



# Introduction to a Firing Train



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# Overview

- Definition, Purpose, and Components of a Firing Train
- Power Source
- Switch
- Initiator
- Booster
- Main Charge
- Trends / Analysis
- Glossary



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# Definition, Purpose, and Components of a Firing Train

- **Definition**
  - A succession of initiating and igniting elements arranged to cause a charge to function\*
- **Purpose**
  - A firing train is necessary to ensure the efficient detonation of an improvised explosive device (IED) because of the differing sensitivities of military, commercial, and homemade explosives
  - The explosive used as the main charge of the device will determine the length and construction of the firing train
- A firing train may contain some or all of the following components:



 = Mandatory component

\* Weapons Technical Intelligence (WTI) Improvised Explosive Device (IED) Lexicon, dated 6 June 2007.



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# Power Source

- This component provides the electrical energy to the initiator
- There are two different types of electrical power sources:
  - Direct Current (DC)
  - Alternating Current (AC)
- In most IEDs, the power source is provided in the form of electricity through batteries
- Power may also be supplied through an electrical wall outlet, though this setup would be tactically limiting as the IED would have to be emplaced near an outlet to receive power



Battery attached to a timer switch



Power cord



Battery attached to a remote control switch



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# Switch

- The switch component of the firing train serves to make, break, or change a connection
- There are three different types of switches, which incorporate both electric and non-electric schemes:
  - Command (remote control, doorbell, etc.)
  - Time (clock or watch)
  - Victim-Operated (pressure, tension/pull, etc.)



*Doorbell switch*



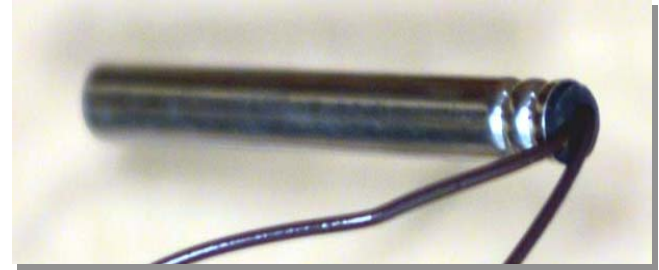
*Switch using a clock*



*Active infrared (AIR) switch*

# Initiator

- The initiator in the firing train starts the deflagration or detonation of the device by providing the necessary heat, shock, and/or friction
- There are two different types of initiators:
  - Electric (blasting caps, igniters, light bulbs, etc.)
  - Non-electric (safety fuse, detonating cord, non-electric blasting caps, percussion cap, etc.)
- The type of initiator used varies according to the sensitivity of the main charge of the IED
  - The presence of a booster charge will also determine the type of initiator used



*Electric blasting cap*



*Detonating cord (detcord)*



*Percussion caps*



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# Booster

- A booster charge is an optional component of a firing train that is used when the main charge of the IED is an insensitive high explosive, such as HMX (high molecular weight RDX) or ANFO (ammonium nitrate fuel oil), neither of which are blasting cap-sensitive
- Explosives used as booster charges include PETN (pentaerythritol tetranitrate) and RDX (cyclonite), and TNT (trinitrotoluene), all of which are cap-sensitive high explosives
- The booster charge provides the necessary kinetic energy to ensure successful detonation of an insensitive high explosive



*Pentolite (PETN and TNT) cast booster*

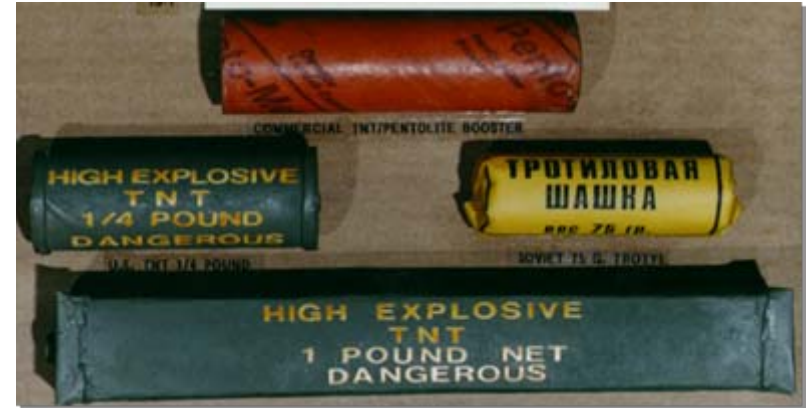


*Booster containing combination of PETN, RDX, and TNT*

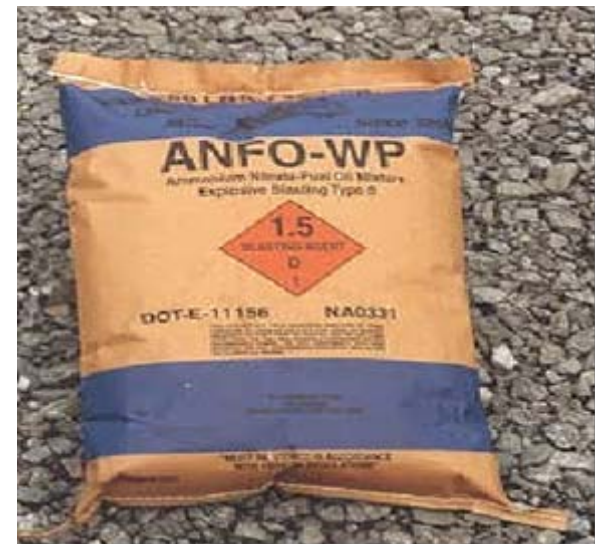


# Main Charge

- The main charge provides an explosion by its own energy when initiated
- While there are three overall categories of explosives (commercial, military, and homemade\*), every explosive is also categorized by its sensitivity to heat, shock, and friction:
  - **Most Sensitive:** low explosives (black powder, smokeless powder)
  - **Moderately Sensitive:** primary high explosives (mercury fulminate, lead azide)
  - **Least Sensitive:** secondary high explosives (ANFO, RDX, TNT)



Examples of different blocks of TNT



Commercial ANFO

•For more information on explosives, please see the Introduction to Explosives presentation on TRIPwire



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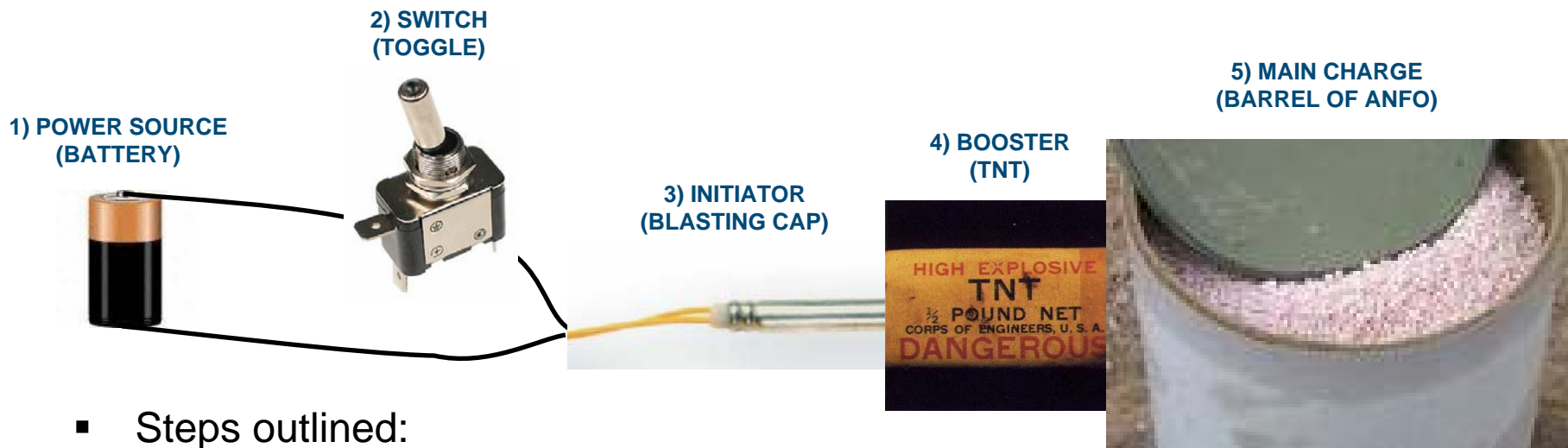
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# Trends / Analysis

- The most basic firing train for an IED with a secondary high explosive as its main charge contains all five firing train components (steps):



- Steps outlined:

- 1) The power source supplies electricity to the circuit
- 2) The switch closes the circuit to supply power to the initiator
- 3) The initiator provides required kinetic energy to detonate the booster charge
- 4) The booster charge detonates, creating the required “boost” in kinetic energy needed to detonate the insensitive main charge
- 5) The main charge detonates



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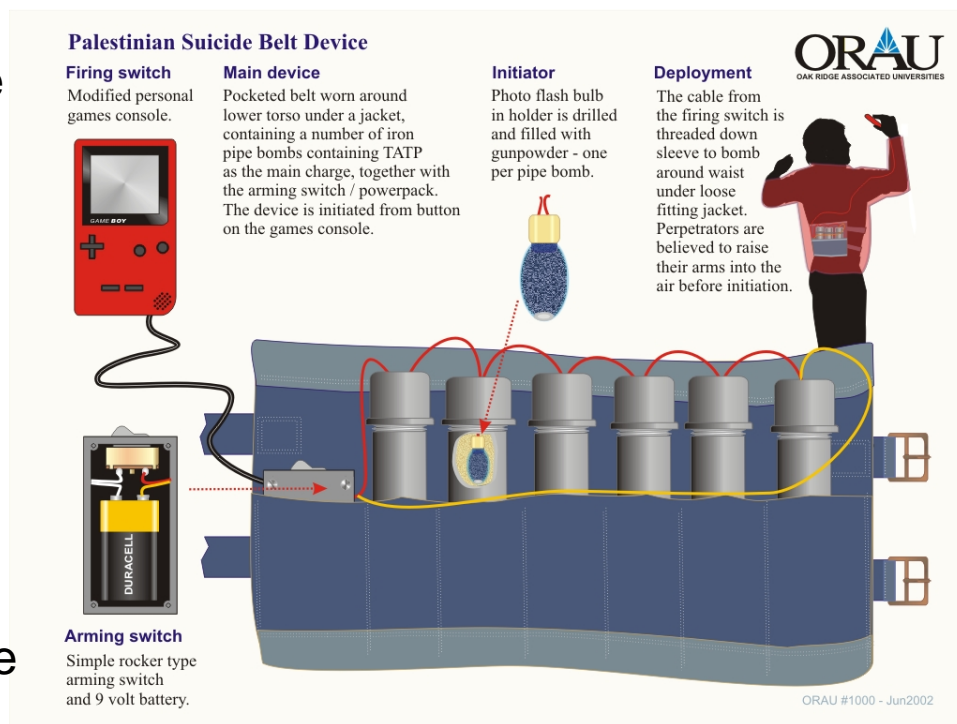
# Trends / Analysis Continued

- However, depending on the sophistication of the device and the explosives incorporated, a firing train may contain as few as two components
- The most sensitive explosives (low explosives, peroxide-based explosives such as TATP, HMTD) do not need all five components of a firing train for detonation
- **Example:** Pipe bomb
  - Main charge is usually black powder (rated most sensitive to heat, shock, and friction)
  - An initiator such as a safety fuse provides enough heat to ignite the black powder contained inside the pipe
  - A power source, switch, and booster are unnecessary



# Trends / Analysis Continued

- **Example:** Palestinian suicide belt containing improvised components
  - Power source is a battery
  - Switch is a modified gaming console
  - Initiator is a light bulb filled with black powder
  - Main charge is TATP placed inside a pipe
- Once the switch is activated, the light bulb filament becomes hot and ignites the black powder
- The heat created from the black powder is enough to detonate the sensitive TATP contained inside the pipe
- This firing train has four steps (power source, switch, initiator, and main charge), and all but the battery have been improvised



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# Glossary

- ANFO: An acronym for ammonium nitrate and fuel oil
- Blasting Cap: A small tube, usually copper or aluminum, closed at one end and loaded with a charge or charges of sensitive high explosives. They contain three separate charges: an ignition charge, an intermediate charge, and a base charge. Non-electric blasting caps are detonated by the spit of flame or sparks from a time blasting fuse, electric blasting caps are provided with a means for firing by an electric current. Most blasting caps contain a primary high explosive and may also contain a booster (considered more reliable for detonating secondary high explosives).
- Booster: A high explosive element, sufficiently sensitive to be actuated by small explosive elements and powerful enough to cause detonation of the main explosive filler
- Brisance: Property of an explosive which characterizes its shattering (shock force) effect
- Deflagration: The rapid burning of an explosive, at subsonic speed, along the surface of the explosive
- Detonating Cord: Flexible fabric tube containing a filler of high explosive intend to be initiated by a blasting cap. Also called "Primacord."
- Detonation: A detonation is a chemical reaction that propagates with such rapidity that the rate of advance of the reaction zone into the material exceeds the velocity of sound in the material. The rate of advance of the reaction zone is termed "detonation rate" or "detonation velocity." When this rate of advance attains such a value that it will continue without diminution through the entire material it is termed the "stable detonation velocity." When the detonation rate is equal to or greater than the stable detonation velocity of the explosive, the reaction is termed a "high-order detonation." When the detonation rate is lower than the stable detonation velocity of the explosive the reaction is called a "low-order detonation."
- Detonation Velocity: The velocity at which a detonation progresses through an explosive
- Emplace: To put in place or position
- High Explosive: An explosive which normally detonates rather than deflagrates or burns, that is, the rate of advance of the reaction zone into the unreacted material exceeds the velocity of sound in the unreacted material. High explosives are divided into two classes according to their sensitivity to heat and shock: primary high explosives and secondary high explosives.
- HMTD: An acronym for hexamethylene triperoxide diamine
- HMX: An acronym for cyclotetramethylenetetranitramine
- IED: An acronym for improvised explosive device



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# Glossary Continued

- **Initiator:** A chemical compound or electric device that initiates a chain reaction
- **Low Explosive:** An explosive which deflagrates or burns rather than detonates; that is, the rate of advance of the reaction zone into the unreacted material is less than the velocity of sound in the unreacted material. An explosive may react as a low explosive or as a high explosive depending on how it is initiated and confined. For example, a double base propellant when initiated in the usual manner is a low explosive, but can be made to detonate if it is initiated by an intense shock. Conversely, a high explosive like TNT can be ignited by flame and will burn without detonating under certain conditions. Low explosives include propellants, certain primer mixtures, black powder, photoflash powders, and delay compositions.
- **Main Charge:** The main explosive component of a device, as opposed to the primary or booster elements. Generally the least sensitive and most powerful element.
- **Percussion Cap:** A thin metal cap containing an explosive substance (such as mercury fulminate) that explodes on being struck
- **PETN:** An acronym for pentaerythritol tetranitrate
- **Power Source:** The source of power that stores or creates electrical energy for an electrically initiated IED
- **Primary High Explosive:** An explosive which is extremely sensitive to heat and shock that is normally used to initiate a secondary high explosive. The term is generally used to refer to a pure compound rather than to an explosive mixture. A primary high explosive is capable of proceeding from deflagration to detonation in an extremely short distance and time, it can also propagate a detonation wave in an extremely small diameter column. Upon slow heating primary high explosives will generally decompose explosively while still in the solid state, while secondary high explosives will melt before undergoing an explosive reaction. This characteristic of primary high explosives is true for mercury fulminate, lead azide, lead styphnate, and tetracene. However, data are not available for all primary high explosives.
- **RDX:** An acronym for cyclonite
- **Safety Fuse:** A pyrotechnic contained in a flexible and weatherproof sheath burning at a timed and constant rate, used to transmit a flame to the initiator.
- **Secondary High Explosive:** An explosive relatively insensitive to heat and shock, and usually initiated by a primary high explosive. It requires a relatively long distance and time to build up from a deflagration to detonation and will not propagate in extremely small diameter columns. Used for boosters and bursting charges. Sometimes called non-initiating high explosives. Examples include dynamite, TNT, RDX, PETN, and HMX.



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# Glossary Continued

- Sensitivity: An explosive's susceptibility to initiation by externally applied energy
- Switch: A device that opens or closes an electrical current. Explosive devices may utilize multiple sophisticated switching systems.
- TATP: An acronym for triacetone triperoxide
- TNT: An acronym to trinitrotoluene



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