80                                          | 7.74                                                   | 47.65                                                 | 564                                                  | 864                                                         | 1636                                                  | 34                      |
| 12              | 3.98                                        | 1655                             | 7.20                                          | 9.60                                                   | 52.77                                                 | 562                                                  | 862                                                         | 1638                                                  | 31                      |
| 13              | 5.14                                        | 1925                             | 8.37                                          | 11.18                                                  | 57.26                                                 | 564                                                  | 864                                                         | 1636                                                  | 28                      |
| 14              | 6.24                                        | 2220                             | 9.65                                          | 12.85                                                  | 61.86                                                 | 571                                                  | 871                                                         | 1629                                                  | 26                      |
| 15              | 7.28                                        | 2417                             | 10.5                                          | 14.00                                                  | 65.42                                                 | 583                                                  | 883                                                         | 1617                                                  | 24                      |
| 16              | 2.26                                        | 1168                             | 5.06                                          | 6.75                                                   | 45.20                                                 | 521                                                  | 821                                                         | 1679                                                  | 37                      |
| 17              | 3.28                                        | 1478                             | 6.42                                          | 8.55                                                   | 49.89                                                 | 519                                                  | 819                                                         | 1681                                                  | 33                      |
| 18              | 4.24                                        | 1720                             | 7.47                                          | 9.95                                                   | 53.78                                                 | 522                                                  | 822                                                         | 1678                                                  | 31                      |
| 19              | 5.16                                        | 1929                             | 8.39                                          | 11.19                                                  | 57.32                                                 | 527                                                  | 828                                                         | 1672                                                  | 29                      |
| 20              | 6.02                                        | 2120                             | 9.21                                          | 12.30                                                  | 60.54                                                 | 539                                                  | 839                                                         | 1661                                                  | 27                      |

TABLE 3

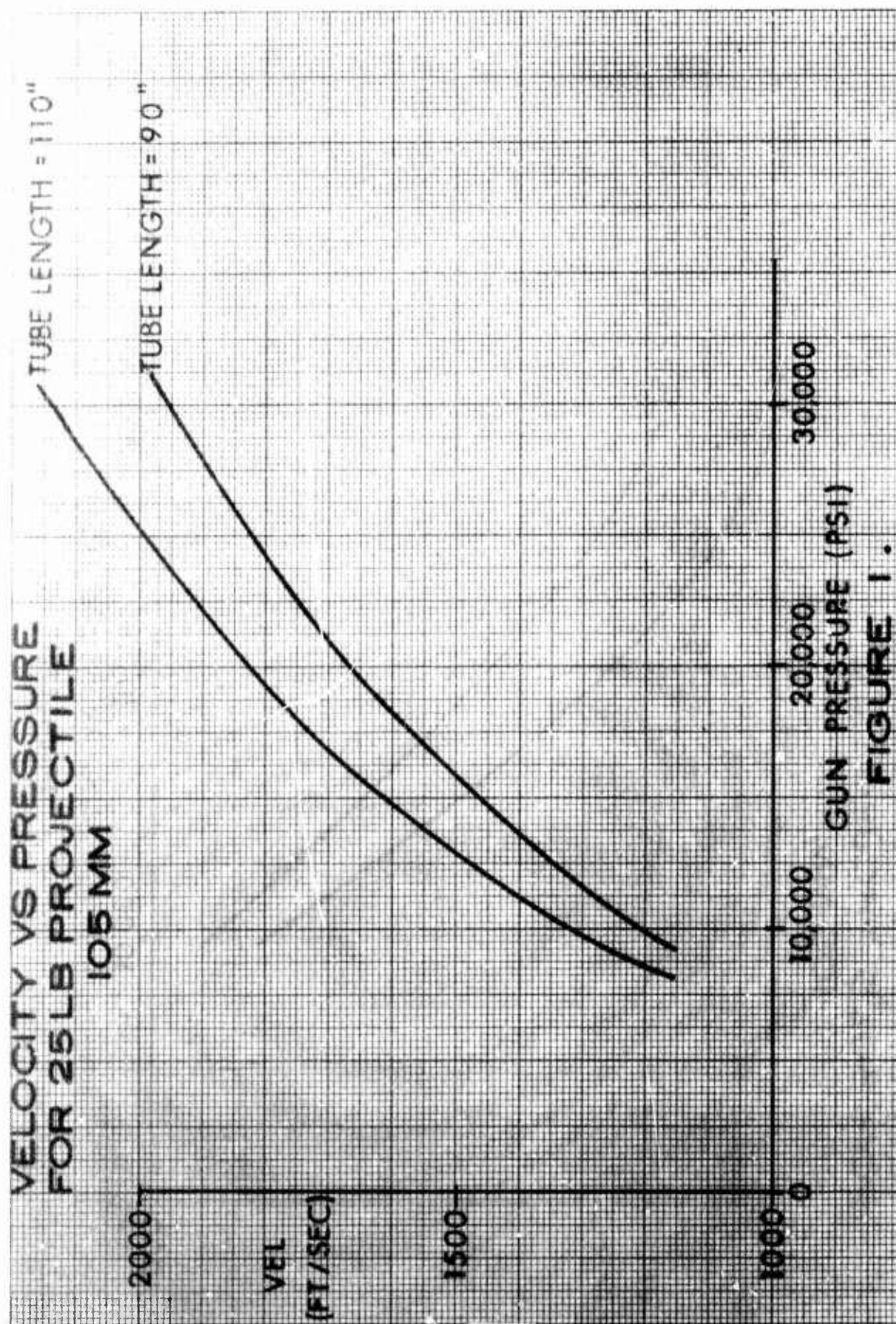
## MUZZLE BLAST OVERPRESSURE

| CONDITION<br>NO | $\Delta P_1$ |            | $\Delta P_2$ |            | $\Delta P_3$ |            | $\Delta P_4$ |            | $\Delta P_5$ |            |
|-----------------|--------------|------------|--------------|------------|--------------|------------|--------------|------------|--------------|------------|
|                 | 20" FWD      | 25" R or L | 20" FWD      | 30" R or L | 20" FWD      | 40" R or L | 20" FWD      | 50" R or L | 20" FWD      | 62" R or L |
|                 | PSI          | PSI        | PSI          | PSI        | PSI          | PSI        | PSI          | PSI        | PSI          | PSI        |
| 1               | 33.6         |            | 22.8         |            | 16.2         |            | 12.1         |            | 8.1          |            |
| 2               | 48.6         |            | 33.0         |            | 23.4         |            | 17.5         |            | 11.7         |            |
| 3               | 63.5         |            | 43.0         |            | 30.4         |            | 22.8         |            | 15.2         |            |
| 4               | 76.5         |            | 51.9         |            | 36.8         |            | 27.6         |            | 18.4         |            |
| 5               | 89.2         |            | 60.5         |            | 42.8         |            | 32.2         |            | 21.4         |            |
| 6               | 34.8         |            | 23.6         |            | 16.5         |            | 12.4         |            | 8.3          |            |
| 7               | 50.4         |            | 34.2         |            | 24.0         |            | 18.1         |            | 12.1         |            |
| 8               | 65.0         |            | 44.2         |            | 30.9         |            | 23.3         |            | 15.6         |            |
| 9               | 79.2         |            | 53.8         |            | 37.9         |            | 28.4         |            | 19.0         |            |
| 10              | 95.4         |            | 64.8         |            | 45.6         |            | 34.2         |            | 22.9         |            |
| 11              | 33.8         |            | 23.0         |            | 16.3         |            | 12.2         |            | 8.2          |            |
| 12              | 49.5         |            | 33.5         |            | 23.7         |            | 17.8         |            | 11.9         |            |
| 13              | 63.5         |            | 43.0         |            | 30.4         |            | 22.8         |            | 15.2         |            |
| 14              | 75.5         |            | 51.3         |            | 36.2         |            | 27.2         |            | 18.1         |            |
| 15              | 90.2         |            | 61.2         |            | 43.4         |            | 32.5         |            | 21.7         |            |
| 16              | 35.3         |            | 24.0         |            | 16.9         |            | 12.7         |            | 8.6          |            |
| 17              | 50.9         |            | 34.6         |            | 24.3         |            | 18.2         |            | 12.2         |            |
| 18              | 65.8         |            | 44.7         |            | 31.4         |            | 23.6         |            | 15.8         |            |
| 19              | 80.1         |            | 54.5         |            | 38.3         |            | 28.8         |            | 19.2         |            |
| 20              | 93.5         |            | 63.5         |            | 44.6         |            | 33.5         |            | 22.4         |            |

TABLE 4

## 105MM DAVIS TYPE GUN DESIGN

| CONDITION<br>NO | GUN<br>WEIGHT<br>W <sub>DC</sub><br>POUNDS | GUN CHARGE<br>WEIGHT<br>W <sub>DC</sub><br>POUNDS | CASE<br>WEIGHT<br>W <sub>DCA</sub><br>POUNDS | TOTAL ROUND<br>WEIGHT<br>W <sub>TDR</sub><br>POUNDS | GUN SYSTEM<br>WEIGHT<br>W <sub>DGS</sub><br>POUNDS | TOTAL WEAPON<br>SYSTEM WEIGHT<br>W <sub>TDWS</sub><br>POUNDS | AVAILABLE<br>COMBAT LOAD<br>W <sub>AV</sub><br>POUNDS | NUMBER OF<br>ROUNDS<br>N |
|-----------------|--------------------------------------------|---------------------------------------------------|----------------------------------------------|-----------------------------------------------------|----------------------------------------------------|--------------------------------------------------------------|-------------------------------------------------------|--------------------------|
| 1               | 628                                        | 2.72                                              | 5.54                                         | 58.16                                               | 878                                                | 1178                                                         | 1322                                                  | 22                       |
| 2               | 622                                        | 3.94                                              | 7.88                                         | 61.82                                               | 872                                                | 1172                                                         | 1328                                                  | 21                       |
| 3               | 626                                        | 5.10                                              | 10.20                                        | 65.30                                               | 876                                                | 1176                                                         | 1324                                                  | 20                       |
| 4               | 640                                        | 6.18                                              | 12.36                                        | 68.54                                               | 890                                                | 1190                                                         | 1310                                                  | 19                       |
| 5               | 664                                        | 7.18                                              | 14.36                                        | 71.54                                               | 914                                                | 1214                                                         | 1286                                                  | 18                       |
| 6               | 542                                        | 2.24                                              | 4.48                                         | 56.78                                               | 792                                                | 1092                                                         | 1408                                                  | 24                       |
| 7               | 538                                        | 3.26                                              | 6.52                                         | 59.78                                               | 788                                                | 1088                                                         | 1412                                                  | 23                       |
| 8               | 544                                        | 4.20                                              | 8.40                                         | 62.60                                               | 794                                                | 1094                                                         | 1406                                                  | 22                       |
| 9               | 554                                        | 5.10                                              | 10.20                                        | 65.30                                               | 804                                                | 1104                                                         | 1396                                                  | 21                       |
| 10              | 576                                        | 5.96                                              | 11.92                                        | 67.88                                               | 826                                                | 1126                                                         | 1374                                                  | 20                       |
| 11              | 628                                        | 2.74                                              | 5.48                                         | 68.22                                               | 878                                                | 1178                                                         | 1322                                                  | 19                       |
| 12              | 624                                        | 3.98                                              | 7.96                                         | 71.94                                               | 874                                                | 1174                                                         | 1328                                                  | 18                       |
| 13              | 628                                        | 5.14                                              | 10.28                                        | 75.42                                               | 878                                                | 1178                                                         | 1322                                                  | 17                       |
| 14              | 642                                        | 6.24                                              | 12.48                                        | 78.72                                               | 892                                                | 1192                                                         | 1308                                                  | 16                       |
| 15              | 666                                        | 7.28                                              | 14.56                                        | 81.84                                               | 916                                                | 1216                                                         | 1284                                                  | 15                       |
| 16              | 542                                        | 2.26                                              | 4.52                                         | 66.78                                               | 792                                                | 1092                                                         | 1408                                                  | 21                       |
| 17              | 538                                        | 3.28                                              | 6.56                                         | 69.84                                               | 780                                                | 1088                                                         | 1412                                                  | 20                       |
| 18              | 544                                        | 4.24                                              | 8.48                                         | 72.72                                               | 794                                                | 1094                                                         | 1406                                                  | 19                       |
| 19              | 556                                        | 5.16                                              | 10.32                                        | 75.48                                               | 806                                                | 1106                                                         | 1394                                                  | 18                       |
| 20              | 578                                        | 6.02                                              | 12.04                                        | 78.06                                               | 828                                                | 1128                                                         | 1372                                                  | 17                       |



VELOCITY VS PRESSURE  
FOR 30LB PROJECTILE  
105 MM

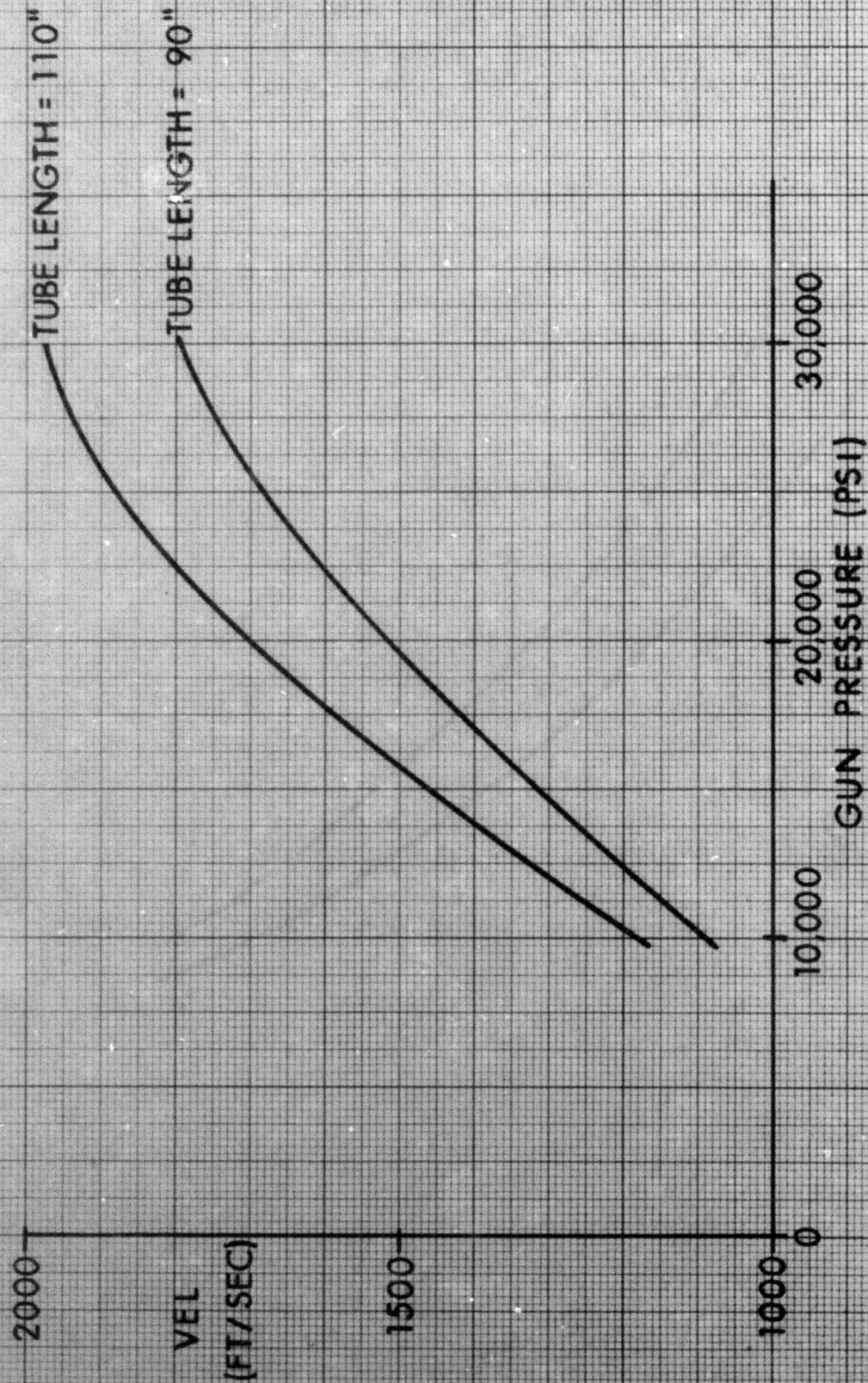


FIGURE 2.

# TRAJECTORIES 25 LB 105 MM PROJECTILES FROM HELICOPTER AT 1000 FT

TUBE LENGTH • 110"

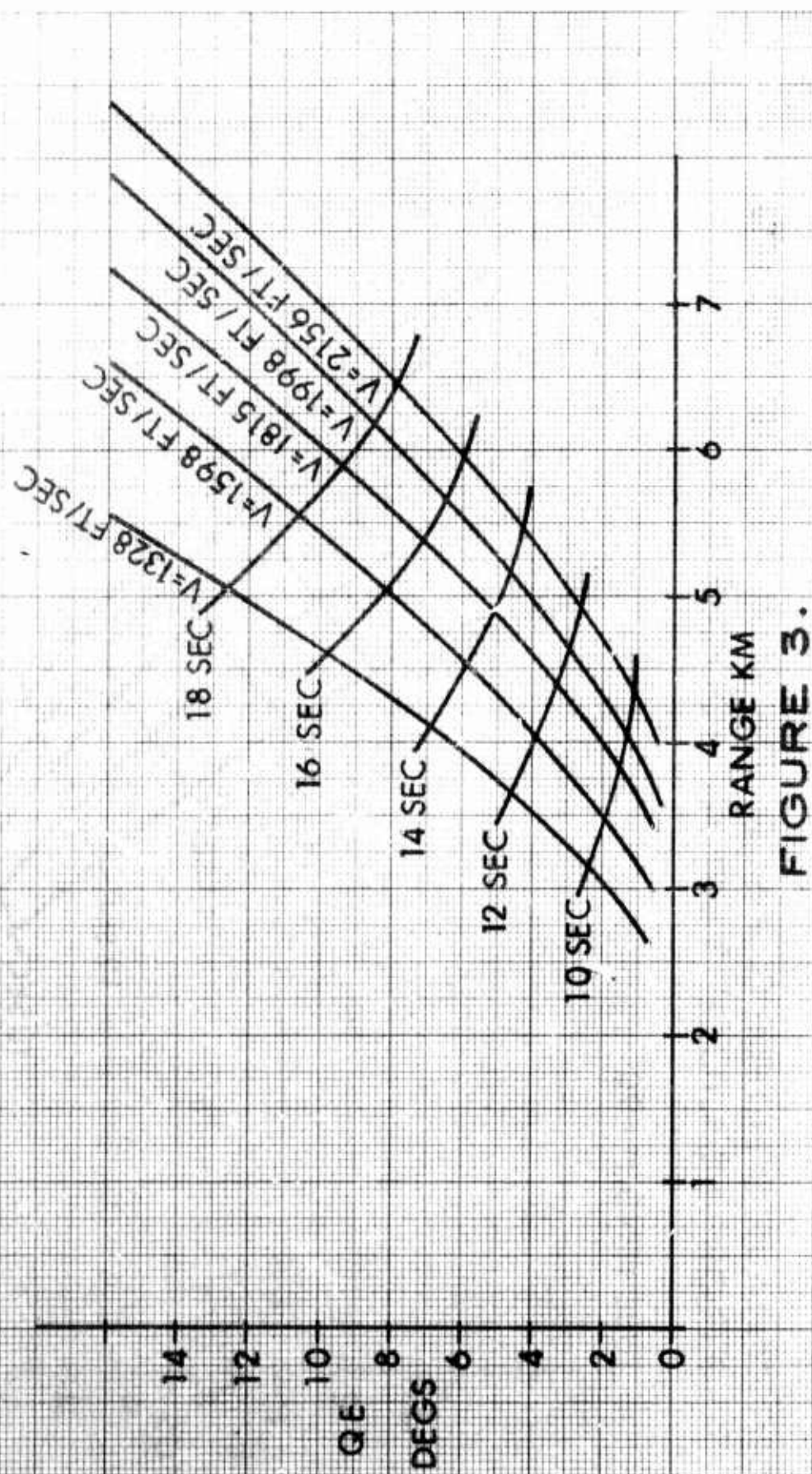


FIGURE 3.

# TRAJECTORIES 25LB 105 MM PROJECTILES FROM HELICOPTER AT 1000 FT

TUBE LENGTH • 90"

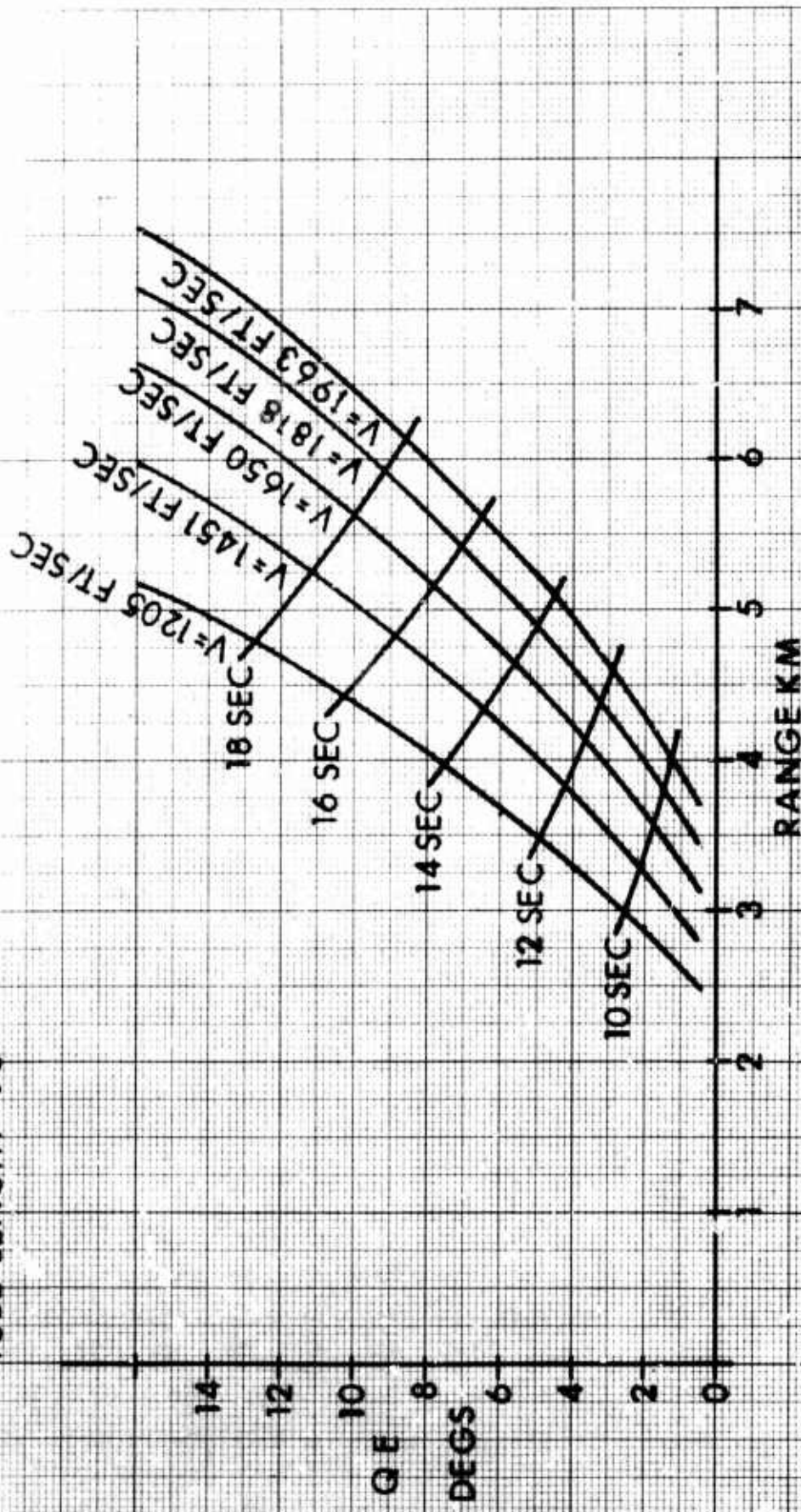


FIGURE 4.

# TRAJECTORIES 30LB 105MM PROJECTILES FROM HELICOPTER AT 1000 FT

TUBE LENGTH - 1:10"

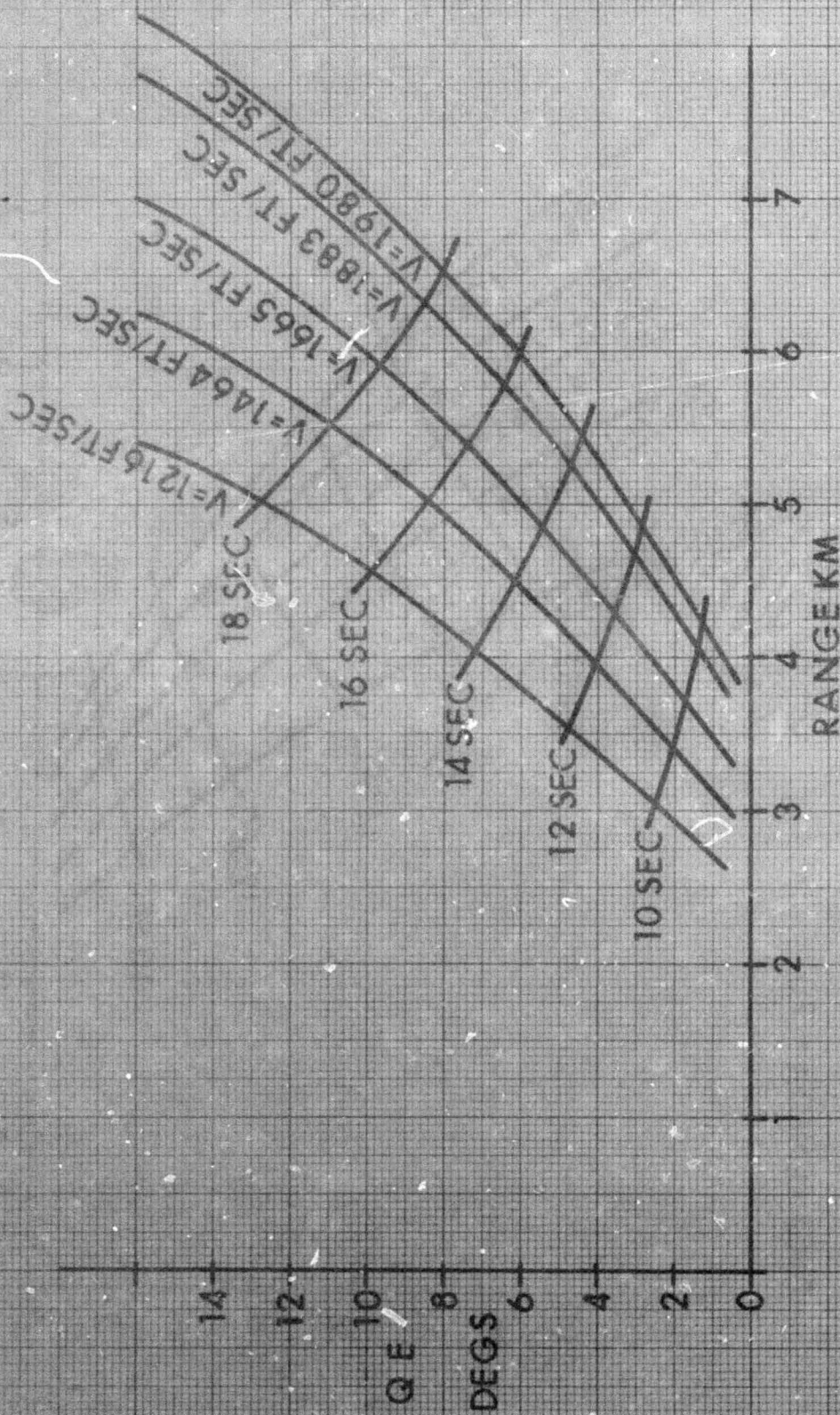


FIGURE 5.

# TRAJECTORIES 30LB 105 MM PROJECTILES FROM HELICOPTER AT 1000 FT

TUBE LENGTH = 90"

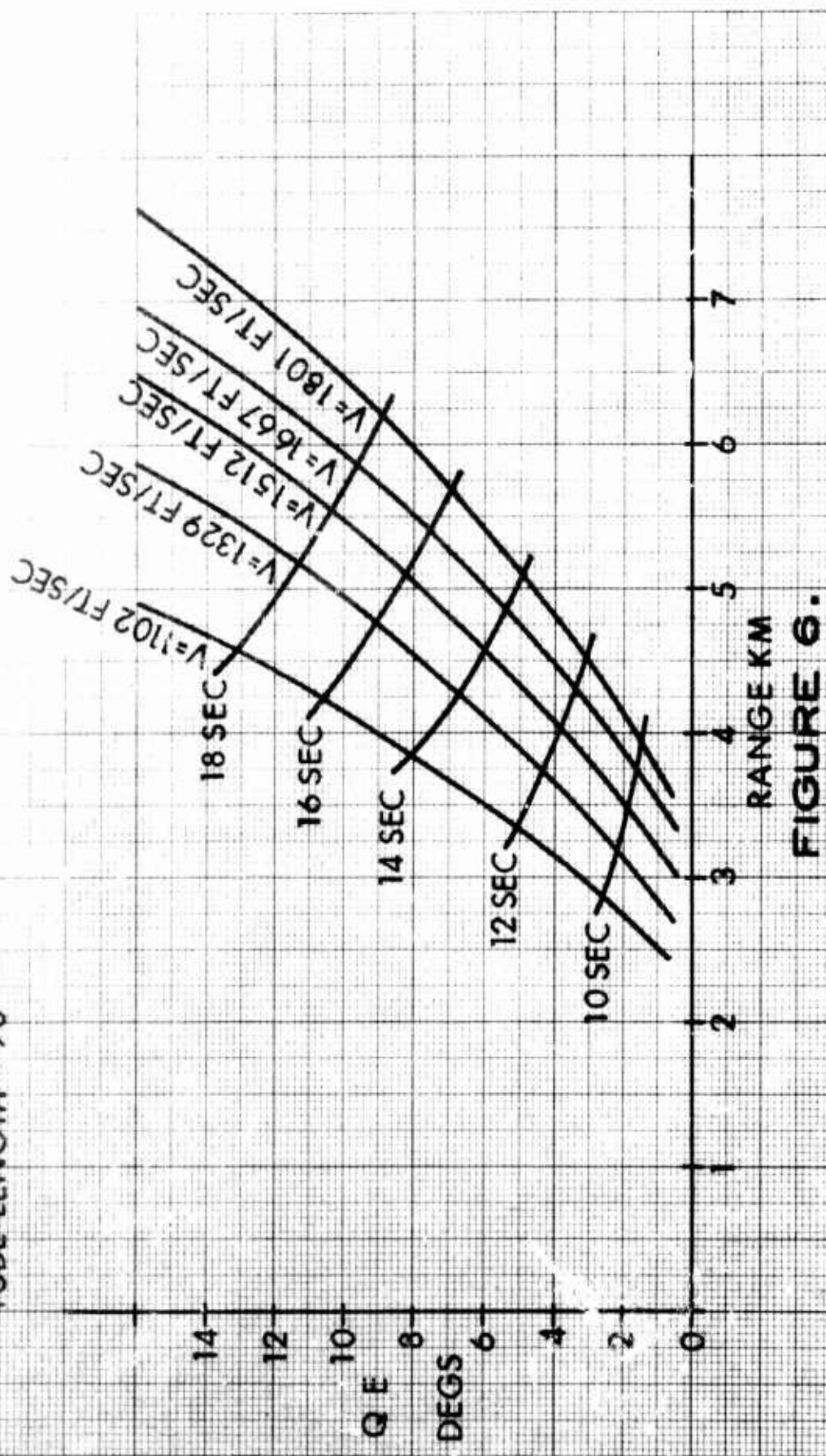
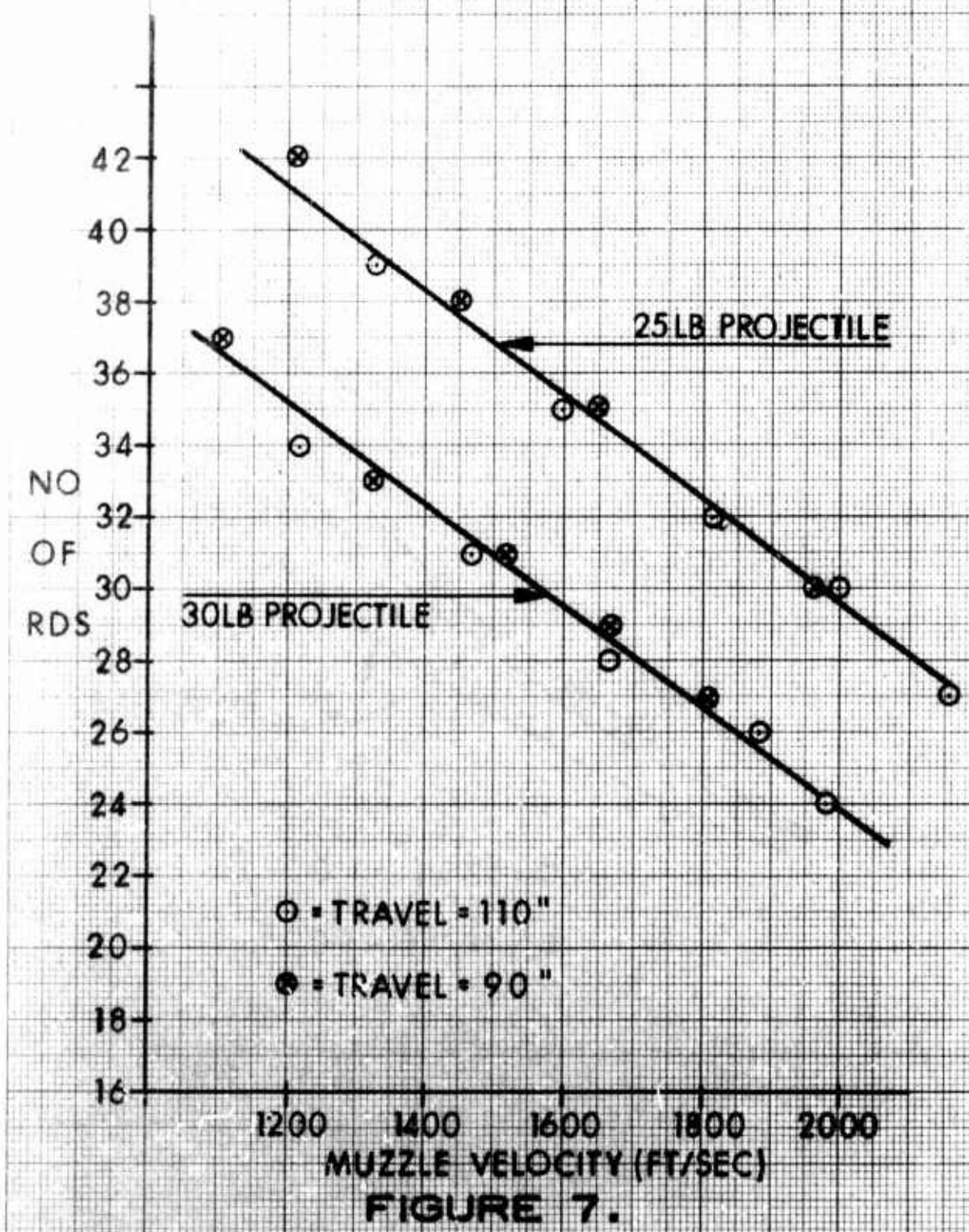


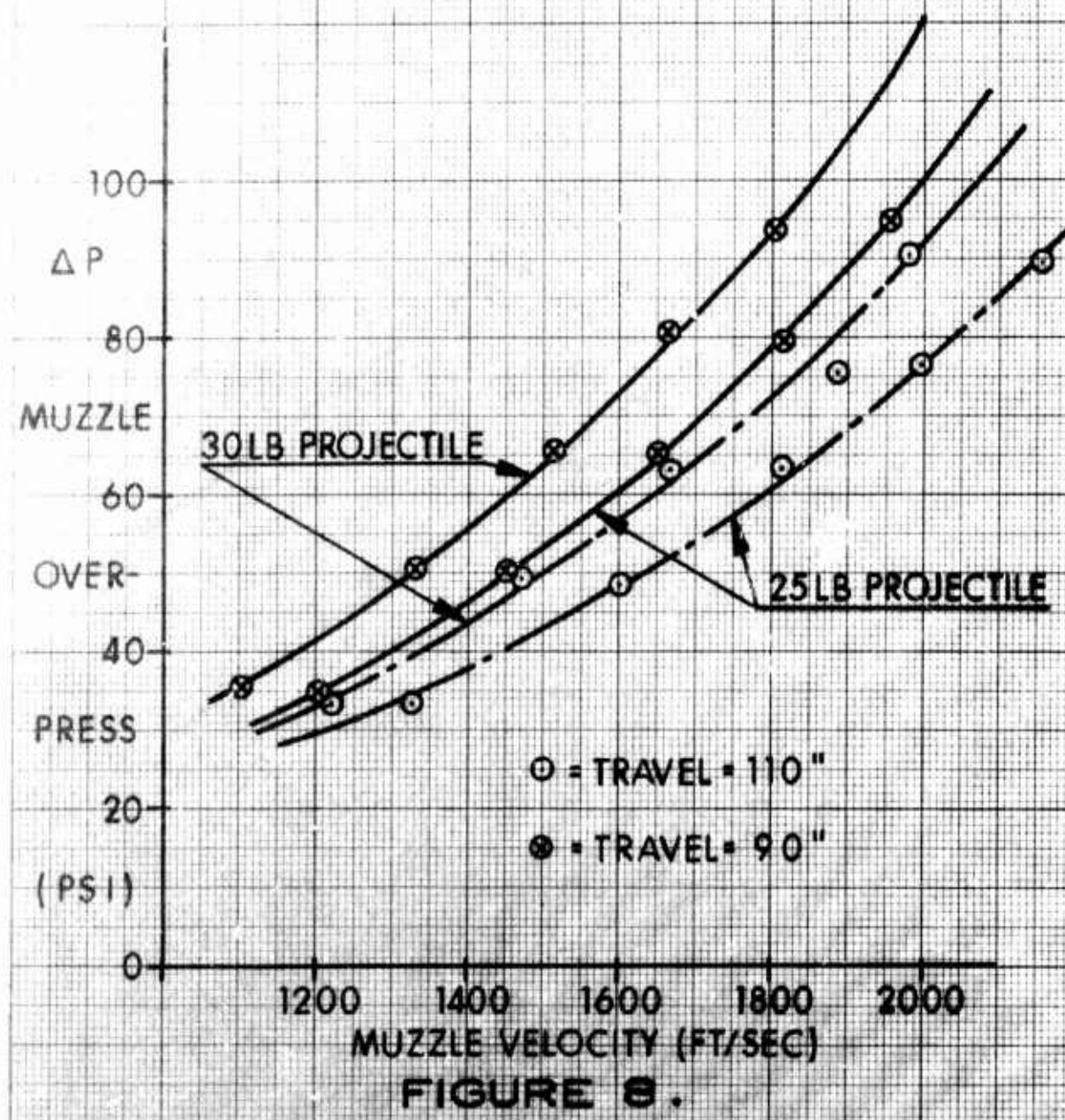
FIGURE 6.

# COMBAT LOAD VS MUZZLE VELOCITY FOR 105 MM CLOSED BREECH GUN DESIGN WITH IMPULSE GENERATOR

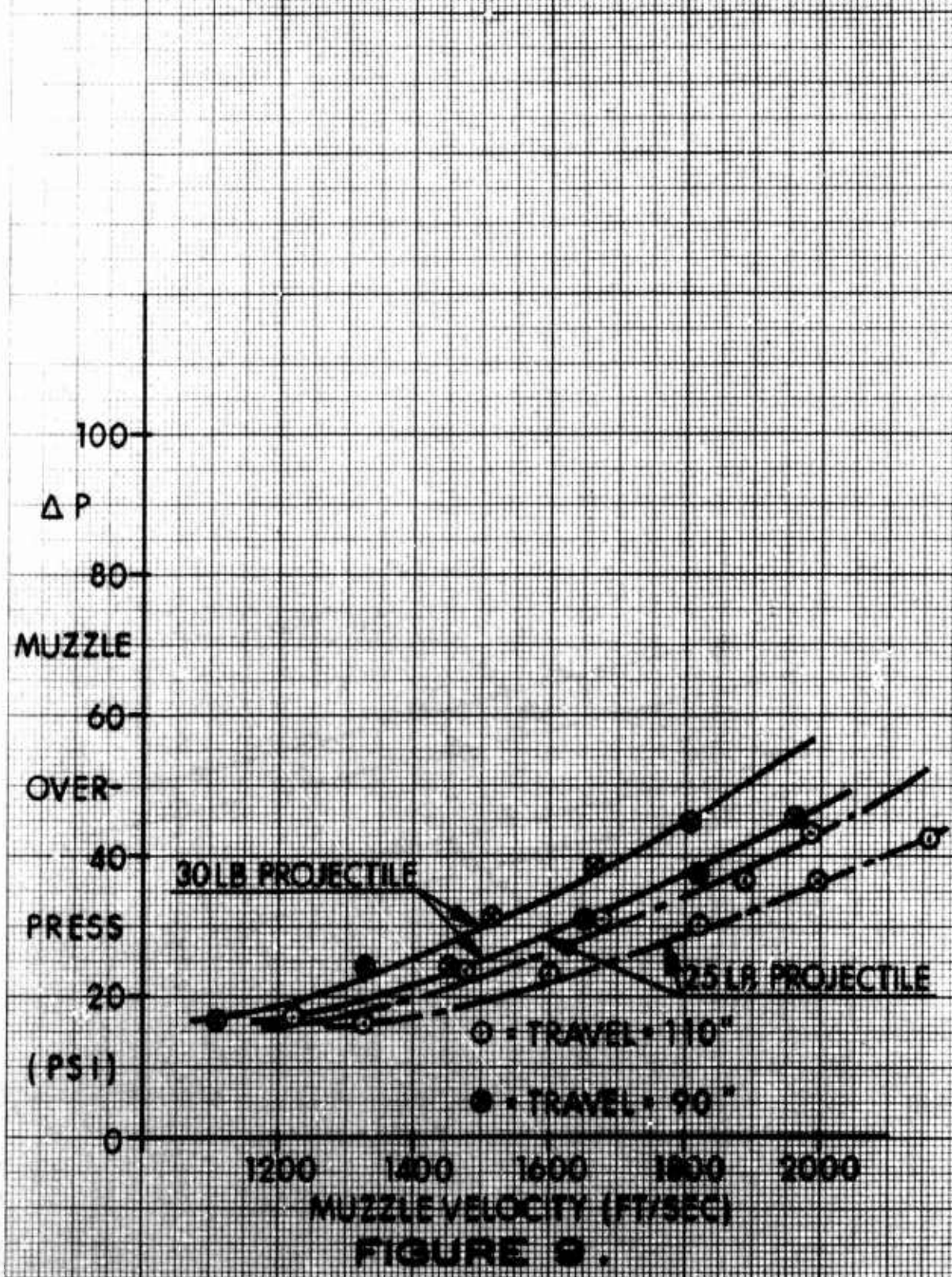
ASSUMED PAYLOAD 2500 LBS



# MUZZLE OVERPRESSURE VS MUZZLE VELOCITY AT 20" FORWARD AND 25" RIGHT OR LEFT OF MUZZLE



# MUZZLE OVERPRESSURE VS MUZZLE VELOCITY AT 20" FORWARD AND 40" RIGHT OR LEFT OF MUZZLE



# COMBAT LOAD VS MUZZLE VELOCITY FOR 105 MM DAVIS TYPE GUN DESIGN

ASSUMED PAYLOAD 2500 LBS

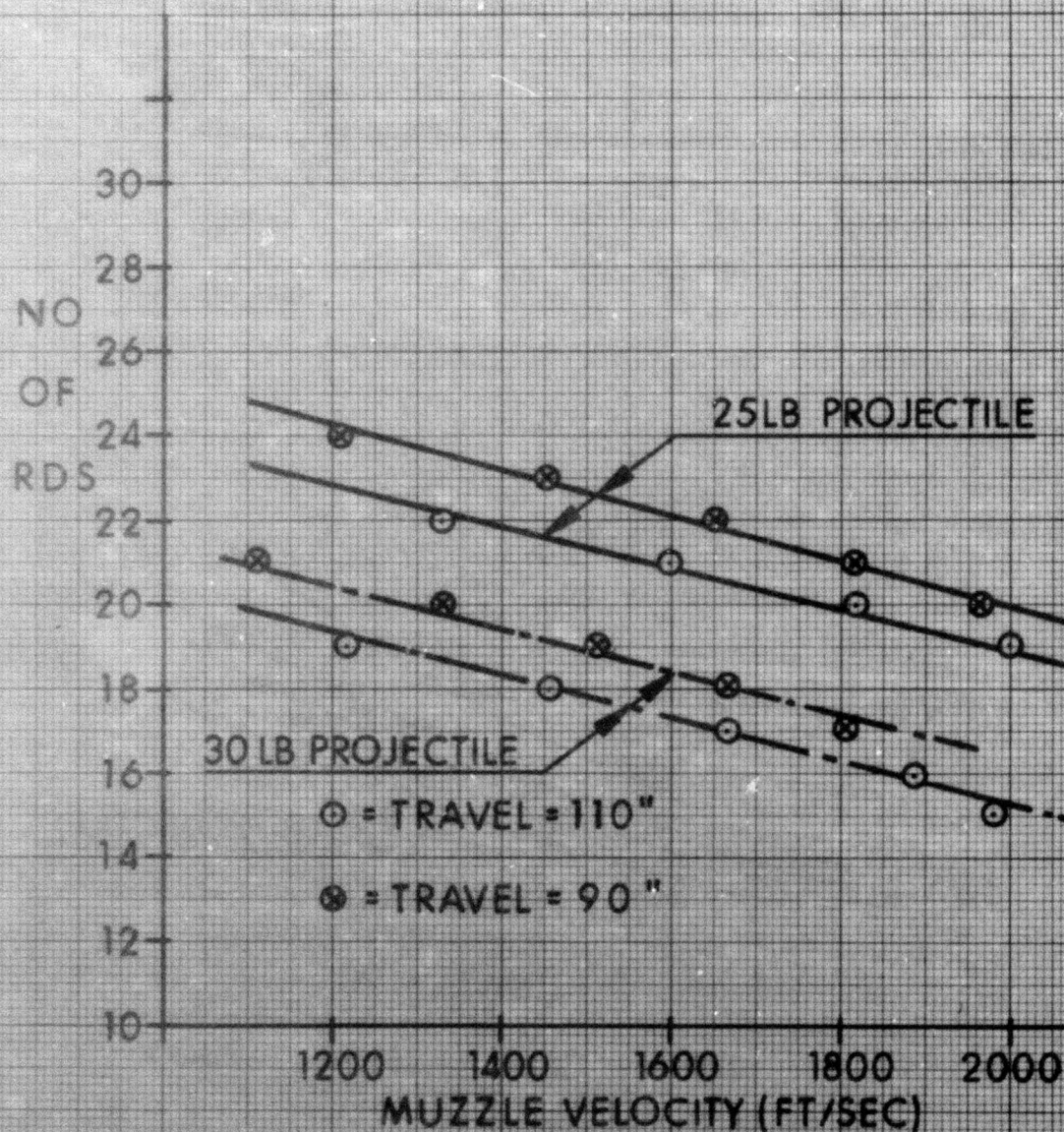


FIGURE 10.

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14.

### KEY WORDS

**LINK A**

**LINK B**

LINK C

ROLE

WT

ROLE

WT

[illegible]

WT

## Helicopter Weapons

## Artillery

## Combat Loads

## Muzzle Blast

|                                                                                                                                                                                                                                                                                                        |               |
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