The Evolution of the Detonator

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The Evolution of the Detonator

PRESENTATION OVERVIEW

- Background
- History
- Evolution
  - Plain, Electric, Electric Delay, Detonating Cord, NONEL® and Electronic
- Future Advancements
- Summary

NONEL® is a registered trademark of Dyno Nobel Asia Pacific Limited
BACKGROUND

- Detonator is a device designed to explode and initiate a high explosive.
- Contain sensitive explosive charges encased in cylindrical metal shell.
- Various detonators categorised with respect to initiation signal energy source, i.e. non-electric, electric, electronic.
- Different strengths dependent on amount of base charge contained and identified by strength number.
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**HISTORY**

- Black powder first used to fragment rock in mining in early 1600s
  - Extremely dangerous as unreliable burning speed, resulting in many deaths

- Hazardous ignition overcome in 1831 with invention of ‘Miners Safety Fuse’ by William Bickford
  - Rope with a strand of yarn infused with black powder

**Mining initiation timeline**

- 1627: Black Powder First Used
- 1831: Invention of Safety Fuse
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HISTORY

- Discovery of Nitroglycerine in 1846 by Ascanio Sobrero
- Safe manufacture in 1880s for industrial use
  - More powerful than black powder
  - Accidents resulted from borehole ignition by safety fuse and black powder
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HISTORY

Hazardous ignition overcome in 1863 with development of ‘practical detonator’ by Alfred Nobel

- Wooden plug of black powder inserted into larger charge of liquid nitroglycerine, enclosed in metal shell

Nobel experimented with design and eventually developed a mercury blasting cap in 1865
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HISTORY

- Mercury blasting cap opened door for all subsequent high explosive use
- All detonator advancements based on original mercury blasting cap

Mining initiation timeline (cont)
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**EVOLUTION**

Plain Detonator

- Substitution of expensive fulminate with a primary (initiating) charge and a base charge of high explosive
- Primary charge of ASA
- Base charge of PETN or RDX

Plain detonator cross section (Olofsson, 1988)
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Instantaneous Electric Detonator

- First prototype emerged late 1880s
- Replacement of safety fuse with electric wires connected to a fusehead
- Initiation via electric current passed through leg wires
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Electric Detonator
- Two cotton insulated leg wires, ignition mixture of mercury fulminate, high-resistance platinum bridge wire and a sulfur plug
- Detonated via ‘the exploder’ patent by H. Julius Smith, making initiation easy and safe
- Design changed slightly over the years

1880s electric detonator cross section

The exploder
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Delay Electric Detonator
- Same as instantaneous electric detonator, except for inclusion of delay powder train
- Delay time based on length and composition of delay powder
- Half-second delay early 1900s, millisecond delay 1943

Electric delay detonator cross section (Olofsson, 1988)
ELECTRIC DETONATOR

Advantages:
- Higher degree of safety – remove blaster from shot
- Total control of initiation time
- Circuit Testing
- Better results with delays - different applications such as bench, trench and tunnel blasting
- Reduction in air blasts and ground vibration
- Could be used in U/G gassy coal mines, where safety fuse was outlawed – copper substituted for aluminium
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ELECTRIC DETONATOR

Disadvantages
- Risk of premature detonation!
- Extraneous sources of electricity such as lightning, static stray currents and radio frequency energy
- Again driving need to find alternative initiation system
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Detonating Cord

- Strong, flexible, continuous detonator
- Developed in 1907 in France and called Cordeau
- Consisted of lead tube enclosing TNT, burning at 4900m/s
- Nowadays, PETN cotton core surrounded by various textile combinations, plastics and waterproofing materials
- Burning speed in excess of 7000m/s
DETONATING CORD

Advantages:

- Versatile, safe for use in extraneous electricity environments, simultaneously firing without detonators, no hole limit, totally consumed, inexpensive
- Incorporation of delay connector in 1950, allowed sequential blasting of larger patterns than electric

Disadvantages:

- Noisy initiation, large amount of cord movement, disruption to stemming column when down the hole
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EVOLUTION

NONEL

- Total non-electric initiation system developed in 1960s by Dyno Nobel
- Products hit the market in 1973, offering all the advantages of electric initiation and detonating cord but none of the disadvantages
- Range included the NONEL detonator connected to NONEL tube along with surface and downhole delays and surface connectors
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- NONEL tube (shock tube) transmits shock wave to NONEL detonator
- Shock wave results from tube coating of reactive powders and travels at 2100m/s
- Minimal noise and cord movement
NONEL

Advantages:
- Noiseless, still initiation, downhole delays, simplified tie-in patterns, no hole limit, reduction in air blasts/ground vibration, safe to use in extraneous electricity environments

Disadvantages:
- Lack of circuit testing
- Expensive
EVOLUTION

- Electronic
  - Idea of electronics first discussed beginning 1990s
  - Recognised potential to increase detonator accuracy and improve customer results
  - Costly technology served as a deterrent
  - Minesite drive to increase accuracy, resulted in various manufacturers beginning to develop and market versions of electronic detonators
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EVOLUTION

Electronic

- Several different designs, fundamental structure basically the same
- Computer chip used to control delay timing which uses electrical energy stored in one or more capacitors to provide power for timing clock and initiation energy
- Therefore delay is achieved electronically not pyrotechnically (powder)
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Detonator differences (Wiggin, 2003)
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Electronic

Advantages:
- Higher precision
- Improved blasting results (one to several thousand ms delay)
- Reduce downstream costs
- Increased flexibility (programming with LU in borehole)
- Environmental – reduce air blasts/ground vibration
- Streamline stock management
- Circuit functionality testing (2-way communication with LU)
- Used safely in extraneous electricity environments
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Electronic

Disadvantages:

- Limit to the amount of detonators per shot (controlled by LU and Blasting Machine)
- Increased cost per detonator unit
- Intensive user training
FUTURE ADVANCEMENTS

- Original initiation advancements driven by need to increase miner safety
- However as mining became more competitive, better results and precision provided additional catalysts
- Today three main factors of initiation purchase:
  1. Price – Mining industry continually driving blast accessory prices down
  2. Ease of Product Use
  3. Reliability (Market Equity, 2002)
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FUTURE ADVANCEMENTS

Market Success:
- Have to satisfy customer needs
- Need to alter ‘why bother changing’ attitude
- Provide ‘after sales service’
- Design initiation system to achieve best desired results for particular purpose i.e, cast blasting, coal blasting, trench blasting, etc
- Efficient, flexible and precise as productivity demands
FUTURE ADVANCEMENTS

Electronic Initiation:
- Needs to overcome increased cost
- Present usage of the system requires intensive training and needs to be simplified, i.e. system needs to implement with ease, without major changes
- The evolution of electronics needs to be based on customer needs!
SUMMARY

- Evolution of detonation systems has changed over the years based on customer needs
- Development of different systems for different customer markets
- Inclusion of electronic detonators will be challenging as customers have to be convinced of benefits
- As technology advances and customer needs change, detonation systems need to continue to be parallel to this to ensure market success