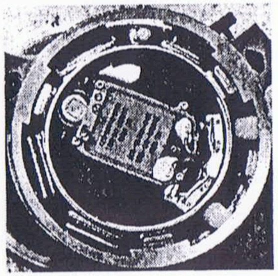
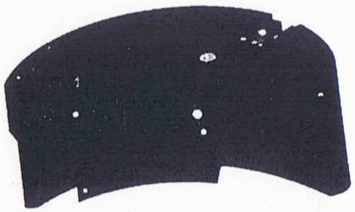
Roadmap for Advanced Firing/Detonation Systems (AF/DS) supports future stockpile needs



Stockpile Firing Systems

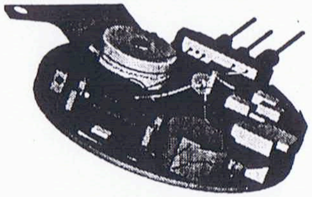


Increased Surety

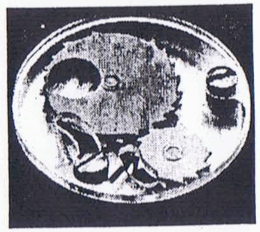
Miniaturization/ Increased System Functionality

Present → Future

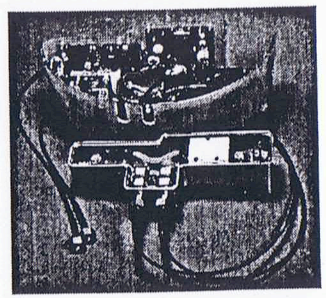
Support Stockpile Life Extension Program



Micro-CDUs



Detonator Stronglinks



Direct Optical Initiation

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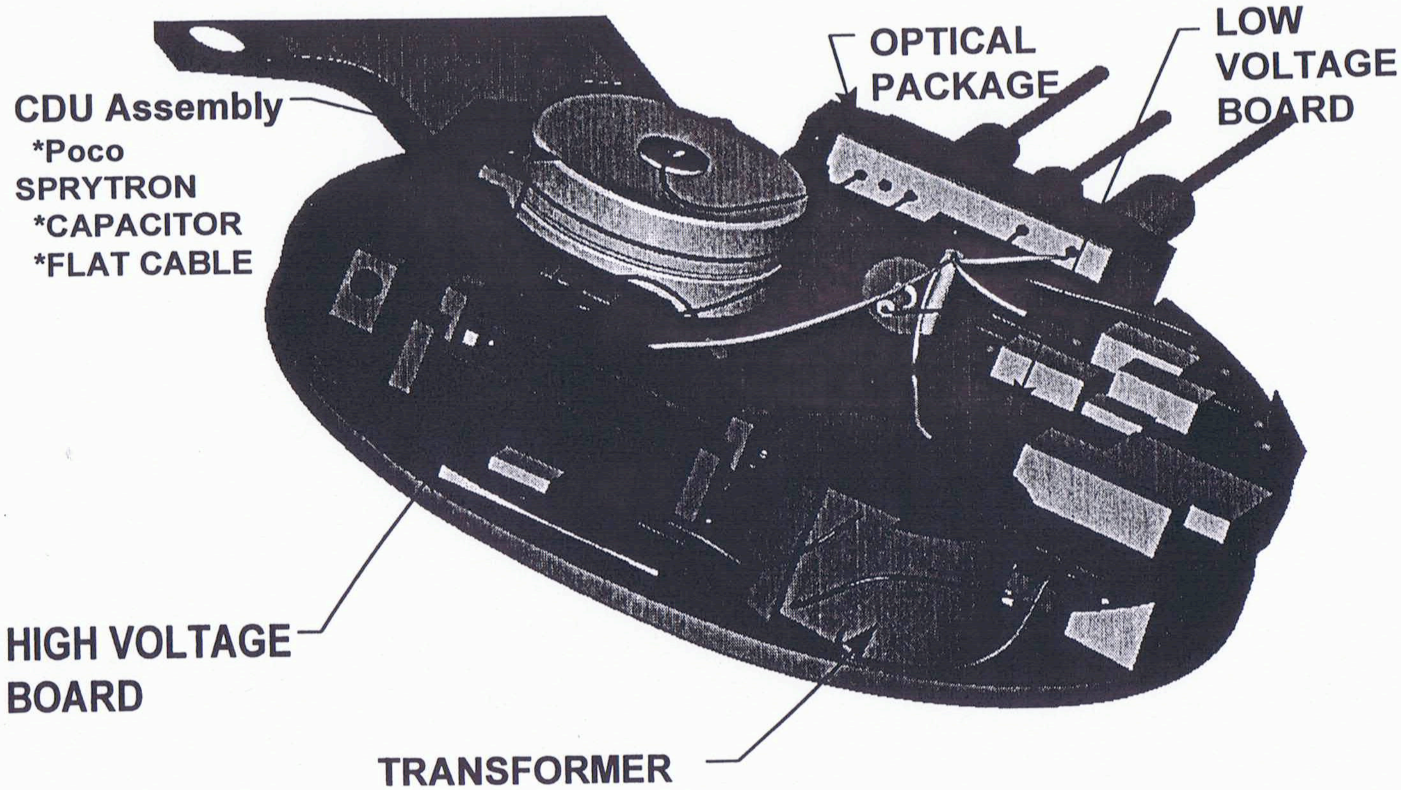
Micro firing set



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Micro CDU firing set working prototype

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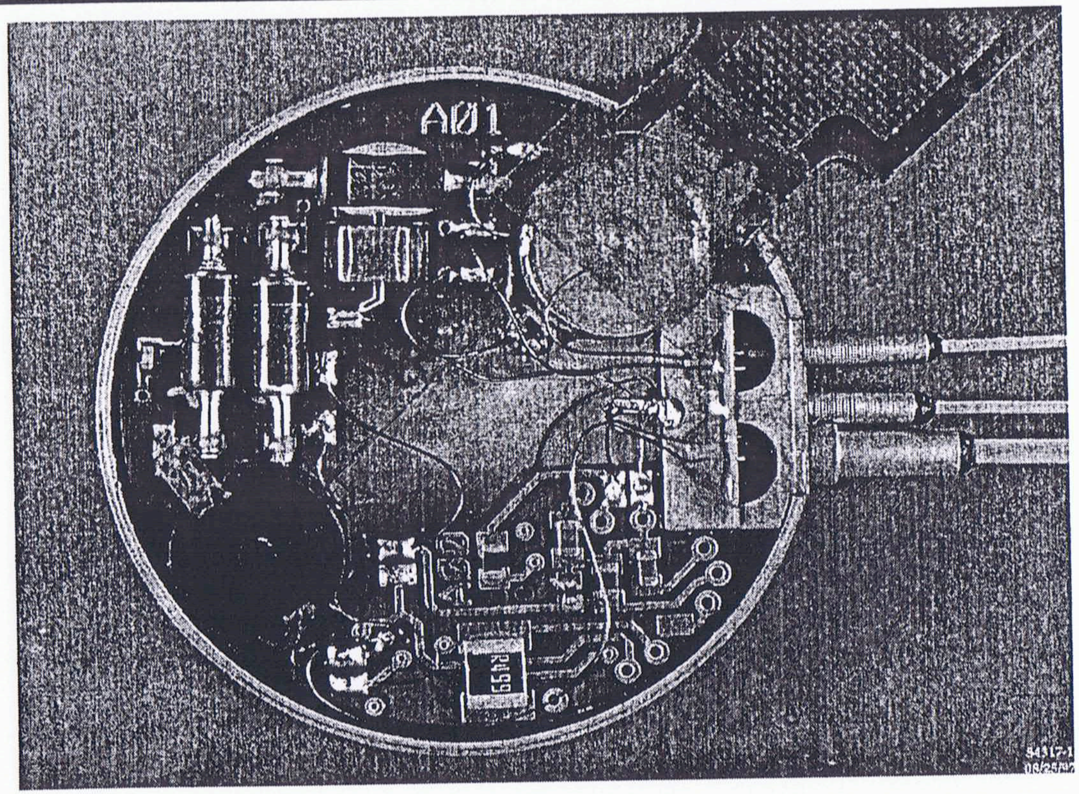

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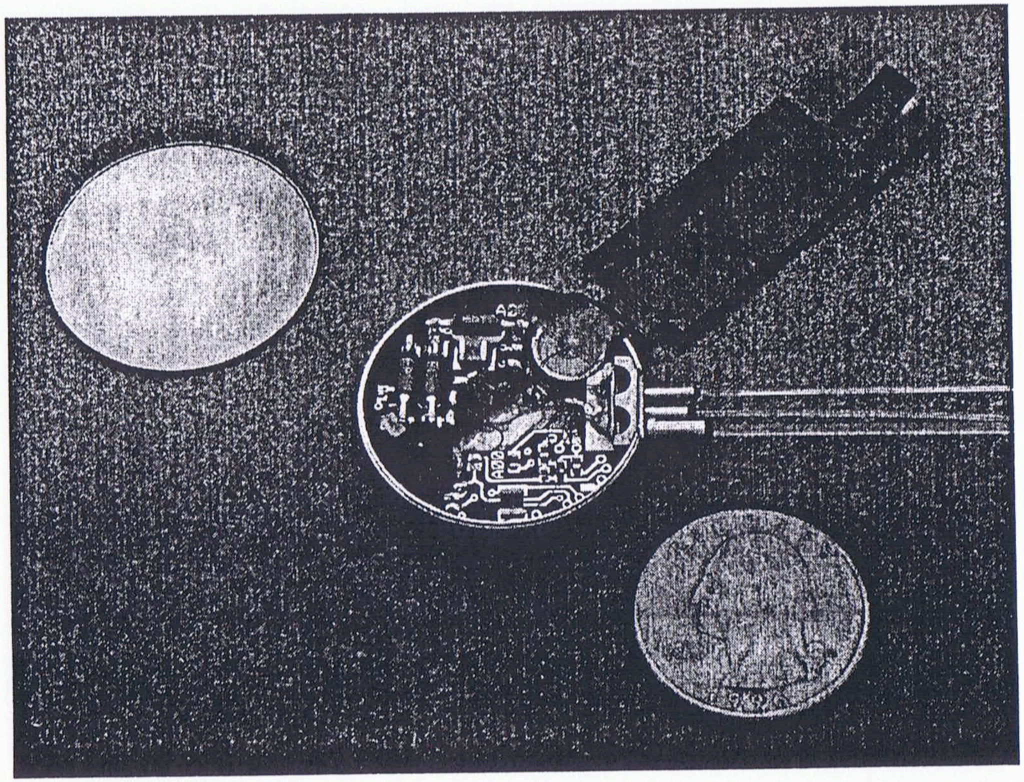
Micro CDU - 0.23 in^3 - Working prototype



Neutron Initiators
Topics to be discussed

- Internal initiators
- External initiators
- Movie - An overview of neutron source technology
- Technology involved
- Evolution of neutron generator development
- Production
- Future systems

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Basics of an Implosion Assembly (IA)

Neutron yield is dependent on ion source material and ion energy

Neutron multiplication rate

There are two fundamental reasons neutron sources are used in weapons

- Jump start the weapon
- Stabilizes the output

Alpha curve

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Show Movie

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Basics of how a neutron tube work

Picture of a neutron tube

Neutron generator using an explosive to electric (EET) power supply

Neutron generator using an electronic power supply

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Implosion Assembly (IA) timing requirements

Neutron generations requirements over time

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Neutron generator timing is affected by several factors

- System center time shift with temperature
- Neutron generator center time shift with temperature
- Neutron generator jitter
- Firing set jitter
- Weapon detonator jitter
- Neutron generator detonator jitter (explosive NG)
- Shift in electronic components (electronic NG)

Neutron generator "family" picture

SNL is now the production agency for neutron generators

- The targets will be loaded at LANL
- The first production requirement is for the W76 (2000)
  - MC4277 Neutron Tube
  - MC4380 Neutron Generator
- Future need for a small tube/generator for W80
  - FY2008? (P&PD 96-0)
  - Requires the small neutron tube, MC4300
  - MC4600 neutron generator

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MC4380 Neutron generator

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MC4300 Neutron Tube

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Design evolution from the MC4300 neutron tube (W76) to the MC4600 neutron tube (future applications)

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Power Systems

- Basic battery types
- Examples of non thermal batteries
- Thermal battery applications
- Thermal battery operation
- Examples of thermal batteries
- Power supply design influences
- Battery performance
- Evolution of Battery Development
- Production
- Future Technology

Basic battery types

- Primary: not rechargeable
  - Active: power immediately available
  - Reserve: must be activated
- Secondary: rechargeable
- Nearly all nuclear weapon batteries are primary batteries
- Most weapon batteries are reserve batteries

Types of power sources in nuclear weapons

- Thermally activated
- Rechargeable - Ni/Cd
- Reserve - Zn/AgO
- Active - Li/SO_2
- Active and reserve - Li/$SOCL_2$
- RTG (fissionable heat source)
  - Radio isotropic Thermal electric Generator (RTG)
- Double-layer capacitor

Non thermal battery applications

- SA2039

Picture of a generic thermal battery

Picture of thermal battery cell

- Current
- Voltage
- Anode, cathode, electrolite
- Thermal vs current handling requirements

Thermal batteries are used in many nuclear weapon applications

- RADARs
- Programmers
- Timer
- Firing sets
- Spin rocked motors
- Parachute deployment
- Telemetry
- Command disable
- Command enable
- Fin activation

What is a thermal battery?

- Thermal batteries are primary reserve batteries that employ inorganic salt electrolytes, which are nonconductive solids at ambient temperatures, and integral pyrotechnic materials scaled to supply sufficient thermal energy to melt the electrolyte.

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Movie

- **Thermal Battery Ignition**

Thermal battery performance- voltage - with constant load

Thermal battery performance- current - with constant load

Calcium chromate performance

Lithium battery performance

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b(3)

Power supply design influences

- Reliability (0.995 - 0.997)
- Shelf life - Thermal battery > 25 years
- Ruggedness - W82 AFAP application
- Operating temperature
- Current density
- Pulse capability
- Voltage - determined by cell chemistry

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Thermal batteries are mechanically and environmentally robust

- Example of the W82 AFAP MC3714 environmental requirements
  - Spin: 18,000 rpm
  - Setback acceleration : 17,000 g's, 10 ms
  - Angular acceleration: 40,000 rad/sec^2
  - Ramming shock: 440 g, 1.83 ms, haversine
  - Rebound acceleration: 4000 g's 0.3 ms

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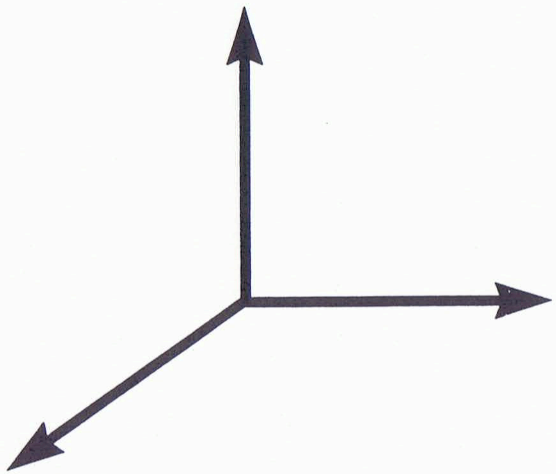
The three dimensional design space for batteries is volume, performance, and life



Picture showing thermal battery performance versus size

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Typical thermal battery performance Values based on Li(Si)/FeS_2 system

Battery Type	Active Life (sec)	Min Volts (v)	Current Density (mA/cm^2)	Specific Power (W/Kg)	Volume (cc)
Pulse	0.050	17.5	7500	8000	10
Pulse	5	26	1000	1700	10
Power	200	12	1800	740	1640
Power	60	25	300	260	137
Power	120	26	120	80	360
Power	1200	26	100	80	320
Long Life	4500	13	55	18	320

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Examples of batteries used in the US nuclear weapons program

Weapon	Technology	Cell Voltage	Approx. Date
Little Boy	Lead Acid	2.0 volts	1945
Fat Man	Lead Acid	2.0 volts	1945
MK4,5,6,7	Nickel-Cadium	1.2 volts	1953
MK15	Thermal $CA\text{-}CaCr0_4$	2.5 volts	1955
W62	Silver-Zinc	1.8 volts	1970
W70	Thermal Li/FeS_2	1.9 volts	1973
B83	Thermal Li/CoS_2	1.8 volts	1980's

W76 thermal battery

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MC2936 thermal battery

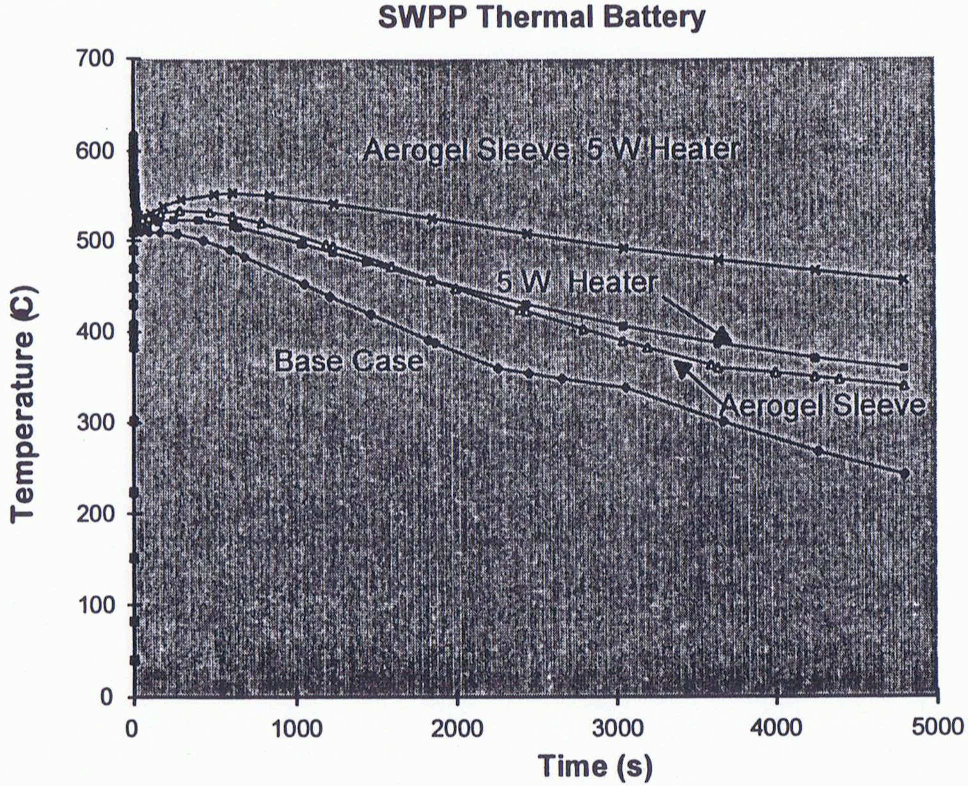
Battery production is currently taking place at three production agencies (PAs)

- Eagle Pitcher
  - The primary PA which resulted from the nonnuclear reconfiguration study
- SNL
  - The backup site for production which resulted from the nonnuclear reconfiguration study
- Enser Corporation - Private Corporation
  - Recently formed out of Martin Marietta Specialty Components, Inc. (GEND, Pinellas Plant)

Battery production is at a low level

Company	Nomenclature	Type	Application	Quantity
Eagle Pitcher	SA3562	Zn/AgO	JTA	~ 2 Dozen
	MC3471A	Thermal	B61	300-400
	MC2736A	Thermal	JTA	~ 2 Dozen
Enser	MC3323A	Thermal	W80 JTA	~ 2 Dozen
SNL	MC4152	Thermal	B61 Common JTA	~ 2 Dozen

Aerogel and a heater may increase battery output without increasing volume



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