A New Species of Gun for the Objective Force

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Outline

• RAVEN Concept
• 35mm RAVEN Implementation
• Experimental Results
• Comments on Blast
• Discussion of Results
Prior Art: DAVIS Gun

- Recoilless
- Accurate
- Capable of High Pressure Propulsion

- Drawbacks:
  - Inefficient
  - Weight
  - Back Blast & Back “Bullet”
RAVEN

How it works

- Initial operation as a closed-breech gun.
- Upon a delayed venting of the chamber RAVEN operates as a recoilless rifle.
- The limiting velocity of the rarefaction wave released by the venting will reduce or eliminate any degradation in projectile propulsion.
- Analogy may be drawn to the rarefaction wave through the driver section of a shock-tube.
Inertial “Blow-Back” Breech

- Intentional rupture of cartridge case.
  - Compatible with combustible case technology.
- Breech travel governed by same propellant pressure that drives the projectile.
- Recoil stroke to vent port and recoil mass determine vent time.
  - Robust, reliable, potentially weaponizable . . . but not the only path forward.
Picture of Test Fixture
Oerlikon KD AA 35mm TP

- 1,175 m/s
- 250 lbs
- 1,100 Ns
- 55 ksi
- 383 MPa
- L 3.1m

- Mp = 0.55 Kg
- Mc = 0.33 Kg
- Mc/Mp = 0.60
The back of the cartridge case was modified to incorporate a rupture notch & accommodate a nylon obturator band.
Internal Workings of Test Fixture

- Shear Plug
- Firing Pin
- Actuator
- Firing Pin Bushing
- Nylon Obturator Band Fit Over Case Head
First Firing, 30 August 2001

- Firing event
First Firing, 30 August 2001

- Case Head Ejection
- Case Body Ejection
First Firing Video
Primary Recoil

The primary recoil rods, utilizing simple copper plumbing tubing as crush tubes worked well.
Non-Venting Pressure Data

Inertial Blow-Back Breech

1135 m/s Muzzle Velocity

Wednesday, April 17, 2002
Pressure Travel Time Curve

Inertial Blow-Back Breech
Heavy/Early RAVEN Pressure Data

1131 m/s Muzzle Velocity 2-3-5

Wednesday, April 17, 2002
Superimposed Chamber Pressure
Light-Nominal-RAVEN vs. Non-Venting

1131 m/s Vented vs 1135 m/s NV
Rarefaction Wave Head Identification

Local Minimum of second derivative of pressure trace is indicative of wave head passage.
Rarefaction Wave Head Identification

- Intersection of exponential fits avoids sensitivity to smoothing drift.
Pressure Travel Time Curve
Light-Nominal-RAVEN

Wave Front Chases Projo Down Bore.
Superimposed Pressure Gradient

Heavy-Early-RAVEN vs. Non-Venting

1131m/s Vented vs 1135m/s NV
Superimposed Pressure Gradient
Heavy-Early-RAVEN vs. Non-Venting

1131 m/s Vented vs 1135 m/s NV
RAVEN

Measured Recoil Reduction

Two Base Lines:
- 51% reduction vs closed breech
- 58% reduction vs inertial breech
Reduced Heat Transfer

- 20% Reduction in Temperature at Mouth of Chamber
Reduced Heat Transfer

50% Reduction Over Muzzle Half of Barrel
Muzzle Velocity

- The inertial breech may be anticipated to reduce muzzle velocity due to energy imparted to breech.

- **Theoretical (Lumped IB) Vs. Test [m/s]**
  - Closed Breech, 1175 vs. 1175 (Matched)
  - Heavy Breech, 1130 vs. 1151
  - Light Breech, 1095 vs. 1100
  - Non Vent Breech, 1124 vs. 1121

CB: 334 Kg, HB: 35.9 Kg, LB: 20.9 Kg, NV: 31.8 Kg
Comparison to Muzzle Brakes

- RAVEN exceeded the performance of a double baffle brake.
- Fitted with a G=1 brake, RAVEN is estimated to nearly halve the remaining M109 momentum.
No Nozzle Throat Erosion

- Metallographic analysis of the edge of the “valve seat” indicate a heat affected zone approximately 5 µm deep.
- Zero Erosion Discerned
- Prior concerns regarding erosion may have been overstated.
- Remains to be seen how it will perform with “hot” propellant.
Potential RAVEN Applications

- Big Guns
- Shoulder Fired Cannon Caliber Kinetic Energy (Anti Tank Rifle)
- Large Caliber Fixed-Wing/Rotor-Craft Cannon

UAV, MAV, & UCAV

FCS
Comments on Back Blast

- Danger zone extent behind prior large caliber recoilless is similar to current TOW missiles.

Source: AMCP 706-238 Recoilless Rifle Weapon systems on 105mm M27 (8 lb,m charge) & FM 23-34 TOW Weapon Systems.
Muzzle Blast

Legacy compatible Ultra-Light 120mm tank gun on a Block I FCS.

The CV90120-T tank has been developed to provide a lighter highly mobile main battle tank with 120mm high pressure smoothbore 120mm gun, battlefield management and extensive defensive aids suite.
ELEVATED TOW SYSTEM (ETS)

The mast mounted TOW system developed by Delco in conjunction with Falck-Schmidt of Denmark provides a unique battlefield capability. Chassis mounted, it is a highly mobile, armored TOW platform capable of reconnaissance and engagement from defilade.
Gun on a Wing-Tip

Advances in composite cannon technology, fire control stabilization, and smart ammunition may work with recoilless operation to provide formidable armament for overwhelming lethality.

U.S. P-51 with 106 mm Recoilless Rifle on each wingtip
Conclusions

• RAVEN concept experimentally validated.
• Dramatic reduction in measured recoil momentum observed w/out compromise in projectile propulsion.
• Substantial reduction in barrel heating observed.

Comments:
• Recoil and Barrel Heating Reduction may prove Enabling for Future Composite Guns.
• Efficient Recoilless Operation Also Viable.