Scalable Gen-Set Concept for Directed Energy Weapons

Presented for:

The 46th Annual NDIA Armaments Systems, Gun & Missiles Conference, Abstract 11828

Aug 29 – Sept 1, 2011

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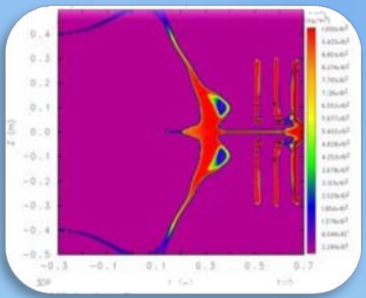
RMSL Background

Energetic Materials Specialists

- Explosives, propellants, pyrotechnics, nano-composites, fuels, oxidizers, etc.
- Design & Synthesis
- Chemical and Material Characterization
- Performance Evaluations



Test Engineering

- Laboratory & Field Studies
- Improvised Explosive Devices
- Munitions

Modeling

- FEA, CFD, Hydrocode, Multi-Physics

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Directed Energy Overview

Pros – Tunable Energy

- Anti-Materiel
- Area Denial
- Vehicle/Vessel Disablement
- Counter-Personnel
- Crowd Dispersal
- Distract/Disorient
- Reversible Effects

Cons – Power & Weight

- Rapid Start
- High Demand
- Short Duration
- Proportional Control
- Portability

Area Denial System – 95 GHz

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Problem Definition

Develop a power supply system that offers the following:

- Near instant response
- High-demand capabilities
- Refueling/recharging/reloading convenience
- Smaller, lighter, and more scalable than other gen-sets
- Potential for man-portable DE systems

IT BECOMES A POWER TO WEIGHT RATIO PROBLEM WITH INTERESTING CONSTRAINTS!

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Power to Weight Statistics

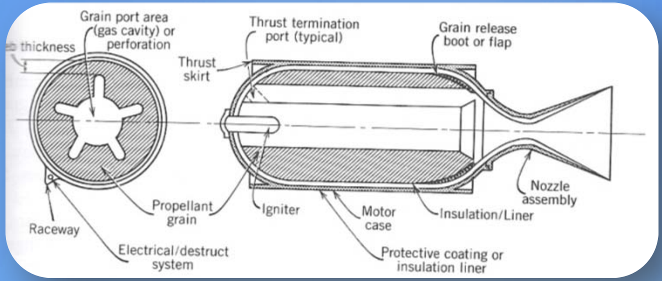
Generator	Type	Power	Weight	Power/Weight
Smart Fuel Cell Jenny 600S[7]	Fuel Cell	.0038 hp	3.8 lbs	**.001 hp/lb**
Energizer 522 Alkaline 9V[6]	Battery	.006 hp	.1 lbs	**.06 hp/lb**
GM 6.6L V8 turbo Diesel[3]	ICP	330 hp	825 lbs	**.4 hp/lb**
Mazda 13B-MSP 1.3 L Wankel[4]	ICR	247 hp	268 lbs	**.92 hp/lb**
BMW V10 3L P84/5[5]	ICP	925 hp	201 lbs	**4.6 hp/lb**
Pratt and Whitney J58[1]	Jet	160,000 hp	6000 lbs	**26.7 hp/lb**

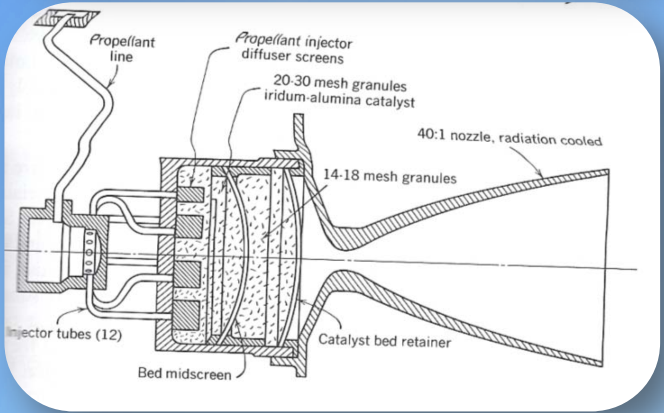
Generator	Type	Thrust	Weight	Thrust/Weight
Pratt and Whitney J58[1]	Jet	150,000 N	26,700 N	**5.62 N/N**
GE90-115B[8]	Jet	511,545 N	81,221 N	**28 N/N**
Pratt and Whitney RD-180[2]	L Rocket	4,152,000 N	53,700 N	**77.3 N/N**
Rocketdyne F-1[9]	L Rocket	7,740,500 N	82,290 N	**94.1 N/N**
Solid Rockets[10]	S Rocket	Varies	Varies	**5 to 200 N/N**

[1] http://www.marchfield.org/sr71a.htm [2] http://www.astronautix.com/engines/rd180.htm [8] http://www.geae.com/engines/commercial/ge90/ge90-115b.html
[3] http://eogld.ecomm.gm.com/images/mediumduty/techspecs/engine.pdf [4] http://www.mazda.com/mazdaspirit/rotary/about/
[5] http://www.allf1.info/engines/bmw.php [6] http://data.energizer.com/PDFs/522.pdf [7] http://www.sfc.com/en/man-portable-jenny.html
[9] http://www.rocketdynearchives.com/engines/f1.html [10] Sutton, George. Rocket Propulsion Elements (1986)

Types of Rocket Motors

- **Solid** – Propellant carries all of it's own oxygen, can be single or multi component.
- **Liquid** – Liquid propellant is injected into combustion chamber. Propellant carries all of it's own oxygen, can be single or multi-component.
- **Hybrid** – Solid fuel with injection of liquid oxidizer, allows for easy adjustment of power.





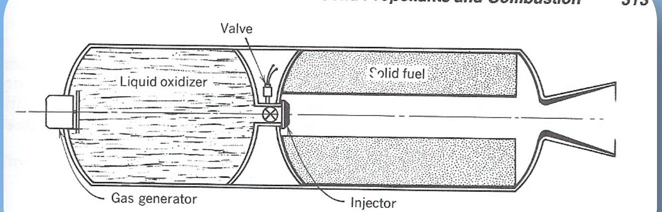
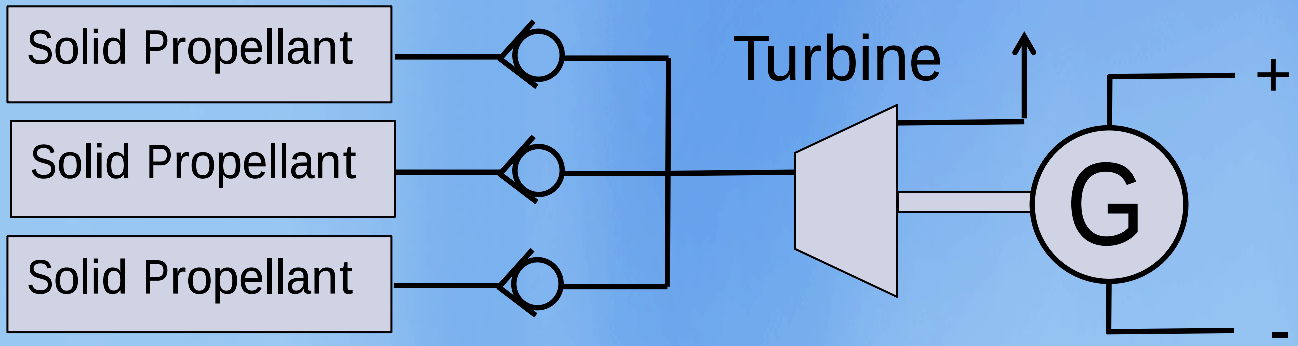


Fig. 11–7. Schematic diagram of a hybrid rocket.

All pictures from Sutton, George. Rocket Propulsion Elements (1986)

Prior-Art Analysis



Existing Patent

- Backup electrical power for aircraft with engine failure
- One or more solid propellant motors
- Turbine power extraction
- Instant response, short duration, light weight (compared to batteries)

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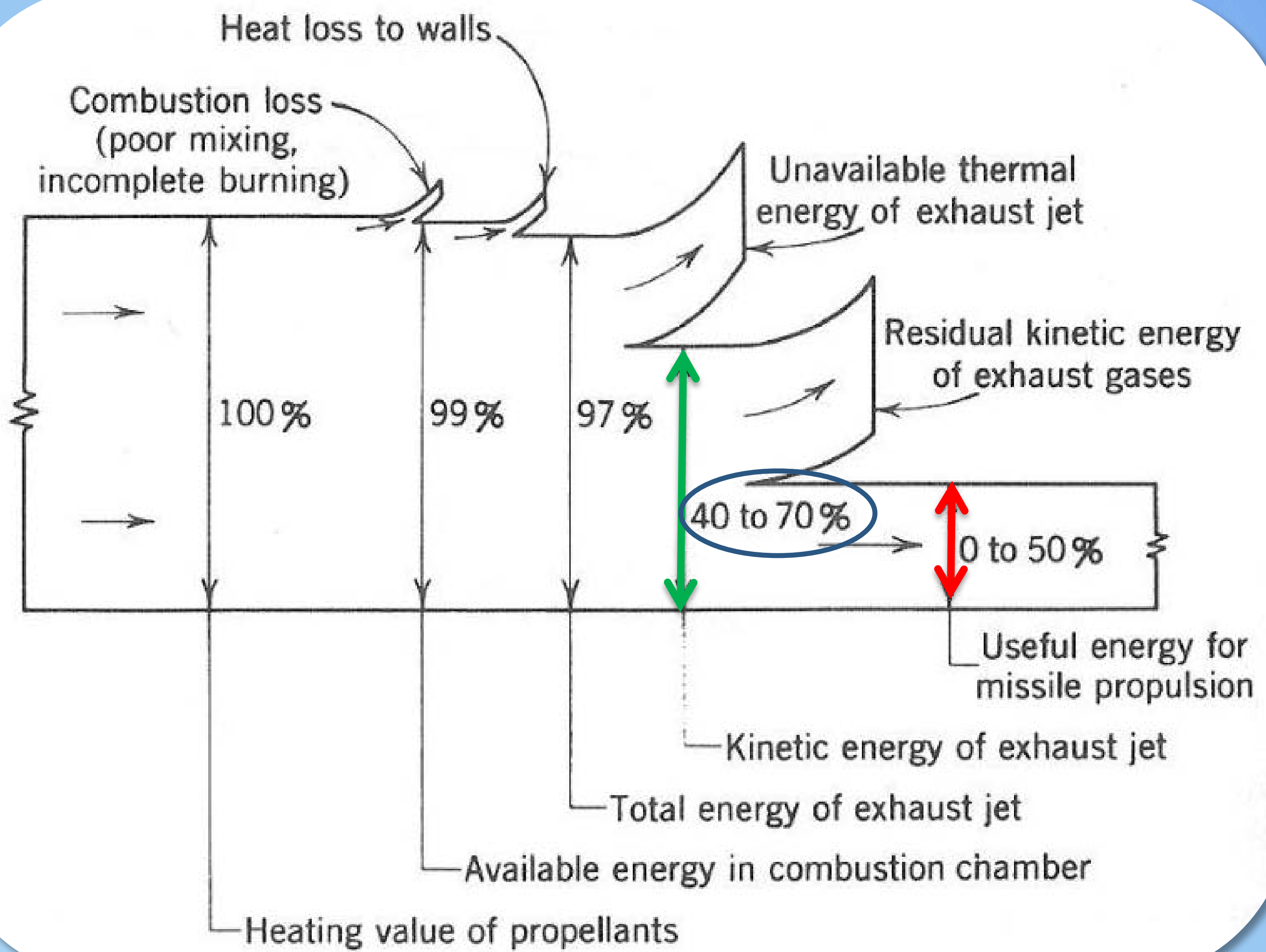
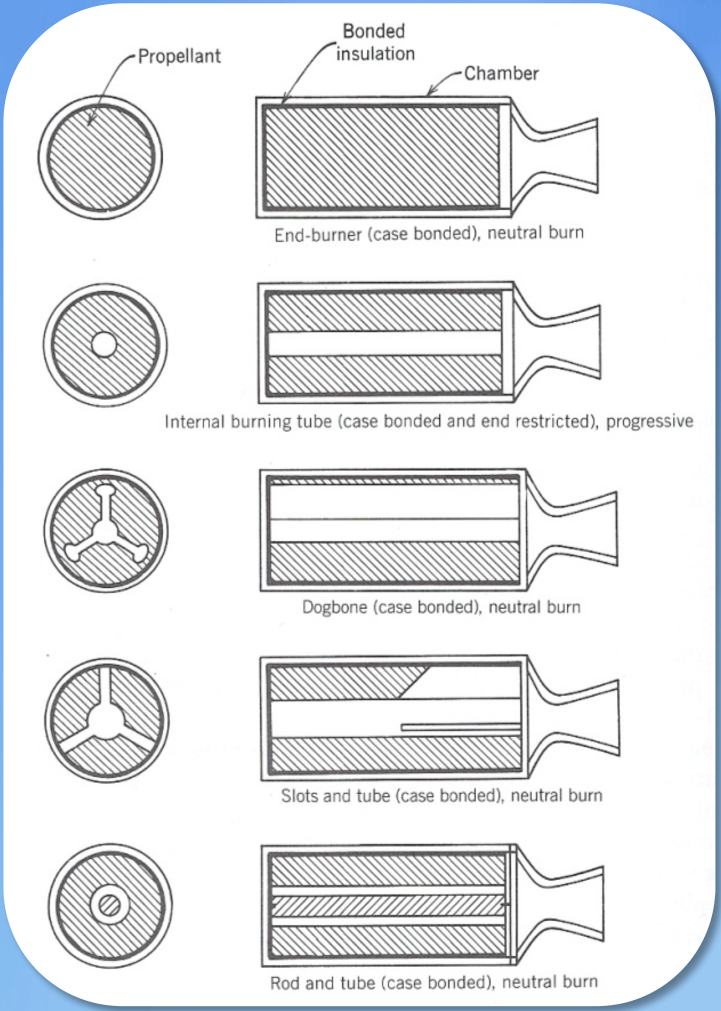
Efficiencies



All pictures from Sutton, George. Rocket Propulsion Elements (1986)

Motor Design Considerations

- Up to 98% of the mass in solid propellant motors can be energetic
- Neutral burn rates keep constant power applied to the turbine
- End-burning propellant configuration increases duration of burn
- Center-perforated motors maximize power
- Hybrid motors allow throttling



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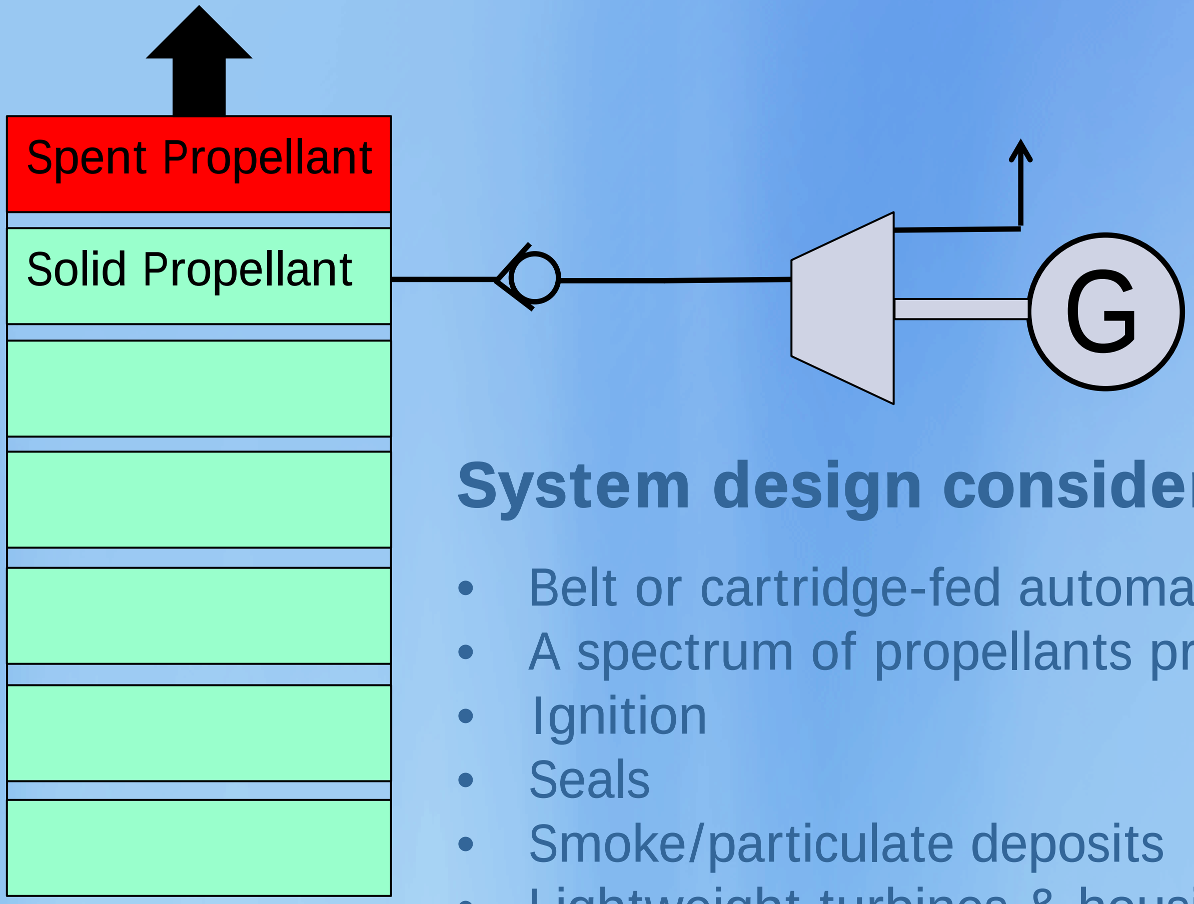
System Integration



System design considerations

- Belt or cartridge-fed automatic loading
- A spectrum of propellants provide varying effects
- Ignition
- Seals
- Smoke/particulate deposits
- Lightweight turbines & housings
- Lightweight generators
- Capatteries (Batteries/Capacitors)

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Weekend Research Project

Version 1.0

- Hobby grade motors (Estes)
- Die grinder turbine
- 18VDC generator, 20,000 RPM
- Worked with air supply
- Worked for seconds with motors

Version 2.0

- Custom motors
- Double based propellant
- Motorcycle turbo
- Size mismatch
- Ruptured motor casings

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Desired End-State

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Conclusions

- Solid propellant gen-sets show promise for DE applications
  - Extensive scalability
  - Propellant motors already in logistics chain
  - Instant response, high power, light weight, reloadable, compact,
- Quantum-leap developments are not always necessary for a significant capability increase
- Recycling/re-applying existing technologies offers a wealth of potential
- Questions?