SURVEY OF WEAPONS DEVELOPMENT AND TECHNOLOGY

WR708

SECRET

UNCLASSIFIED

SESSION XI

- DETONATORS
- FIRING SYSTEMS
- NEUTRONS INITIATION
- POWER SUPPLIES

UNCLASSIFIED

SECRET

Topics to be discussed

- Review of implosion assembly (IA) operation
- Review of stockpile detonators
- Firing system components
- Operation of explosive firing sets
- Stockpile firing sets
- Nuclear safety
- Production
- Future systems

Assumptions for briefing

- Students have an undergraduate background in engineering or science

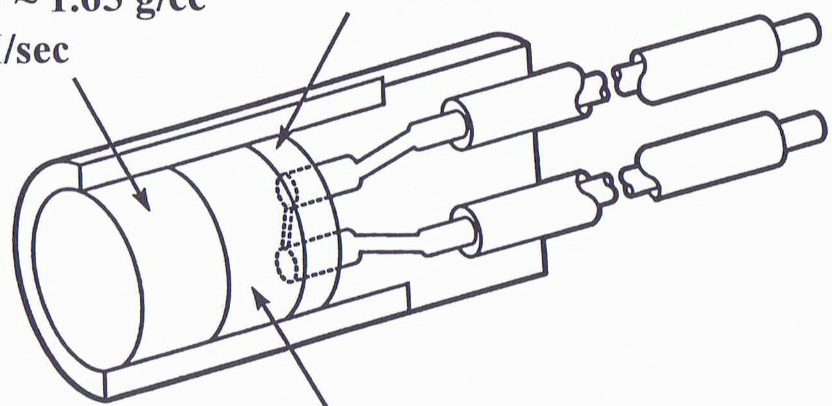
Basics of an Implosion Assembly (IA)

~~SECRET~~ UNCLASSIFIED

Typical hot wire detonator
(Firing current ~ 5 amps)

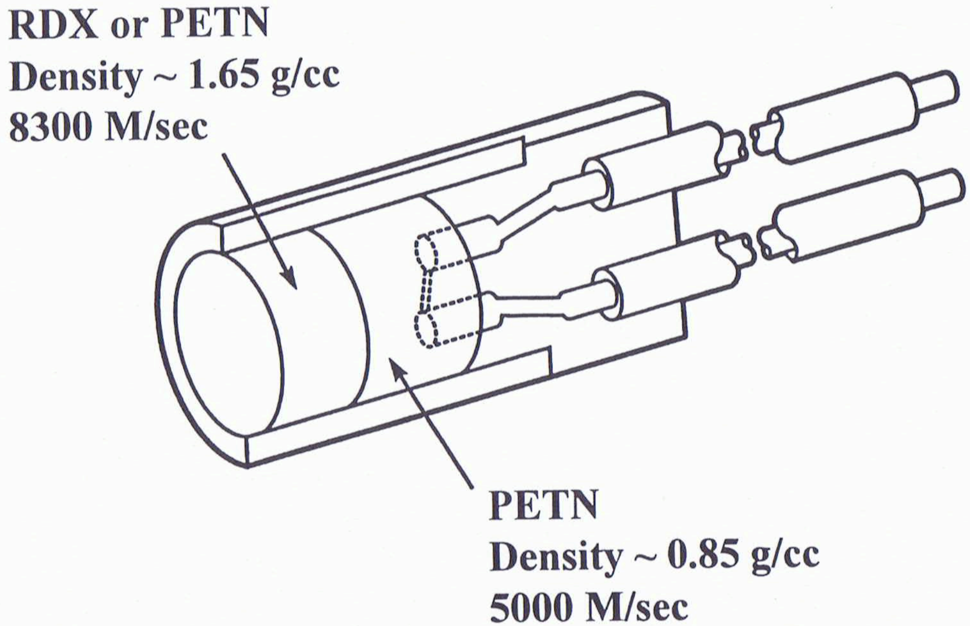
RDX or PETN
Density ~ 1.65 g/cc
8300 M/sec

Lead Styphnate
Density ~3.0 g/cc
5200 M/sec

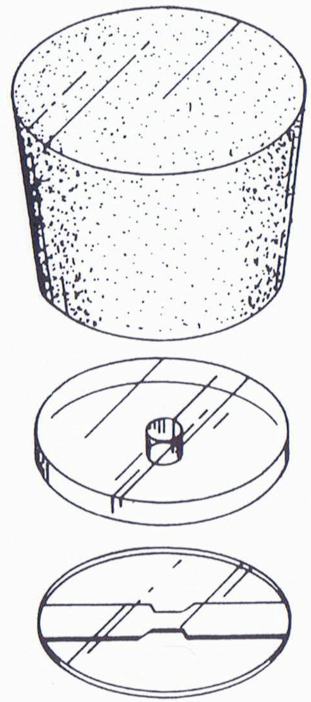


Lead Azide
Density ~ 4.0 g/cc
5100 M/sec

An exploding bridgewire (EBW) detonator (1.5 X 40 mil gold) initiation requires ~ 300 amps



A basic exploding foil initiator (EFI), slapper detonator, consists of three components



Secondary Explosive Pellet (Typically HNS IV)

Insulating disk with barrel (hole)

Etched metal foil with insulated flyer

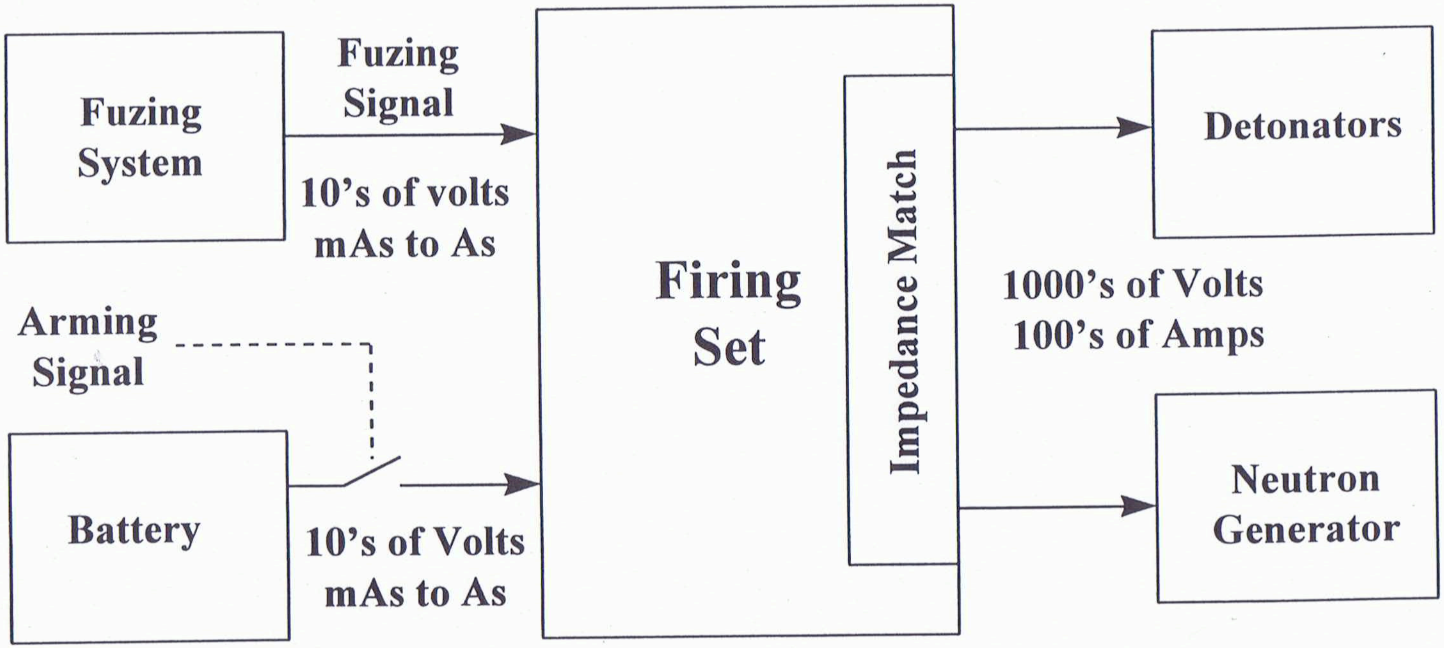
The Mechanical Safe and Arm Device (MSAD) controls the detonator pellet in the W84 and W87

EBW and EFI comparison for detonators which requires approximately the same initiation energy

	Exploding Bridge Wire	Exploding Foil Initiator
Energy	250 mJ	250 mJ
Current	1000 Amps	2,500 Amps
Function time	2.0 μs	0.5 μs
Energy coupled into explosive	~ 20 % of stored energy	~ 5 % of stored energy
Explosive	PETN (0.8 gm/cc)	HNS (1.6 gm/cc)
HE melting point	140° C (100° C degrades)	320° C (doesn't degrade)

* EBWs need recovery; slappers don't.
* Slappers are more environmentally rugged.

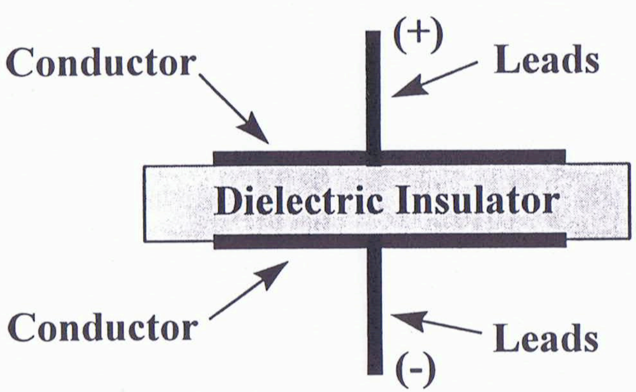
Firing set provides: 1) Low to high voltage/current conversion; 2) Fuze/Fire interface; & 3) Det/NG interface

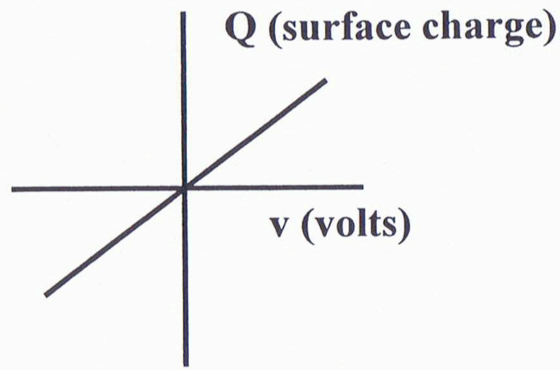


{Arming, Fuzing and Firing (AF&F)}

b(3)

What is a capacitor? Basically two conductors seperated by a dielectric



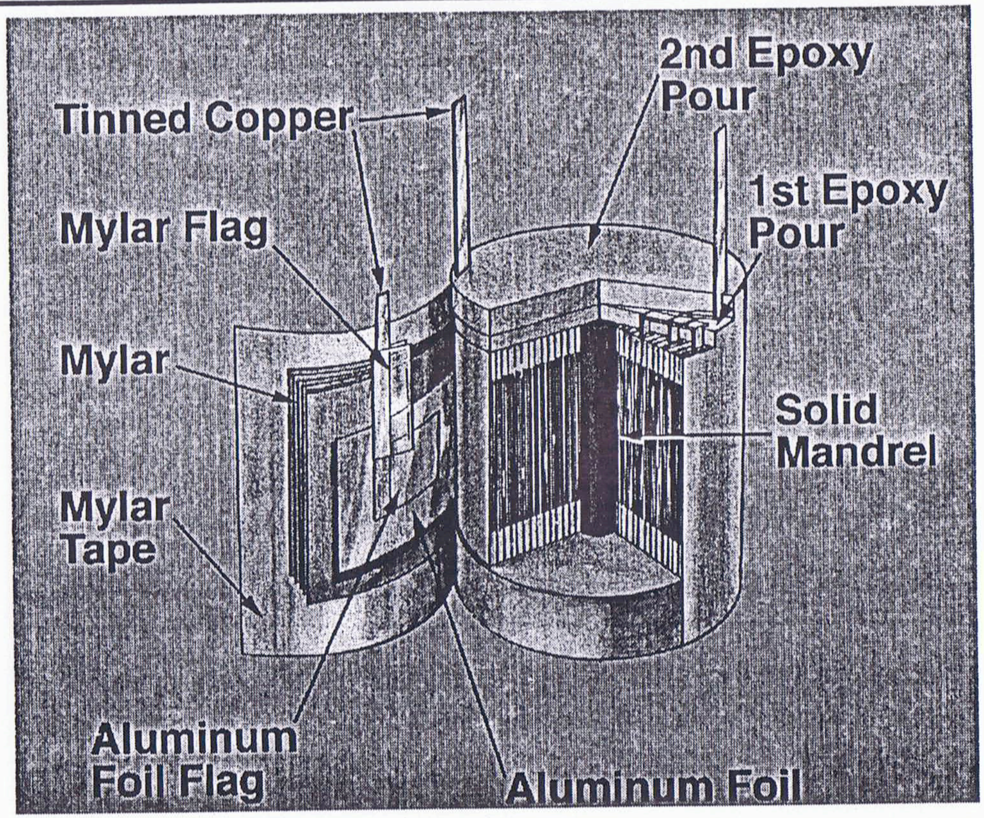


$$\text{Energy} = 1/2\ CV^2 = 1/2\frac{Q^2}{C}$$

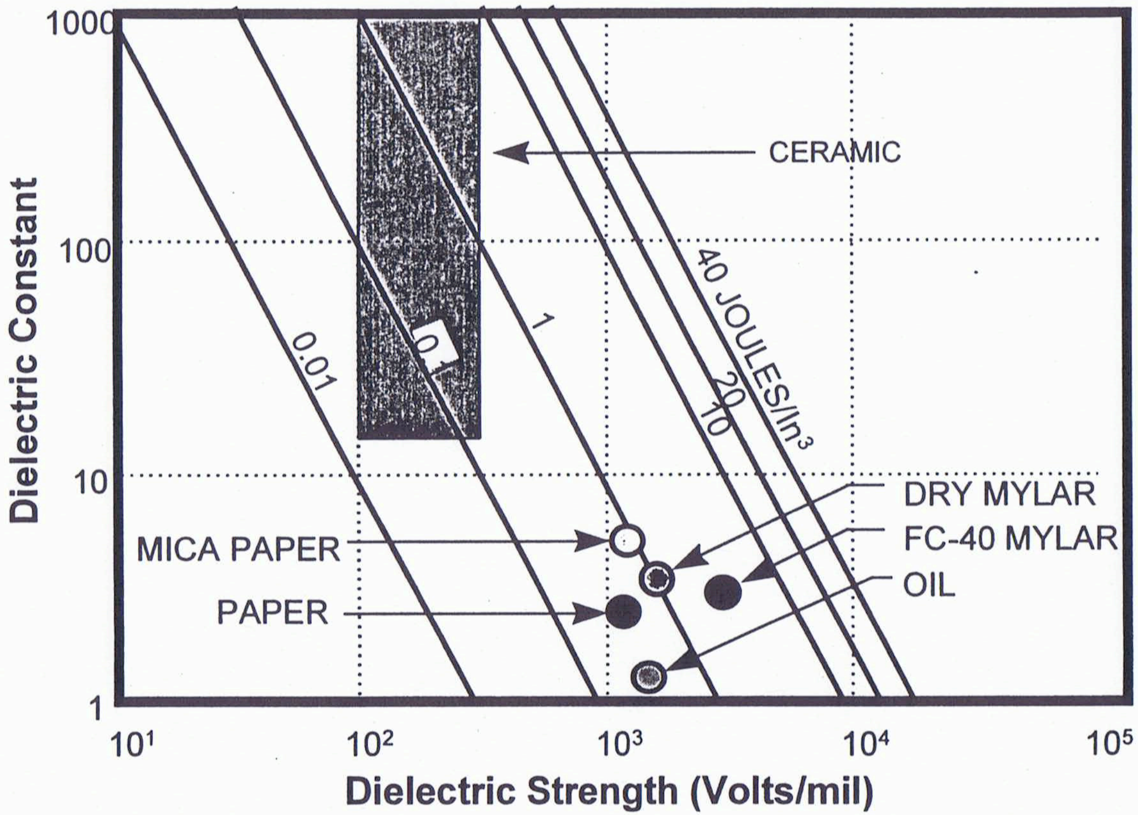
- Q is the charge in coulombs
- C is the capacitance in farads
- V is the potential in volts

UNCLASSIFIED ~~SECRET~~

High voltage firing set capacitor (High Energy Density (HED) capacitor)



Tradeoff of dielectric strength and dielectric constant - at field use condition

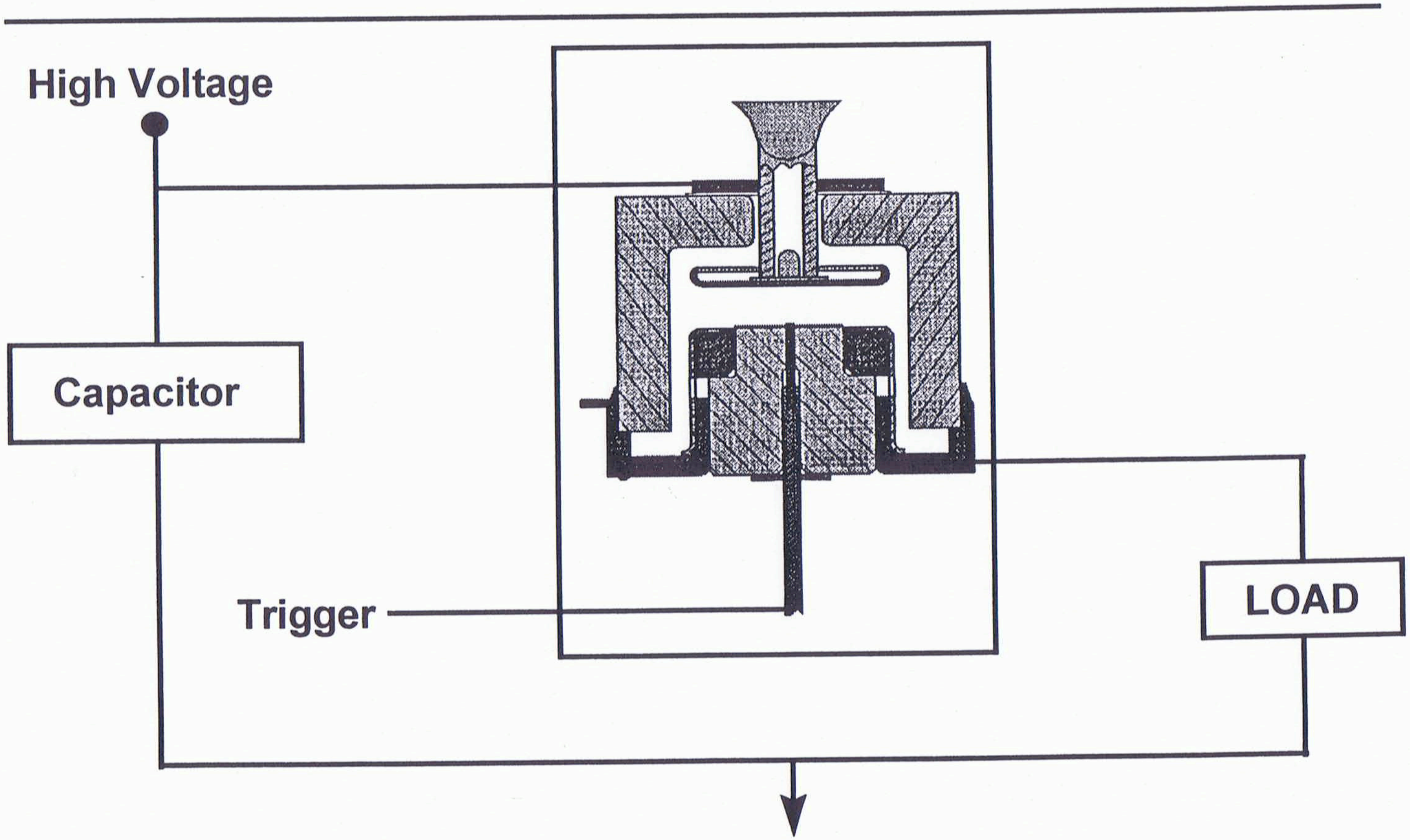


Firing set capacitor bank for a large number of detonators

UNCLASSIFIED ~~SECRET~~

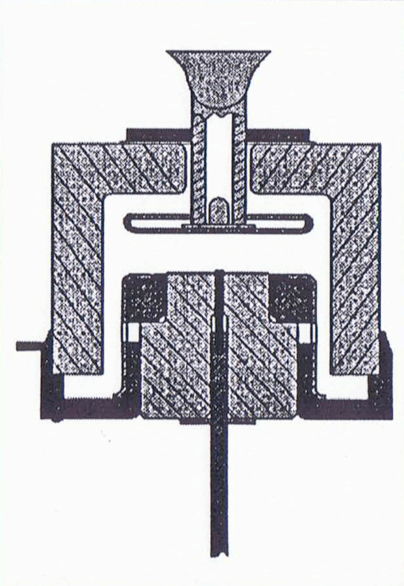
Examples of high energy density capacitors

Basic operation of a switch tube



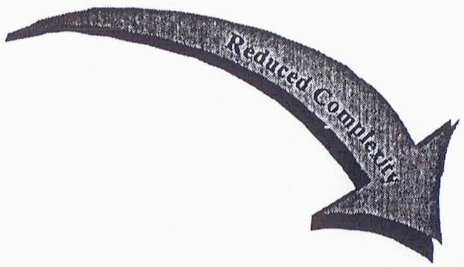
Vacuum and gas switches

Technology shift has led to reduced complexity and more repeatable processes

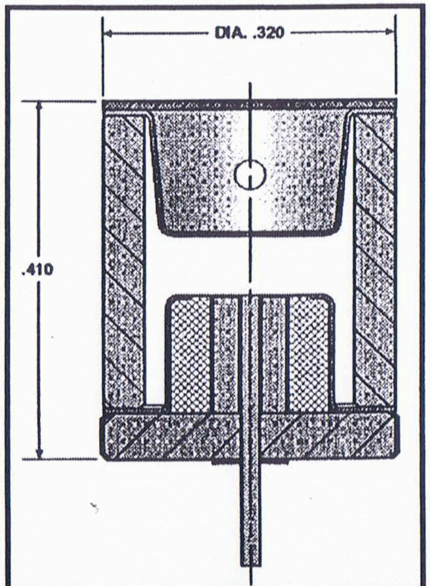


Typical Sprytron

❶ Fab/Test Cycle Time ~ 2-4 months
❷ Unit Cost ~ $2-3K
❸ Facility Space ~ 65,000 sq. ft.
❹ Facility Cost ~ $5M
❺ Multiple operations to closure

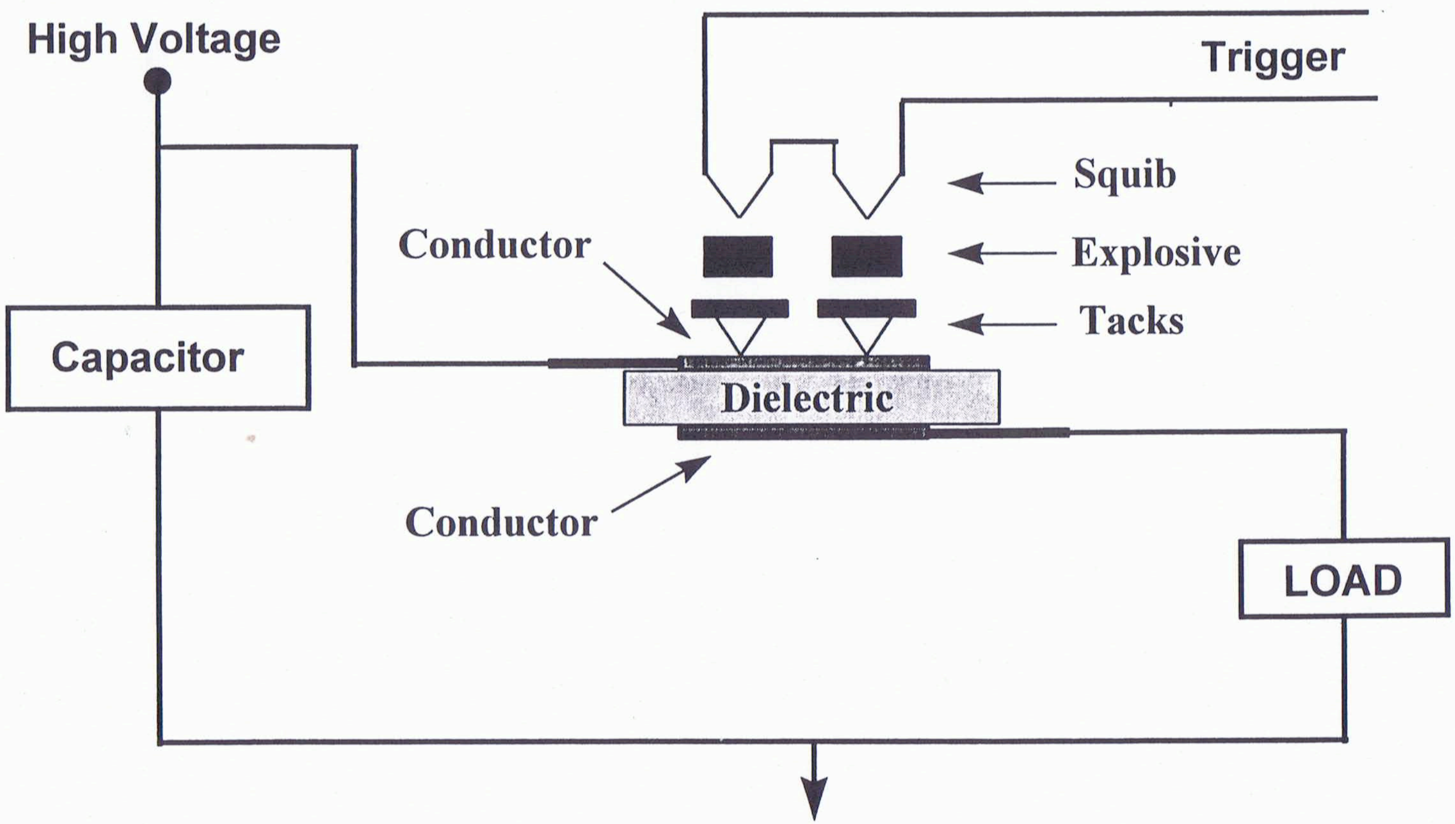


❶ Fab/Test Cycle Time ~ 2-4 weeks
❷ Unit Cost ~ $200-400
❸ Facility Space ~ 5,000 sq. ft.
❹ Facility Cost ~ $1M
❺ Single Step closure



Poco Sprytron

Explosive tack switch system - (Solid dielectric switch (SDS), Explosively driven switch)

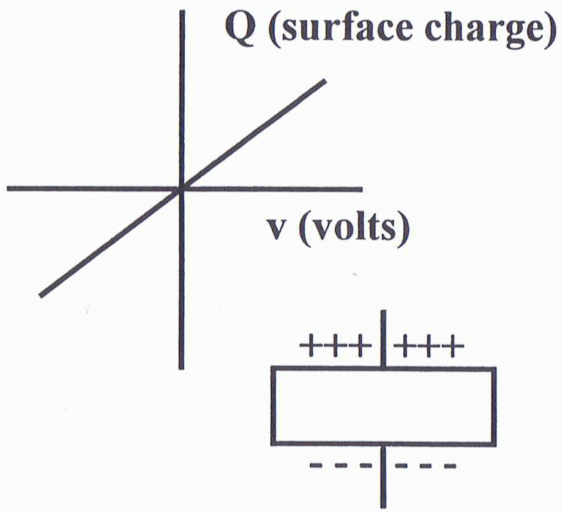


There are two technology areas that have been employed in the stockpile

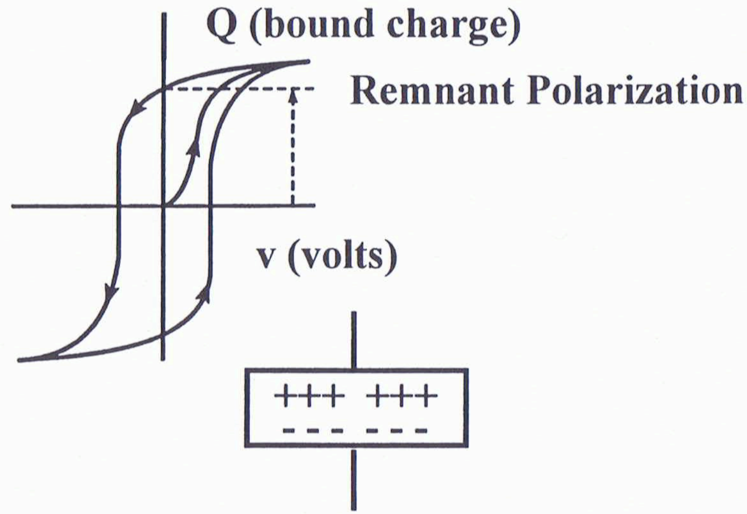
- Capacitor Discharge Unit (CDU) Firing Set
  - Typically all electric
  - Re-testable when it is all electric
- Explosive-to-Electric Transducers (EETs)
  - Chemical energy from explosives are used in the production of electrical energy
  - Single pulse or one shot device

Ferroelectric (FE) material retains a bound charge like a capacitor retains a surface charge

CDU

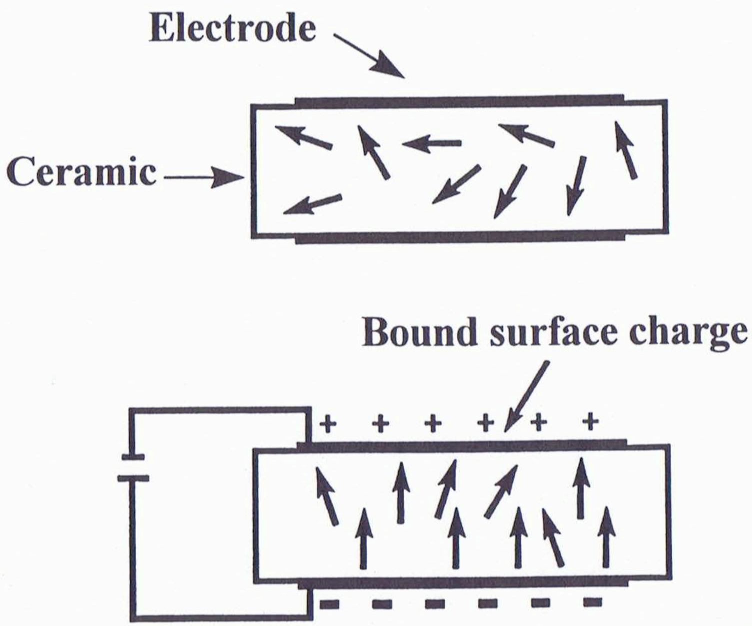


FE



$$\text{Energy} = 1/2\, CV^2 = 1/2 \frac{Q^2}{C}$$

Bound charges are formed in a ferroelectric (FE) material during poling process



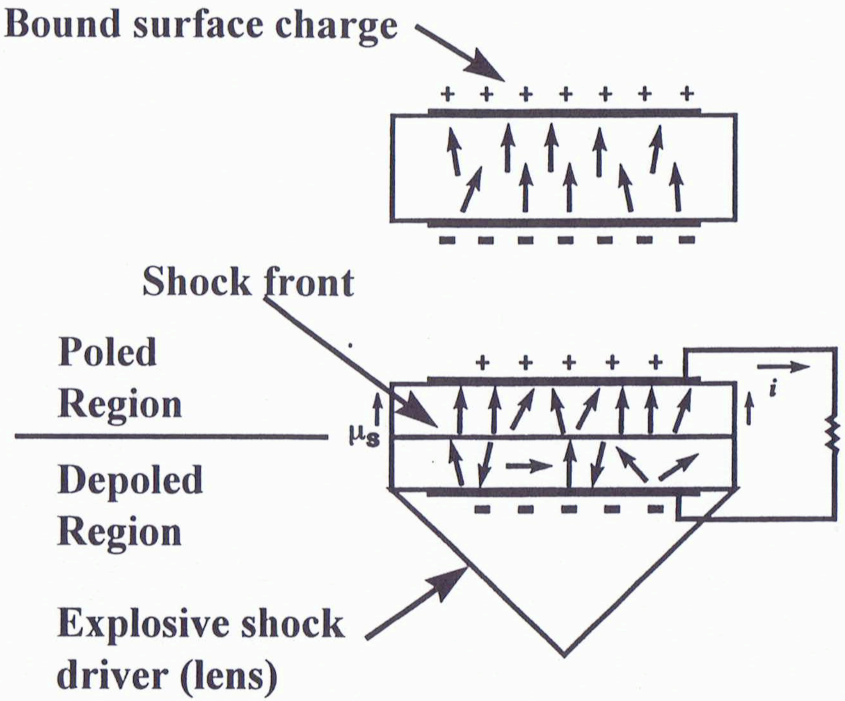
Unpoled Ceramic

Polycrystaline multidomain ferroelectric ceramic

Polling Process

Domains aligned by impressing external electric field

A shock wave of the correct magnitude releases bound charges in ferroelectric (FE) material



<u>Poled Ceramic</u>
Bound surface charge remains due to internal electric field

<u>Shock Depoling Process</u>
Shock wave randomizes dipoles elminating internal field, thus freeing bound charge to external circuit.

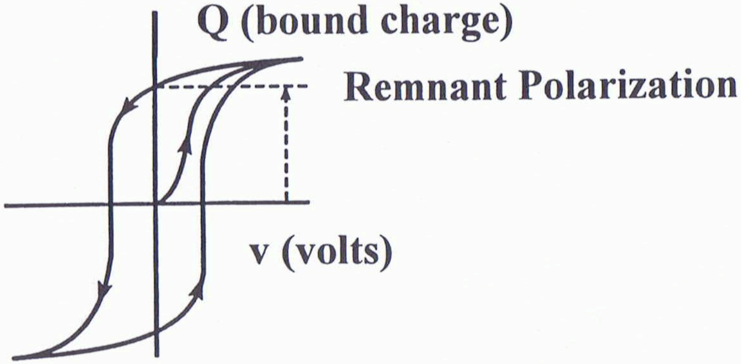
Ferroelectric firing set

B54 and/or Isolator

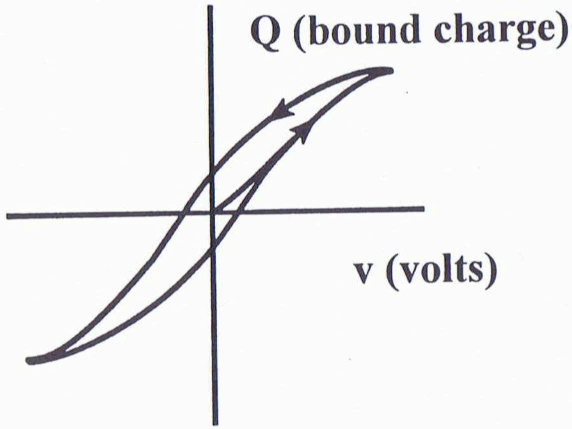
Define isolator and where it is used and why it is used

Slim Loop Ferroelectric (SFE) material reduces remnant polarization to fraction of a micro coulomb

FE



SFE



$$\text{Energy} = 1/2\ CV^2 = 1/2 \frac{Q^2}{C}$$

MC3028 Firing set

SECRET

UNCLASSIFIED

SECRET

Firing set technology comparisons

Firing Set Technology	Typical Application	Relative Advantages	Relative Disadvantages
CDU	Bombs & Cruise missiles	Retestable no HE	Special effort to Harden
FE	Isolators	Power source not required, small, inherently rad hard	HE required Stored energy
SFE	Missiles (RBs, RVs)	Small, inherently rad hard	HE required Requires trigger
FM	Artillery shells (AFAPs)	Fastest arm/disarm Small, rad hard	HE required
CMF	Under ground testing (UGT)	Large output current & energy, rad hard	Long function time, HE required, requires timed trigger

Firing sets have many complex requirements beyond that of initiating detonators

- Firing set complexity may be driven by
  - Nuclear safety
  - Radiation
  - Use control
  - Housing/mounting for other components
  - Testability
  - Manufacturability
  - Cost
- There may not be syngerism between requirements

Nuclear safety requirements require the implementation of several complex features

Principles	Implementation
Isolation	Barriers, Strong links
Inoperability	Weak links, Colocation
Incompatibility	Unique signal operated devices
Independence	Multiple independent safety subsystems

Firing system with enhanced nuclear detonation system (ENDS) features

~~SECRET~~

UNCLASSIFIED

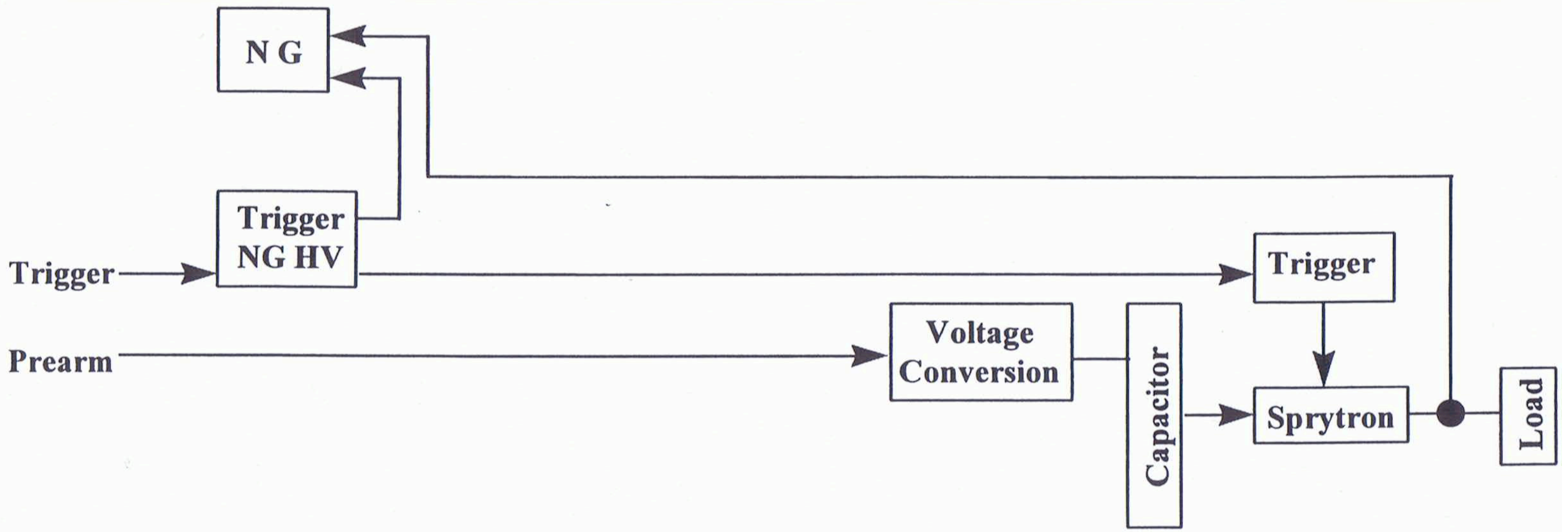
~~SECRET~~

Capacitor technology - tradeoff of thermal weak link properties and radiation properties

Packaging of the printed wiring assembly (PWA) in the B83 firing set <u>before</u> "sylgard 184 GMB"

Packaging of the printed wiring assembly (PWA) in the B83 firing set after "sylgard 184 GMB"

Simple nuclear weapon firing set



b (3)

~~SECRET~~

UNCLASSIFIED

Firing systems in the active stockpile

Firing sets and detonators in the active stockpile

Firing set production is ongoing at a low level

Weapon	MC Number	Technology	Quantity
B83	MC3971A	CDU	~ 10/month ongoing
W87	MC3719	CDU	~ 3-4/month starting 1998