How Landmines Work

One of the most deadly legacies of the 20th century is the use of **landmines** in warfare. Anti-personnel landmines continue to have tragic, unintended consequences years after a battle and even the entire war has ended. As time passes, the location of landmines is often forgotten, even by those who planted them. These mines continue to be functional for many decades, causing further damage, injury and death.

Landmines are basically explosive devices that are designed to explode when triggered by pressure or a tripwire. These devices are typically found on or just below the surface of the ground. The purpose of mines when used by armed forces is to disable any person or vehicle that comes into contact with it by an explosion or fragments released at high speeds.

Currently, there are more than 100-million landmines located in 70 countries around the world, according to OneWorld International. Since 1975, landmines have killed or maimed more than 1-million people, which has led to a worldwide effort to ban further landmine use and clear away existing landmines. In this article, we will look at the different types of landmines, their basic operation and the techniques used to clear mine fields.

Landmine Basics

Landmines are easy-to-make, cheap and effective weapons that can be deployed easily over large areas to prevent enemy movements. Mines are typically placed in the ground by hand, but there are also **mechanical minelayers** that can plow the earth and drop and bury mines at specific intervals.

Mines are often laid in groups, called **mine fields**, and are designed to prevent the enemy from passing through a certain area, or sometimes to force an enemy through a particular area. An army also will use landmines to slow an enemy until reinforcements can arrive. While more than 350 varieties of mines exist, they can be broken into two categories:

- **Anti-personnel (AP) mines**
- **Anti-tank (AT) mines**

The basic function of both of these types of landmines is the same, but there are a couple of key differences between them. Anti-tank mines are typically larger and contain several times more explosive material than anti-personnel mines. There is enough explosive in an anti-tank mine to destroy a tank or truck, as well as kill people in or around the vehicle. Additionally, more pressure is usually required for an anti-tank mine to detonate. Most of these mines are found on roads, bridges and large clearances where tanks may travel.

Landmine Terms

- **Belleville spring** - A piece of curved steel shaped like a doughnut, used to cushion heavy loads
- **Black powder** - A gunpowder used as an explosive, typically made of potassium nitrate or sodium nitrate, charcoal and sulfur
- **Delay element** - A chemical compound that burns for a set time before igniting a fuse or explosive
- **Detonator** - A small amount of explosive used to ignite larger amounts of explosive
- **Firing pin** - The metal pin that is forced down into the detonator when the mine is activated
- **Fuse** - A combustible material used to ignite an explosive charge
- **Igniter** - A metal rod (in bounding mines) that protrudes from the ground, triggering the mine when it's stepped on; also called the **striker**
- **Magnetic mine** - A mine equipped with magnets, triggered by large metal objects entering its immediate area
- **Main charge** - The large of amount of explosive in the mine that causes it to explode
- **Percussion cap** - A chemical compound detonated by striking or applying pressure to it
- **Pressure plate** - The metal disc on top of the mine that depresses and triggers the mine when stepped on
- **Projectiles** - Metal balls or glass fragments placed in the mine to cause greater injuries to victims (The mine's metal casing can also become projectiles after the mine explodes.)
- **Propelling charge** - A small amount of explosive placed at the bottom of a bounding mine to propel it into the air
- **Safety pin/clip** - A pin placed in the mine to prevent it from being activated while not in use

Anti-personnel Mines

Anti-personnel landmines are designed specifically to reroute or push back foot soldiers from a given geographic area. These mines can kill or disable their victims, and are activated by pressure, tripwire or remote detonation. There are also **smart mines**, which automatically de-activate themselves after a certain amount of time. These are the most common types of mines currently used by the U.S. military.

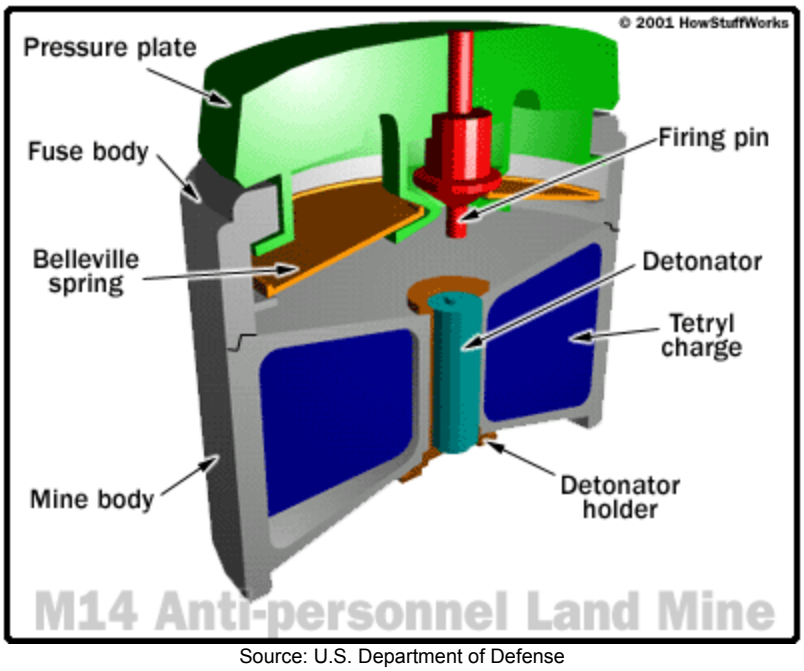
Anti-personnel mines fit into three basic categories:

- **Blast** - The most common type of mine, blast mines are buried no deeper than a few centimeters and are generally triggered by someone stepping on the **pressure plate**, applying about 11 to 35.3 pounds (5 to 16 kg) of pressure. These mines are designed to destroy an object in close proximity, such as a person's foot or leg. A blast mine is designed to break the targeted object into fragments, which can cause secondary damage, such as infection and amputation.
- **Bounding** - Usually buried with only a small part of the **igniter** protruding from the ground, these mines are pressure or tripwire activated. You may also hear this type of mine referred to as a "**Bouncing Betty**." When activated, the igniter sets off a **propelling charge**, lifting the mine about 1 meter into the air. The mine then ignites a main charge, causing injury to a person's head and chest.
- **Fragmentation** - These mines release fragments in all directions, or can be arranged to send fragments in one direction (**directional fragmentation mines**). These mines can cause injury up to 200 meters away and kill at closer distances. The fragments used in the mines are either metal or glass. Fragmentation mines can be bounding or ground-based.

There are several-hundred different kinds of anti-personnel mines in use by many countries. For the purposes of this article, we have chosen two landmines developed by the United States military that demonstrate the varying characteristics of landmines. The first landmine, the **M14**, is a pressure-operated blast mine. We also examine the **M16** bounding/fragmentation landmine.

M14 Blast Mine

The M14 is a small, cylindrical, plastic-bodied blast mine. It is just 1.57 inches (40 mm) tall and 2.2 inches (56 mm) in diameter. It was originally developed and used by the United States in the 1950s, but it has been used and copied by many nations around the world. This particular anti-personnel mine contains only a small amount of explosive, about 31 grams of **Tetryl**. It is designed to cause damage to people and objects in close proximity to it.



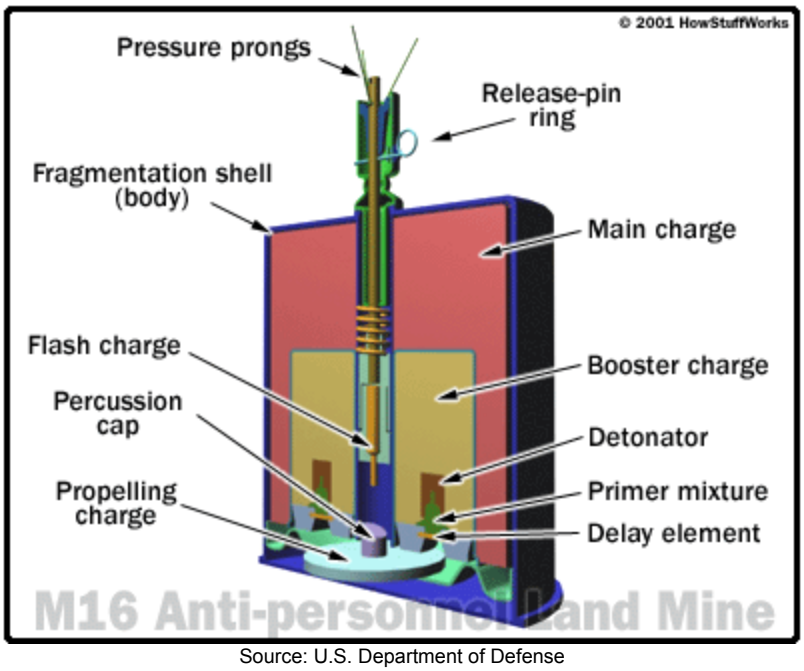
Source: U.S. Department of Defense

The M14 is initially equipped with a U-shaped **safety clip**, which is fitted around the pressure plate. In order to activate the M14, the safety clip is removed and the pressure plate is rotated from its safety position to its armed position. The letters A (armed) and S (safety) are embossed on the pressure plate. Soldiers simply align an arrow with the A to arm the mine.

Once it is armed, any pressure of at least 19.8 pounds (9 kg) can cause the mine to detonate. When the proper amount of pressure is applied it pushes down on the **Belleville spring** underneath the pressure plate. This spring pushes the **firing pin** down on to the **detonator**, which ignites the **main charge** of Tetryl explosive.

M16 Bounding/Fragmentation Mine

Bounding mines fire up out of the ground and then explode. The M16 is made of three main parts: a **mine fuse**, a **propelling charge** to lift the mine and a **projectile** contained in a cast-iron housing. It is 7.83 inches (199 mm) tall and 5.24 inches (133 mm) in diameter. The M16 mine contains about 1.15 pounds (521 grams) of **trinitrotoluene** (TNT) explosive.



Source: U.S. Department of Defense

The fuse extends through the center of the mine to the bottom, where the propelling charge is located. To arm the mine, a safety pin is removed from the **striker** on top of the fuse. There are three **prongs** located on top of the fuse, connected to a **spring-loaded wedge**. The fuse encloses a **percussion cap**, a **delay** element and a **black-powder charge**.

The M16 can be detonated in two ways: by applying pressure or by pulling the spring-loaded release pin. Either method causes the pin to pull out of the fuse, releasing the striker and igniting the percussion cap. The percussion cap fires a delay element in the fuse, which fires a detonator after a short delay. The detonator ignites the black powder in the fuse, firing the propelling charge in the bottom of the mine. The mine flies upward to about 1.2 meters; the main charge then detonates and releases a shower of metal fragments.

Anti-tank Mines

When it comes to developing new military weaponry, countries try to keep up with the developments of other countries. The development of tanks during World War I led to **anti-tank mines**, and anti-personnel mines were developed to prevent enemy armies from moving anti-tank mines.

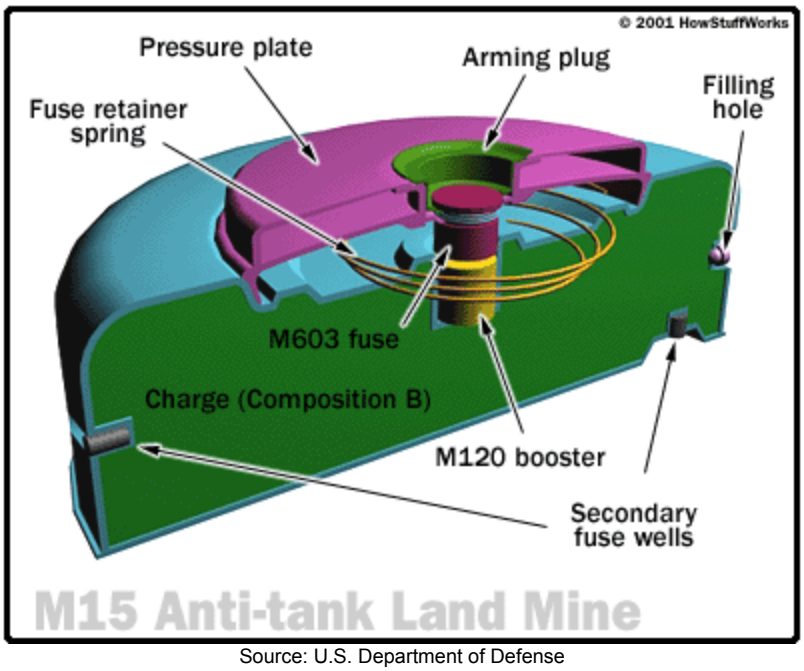
Photo courtesy U.S. Department of Defense

A close-up look at an M15 anti-tank mine

Anti-tank mines are very similar to their anti-personnel cousins, but are much larger. These mines are pressure activated, but are typically designed so that the footstep of a person won't detonate them. Most anti-tank mines require an applied pressure of 348.33 pounds (158 kg) to 745.16 pounds (338 kg) in order to detonate. Most tanks and other military vehicles apply that kind of pressure. Let's take a closer look at one of these anti-tank mines.

M15 Pressure-operated Blast Mine

All anti-tank mines are blast mines, because the goal of the anti-tank mine is to destroy the tank's tracks and as much of its body as possible. There's no need for a bounding or fragmentation anti-tank mine. The M15 is a circular, steel anti-tank mine that contains a main charge of TNT. It has a diameter of 13.27 inches (337 mm) and a height of 4.92 inches (125 mm). The main component of the M15 is the 22.82 pounds (10.35 kg) of **Composition B** explosive. Composition B is a mix of TNT and **cyclotrimethylene trinitramine** (RDX).



Source: U.S. Department of Defense

The M15 is armed by rotating the arming switch so that it is set atop the head of the fuse. The cylindrical fuse is made of iron and is attached to the pressure plate by a copper cover. As a tank rolls over the mine, it pushes down on the **pressure plate**. Underneath the pressure plate is a **Belleville spring** with a **firing pin** affixed to its underside. The firing pin is driven down into the detonator, which detonates and fires the **M120 booster charge** beneath the fuse, which then sets off the **main charge**.

Location and De-mining Techniques

Landmines can remain active more than 50 years after they are planted in the ground. For this reason, there is a growing worldwide effort to rid the world of landmines. To do this, we must first locate the millions of landmines that are still buried in dozens of countries around the world. Finding these landmines is extremely difficult, as most minefields are unmarked. And those that are marked can take years to de-mine.

Landmine detection is a slow, methodical process due to the danger involved in locating landmines. While location technology is improving, the following conventional techniques are still relied on heavily:

- **Probing the ground** - For many years, the most sophisticated technology used for locating landmines was probing the ground with a stick or bayonet. Soldiers are trained to poke the ground lightly with a bayonet, knowing that just one mistake may cost them their lives.
- **Trained dogs** - Dogs can be trained to sniff out vapors coming from the explosive ingredients inside the landmine.

- **Metal detectors** - Metal detectors are limited in their ability to find mines, because many mines are made of plastic with only a tiny bit of metal.

Scientists at Ohio State University are developing a new **ground-penetrating radar** (GPR) device that may be more effective in locating and disarming landmines. This new device would be helpful in locating mines that have little or no metal content. All landmines, including plastic ones, are filled with explosive agents that have electrical properties that make them detectable to the right technology, such as GPR.

A GPR device focuses radar energy just below the ground and just a few feet in front of the user, according to researchers. The device ignores signals that bounce back from the surface and uses specially designed software to make buried objects shine brighter in the radar image. The GPR has been successful in detecting two common landmine casings filled with a waxy substance that is similar to TNT.

Once a landmine is detected, the GPR device shoots two chemical agents into the ground to deactivate it. One agent solidifies the triggering mechanism along with surrounding soil, allowing soldiers to cross the ground. The second chemical agent then solidifies the mine and soil permanently. The mine can then be shoveled out and destroyed.

Mine Clearing Machines

When there is not a lot of time for an army to clear a minefield, it will often employ the use of certain machines to roll through and clear a safe path. Military forces employ several kinds of mine-clearing machines to clear out or detonate mines. Some machines are specifically designed for the task of mine clearance, while tanks can also be fitted with certain mine-clearing devices.

Photo courtesy U.S. Department of Defense

A remotely controlled Panther armored mine-clearing vehicle leads a column of armored vehicles down a road near

McGovern Base, in Bosnia-Herzegovina on May 16, 1996.

There are several types of mine-clearing machines. New machines are remote controlled, which minimizes the risk to personnel. Mine-clearing machines use one of three techniques, including flailing chains to beat the ground, rollers to roll over and detonate mines, and rakes or blades to plow through the minefields, pushing the mines to the side. Let's look at a few of these machines:

- **Tanks** - Tanks, like the U.S. Army **M-1A1 Abrams main battle tank**, are often equipped with a **mine plow** designed to push mines out of the tank's path. The plow consists of several **blades** that extract the mines, a **moldboard** to push the mines to the side and a **leveling skid** to control the depth of the blade. Click here to see an M-1A1 Abrams tank equipped with a mine-clearing plow.
- **Panther** - The Panther is a 60-ton remote-controlled vehicle that is based on a modified M-60 tank hull. Using a joy stick, an operator navigates the Panther through a minefield. The vehicle, as you can see in the picture above, uses **metal rollers** to set off blast or magnetic mines.
- **Aardvark** - The **Aardvark Mk III** vehicle is designed with a flail mechanism that beats chains against the ground in a rotating motion to detonate and destroy mines. This machine is often used in humanitarian de-mining operations, according to the Norwegian Peoples Aid.
- **Berm Processing Assembly** - As a plowing machine rolls through a minefield, it leaves large mounds of soil that contain landmines. The Berm Processing Assembly gets its name from the word **berm**, which means a mound of earth. The machine scoops up dirt, shakes out mines from the dirt and leaves the mines exposed on the ground for de-mining units to safely destroy them. Click here to see an image of the Berm Processing Assembly.

New mines are laid at a rate 25 times faster than they are being cleared. New technologies will make it easier to find and locate mines, but can't prevent their placement. As long as nations continue to use landmines, these devices will be a danger for civilians as well as soldiers.

Landmines by the Numbers

- **33 billion** - Cost in U.S. dollars to remove every mine in the world, if no others are planted
- **250 million** - Stockpiled landmines worldwide
- **110 million** - Landmines in the ground worldwide
- **2.5 million** - New landmines laid each year
- **1 million** - People killed or maimed by anti-personnel mines since 1975
- **100,000** - Americans killed or injured by landmines in the 1900s
- **26,000** - People killed or maimed annually by landmines
- **1,000** - Cost in U.S. dollars to remove one landmine

- **350** - Minimum number of different types of landmines
- **70** - Number of people killed or injured daily by landmines
- **33** - Percent of U.S. casualties caused by landmines during the Vietnam War

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