

LIGHT MACHINE GUN

5.56-MM

CMG-2

Submitted To:

UNITED STATES ARMY

Colt Industries  Colt's Inc Military Arms Division

11

LIGHT MACHINE GUN

September 22, 1969

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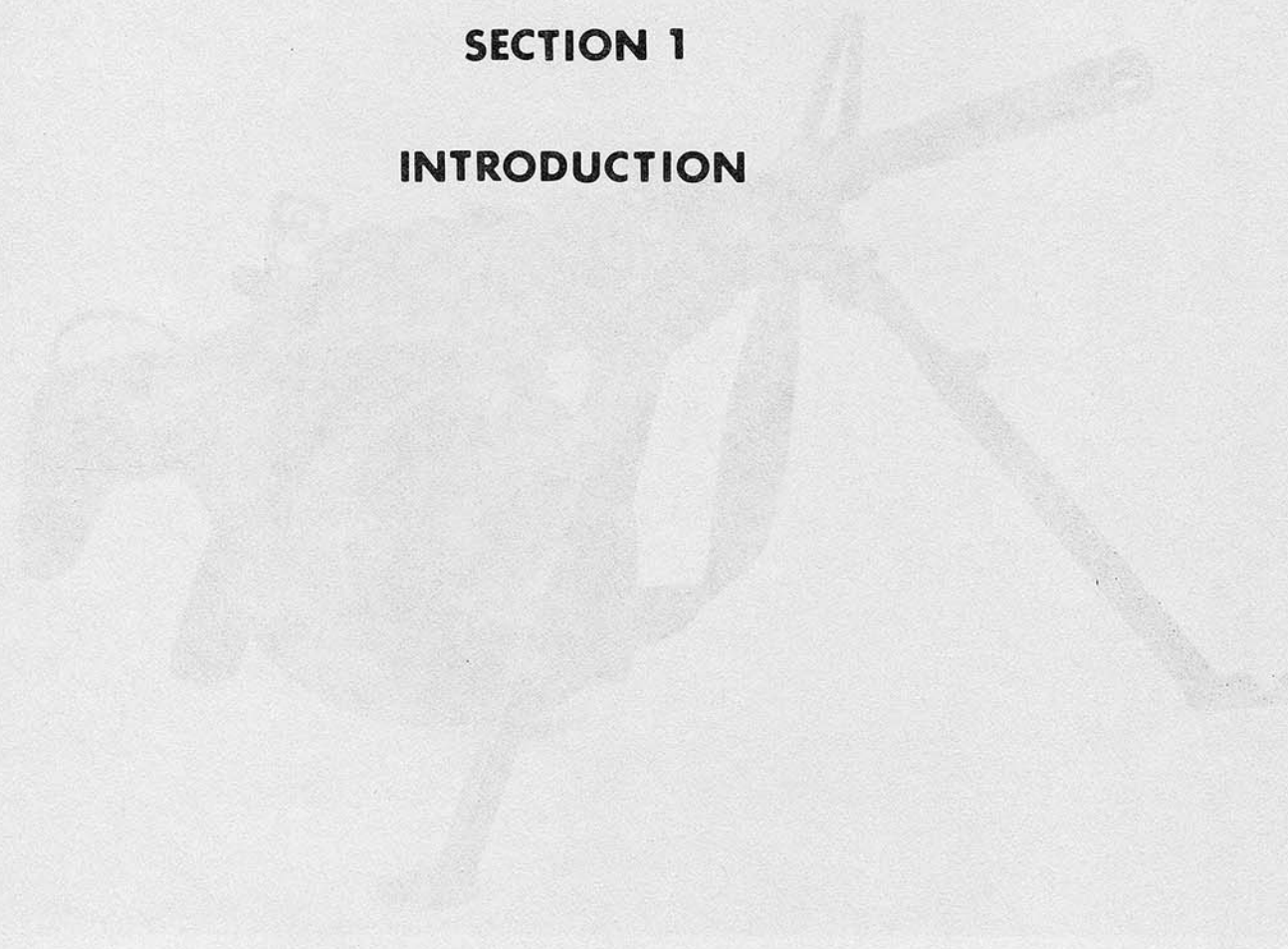
UNITED STATES ARMY

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SECTION 1
INTRODUCTION



SECTION 1

INTRODUCTION

Colt's Firearms Division of Colt Industries is pleased to submit this proposal for a light infantry machine gun to the United States Army. This weapon is offered as a compatible support weapon for the M16 family of weapons.

Colt's Firearms recognizes the need for a versatile light machine gun to provide increased fire support for combat units in the field. The fluidity of tactical situations currently experienced demands a weapon which can be easily transported for long distances with sufficient ammunition to be effective without frequent resupply. The weapon must be so designed that it is reliable when operated in extremes of adverse climatic and terrain conditions. The light machine gun proposed by Colt's offers a most practical trade off of design parameters to obtain the required durability and sustainability of operation.

Recognizing the urgency of fielding a completely dependable and effective system in as short a time as possible, Colt's proposes to provide ten (10) prototype test weapons for engineering development testing. These weapons will be representative of the technical description in this proposal and will be offered in accordance with the price and terms in Appendix A. In the event the government decides that the weapon merits continued consideration as a result of these tests, Colt's further proposes to provide additional weapons for engineering and service testing on a Government funded basis.

SECTION 2

DESCRIPTION

SECTION 2

DESCRIPTION

2-1. GENERAL DESCRIPTION

The proposed weapon is designated as Colt's Machine Gun, Model 2 (CMG-2). It is a lightweight, gas operated, link belt fed, air-cooled machine gun utilizing the 5.56 mm cartridge. Single rounds, short bursts, or automatic fire (approximately 650 rounds per minute) can be easily fired. The gun is designed to be fired from the shoulder or hip and, with the bipod, from the sitting and prone positions by either left or right handed gunners with equal ease. The quick-change barrel feature extends the life of the weapon. The primary use of this weapon is for ground operations.

The CMG-2 is designed to provide a high level of performance, reliability, and long service life by use of simple, rugged mechanisms which are readily producible. This simplicity of design will facilitate manufacture, training, maintenance and logistics.



Figure 2-1. Colt's Machine Gun, Model 2 (CMG-2)



Figure 2-2. CMG-2, Right Side



Figure 2-3. CMG-2, Left Side

TABLE 1
 CHARACTERISTICS -- CMG-2

Type	Ground Machine Gun
Caliber	5.56 mm
Ammunition	Ball M 193 (55 gr) Ball MG (68 gr) Tracer M196
Link	M13 type
Overall length	41 15/16"
Weights	
Weapon w/o bipod	13.5 lbs
Bipod	1.56 lbs
Spare barrel	4.125 lbs
Magazine	1.57 lbs
Rate of fire	650 rds per min. (approx.)
Type of operation	Gas
Method of feeding	Link belt
Capacity of magazine	150 rds.

TABLE 2

TABULATED DATA -- CMG-2

Total components basic weapon	138
Bipod (Government furnished)	35
Standard components (Rivets, screws, etc.)	30
Magazine	16
Barrel (spare)	10
Combination Tool	6
Total Drawings	146
Standard component drawings (rivets, screws, etc.)	19
Detail Drawings	112
Assembly drawings	15

TABLE 3

UNIQUE FEATURES -- CMG-2

- a) The fire control group is used to charge the weapon.
- b) The extractor is a machined groove in the face of the bolt eliminating it as a repair part.
- c) The ejector is a three piece cam actuated pivot arm which is receiver mounted and easily removable.
- d) The feed mechanism is a six-piece unit, mounted on the side of the receiver. It is actuated by cams on the bolt carrier. The feed pawls engage the ammunition belt from underneath permitting a simple, short and lightweight feed tray cover.
- e) The firing pin has a striker point on each end which provides for foolproof assembly and extended service life.
- f) Disassembly and reassembly of the weapon for field or detail stripping can be readily accomplished without the use of tools except in one instance, i.e., a cartridge is required to remove and assemble the forward grip and gas cylinder.

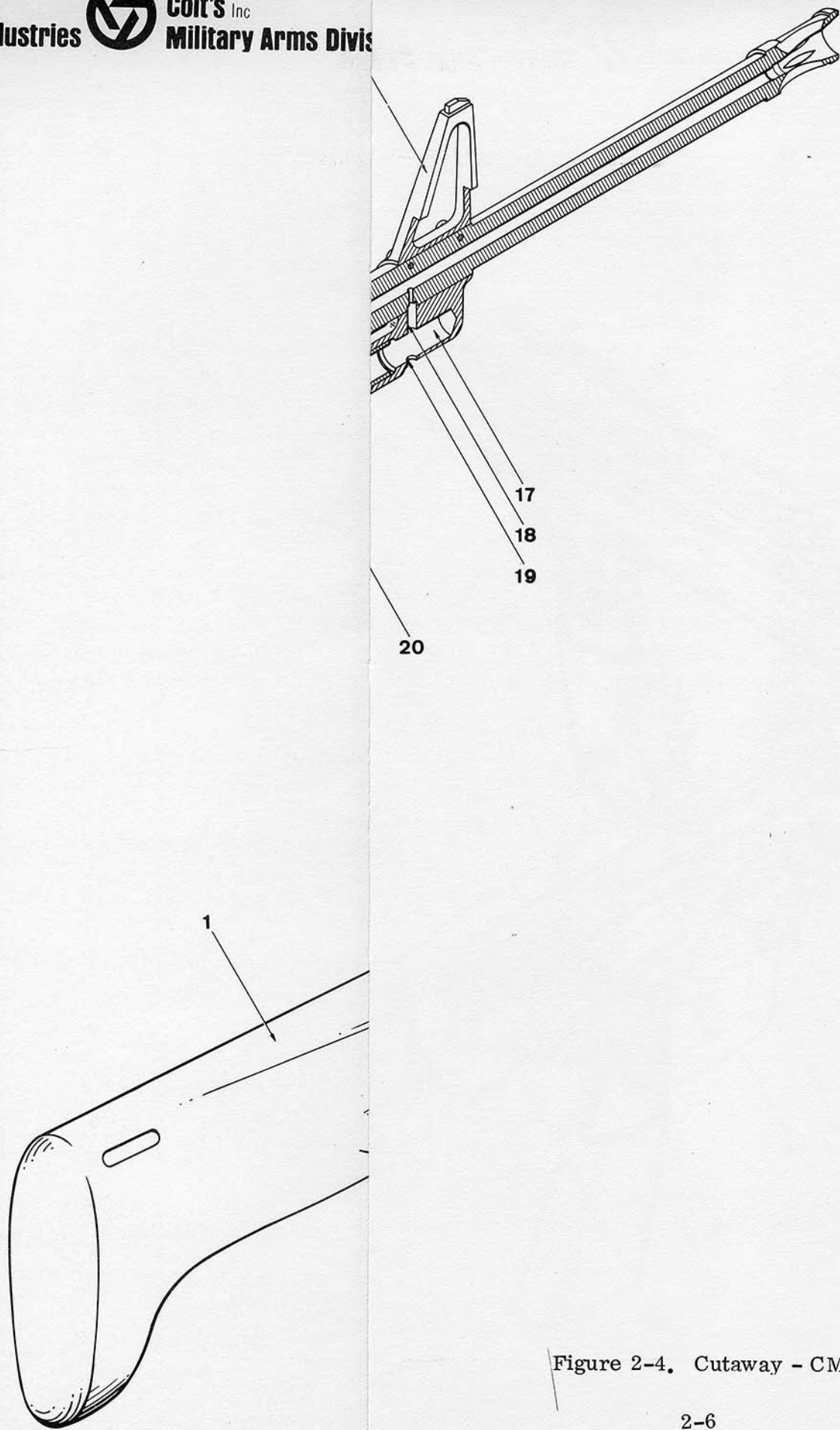


Figure 2-4. Cutaway - CMG-2

2-2. DETAILED DESCRIPTION

2-2.1 RECEIVER ASSEMBLY

The receiver assembly consists of the rear sight base, the forward sling loops, and a channel support riveted to an electron-beam welded unit made up of the left, right, and lower receiver channels, the left and right cam plates and the bearing block.

2-2.1.1 The rear sight base provides mounting for the rear sight and the ejector. It also supports the feed tray and cover, houses the feed tray cover latch, actuator cover latch, and a flat spring which retains the sight leaf in either the folded or upright position.

2-2.1.2 The bearing block provides rear support for the barrel, forward support for the guide rods, retains the actuator, and provides lugs for mounting the feed tray, feed tray cover, and barrel latch.

2-2.1.3 The cam plates provide a camming surface for the follower pin. In addition, the left cam plate provides bolt lug guidance during the early portion of the bolt carrier recoil.

2-2.1.4 The lower channel serves as a guide rail for the fore and aft movement of the fire control group during the charging cycle. It also provides mounting lugs for the magazine and a locking notch for the safety.

- 2-2.1.5 The forward portion of the side channels provides a shroud for the barrel and the rear portion houses and supports the feeding and operating groups.
- 2-2.2 **BARREL ASSEMBLY**
- The barrel assembly is a quick change type with fixed headspace. The gun carrying handle is attached to facilitate changing hot barrels.
- 2-2.2.1 The flash suppressor is machined into the barrel tube. This simplifies fabrication and eliminates two repair parts.
- 2-2.2.2 The twist of the rifling in the barrel tube is one turn in 8 $\frac{7}{8}$ inches. This degree of twist is necessary to stabilize Colt's 68 grain projectile. It also provides adequate stabilization for the standard 55 grain projectile.
- 2-2.2.3 The one piece front sight is non-adjustable and permanently attached to the barrel tube. The gas port, gas expansion chamber, gas exhaust port, and forward barrel support are integral with the sight.
- 2-2.2.4 The barrel socket is permanently attached to the barrel tube and contains the cartridge chamber and bolt locking recess. It also provides the rear barrel support, the flange for the barrel locking latch, and the notch for the barrel latch key.

2-2.3 OPERATING GROUP

The operating group consists of the bolt carrier assembly, driving springs, guide rods, and buffer and buttstock assembly. In addition, the body of the bolt carrier houses the bolt assembly, firing pin, bolt cam follower, follower spring and follower pin. The group is removed as one unit from the receiver by depressing a latch contained in the buffer housing.

2-3.3.1

The bolt carrier and the gas piston are rigidly attached. The piston also serves as the bolt carrier front support as it slides in the gas cylinder. The rear of the carrier is supported and guided by the two driving spring guide rods. The cams for the feeding mechanism are machined into the left side. The ejector actuating lug is also located on the left side, aft of the cams. An opening in the body of the carrier is provided to permit passage of ejected cartridge cases. The sear notch is located on the lower aft portion of the body. The body of the carrier houses the bolt assembly, firing pin, bolt cam follower, follower spring and follower pin.

2-3.3.2

The bolt assembly is a rotary locking four piece unit consisting of the bolt, the cartridge retaining plunger, the plunger spring, and the plunger retaining pin. The bolt has eight locking lugs at the forward end. The cartridge seat, the extractor, and the cartridge retaining lip are

machined into the face of the bolt. A hole in the face of the bolt is provided for the cartridge retaining plunger. The body of the bolt is hollow to accept the firing pin. The bolt locking cam is machined into the bolt body. The firing pin is constructed with a tapered striker point at each end and has a hole in the mid-section for the cam follower. The cam follower is a straight pin, contoured at one end compatible with the firing pin hole in the bolt, and has a spring seat hole at the opposite end. A cross hole in the mid-section is provided for the follower pin. The follower pin is a straight pin with the center section undercut to provide retention with the cam follower.

2-2.3.3 The guide rods are straight tubular shafts. An undercut at one end to accept the retaining plate and a shoulder at the other end to hold the bolt carrier captive provide unit assembly retention of the operating group. The rods also serve as guide rails for the driving springs and the bolt carrier. The shouldered end of the left rod serves as the forward bearing surface of the feed mechanism actuator. The two rods are interchangeable.

2-2.3.4 The hydraulic buffer is a sealed unit attached to the buttstock. It has a protruding plunger and contains the main assembly latch. The buffer housing also supports the rear portion of the guide rods and holds the guide rod retaining plate captive.

2-2.4 FIRE CONTROL

The fire control group is a 16-piece unit which also serves as the charging mechanism. It is simple in design, requiring no tools for disassembly or assembly. The grip is a one-piece plastic molding attached to the housing. The trigger guard, while rigidly attached, can be removed for firing with winter mittens. The crossbolt safety is also the trigger pivot pin. The sear serves as the bolt carrier catch when charging the weapon. The mechanism does not require retaining pins as the sear pivot pin, crossbolt safety and locking latch are held in place by the lower receiver channel when the group is assembled to the weapon. The ejection port cover, which also serves as the stop for the group when charging the weapon, is attached to the rear of the trigger housing.

2-2.5 FEED MECHANISM

The feed mechanism's main components are the actuator assembly, actuator cover, feed tray, and feed tray cover assembly. The forward end of the actuator pivots about the left guide rod. The rear bearing of the actuator is guided between the outside of the receiver channel and inside of the actuator cover. The actuator roller follows the lower cam path on the bolt carrier. The lug located above the roller follows the upper cam path on the bolt carrier. The feed pawls, which are attached to the upper portion of the actuator, protrude through the base of the feed tray.

The feed tray is a one piece stamping. The feed tray cover is made up of two stampings welded together. The front end of both the feed tray and the feed tray cover are attached to the bearing block by the hinge pin. The back end of both rest on a shelf of the rear sight base and are secured by a sliding latch. The cover is spring actuated into the open position by a torsion spring which nests over the hinge pin. The cartridge guide is a one piece stamping mounted on the feed tray cover by overlapping loops. The loop on the guide pivots around a mating loop on the cover. The belt retaining pawl is also a one piece stamping. It pivots about a shaft mounted in the cartridge guide and protrudes through the guide. Both the guide and pawl springs are nested on the pawl shaft. The cartridge guide and retaining pawl shaft are held captive by the cover. Neither requires retaining pins or clips.

2-2.6 EJECTOR

The ejector is a three-piece unit consisting of the ejector, the ejector lever, and a torsion spring. It is self-retained and pivots within the rear sight base. Assembly and disassembly is readily accomplished without the use of tools.

2-2.7 REAR SIGHT

The rear sight leaf is attached to the rear sight base by the lateral adjustment screw. The leaf folds forward for protection when not in

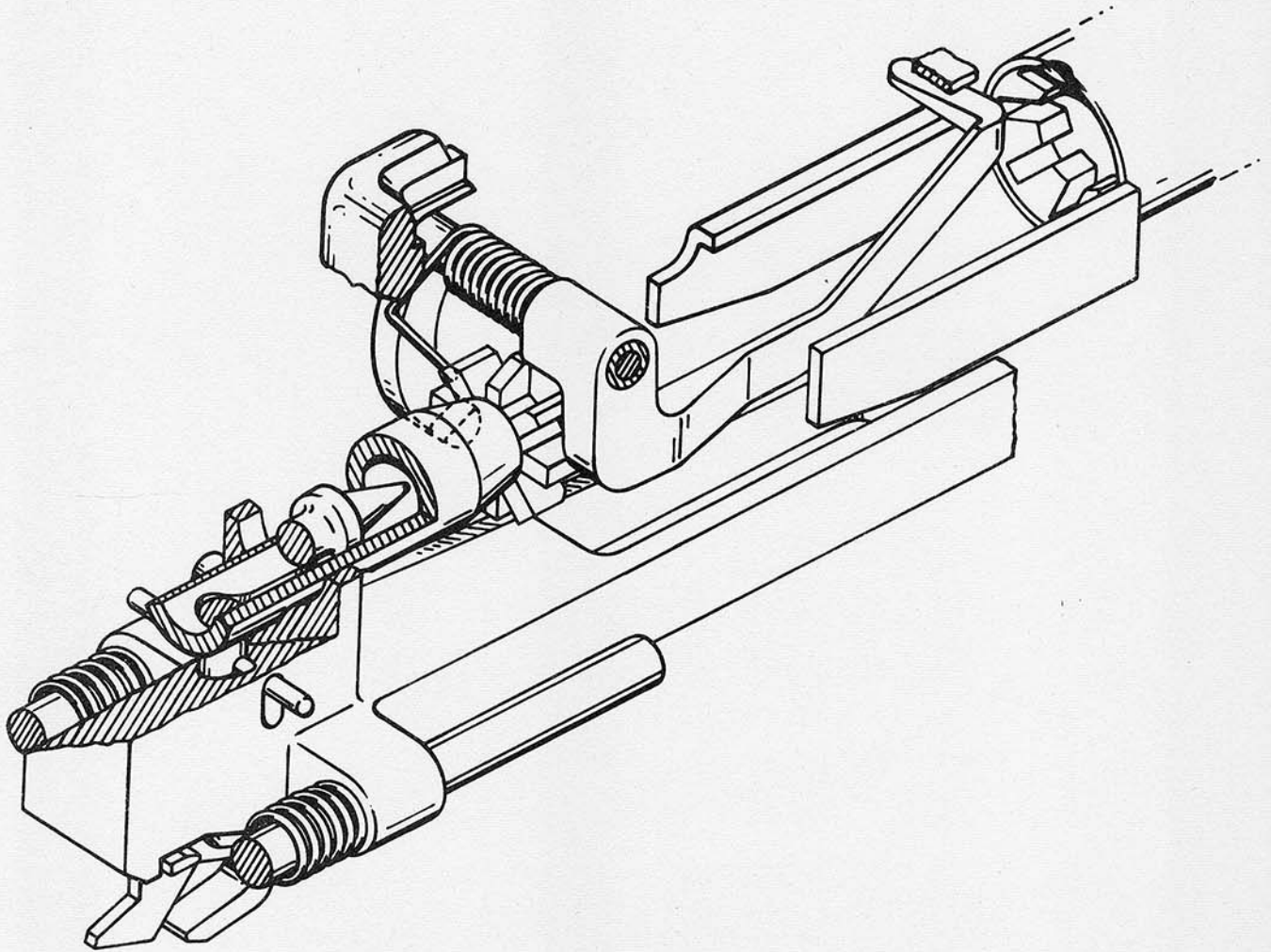


Figure 2-7. Cutaway - CMG-2 Firing Pin, Bolt, Ejector

use. It is held in the upright or folded position by a flat spring. The lateral adjustment knob contains two spring loaded ball detents which prevent backlash. Lateral adjustment is one mil per click. An adjustable index plate is provided for lateral zero reference. The elevation adjustment knob contains a ball detent which provides half mil clicks. The peep-type aperture is spring loaded eliminating vertical adjustment backlash. There is also an adjustable index plate for vertical zero reference.

2-2.8 BIPOD

The bipod is an adaptation of the M2 bipod currently used on the M14 E-2 rifle. The pivot and pivot plates have been designed to adopt the legs of the M2. The square tube, brazed construction of the legs will provide more than adequate strength for use in the light machine gun role.

2-2.9 MAGAZINE

The magazine is a drum type container for a 150 round belt of linked ammunition. Construction is of thin-walled sheet metal stampings. The magazine is teflon coated to reduce frictional drag of the ammunition belt. It is mounted underneath the weapon on the lower receiver channel, forward of the ejection port. An integral helical chute provides guidance of the ammunition belt from the magazine to the feed tray.

SECTION 3
OPERATING INSTRUCTIONS

SECTION 3

OPERATING INSTRUCTIONS

3.1 LOADING

The feed tray cover is opened by sliding the latch, located at the forward end of the rear sight base, rearward releasing the cover which is pivoted to the open position by a torsion spring. The ammunition belt, with the open side of the links down, is placed on the feed tray, locating the lead cartridge immediately in front of the feed pawls. The feed tray cover is then closed and latched by the spring-loaded cover latch. The bolt can be retracted at this time or prior to loading the weapon. The bolt is retracted by depressing the latch lever located at the rear left side of the trigger housing, sliding the trigger housing forward to its stopping surface on the lower channel automatically engaging the sear with the bolt carrier, and then pulling the trigger housing rearward by its grip to its stopping surface on the back plate, automatically engaging the trigger housing latch with the receiver. The weapon is now ready to fire. To unload the weapon, open the feed tray cover and remove the ammunition belt from the feed tray.

3.2 SAFETY OPERATION

The weapon is placed in the safe mode by pushing the cross-bolt safety, located directly above the trigger, from right to left, mechanically preventing the sear from becoming disengaged from the bolt carrier.

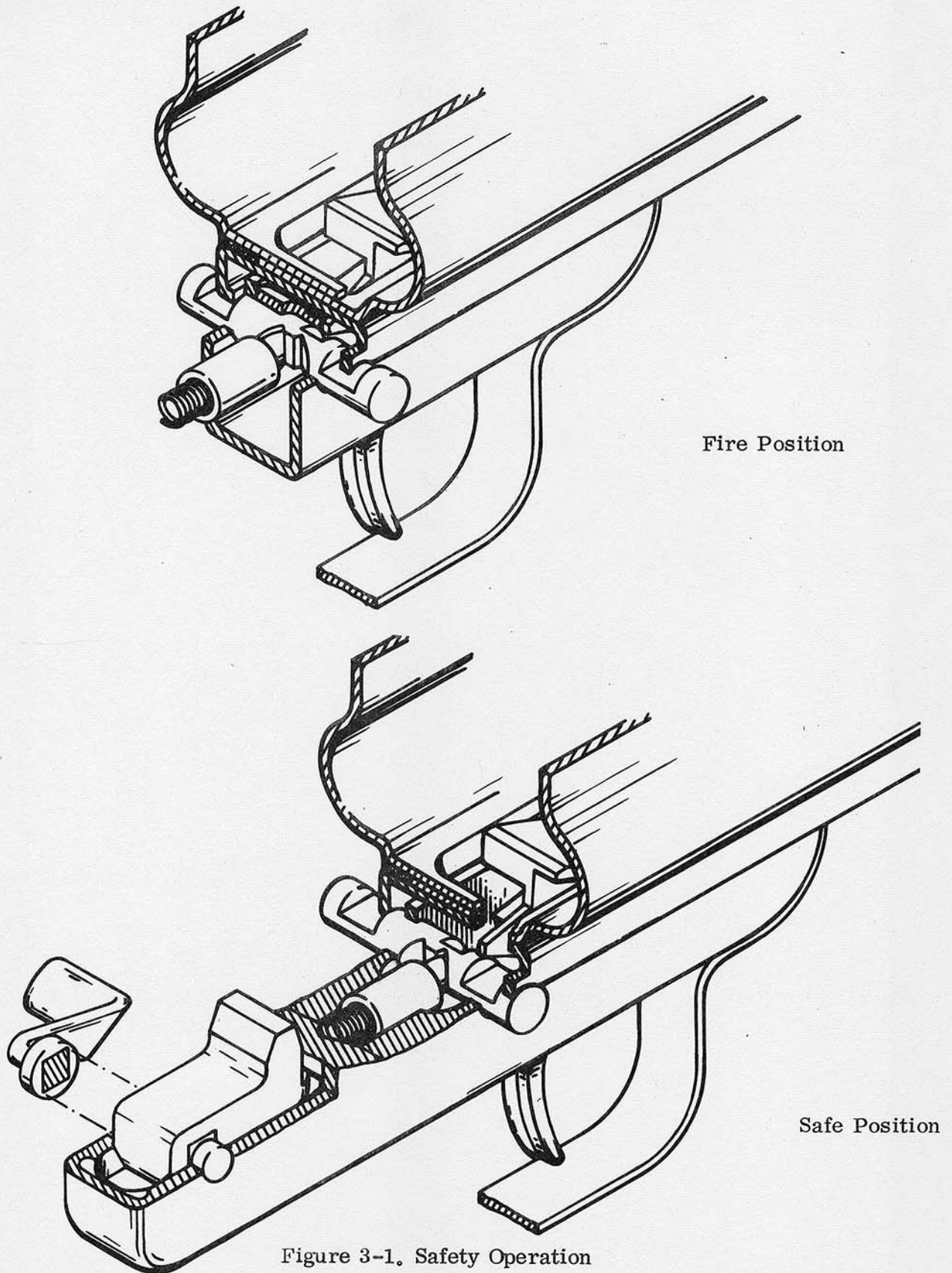


Figure 3-1. Safety Operation

3.3 SIGHT ADJUSTMENT

All sighting adjustments are made with the rear sight as the front sight position is fixed. Adjustments are in increments of 1/2 mil per click for the vertical and 1 mil per click for the lateral. Clockwise rotation of the vertical adjustment knob, located on the right side of the sight leaf, lowers the sight aperture. Clockwise rotation of the lateral adjustment knob, located on the left side of the sight base, moves the sight leaf to the left.

3.4 BARREL CHANGING

The barrel can be quickly and easily changed. It is disassembled from the weapon by grasping the carrying handle with one hand and the receiver group with the other hand, depressing the barrel latch located on the top of weapon just aft of the carrying handle with the thumb of the hand holding the receiver group, and sliding the barrel forward and out of the receiver. Disassembly may be accomplished with the bolt retracted or in the forward battery position. The barrel is assembled to the weapon by reversing the above procedure except for depressing the barrel latch. The latch is activated by the barrel and automatically locks the barrel in position. The bolt must be in the retracted position before assembly of the barrel to the weapon.

SECTION 4
CYCLE OF OPERATION

SECTION 4

CYCLE OF OPERATION

The Colt Machine Gun is a fully automatic weapon, fired from the open bolt. A rearward movement of the trigger depresses the sear, releasing the bolt carrier which is propelled forward by the driving springs. The cartridge stripping lug on the bolt contacts the base of the cartridge during the forward travel of the bolt carrier, stripping it from the link, and driving it into the chamber. The base of the cartridge slides down the face of the bolt as it leaves the feed tray. It is held in contact with the face of the bolt by a lip which engages the extractor groove in the cartridge. The extractor is fully engaged when the cartridge becomes aligned with the chamber. The cartridge retaining plunger, which was depressed by the cartridge during the feeding, returns at this time to its forward position preventing the cartridge from prematurely moving up and out of the extractor before ejection. The follower pin, as the bolt lugs enter the socket, contacts the cam plates depressing the cam follower which unlocks the bolt from the carrier. Subsequent to chambering the cartridge, the bolt is rotated 22.5 degrees, fully engaging its eight locking lugs with the mating lugs in the barrel socket. This rotation is imparted by the cam follower acting on the cycloidal cam path in the bolt. The firing pin, which is affixed to the bolt carrier by the cam follower, continues forward three eighths of an inch, after the bolt is rotated to the lock position, and strikes the primer.

Gas is bled through a port in the barrel and front sight into the expansion chamber through a hole in the top of the piston. The expanding gases in the hollow piston and

front sight chamber force the bolt carrier rearward misaligning the hole in the piston with the gas port in the front sight and cutting off the gas flow. The gas cutoff provides a regulated impulse to the piston partially compensating for variations in ammunition. The gas exhaust port is exposed after only 0.6 of an inch rearward movement of the bolt carrier. Early exhausting of the gas at relatively high pressure provides a scavenging effect which reduces fouling accumulation in the gas system.

The bolt dwells before rotating to the unlocked position for three eighths of an inch of rearward movement of the bolt carrier. The cartridge is extracted subsequent to bolt unlocking. The cam follower is raised by a compression spring, locking the bolt to the carrier as the bolt is being withdrawn from the barrel socket. (The cam follower is held down during bolt rotation and firing by the follower pin and the cam plates in the receiver.)

The ejector lever contacts a lug on the side of the bolt carrier after the forward end of the fired case clears the socket. (Allowances have been made for whole cartridges.) This activates the ejector which pivots in the rear sight base striking the fired case and ejecting it down through the openings in the bolt carrier and receiver. The ejector and lever are returned to their original position by a torsion spring after the lever is disengaged from the lug on the carrier. The lever is deflected by the lug on the bolt carrier during the counter-recoil stroke without imparting movement to the ejector and is returned to its original position by the torsion spring.

Feeding of the linked ammunition belt is also accomplished during rearward movement of the bolt carrier. The cam on the side of the bolt carrier pivots the actuator through 30 degrees, positioning the first cartridge in the belt one sixteenth of an inch past the center of the stripping slot in the feed tray. This assures engagement of the belt retaining pawl under heavy belt pull conditions. The feed pawls engage the cartridge belt from underneath. The actuator is returned to its original position by the cam on the top surface of the bolt carrier during the counter-recoil phase.

The belt retaining pawl engages the ammunition belt from above, contacting the link. The cartridge guide depresses the cartridge into the stripping slot of the feed tray and holds the link while the cartridge is being stripped. The links are forced out the right side of the feed tray by successive rounds.

The rearward movement of the bolt carrier is arrested by the hydraulic buffer. The excess energy of the recoiling mass is absorbed and dissipated within three quarters of an inch of stroke of the buffer plunger.

The bolt carrier is propelled forward by the driving springs continuing the firing cycle unless the trigger is released.

SECTION 5

WEAPON DESIGN ANALYSIS

The CMG-2 was designed to fire the 5.56 mm Ball M193 and the Colt 68 grain bullet MG 5.56 mm cartridges. These cartridges can be fired interchangeably without adjustment to the gun. Cartridge data including pressure-time and pressure-travel curves typical for both cartridges are included in this section. A kinematics and dynamics study of the weapon operational components was also performed during the development of the weapon. The results of this study shows the operational cycle to be free of problem areas. A tabulation of data and displacement-time, velocity-time and acceleration-time curves are also included.

CARTRIDGE DATA - CALIBER 5.56 MM

	<u>Ball M193</u>	<u>MG, Ball</u>
Projectile	Gilding Jacket, Lead Cored	Gilding Jacket
Projectile Weight	55 grains	68 grains
Propellant Type	Ball	Chopped tubular
Propellant Charge Weight	27 grains	24 grains
C/M Ratio - Propellant Charge Weight to Projectile Weight	0.49	0.35
Primer	DWG 10534013	DWG 10534013
Bore Area	0.0387 in. ²	0.0387 in. ²
Case Volume	0.119 in. ³	0.119 in. ³
Equivalent Chamber Length	3.06 in.	3.06 in.
Projectile Travel to Gas Port	10.84 in.	10.96 in.
Total travel	18.25 in.	18.37 in.
Volume of Gun to Gas Port	0.543 in. ³	0.543 in. ³
Total Gun Volume	0.827 in. ³	0.827 in. ³
Expansion Ratio to Gas Port	4.53	4.53
Final Expansion Ratio	6.95	6.95
Propellant Ignition Time	0.0002 sec.	0.0002 sec.
Time of Projectile Travel to Gas Port	0.00092 sec.	0.00104 sec.
Projectile Residence Time	0.0011 sec.	0.0014 sec.
Action Time	0.004 sec. max.	0.004 sec.
Average Port Pressure	21,000 p.s.i.	17,000 p.s.i.
Maximum Chamber Pressure	52,000 p.s.i.	52,000 p.s.i.
Velocity	3,250 f/s at 15 feet	2,980 f/s at 15 feet
Impulse	1.23 lb. -sec.	1.31 lb. -sec.

PRESSURE, VELOCITY AND TRAVEL VS. TIME

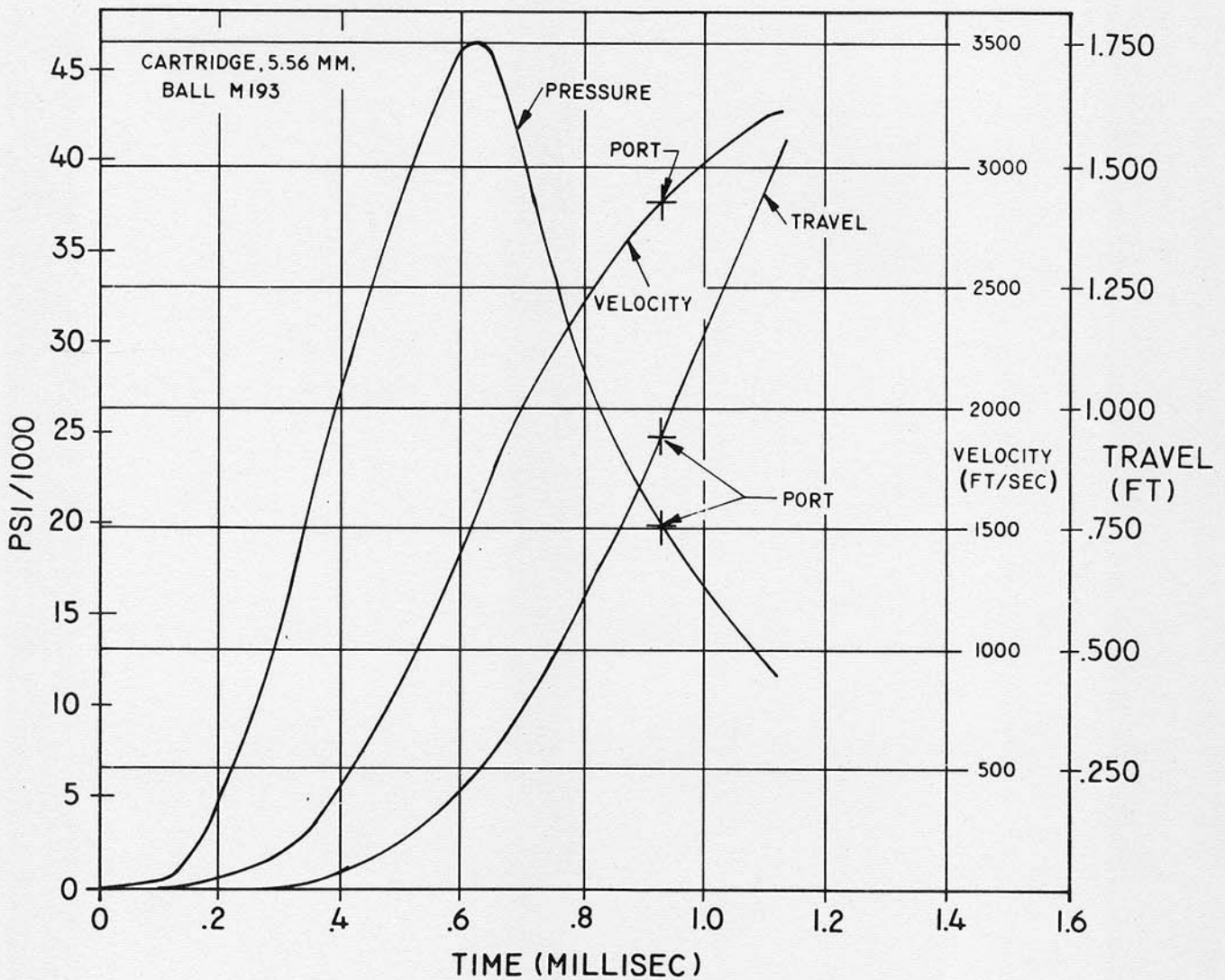


Figure 5-1. Pressure, Velocity and Travel Vs. Time (5.56 mm Ball, M193)

PRESSURE AND VELOCITY VS. TRAVEL

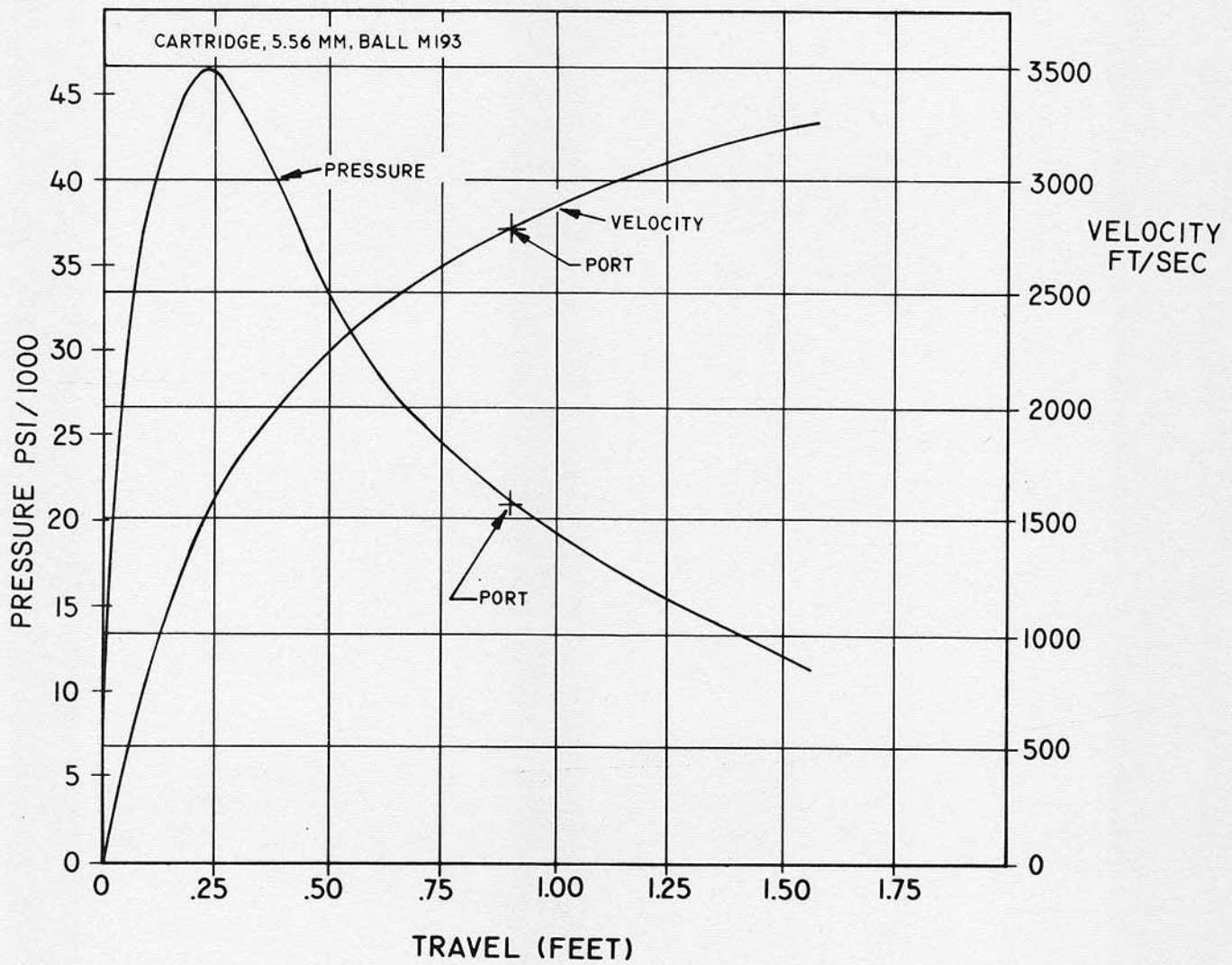


Figure 5-2. Pressure and Velocity Vs. Travel (5.56 mm Ball, M193)

PRESSURE VELOCITY AND TRAVEL VS. TIME

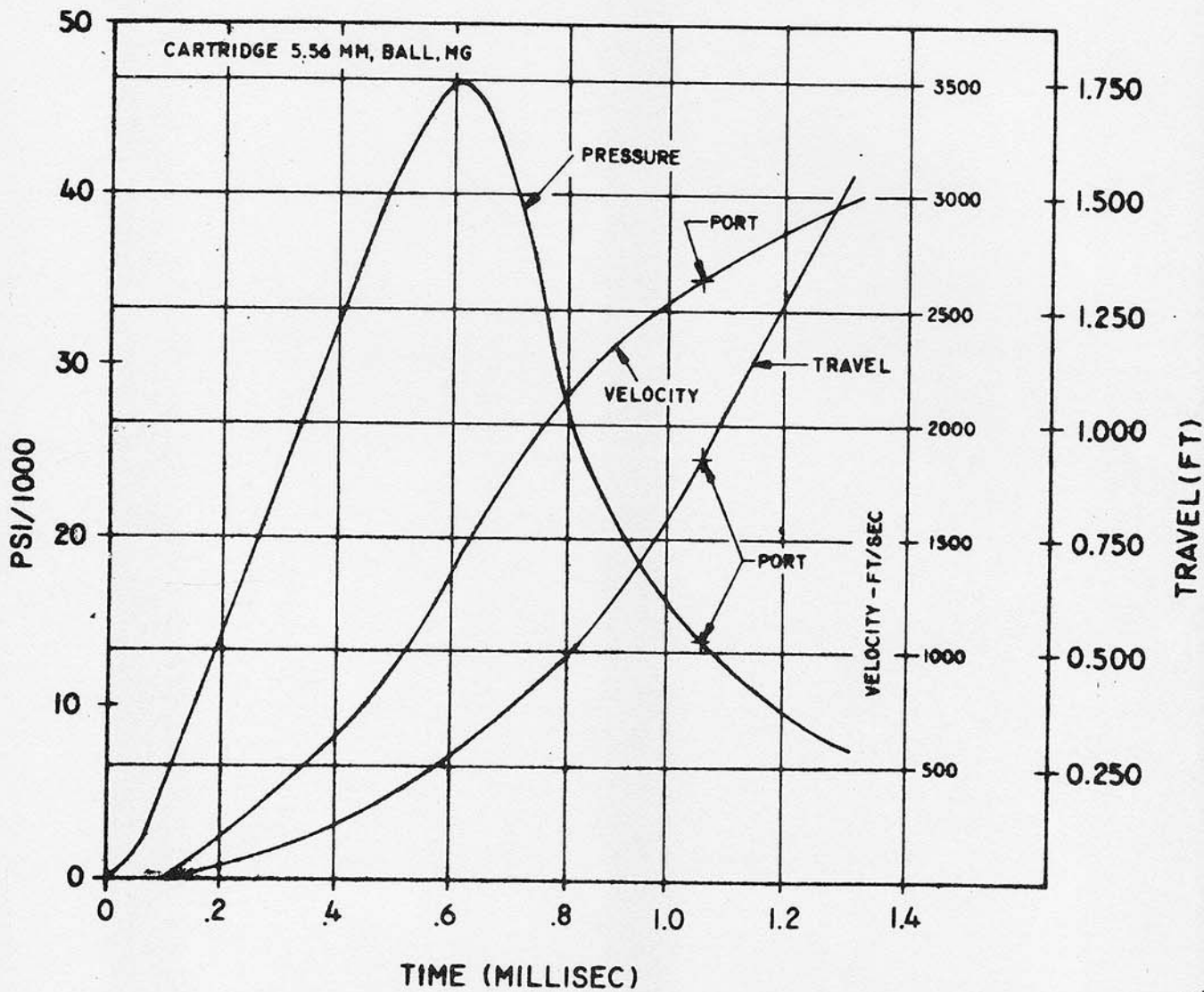


Figure 5-3. Pressure, Velocity and Travel Vs. Time (5.56mm Ball, MG)

PRESSURE AND VELOCITY VS. TRAVEL

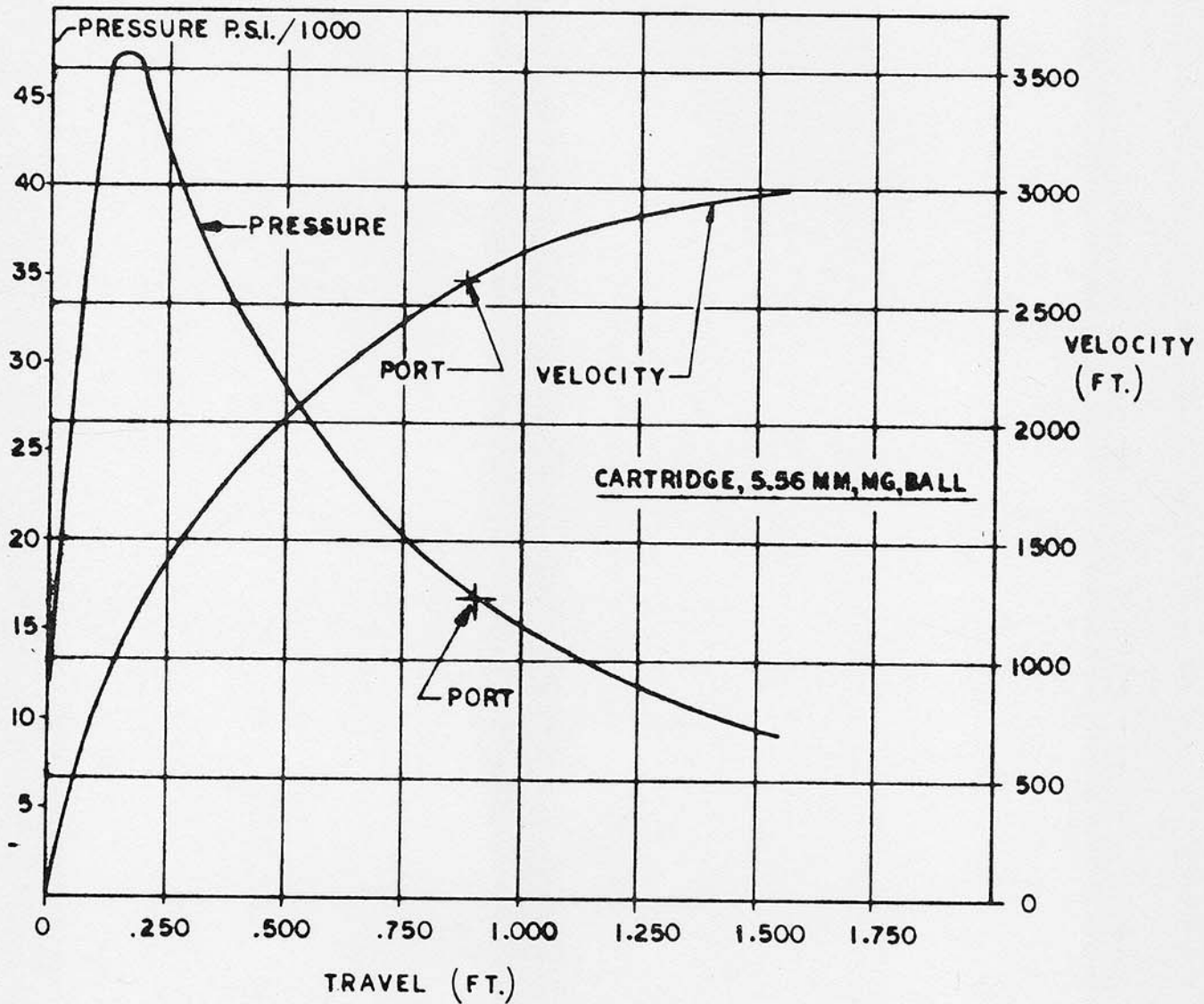


Figure 5-4. Pressure and Velocity Vs. Travel (5.56mm Ball, MG)

D-T Data

Time in Milliseocs	Displacement Inches Recoil	Operational Event	Recoiling Parts		
			Velocity, in/sec	Kinetic Energy in-lb	Acceleration G's
0	0	Full primer indentation	-136	33.9*	+883**
2.50	0.352	Start of unlocking	+310	176.4*	indeterminate
4.20	0.82	End of unlocking	+293	157.5*	-31
4.40	0.842	Start of bolt motion	+290	169.8	-30
15.10	3.37	Start of ejector motion	+200	80.8	-16
16.30	3.60	Ejection of case	+193	75.1	-14
17.70	3.88	Release of ejector	+184	68.3	-13
24.90	5.11	Buffer contact	+145	42.4	-96
25.40	5.17	Sear position	+115	26.7	-91
33.00	5.50	Full recoil	0	0	-16
43.30	5.17	Sear position	-49	4.8	-9
48.00	4.85	Start of stripping	-65	8.5	-7
60.80	3.79	End of stripping	-96	18.6	-5
86.10	0.842	Cartridge chambered	-129	30.6*	-2.5
86.40	0.82	Start of locking	-130	31.0*	-2.5
89.90	0.352	Bolt locked	-133	32.5*	-2.0
92.00	0.032	Primer contact	-136	33.9*	
92.30	0	Full primer indentation	-136	33.9*	+883**

*Bolt is not part of recoiling mass, at these times.

**Estimated value.

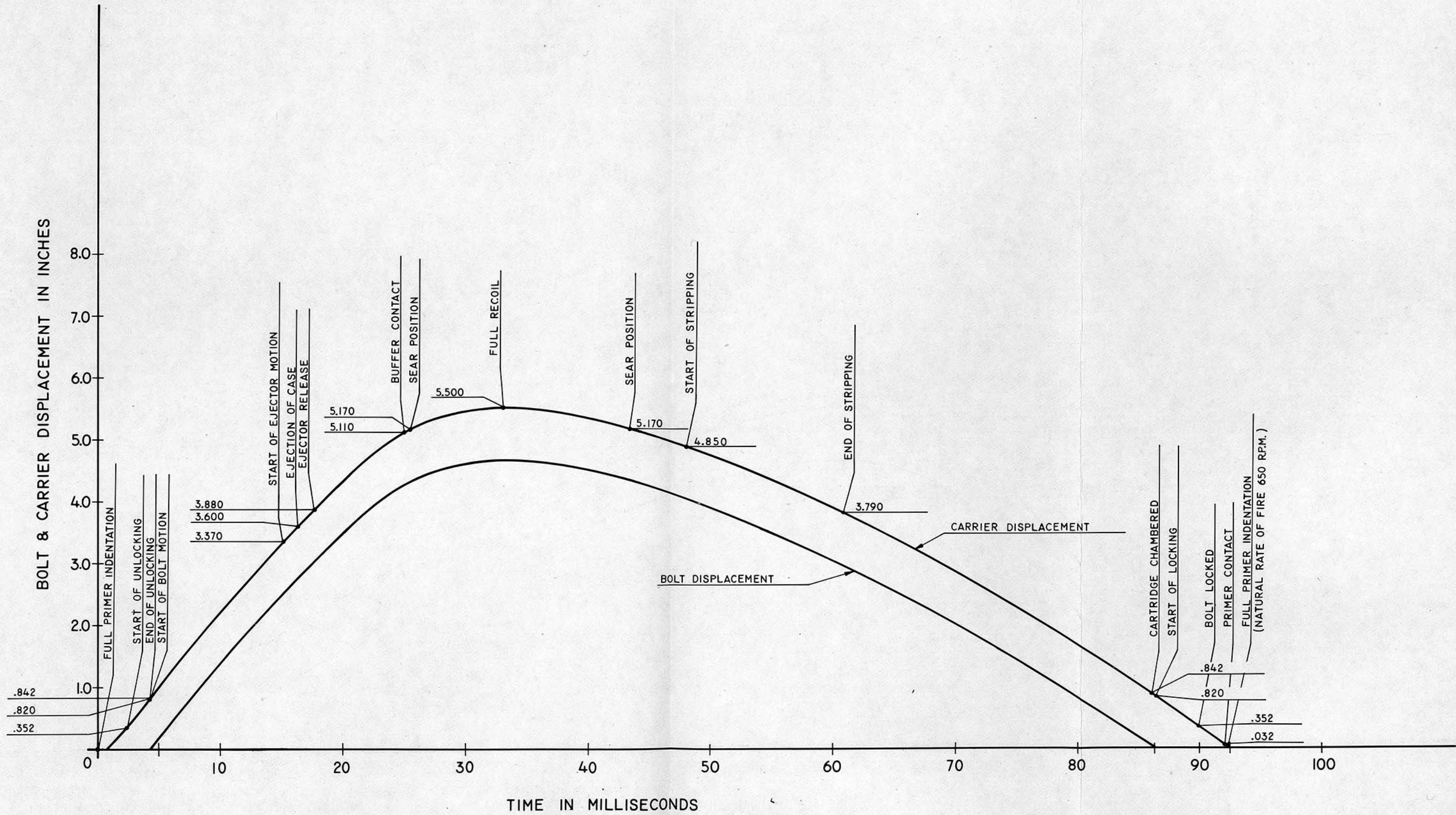


Figure 5-5. Displacement - Time Curve Operating Group

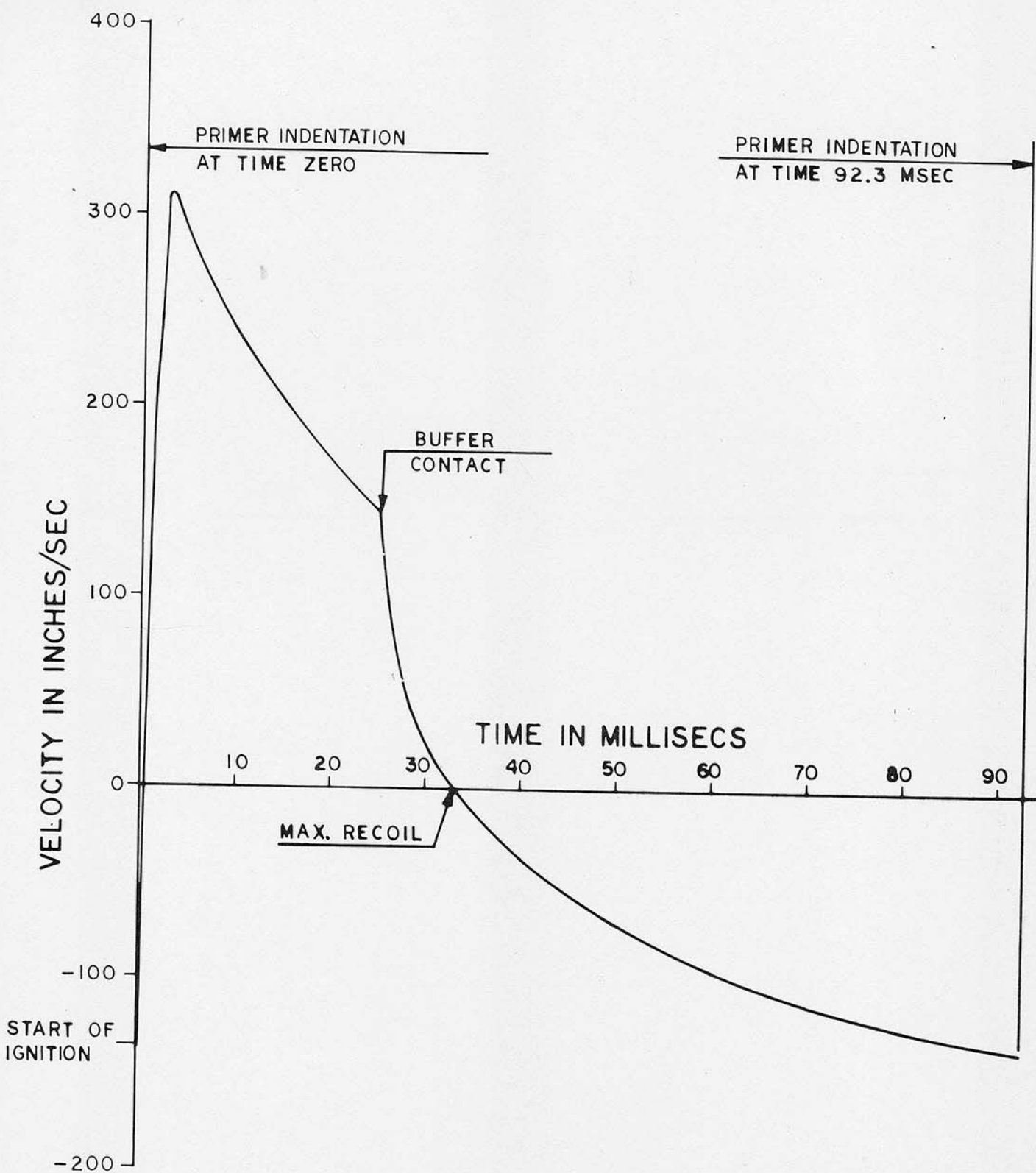


Figure 5-6. Velocity - Time Curve - Operating Group

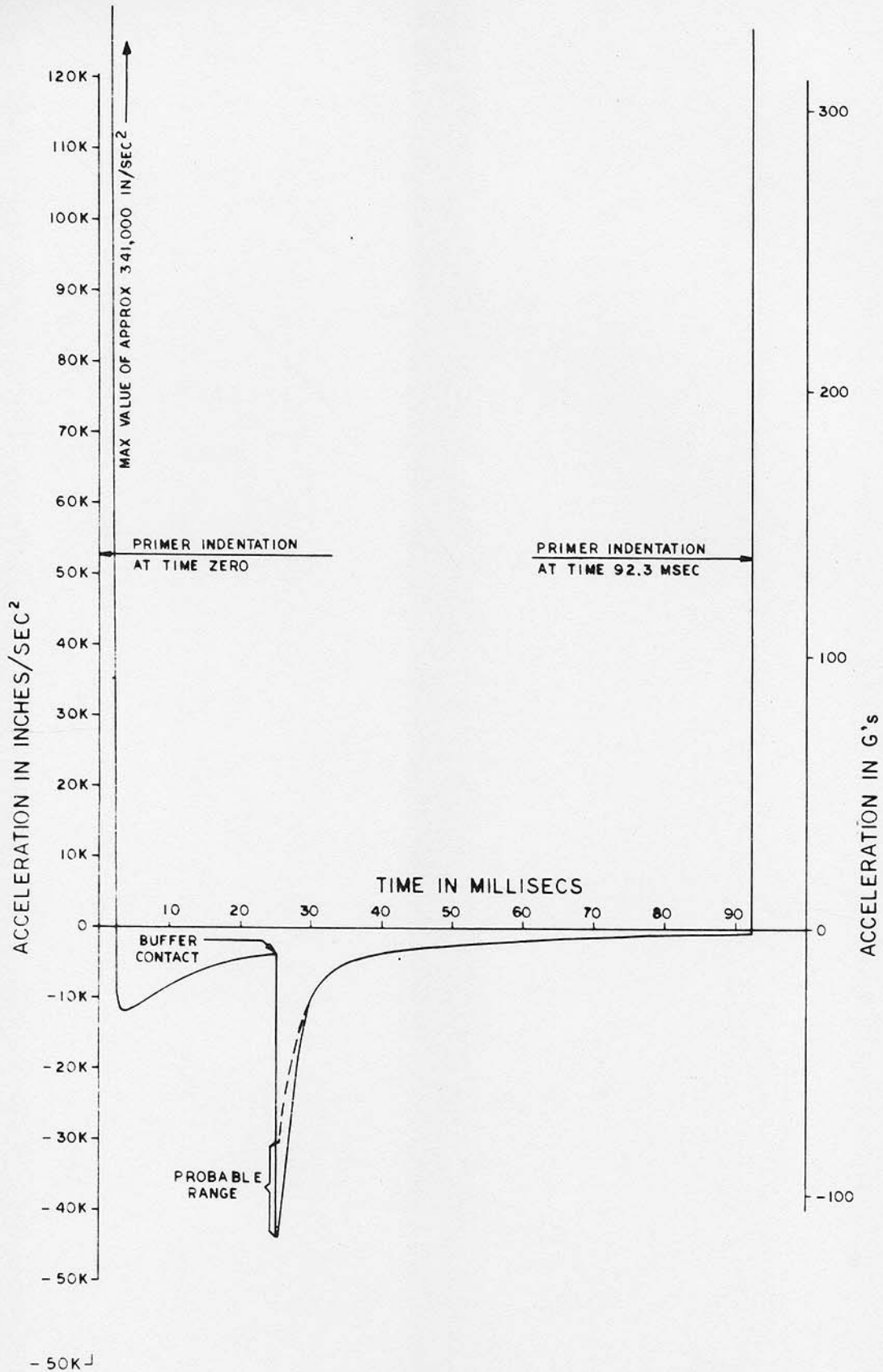


Figure 5-7. Acceleration Time Curve - Operating Group

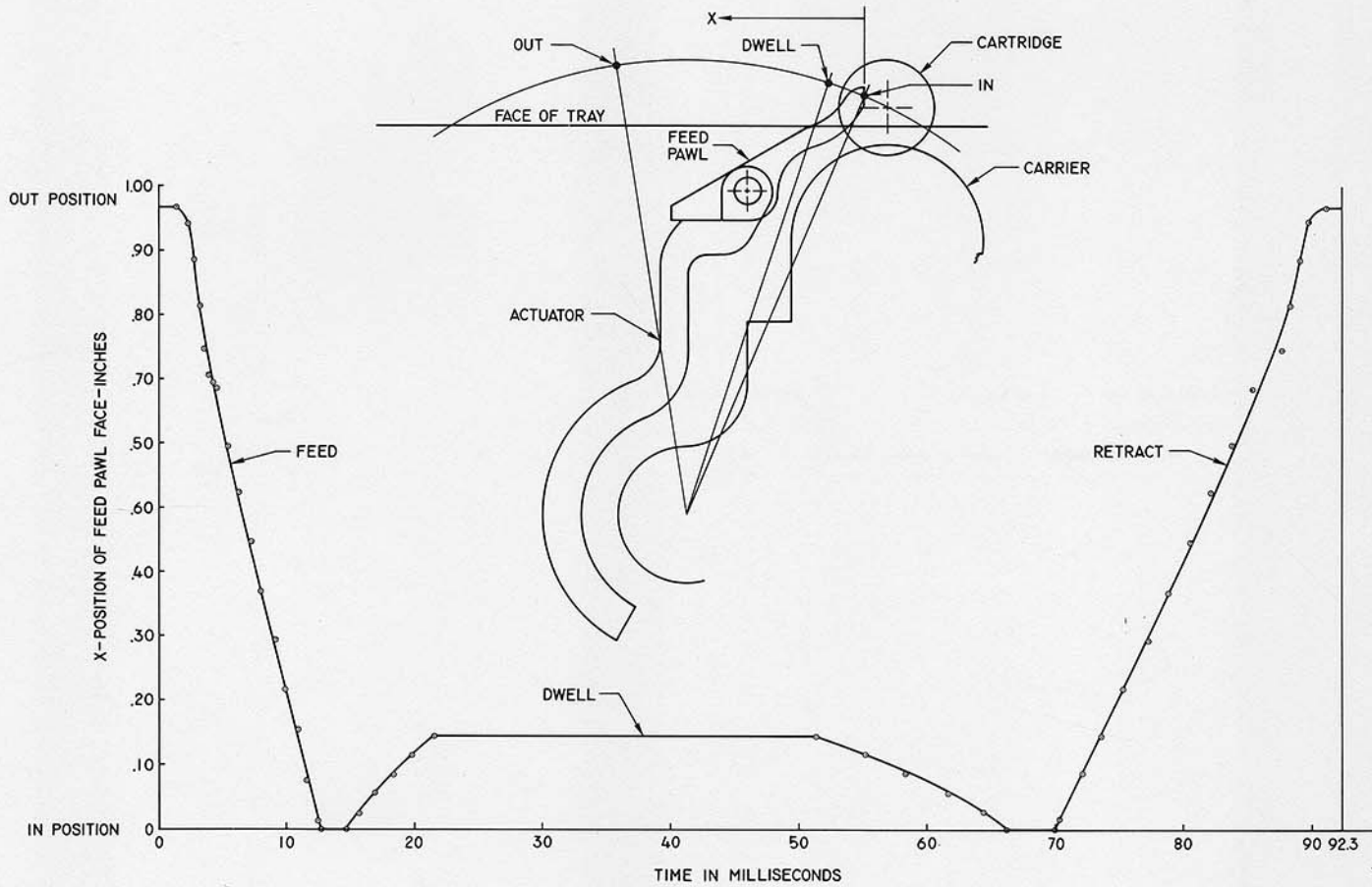


Figure 5-8. Displacement - Time Curve - Feed Pawls

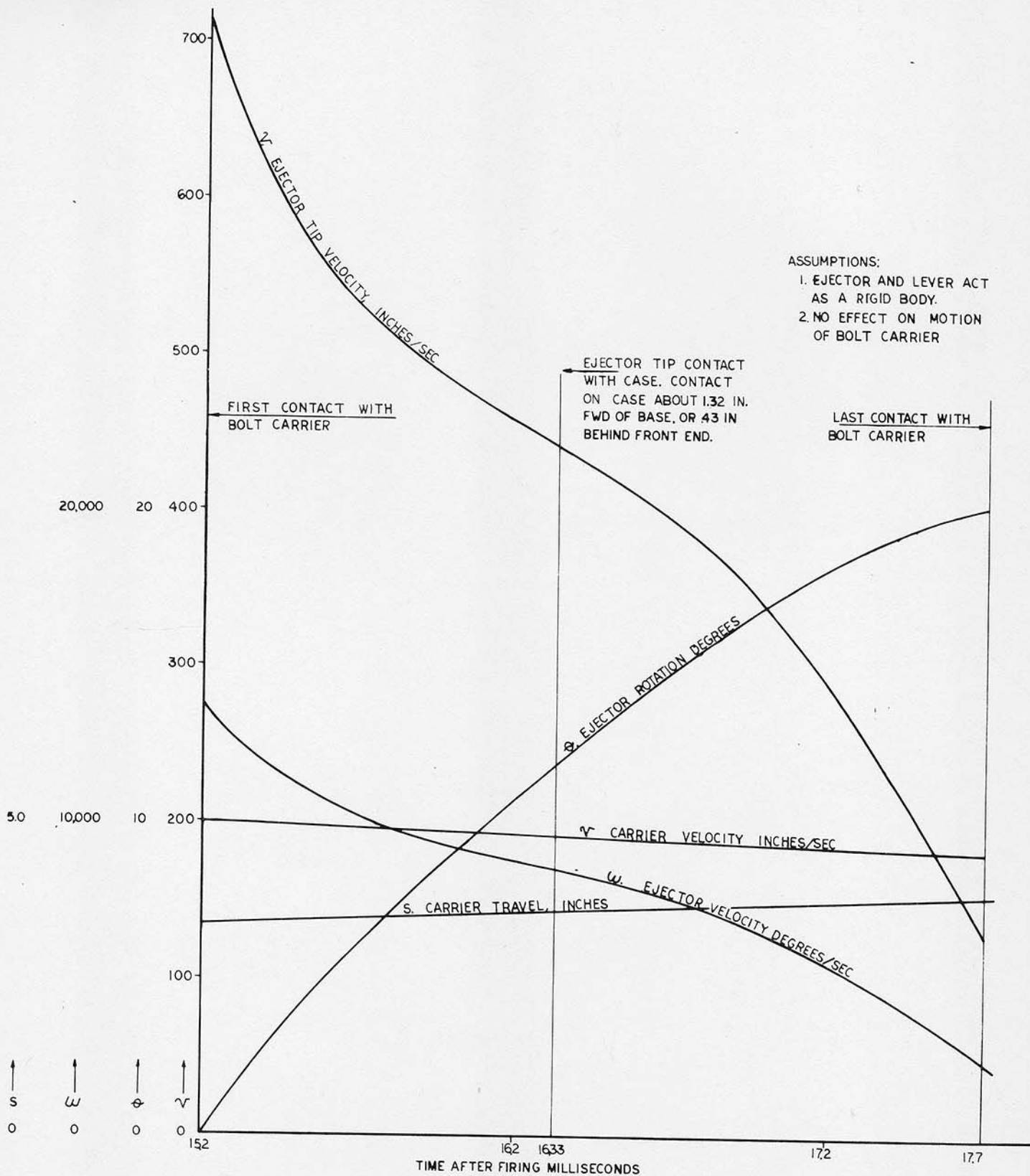


Figure 5-9. Displacement and Velocity Time Curve - Ejector

GAS SYSTEM ANALYSIS

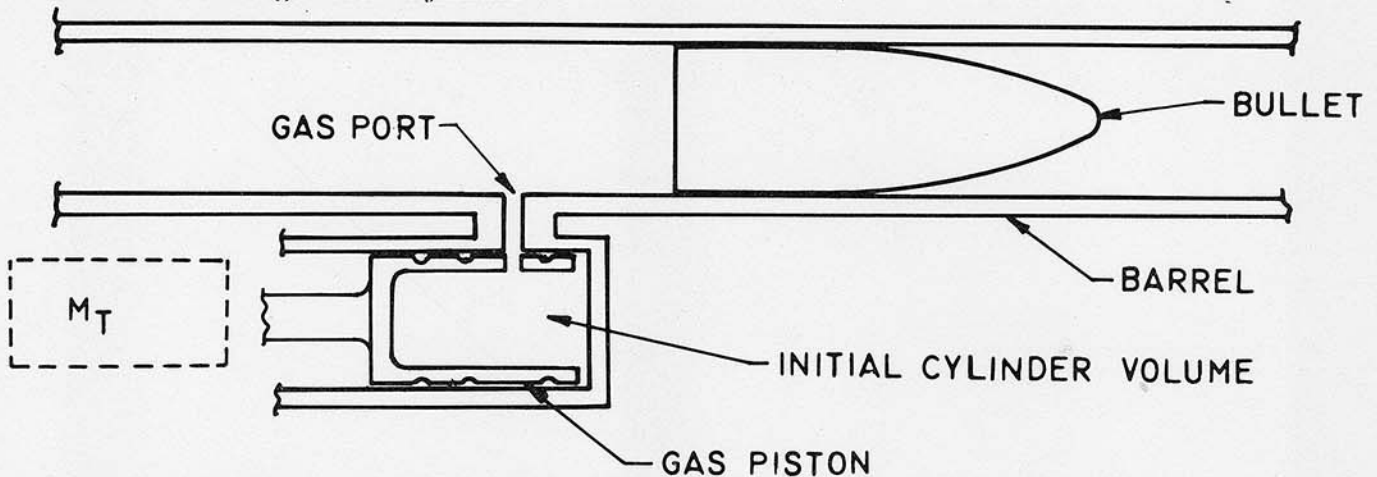
The actuation energy in a gas operated weapon is derived from the expansion of propellant gases. The gases expand through the gas port into the gas cylinder where they act upon the gas piston, imparting motion to the bolt carrier, initiating the recoil cycle.

The gas dynamics process is divided into two phases. The first phase starts with the mass flow of gases through the port into the initial volume of the gas cylinder. Gas expansion within the cylinder takes place during the second phase. The gas expansion drives the piston rearward.

Gas leakage around the piston and back through the gas port occurs during the expansion process.

- $A_1 =$ cross sectional area of gas port, 0.00238 in.^2
 $A_0 =$ effective cross sectional area of gas port, 0.0008 in.^2
 $A_p =$ area of piston face 0.282 in.^2
 $C_w =$ discharge coefficient of gas port, 0.336
 $C_v =$ specific heat of constant volume, $5846 \frac{\text{in.-lb}}{\text{lb-}^\circ\text{K}}$
 $C_p =$ specific heat of constant pressure, $7,307 \frac{\text{in.-lb}}{\text{lb-}^\circ\text{K}}$
 $E_K =$ kinetic energy imparted to inertia group prior to pickup of bolt (in. -lb)
 $E_T =$ total energy of gas after filling gas cylinder (in. -lb)
 $g =$ gravitational constant, 386 in./sec^2
 $\Delta h =$ enthalpy of gas within cylinder
 $K =$ ratio of specific heats, $C_p/C_v = 1.25$
 $M_T =$ mass of inertia group prior to pickup of bolt, $\frac{0.330}{386} = 8.54 \times 10^{-4} \frac{\text{lb sec}^2}{\text{in.}}$
 $P_b =$ gas pressure in the bore at the gas port, $17,000 \text{ psi}$
 $R =$ universal gas constant, $18,510 \text{ in./}^\circ\text{R}$
 $T_b =$ gas temperature in barrel, 1800°K
 $V_0 =$ initial volume of gas cylinder, 0.071 in.^3
 $V_1 =$ final volume of gas cylinder, 0.142 in.^3
 $W =$ weight of gas trapped in cylinder, (lb)
 $P_1 =$ gas cylinder pressure at start of filling process, 15 psi
 $P_2 =$ gas cylinder pressure at end of filling process, $2,000 \text{ psi}$

Phase 1 - Filling of Gas Cylinder



Mass flow through the gas port into cylinder

$$dw/dt = C_w A_1 P_b \left[(K_g/RT_b) \left(2/(K+1) \right) \left((K+1)/(K-1) \right) \right]^{1/2}$$

Effective port area

$$A_o = C_w A_1$$

$$sw/dt = A_o P_b \left[(K_g/RT_b) \left(2/(K+1) \right) \left((K+1)/(K-1) \right) \right]^{1/2}$$

$$= (0.0008) (17,000) \left[(1.25 \times 386/18,510 \times 1800) \left(2/(1.25+1) \right) \left((1.25+1)/(1.25-1) \right) \right]^{1/2}$$

$$= 13.6 \left[0.0000144 (0.346) \right]^{1/2}$$

$$= (13.6) (0.0022)$$

$$= 0.0302 \text{ lb/sec} = 3.02 \times 10^{-5} \text{ lb/msec}$$

Quantity entering in 0.5 msec

$$W_T = 0.5 \times 3.02 \times 10^{-5} \text{ lb}$$

$$= 1.51 \times 10^{-5} \text{ lb}$$

Total energy of gas in cylinder after filling

$$E_T = W (\Delta h)$$

$$= W_T C_p T_b \left(\left(P_2 / P_1 \right)^{(K-1/K)} \right) - 1$$

$$= 1.51 \times 10^{-5} \times 7307 \times 1800 \left(\left(20000/15 \right)^{0.25/1.25} \right)$$

$$= (198.604) (133.3)^{0.200}$$

$$= 528.39 \text{ in. -lb}$$

Phase 2 Expansion of Trapped Gas - Energy Transferred to Piston

$$W = N_e W_T$$

Where $N_e = 1$ - leakage losses, leakage includes blow-by the piston and reverse gas flow through the gas port. Experimentally determined values show N_e to be 0.6 for the gas system used in this design.

$$\begin{aligned}
 E_T &= \left(W R T_b / (K-1) \right) \left(1 - (V_o / V_1)^{(K-1)} \right) \\
 E_K &= \left(N_e W_T R T_b / (K-1) \right) \left(1 - (V_o / V_1)^{(K-1)} \right) \\
 &= \left(0.6 \times 1.51 \times 10^{-5} \times 18510 \times 1800 / (1.25 - 1) \right) \left(1 - (0.071 / 0.142)^{(1.25-1)} \right) \\
 &= (301.86 / .25) \left(1 - (0.5)^{.25} \right) \\
 &= (1207.44) (1 - 0.84) \\
 &= (1207.44) (0.16) \\
 &= 193.19 \text{ in. -lb}
 \end{aligned}$$

The experimentally measured value as obtained from the D-T curve for the energy imparted to the piston was 176.4 in. -lb.

STRESS ANALYSIS

This section is devoted to the stress analysis of some of the critical components. The criteria of maximum stresses was used to perform the calculations. Certain simplified hypothesis were also used and the values determined are considered to be approximate.

The calculations, even though preliminary in nature, are conservative and without overdesign; in the final design fillet radii and tolerances will be considered. All components were tested in the prototype and proved to be completely satisfactory.



TABULATED DATA - CMG-2 STRESS ANALYSIS

Component	Material & Hardness	Nature of the Acting Load	Type of Stress	Calculated or Actual Stress (psi)	Allowable or Working Stress (psi)	Safety Factor *
Bolt	AISI 4340 E, Rockwell C52	Impact and Fatigue	Shear	2,102	38,880	2
			Bending	72,279.6	82,440	1.5
			Equivalent	79,171.8	82,400	1.5
Ejector	AISI 4340 Rockwell C43-48	Impact and Fatigue	Shear	2,876.7	27,000	2
			Bending	43,591	50,000	1.8
			Equivalent	44,874.8	50,000	1.8
Ejector Lever	AISI 4340 Rockwell C43-48	Impact and Fatigue	Bending	74,605	75,000	1.5
			Firing Pin			
Firing Pin	AISI 4340 Rockwell A72-75 (Rockwell C43-48)	Impact and Fatigue	Compression	39,894	54,000	2
			Barrel			
Barrel	Cr-Mo-V Steel (Mil-S-II595B) Rockwell C27-32	Pressure and Temperature	Tangential	-42,074		
			Radial	-80,500		
			Axial	-128,416		
			Equivalent	75,000	105,000	

*The safety factors were established in accordance with Timoshenko: Elements of Strength of Materials.

SYMBOLS

A	Area (in. ²)
A _C	Maximum cross sectional cartridge-case area (in. ²)
a	Cartridge primer radius (in.)
a _C	Acceleration of the mass m _C (in./sec ²)
a _C ^r	Acceleration of mass m _{ct} at the moment of impact (in./sec ²)
b	Radius of plate reinforcement (primer-anvil) (in.)
b	Bolt lug thickness (in.)
CF	Concentration Factor
c	Bolt lug height (in.)
D	Diameter (in.)
D _o , D _i	Different diameters of the barrel chamber (in.)
d	Moment arm (in.)
E	Young's Modulus (psi)
E _a	Young's Modulus (anvil) (psi)
F	Resultant force - chamber pressure (lb)
F _l	Force acting on a bolt lug (lb)
F _S	Striking force acting on firing pin (lb)
h	Primer wall thickness, bolt lug length (in.)
I	Axial moment of inertia (in. ⁴)
I _o	Polar moment of inertia (in. ⁴)
k	Spring constant (lb/in.)
l	Striker length (in.)

SYMBOLS (Continued)

In	Natural or Neperian Logarithm
M	Moment of force (in. -lb)
m	Mass of ejector and lever (lb-mass)
m_c	Mass of bolt carrier, firing pin, cam follower, carrier cam follower pin and driving springs (lb-mass).
m_{ct}	Total mass of the bolt carrier (lb-mass)
p	Propellent maximum pressure (psi)
P_H	High Proof Pressure (psi) (70,000 psi)
Q	Force produced by the displacement of the bolt carrier at the moment of impact with the primer (lb)
r	Lever arm (in.)
SF	Safety Factor
S_B	Bending stress (psi)
S_E	Equivalent stress (psi)
S_e	Endurance limit
S_s	Shear stress (psi)
S_Y	Yield point (compressive or tensile) (psi)
$(S_Y)_s$	Yield point (shear) (psi)
T	Real force acting on lever due to Q (lb)
t	Traveling period of compressive (or tensile) wave (sec)
V	Velocity of the bolt carrier (in. /sec)
v	Linear velocity (in. /sec)
v_c	Velocity of compressive wave (in. /sec)

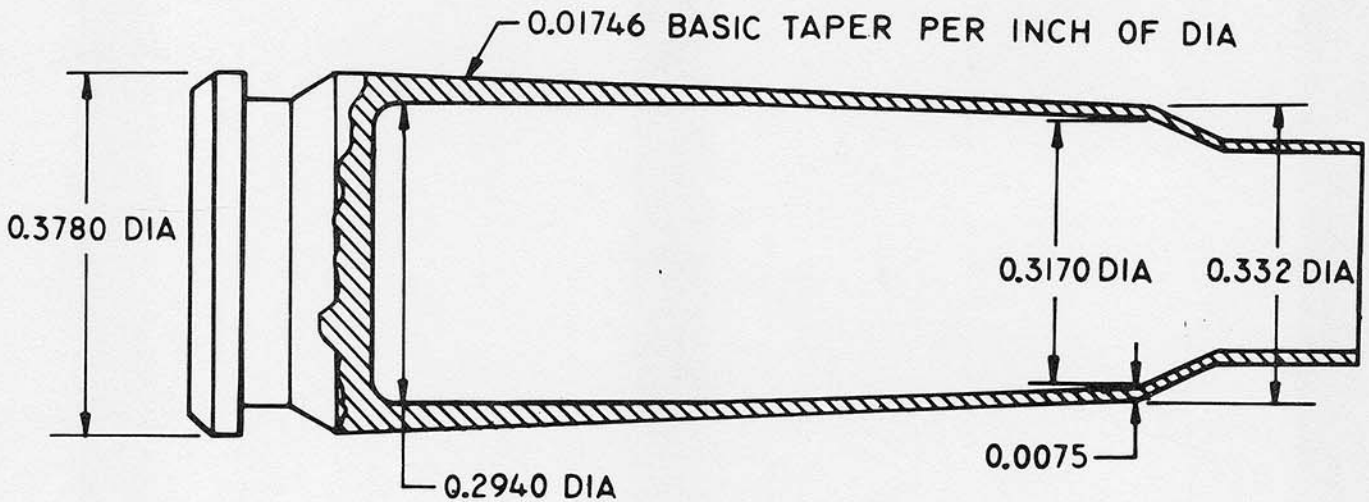
SYMBOLS (Continued)

W	Force acting on lever, by impact (lb)
W	Relation between D_o and D_i
Y	Force at ejector tip of ejector lever - bolt carrier lug impact (lb)
Y_{dyn}	Real Force acting on extracted cartridge due to Y (lb)
α	Mean linear coefficient of thermal expansion (in./in. °F)
Δ	Standard deviation
ΔT	Frequency of firing (sec)
Δt	Increment of time (sec)
$\Delta \theta$	Increment of angular displacement (rad)
ΔT	Temperature difference (°F)
δ_{dyn}	Dynamic deflection of the primer (in.)
δ_{static}	Static deflection of the primer (in.)
ν	Poisson's Modulus
ρ	Mass density (lb-mass/in. ³)
σ_{aT}	Axial stress due to temperature (psi)
σ_c	Compression stress (psi)
σ_e	Von Mises equivalent stress (psi)
σ_{rp}, σ_{rT}	Radial stresses due to pressure and temperature (psi)
σ_{tp}, σ_{tT}	Hoop stresses due to pressure and temperature (psi)
$(\sigma_y)_{600^\circ F}$	Yield strength of barrel material at 600°F
ϕ	Diameter (in.)
ω	Angular velocity (rad/sec)

Calculation of the resultant force from chamber pressure.

The cartridge case used is shown in detail on drawing C10524200, Frankford Arsenal, and has as principal dimensions:

Outside diameter	0.378 inches
Minimum wall thickness	0.0075 inches
Bottom internal diameter	0.294 inches
Maximum internal diameter	0.3170 inches



$$A_c = \pi/4 D^2$$

$$A_c = \pi/4 (0.317)^2 = 0.0789 \text{ in.}^2$$

In accordance with specification MIL-C-46936 (MU)

$$p = p_H + 3 \cdot \Delta$$

$$p = 70,000 + (3 \times 3500)$$

$$p = 80,500 \text{ psi}$$

$$F = p \times A_c$$

$$F = 80,500 \times 0.0789$$

$$F = 6351.45 \text{ lb}$$

\bar{F} is considered applied as a "static quick load".

Calculation of the firing pin striking force.

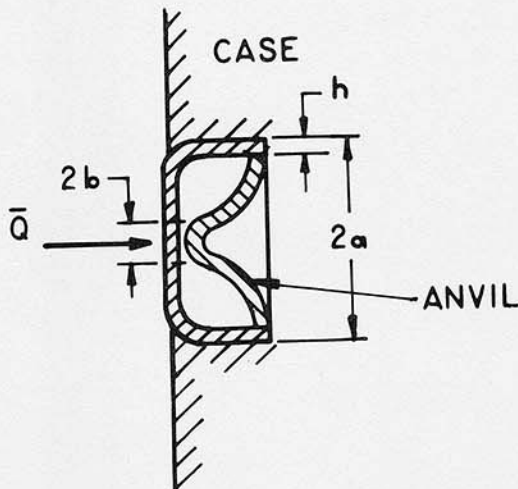
$$Q = m_c \times a_c$$

$$m_c = 1.381 \text{ (lb-mass) (actual weight).}$$

$$a_c = 750 \text{ (in./sec). From D-T curve, after two derivative processes.}$$

$$Q = 1.381 \times 750 / 32.17 \times 12 \text{ (lb)} = 2.6832 \text{ (lb)}$$

In order to arrive at the striking force produced by the dynamic force Q on the firing pin, it is assumed that the primer cup is a circular plate loaded at the center.



Material: Cartridge Brass

$$E_a = 16 \times 10^6 \text{ psi}$$

$$2a = 0.1755 \text{ in.}$$

$$2b = 0.01933 \text{ in.}$$

$$h = 0.01636 \text{ in.}$$

Then by elasticity:

$$\delta_{\text{static}} = (0.25 \times Qa^2) / Eh^3$$

$$k = Q / \delta_{\text{static}} = F_S / \delta_{\text{dyn}} = Eh^3 / 0.25 a^2$$

$$F_S = k \delta_{\text{dyn}}$$

$$\delta_{\text{dyn}} = (m_c / k)^{1/2} V$$

$$F_S = (m_c k)^{1/2} V = (m_c Eh^3 / 0.25 a^2)^{1/2} V$$

$$F_S = \sqrt{(1.381 \text{ lb} \times \text{sec}^2 / 386 \text{ in.}) (16 \times 10^6 \times 0.01636^3 \text{ lb} \times \text{in.}^3) / 0.25 (0.0877)^2 \text{ in.}^4 \times (140) (\text{in.} / \text{sec})}$$

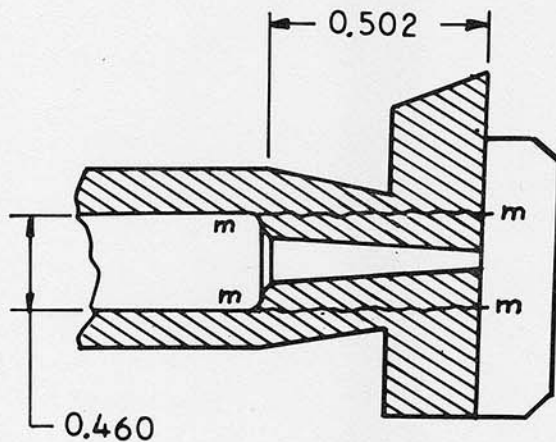
$$F_S = 1524 \text{ (lb)}$$

I. BOLT

(Material AISI 4340 E Rockwell C 48-52).

A. Shear produced by impact.

The shear is developed all around the cylindrical section m-m:



$$A = \pi \times 0.46 \times 0.502 = 0.7251 \text{ in.}^2$$

$$S_s = F_s/A$$

$$S_s = 1524/0.725 = 2102 \text{ psi}$$

$$(S_e)_s \cong 0.6 (S_y)_s$$

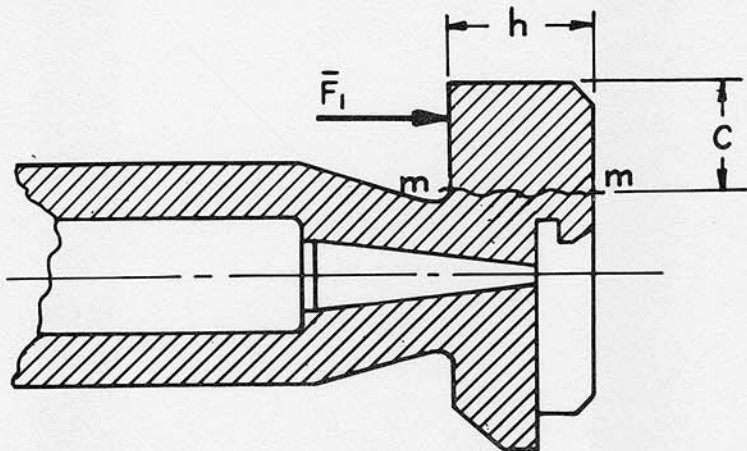
$$(S_e)_s \cong 0.6 (0.6 S_y) \sim 0.36x S_y$$

$$(S_e)_s = 0.36 \times 216,000 = 77,760 \text{ psi}$$

$$(S_e)_s /SF = 77,760/2 = 38,880 \text{ psi}$$

$$(S_e)_s /SF \gg S_s$$

B. - Shear and bending moment at the bolt lugs.



No. of engaged bolt lugs: 7.5

$$h = 0.372 \text{ in.}$$

$$c = 0.2 \text{ in.}$$

$$b = 0.122 \text{ in.}$$

$$F_1 = F/7.5 = 6351.45/7.5 = 846.86 \text{ lb}$$

$$A = 0.372 \times 0.122$$

$$A = 0.0454 \text{ in.}^2$$

$$S_s = F_1/A$$

$$S_s = 846.86/0.0454 = 18,653.3 \text{ psi}$$

$$(S_s)_{\max} = 1.5 \times 18,653.3 = 27,980 \text{ psi}$$

$$M = F_1 \times 2/3 c = 846.86 \times 0.667 \times 0.2 = 112.91 \text{ in. -lb}$$

$$I = (b \times h^3) / 12 = (0.122 \times (0.372)^3) / 12 = 0.000523 \text{ in.}^4$$

$$S_B = (M h) / (2 I) = (112.91 \times 0.372) / (2 \times 0.000523)$$

$$S_B = 40,155.37 \text{ in. -lb}$$

Because of the small fillet at the root of the bolt lug, a stress concentration factor must be considered.

$$\text{Then } (S_B)_{\max} = S_B \times CF$$

$$CF \sim 1.8$$

$$(S_B)_{\max} = 40,155.37 \times 1.8 = 72,279.66 \text{ psi}$$

The equivalent stress:

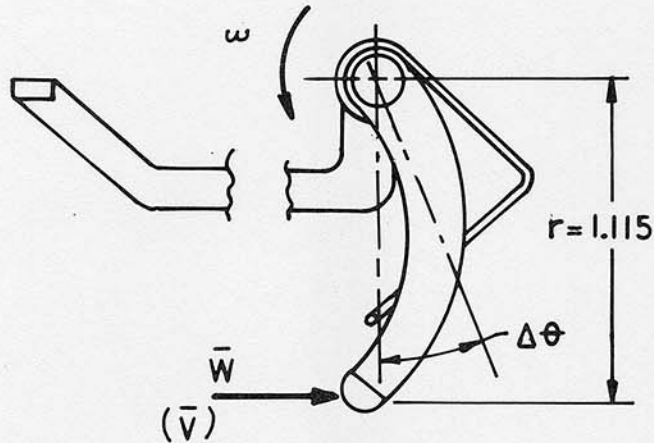
$$S_E = \sqrt{72,279.66^2 + 3 \times 18,653.3^2}$$

$$S_E = 79,171.82 \text{ psi}$$

$$S_e/SF = 82,400 \text{ (psi)} > S_E$$

II. EJECTOR ASSEMBLY

A. Ejector lever (Material: Steel 4340, Rockwell C43-48)



$$W = m_{ct} a'_c$$

$$m_{ct} = 1.5256 \text{ lb-mass (actual weight)}$$

$$a'_c = 5900 \text{ (in./sec}^2\text{)}. \text{ From D-T curve.}$$

$$W = (1.526)(5900)/386 = 23.31 \text{ lb}$$

The force \bar{W} acting by impact at the extreme of the lever will induce on the lever the force \bar{T} .

Neglecting any strain energy:

$$\text{Kinetic energy} = 1/2 \sum m v^2 = 1/2 \sum I_o \omega^2$$

$$\text{Total work done} = M \Delta \theta$$

$$(1/2)(\omega^2) \sum I_o = M \Delta \theta$$

$$\Delta \theta = 20^\circ. \text{ (actual measurement)}$$

$$\Delta \theta_r = 0.3488 \text{ (rad)}$$

$$\omega \sim \Delta\theta r / \Delta t = 0.3488 / 0.0016 = 218 \text{ (1/seg)}$$

$$\Delta t = 0.0016 \text{ sec. (actual measurement)}$$

Breaking the system into partial elemental masses:

$$\begin{aligned} \Sigma I_O &= 0.1397 \text{ lb - mass x in.}^2 \\ &= 3.57 \times 10^{-4} \text{ lb x in. x sec}^2 \end{aligned}$$

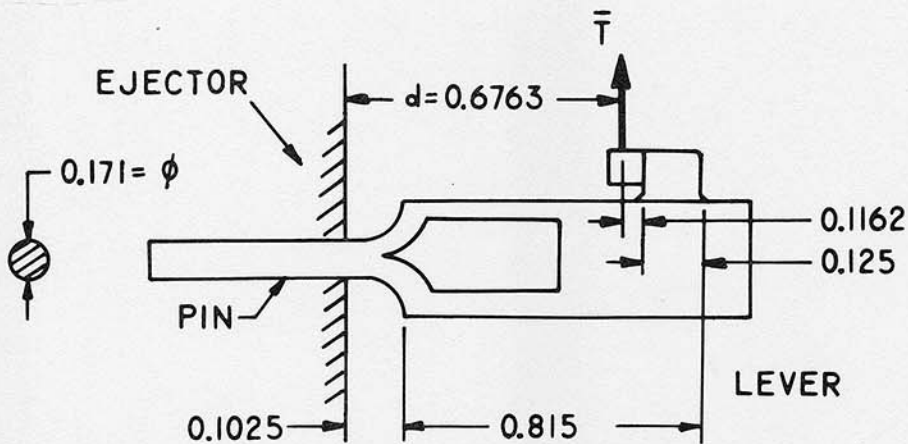
$$M = (\omega^2 / 2\Delta\theta) (\Sigma I_O) = T r$$

$$T = (\omega^2 / 2\Delta\theta^2) (\Sigma I_O)$$

$$T = (218)^2 \times (3.76 \times 10^{-4}) / (2) (0.3488) (1.115)$$

$$T = 23 \text{ lb}$$

The force produces a moment M acting on the pin of the lever.



$$M = Td$$

$$M = (23)(0.6763)$$

$$M = 15.55 \text{ (in. -lb)}$$

$$I = (\pi/64) D^4 = \pi/64 (0.171)^4 = 4 \times 10^{-5} \text{ in.}^4$$

$$S_B = (M)(\phi) / 2I$$

$$S_B = (15.55)(0.0855) / (4.1)(10^{-5}) = 32,438 \text{ psi}$$

Because of the stress concentration:

$$(S_B)_{\max} = (S_B)(CF)$$

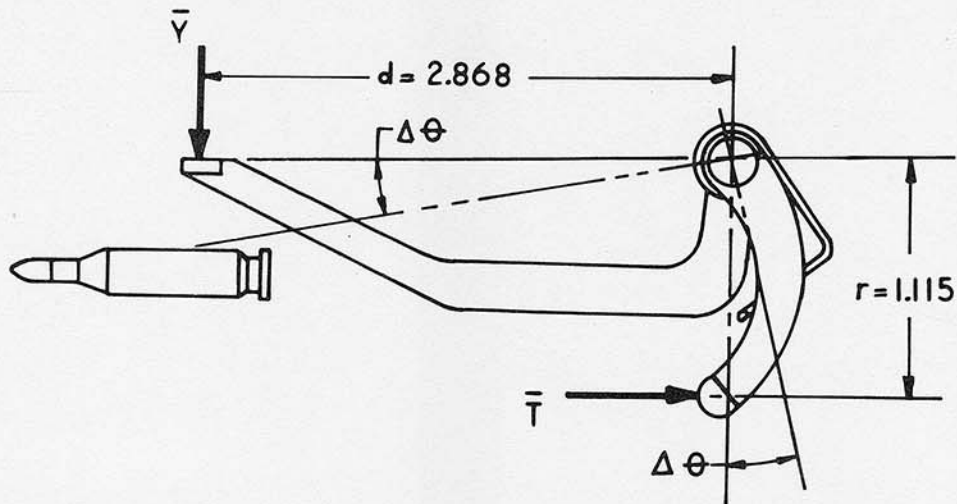
CF would be approximately: 2.3

$$(S_B)_{\max} = (32,437)(2.3) = 74,605 \text{ psi}$$

It is acceptable because: $S_y = 187,500 \text{ psi}$

$$S_e / SF = 75,000 > (S_B)_{\max} = 74,605 \text{ psi}$$

B. Ejector (Material: Steel 4340, Rockwell C43-48)

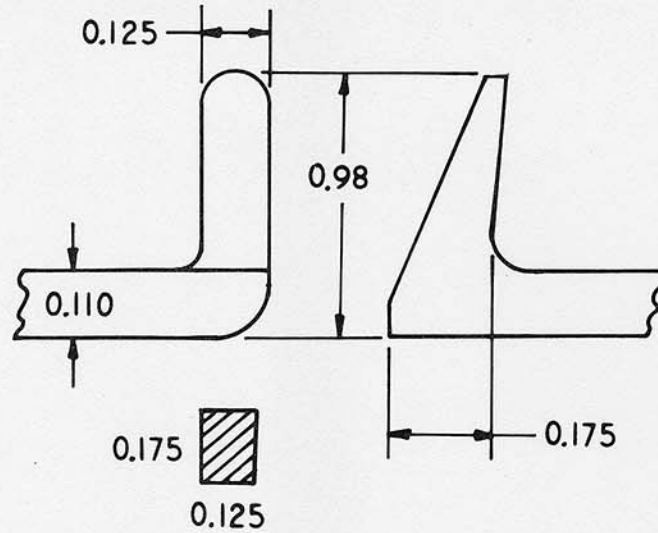


$$Y = T (r/d)$$

$$Y = 23 (1.115) / (2.868) = 8.94 \text{ (lb)}$$

Assuming an impact factor of 7.0:

$$Y_{\text{dyn}} = 7.0Y$$



$$Y_{\text{dyn}} = (7.0) (8.94) = 63 \text{ (lb)}$$

$$A = (0.175) (0.125) = 0.0219 \text{ (in.}^2\text{)}$$

$$I = (bh^3)/12$$

$$I = (0.125 \times 0.175^3)/(12) = (5.5) (10^{-5}) \text{ (in.}^4\text{)}$$

$$M = 63 (0.98 - 0.11)/(2) = 27.4 \text{ in. - lb}$$

$$S_B = M c/I$$

$$S_B = (27.4 \times 0.0875)/(5.5 \times 10^{-5}) = 43,591 \text{ psi}$$

$$S_S = Y_{\text{dyn}}/A$$

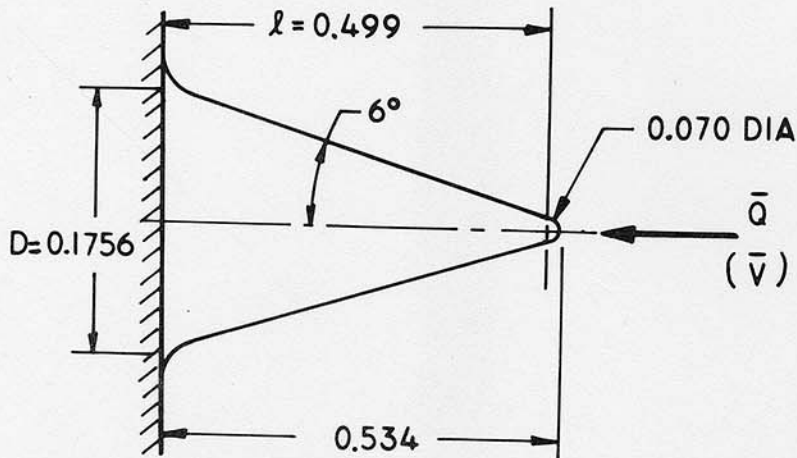
$$S_S = 63/0.0219 = 2,876.7 \text{ psi}$$

$$S_E = \sqrt{S_B^2 + 3 S_S^2}$$

$$S_E = \sqrt{43,591^2 + 3 \times 2,876.7^2} = 43,874.8 \text{ psi}$$

Which is less than the allowable fatigue stress.

III. - FIRING PIN (Steel 4340, Rockwell A72-75)



From elasticity we may deduce:

$$\sigma_c = V \sqrt{E \rho}$$

$V = 140 \text{ in./sec.}$ From D-T curve.

$$E = 29 \times 10^6 \text{ lb/in.}^2$$

$$\rho = 0.28 \text{ lb-mass/in.}^3 = 0.28/386 (\text{lb} \times \text{sec}^2)/(\text{in.})^4 = 7(10^{-4}) (\text{lb} \times \text{sec}^2)/\text{in.}^4$$

$$\sigma_c = 140 (\text{in./sec}) \sqrt{(29 \times 10^6 \text{ lb/in.}^2) (7 \times 10^{-4} \text{ lb} \times \text{sec}^2/\text{in.}^4)}$$

$$\sigma_c = 19,946 \text{ psi}$$

Because of the reflection of the compression wave at the root of the striker, the maximum stress will be:

$$(\sigma_c)_{\max} = 2 \sigma_c$$

$$(\sigma_c)_{\max} = 39,894 \text{ psi}$$

The reflected compression wave will be almost dissipated when the pin hits the primer again. This is demonstrated by the cycle time.

$$\Delta T/2t = 92.3 \text{ msec}/(2)(2.5)(10^{-3}) \text{ msec} = 18,500$$

$\Delta T = 92.3 \text{ msec}$. From the D-T curve.

$$t = 1/v_c \text{ (sec)} = 0.499/199,946 \text{ (sec)} = 2.5 \times 10^{-6} \text{ sec} = 2.5 \times 10^{-3} \text{ msec}$$

$$v_c = \sqrt{E/\rho} = \sqrt{(29 \times 10^6 \times 386)/(0.28)} = 199,946 \text{ in./sec}$$

The pressure on the primer produced by the burning propellant also acts on the firing pin and should be added to the maximum compressive stress.

Then:

$$F = \pi b^2 p$$

$$F = 3.14 \times .00966^2 \times 80,500$$

$$F = 23.58 \text{ lb}$$

$$\sigma_c = \frac{F}{A}$$

$$\sigma_c = \frac{23.58}{3.14 \times .035^2}$$

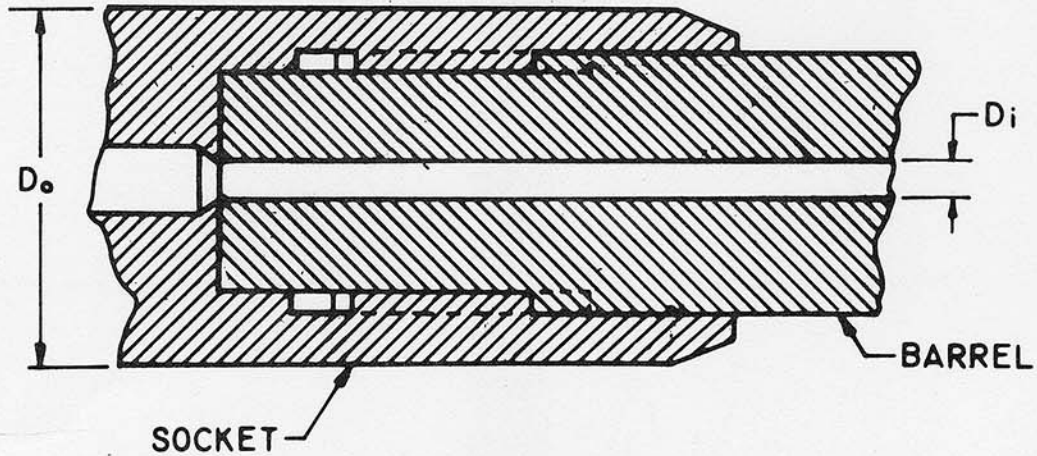
$$\sigma_c = 6,131 \text{ psi}$$

Compressive total stress = 39,894 + 6,131 = 46,025 psi

IV. - BARREL (Material:Cr-M_o-V Steel, MIL-S-11595B)

Pressure and temperature studies have been performed on barrels similar in design. Many calculations have been performed using different assumptions. For brevity, only one is detailed.

Barrel Chamber:



$p = 80,500 \text{ psi}$

$D_i = 0.221 \text{ (in.)}$

$D_o = 1.181 \text{ (in.)}$

$W = D_o/D_i = 5.344$

$\nu = 0.3$

$\alpha = 7 \times 10^{-6} \text{ (in./in.)}^\circ\text{F}$

$E = 29 \times 10^6 \text{ psi}$

Pressure:

$$(\sigma_{tp})_{\max} = p (W^2 + 1) / (W^2 - 1)$$

Inner Wall $\left[\begin{array}{l} (\sigma_{tp})_{\max} = 80,500 (5.344^2 + 1) / (5.344^2 - 1) = 86,342 \text{ psi} \\ (\sigma_{rp})_{\max} = -p = -80,500 \text{ psi} \end{array} \right.$

Temperature:

$$(\sigma_{t\tau})_{\max} = (\alpha E \Delta \tau) \left[\frac{1 - (2W^2) \ln W / (W^2 - 1)}{2(1-\nu) \ln W} \right]$$

$$(\sigma_{t\tau})_{\max} = (7 \times 10^{-6}) (29 \times 10^6) (600) \left[\frac{1 - 2(5.344^2) (\ln 5.344) / (5.344^2 - 1)}{2(1-0.3)} \right] \times (\ln 5.344)$$

Inner Wall

$$\left[\begin{array}{l} (\sigma_{t\tau})_{\max} = -128,416 \text{ psi} \\ (\sigma_{r\tau}) = 0 \\ (\sigma_{a\tau})_{\max} = (\sigma_{t\tau})_{\max} = -128,416 \text{ psi} \end{array} \right.$$

At the inner wall stresses are maximum:

$$\sigma_t = (\sigma_{tp})_{\max} + (\sigma_{t\tau})_{\max}$$

$$\sigma_r = (\sigma_{rp})_{\max}$$

$$\sigma_a = (\sigma_{a\tau})_{\max}$$

Replacing values:

$$\sigma_t = -42,074 \text{ psi}$$

$$\sigma_r = -80,500 \text{ psi}$$

$$\sigma_a = -128,416 \text{ psi}$$

The equivalent stress from Von Mises:

$$2\sigma_e^2 = (\sigma_t - \sigma_r)^2 + (\sigma_r - \sigma_a)^2 + (\sigma_a - \sigma_t)^2$$

$$2\sigma_e^2 = (-42,074 + 80,500)^2 + (-80,500 + 128,416)^2 + (-128,416 + 42,074)^2$$

$$2\sigma_e^2 = 1476.55 \times 10^6 + 2296 \times 10^6 + 7455 \times 10^6$$

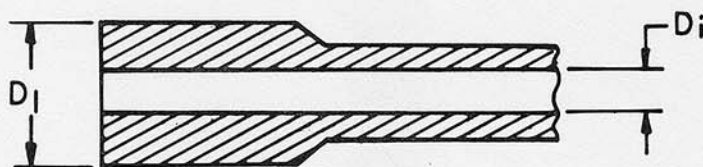
$$2\sigma_e^2 = 11,227 \times 10^6$$

$$\sigma_e = 75 \times 10^3 = 75,000 \text{ psi}$$

Recoilless gun tubes are designed with allowable stress equal to the yield point at the working temperature. For safe operation:

$$(\sigma_y)_{600^{\circ}\text{F}} = 105,000 \text{ psi} \geq \sigma_e$$

It is recommended that a lined barrel be used. Calculations using this assumption show a lessening of stresses on the inner wall.



$$E_L: \text{Young's Modulus (Liner)} = 29 \times 10^6 \text{ psi}$$

$$D_1 = 0.5 \text{ in.}$$

$$W_L = D_1/D_i = 2.262$$

$$\delta = \text{interference shrink fit} = 0.00025 \text{ in.}$$

$$\text{Finally: } \sigma_e = 52,400 \text{ psi}$$

SECTION 6

MAINTENANCE PROCEDURES

SECTION 6

MAINTENANCE

6.1 INTRODUCTION

The CMG-2 machine gun is designed to be maintenance free for extended periods of operation. When required, disassembly of the weapon is easily and rapidly performed without the use of tools. All areas of the weapon are readily accessible for cleaning. Minimal lubrication is required.

6.2 DISASSEMBLY

6.2.1 The barrel is disassembled from the weapon as described in paragraph 3.4.

6.2.2 The operating group is disassembled from the weapon by depressing the main assembly latch, located at the bottom of the receiver just forward of the buttstock, and sliding the group rearward from the receiver. The fire control group must be in the forward position to permit access to the main assembly latch. Disassembly of the operating group is normally not required as all areas of the group requiring lubrication are now accessible. Disassembly of the operating group, if desired, is accomplished in the following sequence: remove the guide rod retaining plate from the buffer housing; separate the guide rods from the buffer-buttstock assembly; remove the driving springs from the guide rods; push the guide rods forward and remove them from the bolt carrier; depress the follower pin, push the bolt to the rear, remove the follower pin and push the bolt forward permitting the cam follower to protrude up through the bolt carrier; lift out the cam follower; push the bolt forward and out of the carrier; remove the firing pin from the bolt; remove the cam follower spring from the bolt carrier.

- 2.3 The fire control group is disassembled from the weapon by sliding it fully forward, depressing the trigger and then sliding it rearward separating it from the receiver. Disassembly of the fire control group is normally not required as it requires little lubrication. Disassembly of this group is accomplished as follows: while holding the sear slightly depressed, push the sear pivot pin from the channel; lift the sear and sear spring from the channel; while holding the fire control group latch slightly depressed, pull the latch lever from the channel; lift the latch and latch spring from the channel; rotate the safety forward 90° and pull it from the channel; lift out the trigger; remove the safety detent, the detent spring and the trigger spring.
- 2.4 The ejector assembly is removed from the weapon in the following manner: with the feed tray and cover held open the ejector assembly is pivoted upwards 90°, moved to the left as far as it will go, the right side is pivoted forward, the assembly is then moved to the right and lifted from the receiver. The ejector assembly is disassembled by releasing the spring tension on the lever and separating it from the ejector.
- 2.5 The feed tray and cover assembly are not normally disassembled from the weapon. If required, it is accomplished in the following manner: with the feed tray and cover assembly held in the vertical position the hinge pin is pushed from the left to the right until the retaining lug on the pin is free of the cover; the feed tray is released allowing it to return to the horizontal position; the hinge pin is pulled free and the cover assembly, cover spring and feed tray are lifted from the receiver. To disassemble the cartridge guide from the cover, depress the guide and slide it rearward until the tab on the guide is aligned with the slot in the link chute plate, release the guide allowing the tab to rise above the plate and then, while holding the guide slightly depressed,

slide it rearward and free of the cover. The retaining pawl shaft can then be removed from the guide, releasing the retaining pawl and spring and the cartridge guide spring.

6.2.6 The bipod is removed from the weapon by rotating it 180°, moving it forward and separating it from the gas cylinder.

6.2.7 The actuator and cover are disassembled from the weapon by depressing the actuator cover latch, pivoting the cover away from the latch and lifting it from the receiver. The actuator is then lifted free of the receiver.

6.2.8 The forward grip and gas cylinder are disassembled from the weapon by inserting a cartridge point in the slot at the rear of the grip, depressing the retaining plunger, and sliding the grip rearward and free of the gas cylinder dovetail. The gas cylinder is then removed from the receiver. Disassembly of the forward grip and gas cylinder from the weapon is the only operation during which a tool, i.e., a cartridge, is required.

6.3 CLEANING

Standard weapon cleaning procedures are applicable to the CMG-2. A scraping tool is provided to remove carbon accumulations from the gas port, front sight expansion chamber, and the gas piston.

6.4 LUBRICATION

MIL-L-46000 lubricant sparingly applied to all wear and bearing surfaces, except in the gas system, after each cleaning and as required, will provide smooth weapon function and increased service life.

6.5 ASSEMBLY

The assembly procedure for the weapon is essentially the same as the disassembly procedure in reverse.

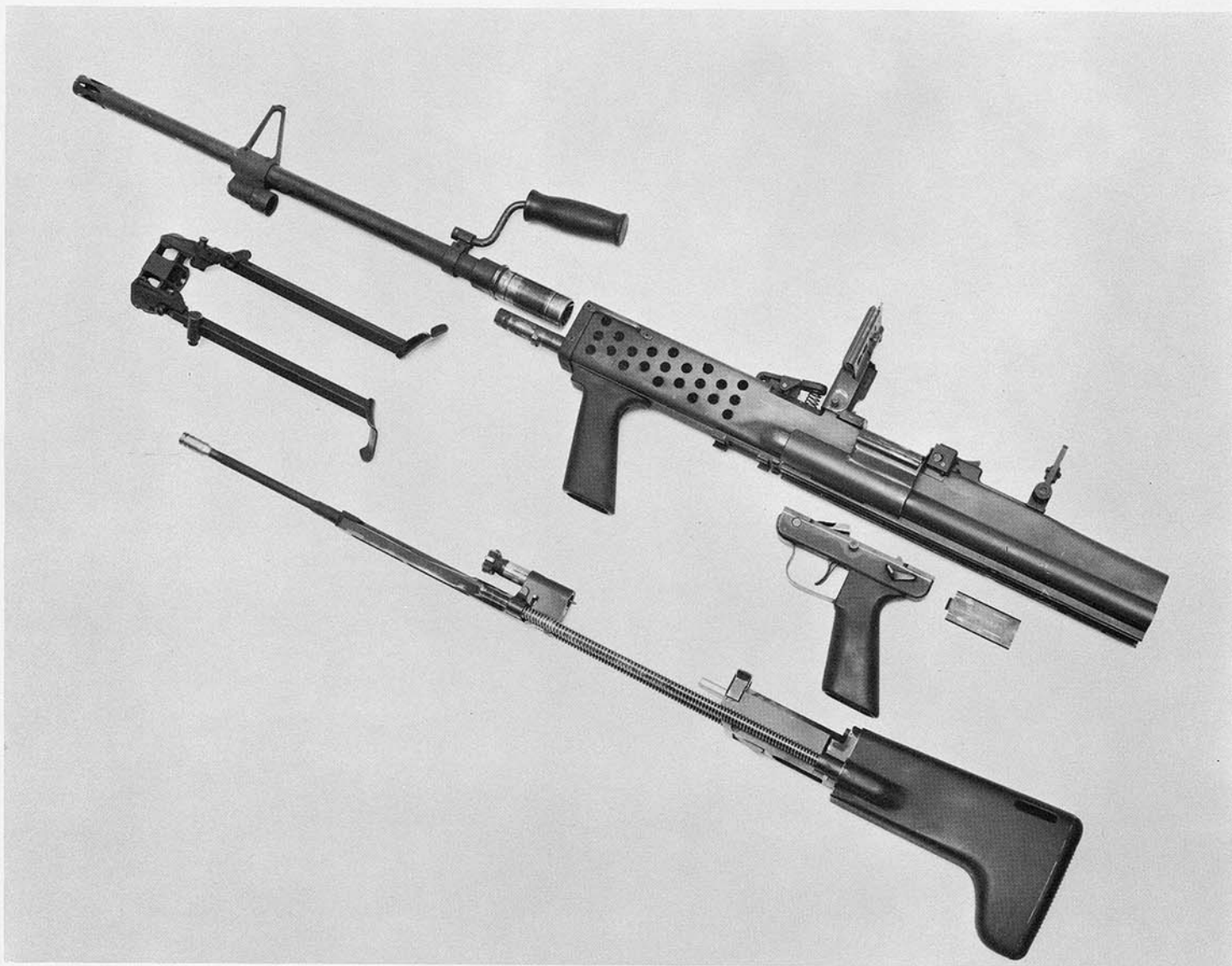


Figure 6-1. CMG-2 Field Stripped

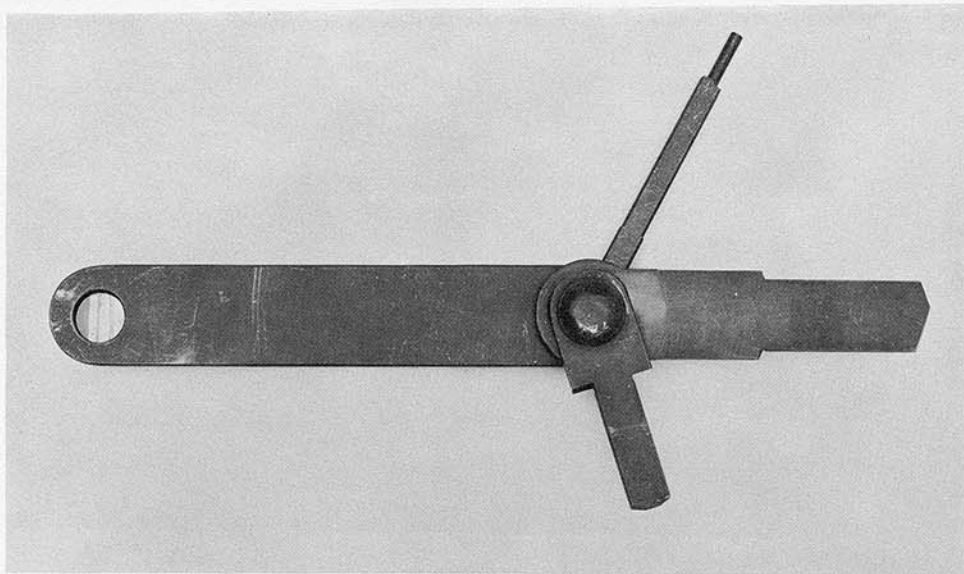


Figure 6-2. Scraping Tool - CMG-2

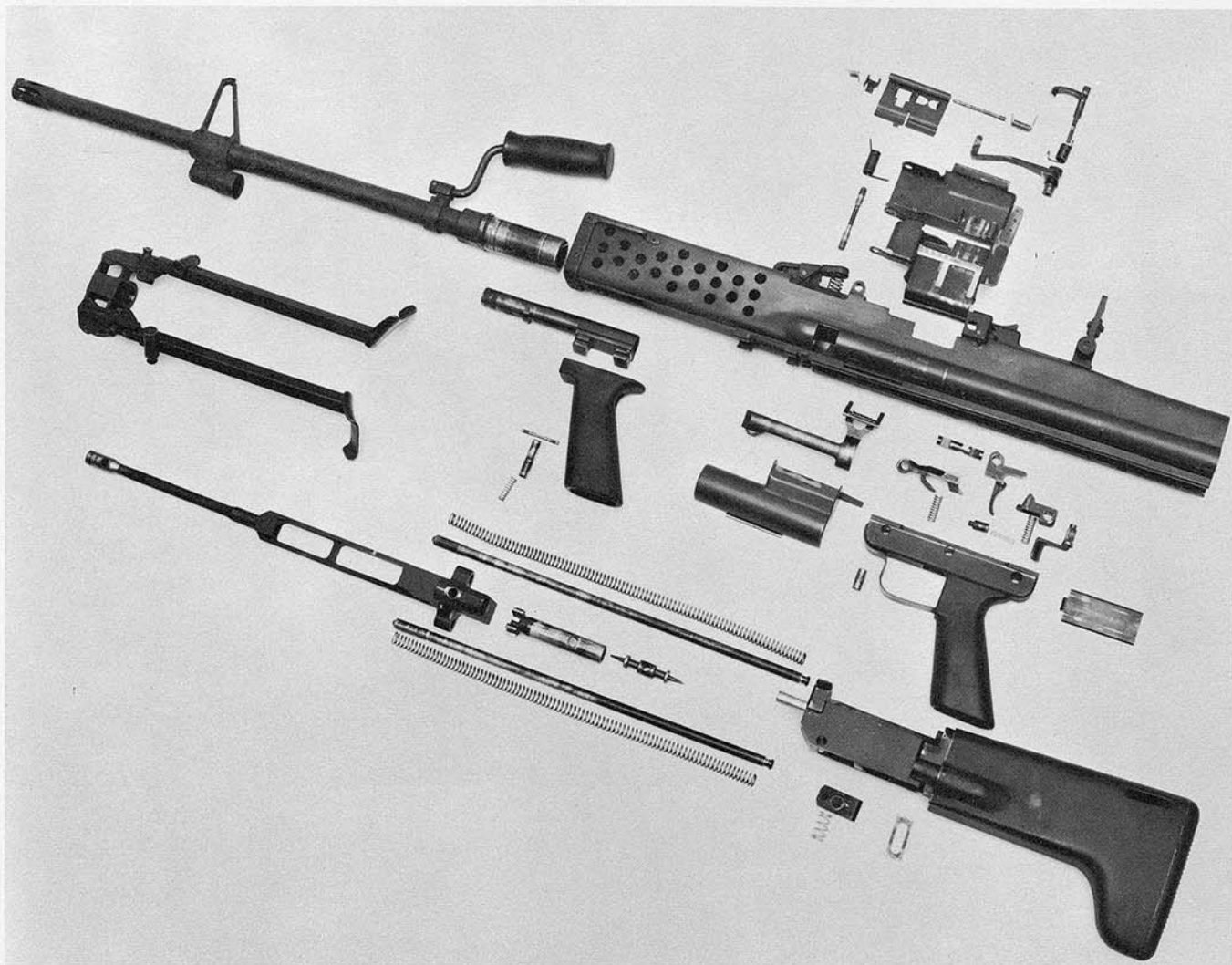


Figure 6-3. CMG-2 Detail Stripped

SECTION 7

MANAGEMENT

SECTION 7

MANAGEMENT

Colt's Firearms will manage the effort described in this proposal using the Project Management Team concept which has proven successful in the development and manufacture of other weapon systems.

The Project Manager -- CMG-2, is responsible for the principle decisions in design, engineering, and manufacturing. He is also responsible for achievement of objectives set forth by company management and stated contractually.

The following functions will support the program to the extent required.

Manufacturing-	Establish and implement fabrication schedule
Design Engineering-	Establish design and make design changes when necessary
Purchasing-	Procure item from qualified vendors
Human Engineering-	Assure a man-integrated weapon
Field Engineering-	Support field test of the weapon
Quality Control-	Assure quality and performance of the weapon.

The personnel involved in this program are highly qualified in the design, test and analysis of new weapons systems. They are extremely familiar with the evolution of light machine guns and were involved in the development of the weapon currently in field use. In addition, they are familiar with the field requirements and the user's needs for such a weapon. The resumes of these people are included in this section along with resumes of Colt's key personnel.

WILLIAM H. GOLDBACH

President - Military Arms Division
Colt's Firearms Group
Colt Industries

EDUCATION

BBA - John Carrol University
Post Graduate - Wooster College, University of Iowa

EXPERIENCE

Colt's Firearms

Mr. Goldbach has had extensive management experience at Colt's, being responsible for meeting technical, schedule and cost objectives for the M16 Automatic Rifle, XM148 Grenade Launcher and the MK-56 Naval Gun Mount. His knowledge of all phases of weapon system management is particularly valuable in directing an existing weapons manufacturing team to solve new development tasks.

TRW

As Ordnance Works Manager, Mr. Goldbach actively supervised all phases of M14 rifle production and other ordnance products. Prior to this assignment, he was divisional Industrial Engineering Manager for three plants in the TRW Jet Engine complex and was also responsible for the start-up of several automotive and jet engine parts facilities.

Mr. Goldbach taught cost improvement and work simplification courses early in his career, and is the author of several related articles in the field.

SOCIETIES

IMS (Award Winner)
ASTME (Past Chapter Chairman)(Handbook Chairman)
A. O. A. , A. U. S. A. , S. A. M. , U. S. A. F. A.

C. WILLIAM BRITCHER

Materials Manager

EDUCATION

BSME - Polytechnic Institute of Brooklyn
MS - Administration - New York University
Licenced Professional Engineer - New York State

EXPERIENCE

Colt's Firearms (1963 -)

Mr. Britcher is the Materials Manager responsible for the purchasing functions and production control connected with the military operations of Colt's Firearms. Previously, he was Manager of Industrial Engineering, having formed and staffed the IE department. He was responsible for preparation of long range business plans, engineering expense reports and labor forecasts. He also supervised the layout of a 200,000 square foot plant expansion for the best man/machine and material flow efficiency.

Stanley Tools (1962 - 1963)

Mr. Britcher was the Manager of Industrial Engineering and as such initiated a corporate training program in MTM specifically aimed at preparation for a plant relocation. He set up a methods improvement program and predetermined standards to take advantage of the new layout. In conjunction with the Controller and Product Line Manager, he prepared a long range business plan for a major product line.

Republic Aviation Corp. (1958 - 1962)

Mr. Britcher was Business Systems Supervisor responsible for the installation of an integrated system of collecting and processing various shop data using transmitters similar to the IBM 1030 reader. The system was used both for labor time reporting

and for order dispatching. He had complete responsibility from the initial planning through the training of shop people. He completed several other projects including requirements planning, engineering accountability, and master scheduling. He also made effective use of PERT in project control.

Mergenthaler Linotype Company (1949 - 1957)

Mr. Britcher was the Chief Industrial Engineer, supervising manufacturing engineering, timestudy, special machinery design and procedures design. Previously he served in the following capacities; methods engineer, quality control engineer, production engineer, administrative engineer and manufacturing engineering supervisor.

SOCIETIES

American Institute of Industrial Engineers (Past Chapter President)

National Association of Purchasing Management

WILLIAM H. CRAVEN

Vice President, Military Manufacturing

EDUCATION

B.S. Iowa State College
Graduate of U. S. Merchant Marine Academy

EXPERIENCE

Colt's Firearms

Mr. Craven is responsible for all manufacturing functions of Colt's military operations. These functions include machining, assembly, manufacturing engineering and industrial engineering. Mr. Craven has an outstanding record for meeting difficult assignments.

Ingersoll Milling Machine Company

Mr. Craven was responsible for product engineering, quality control, purchasing, manufacturing, production control and division accounting. He was effective in establishing significant cost reductions by standardizing product design, purchase of new equipment, and developing an outstanding manufacturing organization.

George F. Curtis
Product Engineer
Military Engineering -- Small Arms Section

Education

Western New England College

Experience

Colt's Firearms (1967 -

Mr. Curtis is the Product Engineer assigned to the CMG-2 light machine gun development. Previously he was assigned to the CGL-5 40 mm grenade launcher development.

Springfield Armory (1962-1967)

Mr. Curtis contributed to the development of the M60E1 7.62 mm machine gun. He was responsible for many of the product improvements made to the M60 machine gun. He was a participant in the product engineering of the M73 machine gun, M122 tripod mount, and the GAU-2B/A aircraft machine gun. His duties also included investigating unsatisfactory equipment reports and recommending or taking corrective action, and evaluating value engineering change proposals.

ROBERT D. FREMONT

Manager
Military Engineering - Small Arms Section

EDUCATION

Itasca Junior College
University of Connecticut, School of Engineering

EXPERIENCE

Colt's Firearms

Mr. Fremont is responsible for all aspect of weapons design and development for military usage. He is responsible for the engineering improvements made to and modifications of Colt's M16 rifle in order to continually meet changing military requirements. Mr. Fremont's experience is unique in that it covers essentially every facet of small arms production, from concept through design, development, tooling and processing, purchasing, quality control, manufacturing, and test and evaluation.

Cadillac Gage Company

Mr. Fremont, as Project Engineer, contributed substantially to the design and development of the Stoner Weapons System, first developed in 7.62 mm NATO caliber (designated the S-62) and then in 5.56 mm and designated the S-63. In addition, from 1962 to 1964 he managed the development facility.

Armalite Division, Fairchild Engine and Airplane Corporation

Mr. Fremont was Project Engineer on the AR-15 as adopted by the Air Force (M16 Army designation). He served as Liaison Engineer and Consultant representing Fairchild Engine and Airplane Corporation assisting in the establishment of production of the AR-15 at Colt's Firearms. Additionally, as a Project Engineer, he was responsible for the AR-10A, an improved version of the AR-10 manufactured by the Dutch government.

SOCIETIES

ASSOCIATION OF THE UNITED STATES ARMY
Army Ordnance Association
U. S. Air Force Association

DANIEL E. GROVE

Manager, Quality Control

EDUCATION

Aeronautical Engineering Graduate Academy of Aeronautics, New York
Business Administration Course Alexander Hamilton Institute
Basic and advanced courses in Statistical Quality Control

EXPERIENCE

Colt's Firearms

Quality Control Manager - Responsible for Inspection, Firing Range and Final Examination, Quality Assurance Engineering and the Standards (Metrology) Laboratory. Credited with developing the high degree of quality awareness and low manufacturing rejects on all Colt products, both commercial and military.

Revere Corporation of America

Quality Control Manager - Responsible for all phases of Quality Control relating to the manufacture of mechanical and electro-mechanical components for the electronics and missile industry.

Aero Supply Manufacturing Company

Chief Test Engineer - Handled all production and qualification testing of pneumatic, hydraulic and fuel system components for the automotive and aircraft industry.

Chance Vought Aircraft

Supervised the structural, hydraulic and fuel system tests conducted on aircraft components.

SOCIETIES

American Society for Quality Control (Senior Member and Past Chairman)

WILLIAM J. JARRETT

Chief-Applied Research And Test Branch
Military Engineering - Small Arms Section

EDUCATION

BSME - Purdue University
University of Hartford
Certificate - U.S. Army Management and Engineering Training Agency

EXPERIENCE

Mr. Jarrett directs the applied research activities in support of the design, development and test of military small arms weapons systems. These activities include the parameters involving stress, dynamics and kinematics of weapon concepts, and the evaluation and preparation of the technical aspects of new hardware proposals.

Springfield Armory

Mr. Jarrett's last assignment was Group Leader, Design Support Group, Research and Engineering Division, directing the design support activities, acting as a consultant to the Chief-Weapons Development Branch and serving as a member of the AMC Engineering Design Handbook Advisory Group. The Design Support Group provided analytical and experimental support to the weapon design engineering groups during the development of a weapon system from concept to type classification.

Support activities were performed for the following machine guns:

7.62 mm M37 GPMG	Cal. 50 T176 Tank MG	15 mm XM122 Spotting MG
7.62 mm T197/M73 Tank MG	Cal. 50 T175/M85 Tank MG	20 mm T220 SRAA MG
7.62 mm T161/M60 GPMG	Cal. 50 XM121 Spotting MG	

SOCIETIES

Registered Professional Engineer, Massachusetts #19767

RELATED PUBLICATIONS

Technical Report No. SA-TR1- 7025,
Development of a Stellite - Lined, Chromium Plated Barrel for 5.56 mm Machine Gun
Springfield Armory

Trunion Reactions and Vibrational Characteristics of the 7.62 mm M60 Machine Gun
in Light Weight Aircraft Mounts (Springfield Armory Report, 1962, unpublished)

ARTURO A. MONTEROS

Stress Analyst Engineer
Applied Research and Development Engineer
Military Engineering, Small Arms Section

EDUCATION

MSME and MSAE - University of Cordoba, Argentina
Advanced Engineering - University of Cordoba

Post Graduate Studies

Diplomas: Material Science (University of Cordoba)
Industrial Management (Technological University)
Linear Programming (Technological University)

Certificates: Numerical Methods in Engineering (Technology University)
Guided Missiles (Superior School of Aeronautics)
Material Science (University of Cordoba)

EXPERIENCE

Colt's Firearms (April 1969 -)

Mr. Monteros has performed stress and mechanical analysis on various advanced automatic and non automatic small arms weapons. He is also studying weapon heat transfer characteristics by both experimental and analytical methods. Using a theoretical approach, he is developing analytical equations and computer programs to solve the problems of temperature distribution. These efforts are oriented towards developing a new philosophy regarding weapons development, and through the use of modern technology to advance the state of the art.

Combustion Engineering

Mr. Monteros was a stress analyst involved in performing piping stress and flexibility analyses of steam power generation units utilizing computer operations to perform the necessary complex calculations.

Allied Control Corp.

Mr. Monteros was a development engineer responsible for the study of the fluid mechanics of production and prototype valves. In addition, he was concerned with applications of fluidics.

Dinfia (Cordoba, Argentina)

Mr. Monteros was a stress analyst involved in the analysis of various aircraft components. He was also involved in patent examination and the translation of technical documents into Spanish from English, French and Italian. Additionally, he was a Research Assistant performing detailed studies of air motor propellers fans and blades, and was Assistant Project Engineer of a Hovercraft Vehicle program, responsible for coordination of the project groups.

SOCIETIES

Society for Experimental Stress Analysis

Consejo Profesional de Ingenieria Aeronautica

Asociasion Profesional de Ingenieros Especialistas

Henry J. Tatro Jr.
Senior Product Engineer
Military Engineering -- Small Arms Section

Education

Springfield Armory Apprentice Toolmakers Course 1952 -1956.

Government Sponsored Engineering Course. Spring Hill College-Alabama
(Military-WW II).

Experience

Colt's Firearms (1967-

Mr. Tatro is the Senior Product Engineer assigned to the CMG-2 light machine gun development. Previously he was assigned to a product improvement program on the XM148 Grenade Launcher.

Springfield Armory (1950-1967)

Mr. Tatro was the project leader in the development of the M60 E1 7.62 mm machine gun. He was responsible for many of the product improvements on the M60 family of weapons as well as the M122 Mount, M8 Spotting Rifle and the Browning Automatic Rifle. He supervised revisions to drawings, new drawings, and complete technical data packages for national procurement of end items. He also supervised planning and surveillance of endurance testing of development and product improvement projects of machine gun concepts and components.

SECTION 8

RELATED EXPERIENCE

SECTION 8

RELATED EXPERIENCE

HISTORICAL EXPERIENCE

Colt's has been involved with the development and production of automatic small arms ever since John Browning turned to Colt's to produce the world's first successful automatic gas-operated machine gun in 1890. This weapon, the Colt Model 1895, was the first automatic machine gun purchased by the United States Government. At the start of World War I, Colt's was given a contract for 1500 of these same weapons, the only change being the incorporation of an interchangeable barrel.



Figure 8-1. Colt Machine Gun Model 1895, as Modified in 1914

At the outbreak of World War I, John Browning, in collaboration with Colt's Patent Firearms Manufacturing Co., which had exclusive concession to manufacture weapons under Browning's patents, concentrated their efforts towards the development of a recoil operated machine gun suitable for mass production. Browning had constructed and tested a recoil operated weapon almost twenty years previously but due to the lack of government funding the project sat on the back shelf until needed. This weapon, the Cal .30 Model 1917, along with the simultaneously developed Browning Automatic Rifle (B.A.R.), were adopted by the government as the most effective guns of their type--the outstanding features were reliability and simplicity of design.

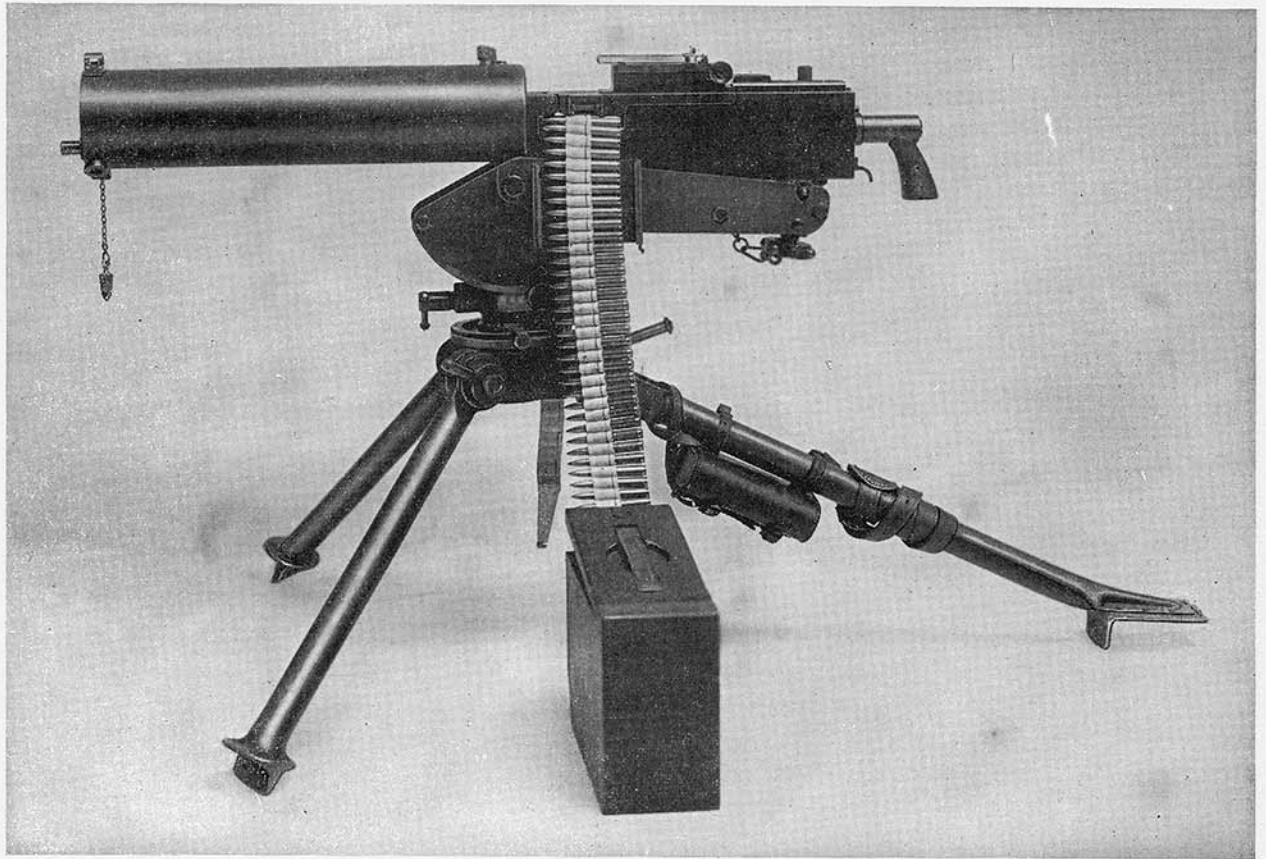


Figure 8-2. Browning Machine Gun, Model 1917, Cal .30

In addition, Colt's has been involved in the development and production of the following military weapons:

37 mm Cannon

Prior to World War II, Colt's, in collaboration with Mr. John Browning, developed this weapon which, soon after Pearl Harbor, went into large scale production at Colt's. A combined monthly production rate of the aircraft and anti-tank versions reached 2,500 units. This rate was sustained for the duration of the war.

.50 Caliber Machine Gun

This well known weapon, also developed in collaboration with John Browning, was produced by Colt's at a rate of up to 14,000 units per month during World War II. Still operational with our Armed Forces, the Browning .50 caliber machine gun was last manufactured by Colt's during the Korean War.

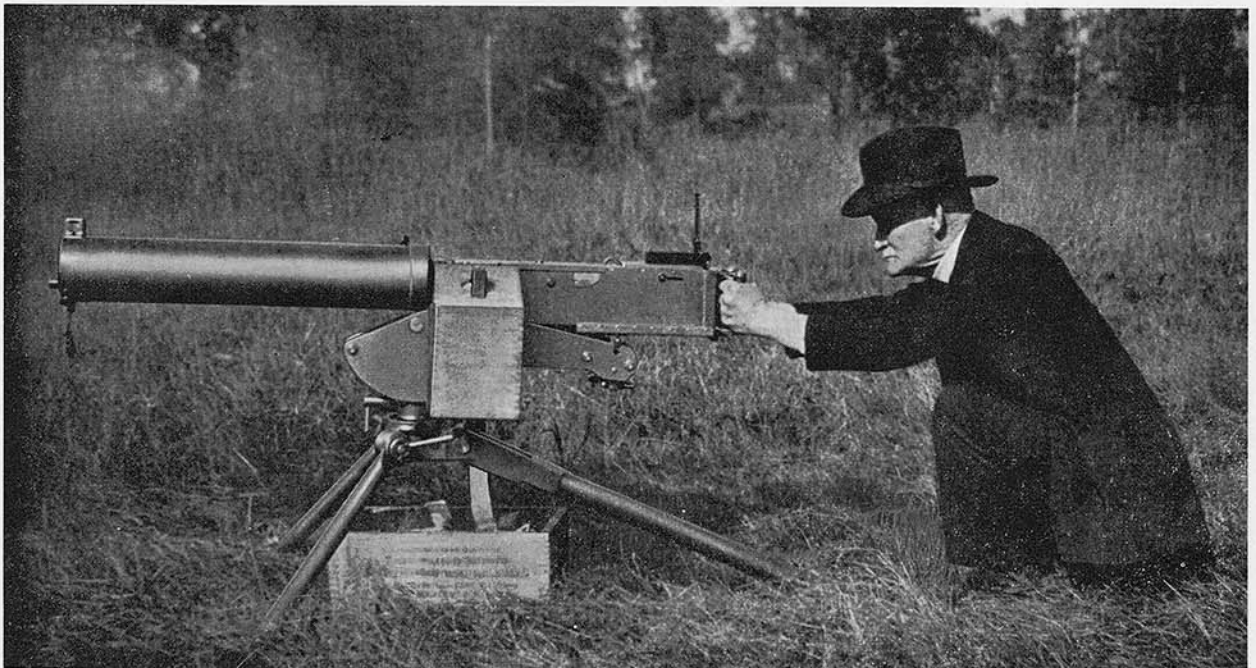


Figure 8-3. John M. Browning firing the .50 Caliber Machine Gun in Colt's Pasture

.45 Caliber Automatic Pistol

Attesting to its reliability and effectiveness as a man-stopper, the Colt .45 Automatic has been in continuous use as the official U. S. Army side arm since its introduction in 1911. During the war years, production reached 20,000 per month.



Figure 8-4. .45 Caliber Automatic Pistol

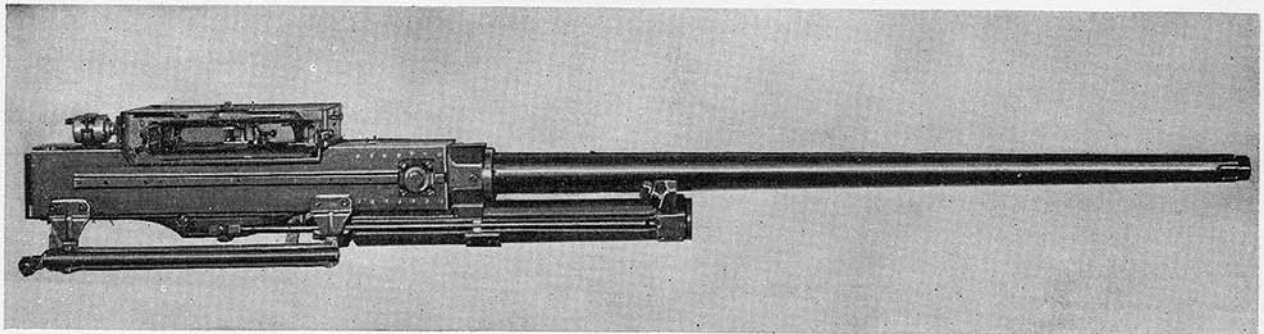


Figure 8-5. 37mm Automatic Aircraft Cannon, M4

RECENT EXPERIENCE

M16 Rifle

Currently, Colt's is the prime manufacturer of the M16 rifle, delivering in excess of 50,000 units monthly. Colt's has consistently met or exceeded contractual delivery requirements. Many original contributions, both in configuration and manufacturing, were made by Colt's in the evolution of the AR-15 to its present form. These included a submachine gun version of the AR-15, prototype versions of the weapon adopted to fire different caliber ammunition, and a new barrel manufacturing process. Colt's produced the Technical Data Package used by all manufacturers of the M16 rifle and retains control of this data in its role as a Weapon Engineering Agency for the government.



Figure 8-6. Colt AR 15 Rifle (M16A1)

CGL-4 Grenade Launcher

Recognizing the tactical advantage of providing the Squad with an area fire capability without sacrifice in point target fire power, Colt's engineers undertook the development of a light weight (2.5 lbs.) 40 mm Grenade Launcher which could be easily attached to the rifle. This was the first 40mm launcher capable of being attached to the M16A1 rifle purchased by the government.

Caliber .223 Ammunition Developments

Using hand loaded .223 cases and Government furnished projectile components, Colt's has developed a flechette round for the rifle which reaches an acceptable muzzle velocity. The ability to fire indiscriminately mixed .223 ball, tracer and flechette rounds without malfunction has been demonstrated in the M16.

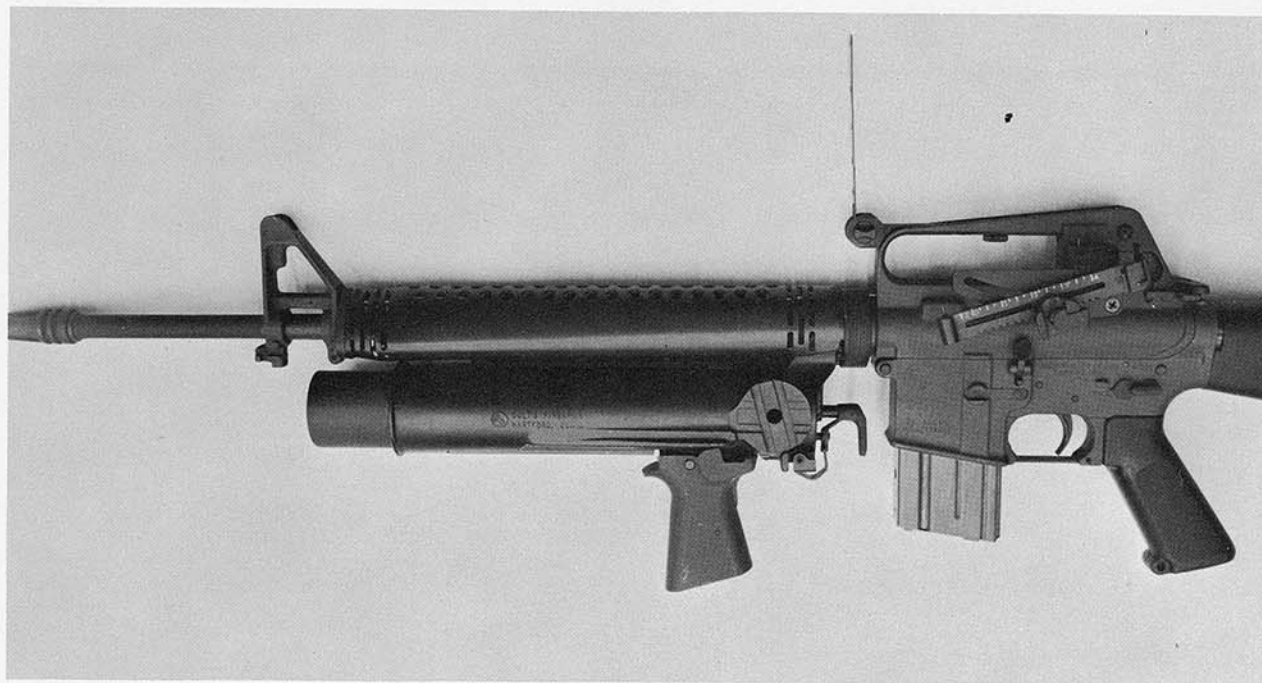


Figure 8-7. M16 Rifle with CGL-4 Grenade Launcher (Modified)

M16 Rifle Buttstock

Colt's has developed a new buttstock for the M16 Rifle featuring a compartment for the stowage of weapon cleaning equipment. The buttstock shell is filled with a closed cell polyurethane foam. Cored holes in the foam are provided for the receiver extension and the stowage compartment. A metal latch plate housed in the rubber buttsplate provides access to the compartment. All components of the buttstock are replaceable.

30 Round Magazine

The 30 round magazine, developed by Colt's, is the result of the armed forces desire for a larger magazine which would yield greater fire power for the M16 rifle. The magazine is a lightweight unit constructed of aluminum with a plastic follower. The plastic follower eliminates the corrosion problem which is inherent with metal followers, thereby simplifying cleaning of the magazine. In addition, the plastic follower has demonstrated superior wear characteristics as compared to the metal follower. The magazines are currently under test by various military agencies.

Salvo Squeezebore (SSB)

Colt's Firearms is involved in a continuing program of development and demonstrations of the Salvo Squeezebore. This concept permits firing a salvo of three to six spin-stabilized, high-velocity bullets through a single barrel at each discharge of a firearm. When applied to a machine gun, the rate of delivery and saturation is therefore from three to six times the rate of fire of the weapon. Salvo Squeezebore is covered by a Secret U.S. Patent (Se No. 129,401/1961), therefore, a complete description cannot be given in this document.

PERFORMANCE

Colt's has a substantial history of excellent contractual performance. Pertinent to this program are the following fixed-price contracts:

M16 .223 Caliber Automatic Rifle

Contract DA-11-199-AMC-508(W) \$26 Million
November 1963 to August 1966
140,000 units delivered to Rock Island ahead of schedule.

XM148, 40 mm Grenade Launcher

Contract DA-11-199-AMC-663(W) \$3.2 Million
January 1966 to February 1967
19,000 units
Initial on-time delivery in July 1966 to Rock Island.

XM16E1 .223 Automatic Rifle

Contract DAAF03-66-C-0018 \$46 Million
December 1965 to December 1967
400,000 units
Deliveries to Rock Island ahead of schedule.

XM16E1 Spare Parts

Contract DAAF-3-66-C-0020 \$3.2 Million
Currently fulfilling requirements for various Spare Parts to Rock Island.

Commando Submachine Gun

Contract DA-11-199-AMC-678(W) \$0.5 Million
March 1966 to December 1966
2,800 units
First delivery to Rock Island in September 1966.

Salvo Squeezebore

Contract N60921-69-C-0109 \$35,000
Currently supplying 25,000 units of Salvo Squeezebore .50/.30 Ammo, 7 Taper Barrels and 7 Inhibitor Bars.

Colt's also is presently delivering 50,000 M16 rifles a month under letter contract DAAF03-69-C-0021 and is delivering M16 spare parts and magazines under various other letter contracts.

SECTION 9

FACILITIES

SECTION 9

FACILITIES

.1 GENERAL

Colt's Firearms Division of Colt Industries is adequately equipped to develop, test and produce military small arms weapons systems.

.1.1 RESEARCH AND DEVELOPMENT FACILITIES

Included in this area are the R&D test range, the research lab, the model shop and the instrumentation necessary to perform dynamic and kinematic analysis of theoretical models and actual hardware.

1.1.1 R&D Test Range. (See figure 9-1) Colt's engineers have available to them a two butt research and development test range for use in the study of weapon design. The range is arranged and equipped so that one butt can be isolated and the weapon under test remotely fired. Rigid mounting tables and rigid or damped weapon mounts are available to provide a controlled stage for displacement time photography.

The Displacement-Time camera (figure 9-2) in the R&D Test Range was designed and built by Colt's military engineering group to satisfy their particular requirements. It is used as a tool to aid in breaking down the operational cycle of the weapon under test into its various phases and to study dwell and unlocking times, buffer energy absorption, frictional energy losses, etc. This camera is an invaluable tool in the development of new weapons systems.

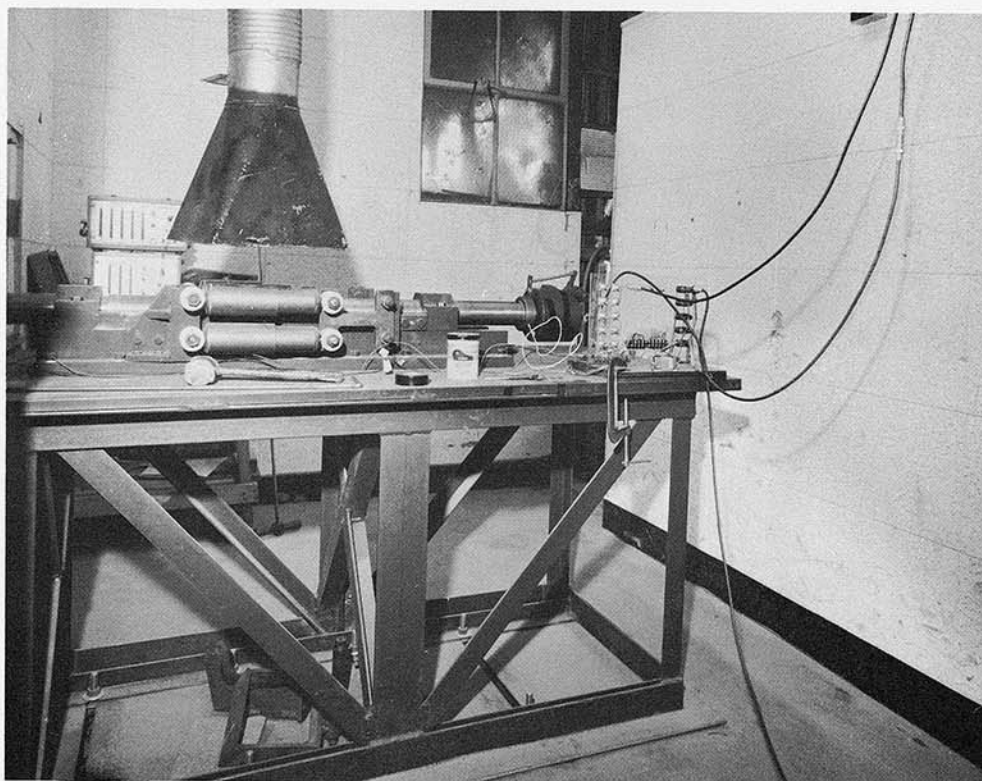
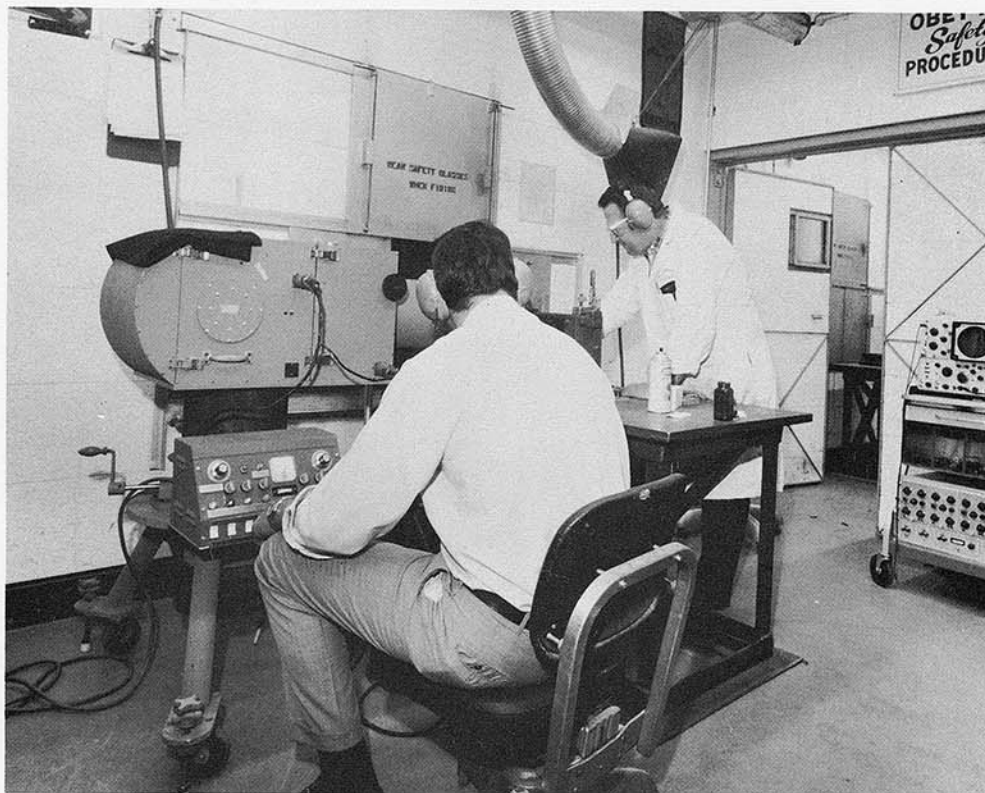


Figure 9-1. R&D Test Range

A photo lab (figure 9-3) adjacent to the R&D range provides the test engineers and technician with rapid processing of D-T photograph so that retesting, if necessary, can be accomplished before teardown of the test setup. An automatic processor-printer unit complements the other equipment in the R&D Range.

9.1.1.2 Model Shop. The model shop (see figure 9-4) is equipped to handle all phases of development work, from wooden mockups to functioning weapons and special tools. The shop is equipped to handle limited production when required. The Yankee craftsmen and the equipment they employ make this shop one of the foremost in the weapons industry.

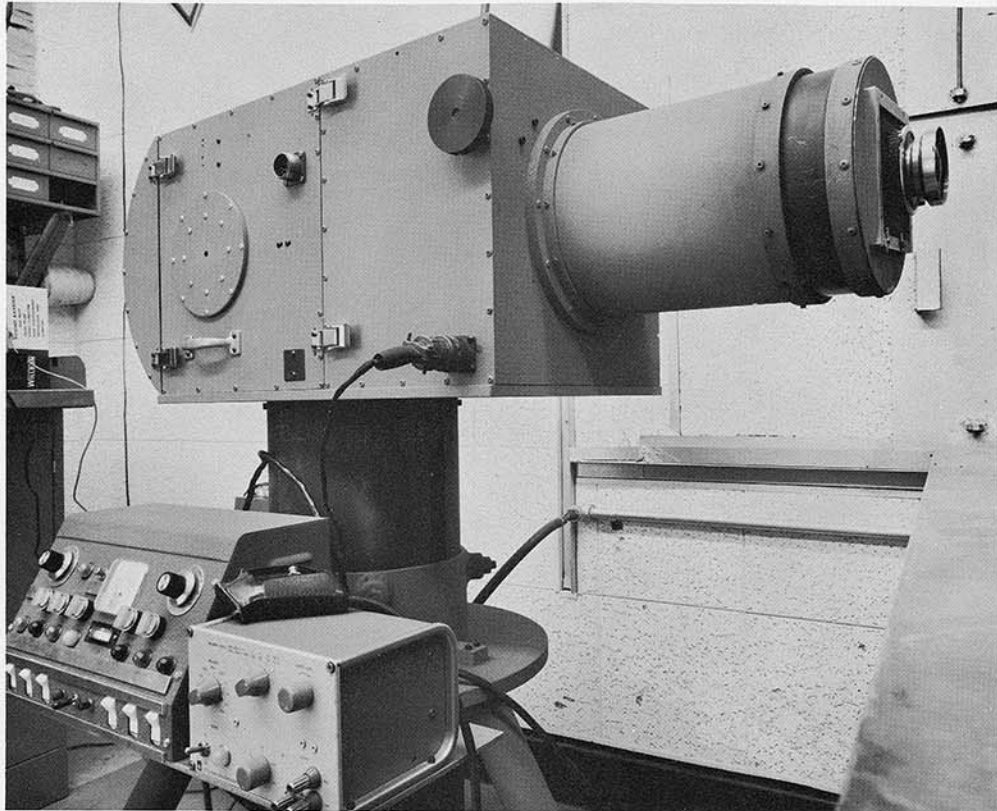


Figure 9-2. Displacement-Time Camera

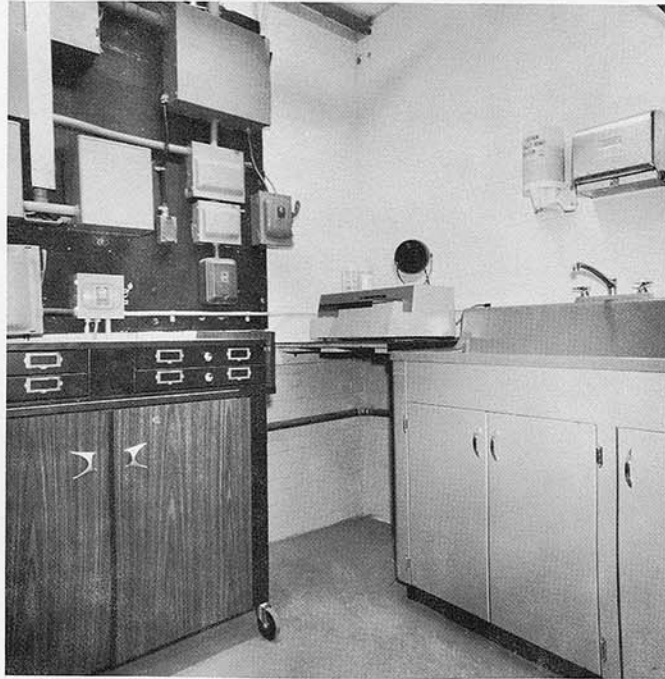


Figure 9-3. Photo Lab

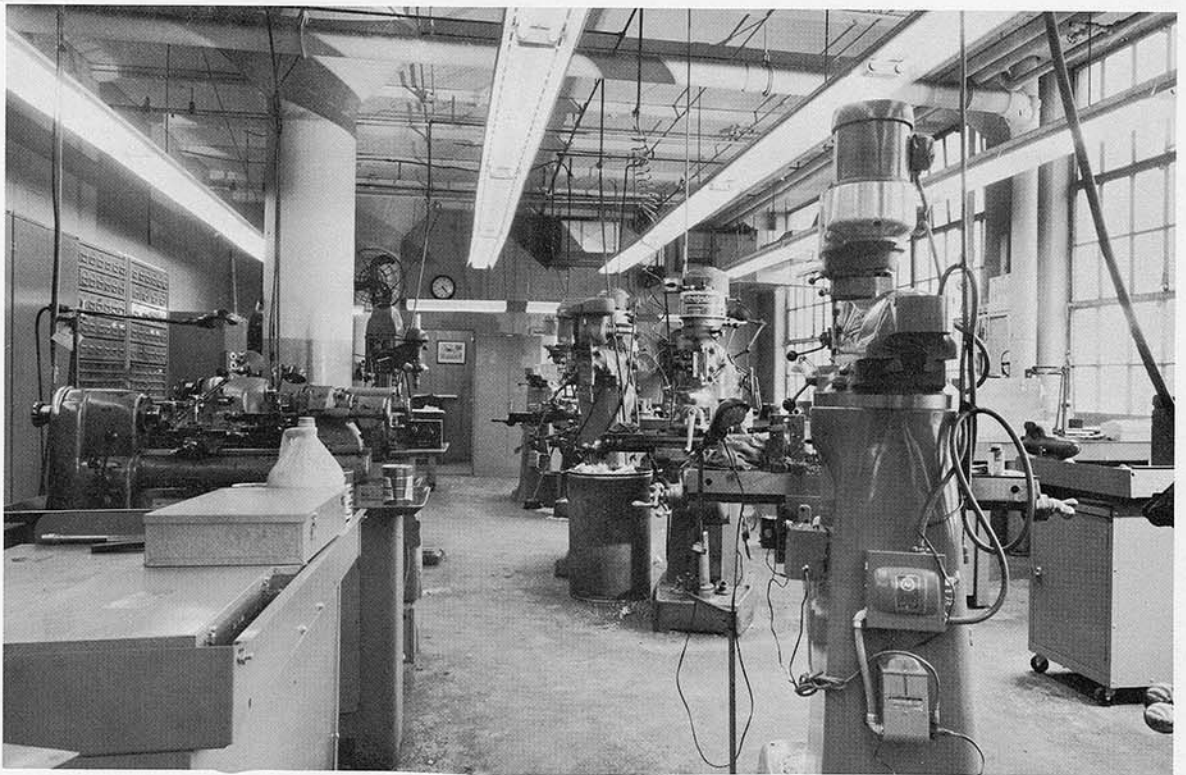


Figure 9-4. Model Shop

9.1.1.3 Research Lab. The research lab is equipped with modern electronic, mechanical and optical test equipment to be used separately or in conjunction with other equipment to perform the evaluations necessary in weapon design, development and improvement programs. In addition, solid-state table top CRT-readout type calculators and a desk top computer are available to solve involved or repetitive calculations.

The availability of this modern equipment allows the engineer to routinely solve involved problems.

9.1.2 TEST FACILITIES

In addition to the test equipment available in the R&D facilities, facilities are available to test hardware for endurance, reliability and maintainability.

9.1.2.1 50-Yard Test Range. The 50-yard test range (see figure 9-5) is used to proof test various small arms weapons, to test weapon-cartridge combinations and to conduct ballistics tests of new cartridge designs. A 16mm camera, with speeds up to 8,000 frames per second, is used for visual study of weapon functions. Several EPUT meters and associated photo-electric screens are available for measuring projectile velocities. A pyrometer with fast response and temperature range to 600^oF (+1.5%), is used to measure barrel temperature under sustained fire.

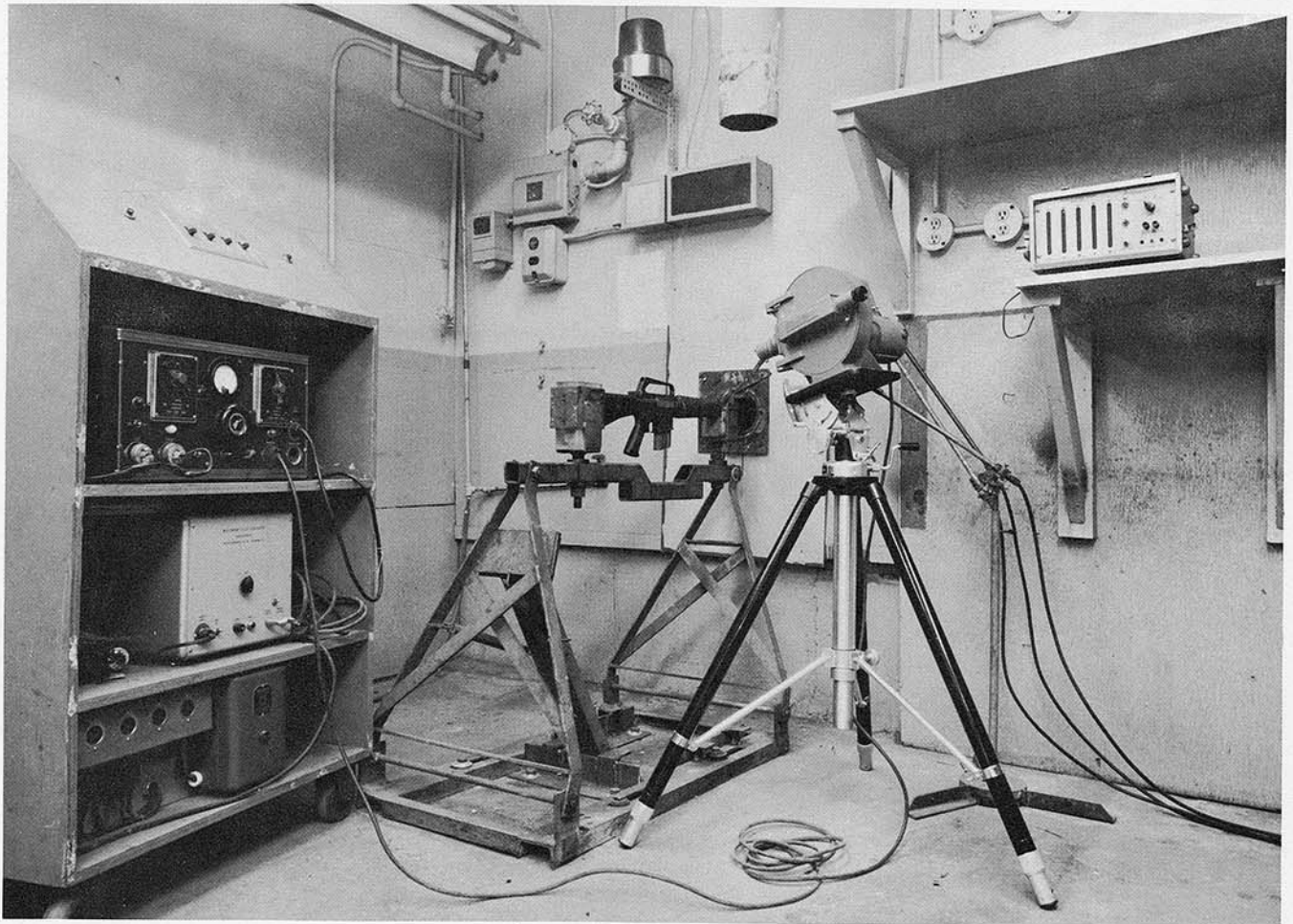
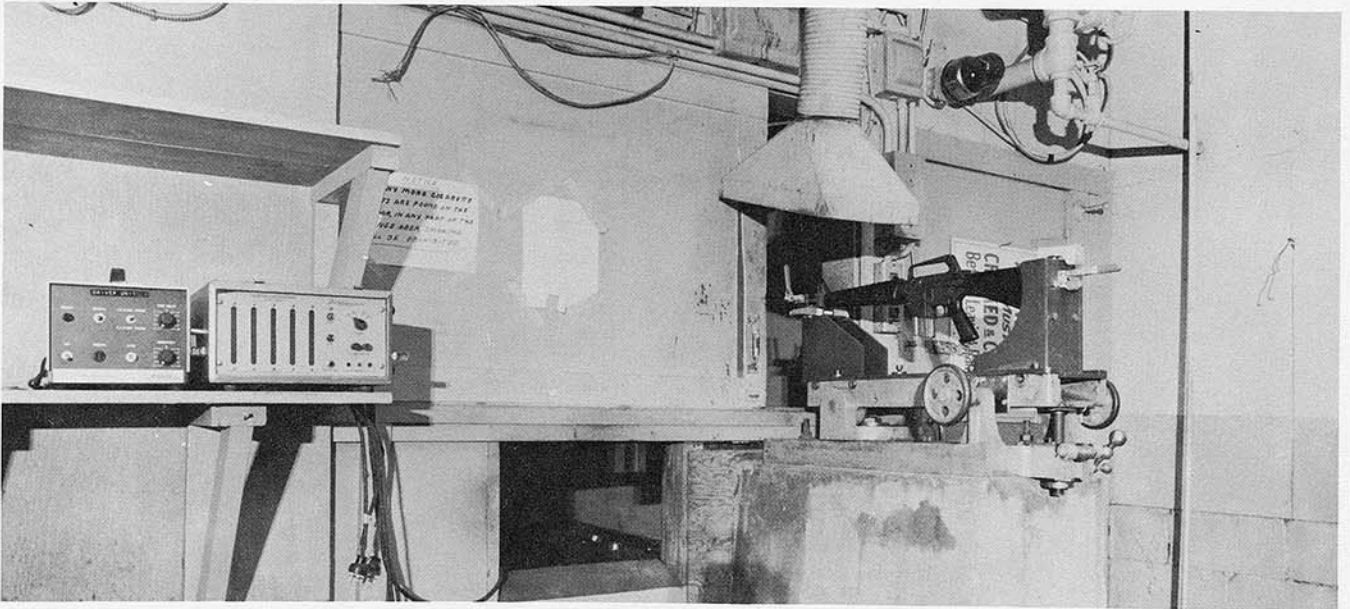


Figure 9-5. 50 yd Test Range

9.1.2.2 Endurance and Acceptance Test Range. One of the countries most modern indoor endurance and acceptance test ranges is located in Colt's West Hartford facility (see figure 9-6). A closed circuit television system brings a visual display of each target to the range technician's side. Targets are changed and positioned automatically from a console at the firing station. A trolley system permits positioning of targets at predetermined distances for trajectory plotting. Two outdoor ranges are available which allow line-of-sight or high trajectory firing to a range of 1000 meters. Both of these ranges are within 45 minutes of Colt's main plant.



Figure 9-6. Endurance and Acceptance Test Range

MANUFACTURING FACILITIES

Colt's Firearms has been a leading manufacturer of quality firearms for well over a century. Its manufacturing facilities are outstanding and, together with qualified vendors in the surrounding area, has won a world-wide reputation for meeting schedule and quality requirements.



Figure 9-7. Manufacturing Engineering

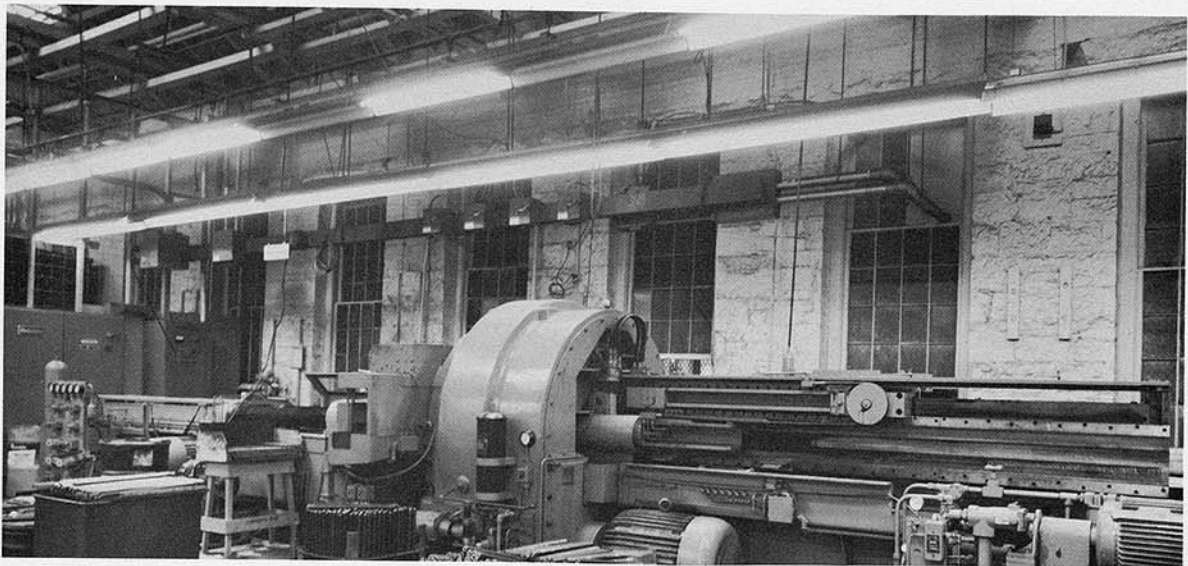


Figure 9-8. Barrel Swager



Figure 9-9. | M16 Upper Receiver Machining Area



Figure 9-10. M16 Final Inspection Area

APPENDIX A

TERMS & CONDITIONS

APPENDIX A

TERMS OF PROPOSAL

Colt Firearms proposes to supply ten (10) prototype CMG-2,5. 56 mm Machine Guns as illustrated herein for test and evaluation by the Government. The guns to be supplied under a contract resulting from this proposal will be functionally complete working prototypes which are intended to demonstrate validity of the design approach. The proposed total contract price for supplying these weapons is \$99,500.00.

The prototypes will be delivered six (6) months after award of contract., FOB Colt's plant, Hartford, Connecticut, subject to the award of contract on or before 15 Oct 69.

Colt's will provide Engineering liaison during the Government tests. This is considered a support cost and is provided in this proposal for a total of sixty (60) days, the cost of which is included in the proposed price.

Any contract resulting from the submission of this proposal will be to provide prototype weapons to the Government for test. As such the proprietary rights to the design will remain with Colt's Inc.; however, Colt's envisions a follow-on contract for Engineering development of this concept at which time the Government will receive the rights.

Should additional weapons be required for initial testing over and above the 10 units proposed, a separate quotation will be submitted.

This proposal is valid in all its terms and conditions for sixty (60) days from its date.