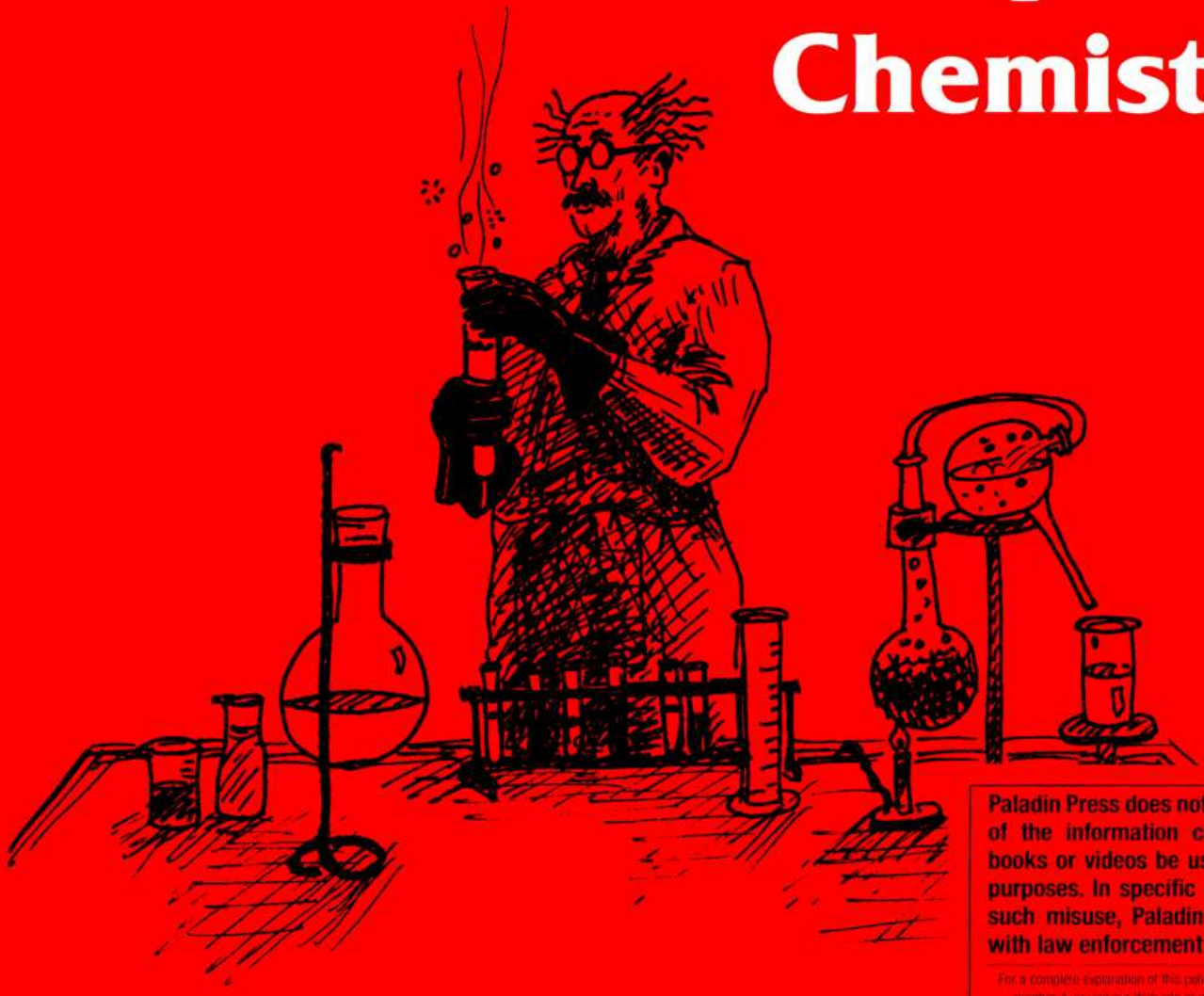
The ALCHEMIST'S SECRETS of Explosive Chemistry



Thomas J. Moffatt

The ALCHEMIST'S SECRETS

of Explosive Chemistry

To my devoted and ever-patient wife, Brenda, for her understanding and endless love.

To my wonderful father, William, for giving me a love of chemistry and pyrotechnics, and without whom none of this would be possible.

And, most of all, my greatest and most appreciative thanks to Dave and Kaye, for their immeasurable patience, help, and endless hours at the computer. Thanks for being there for me. With love and thanks to you all.

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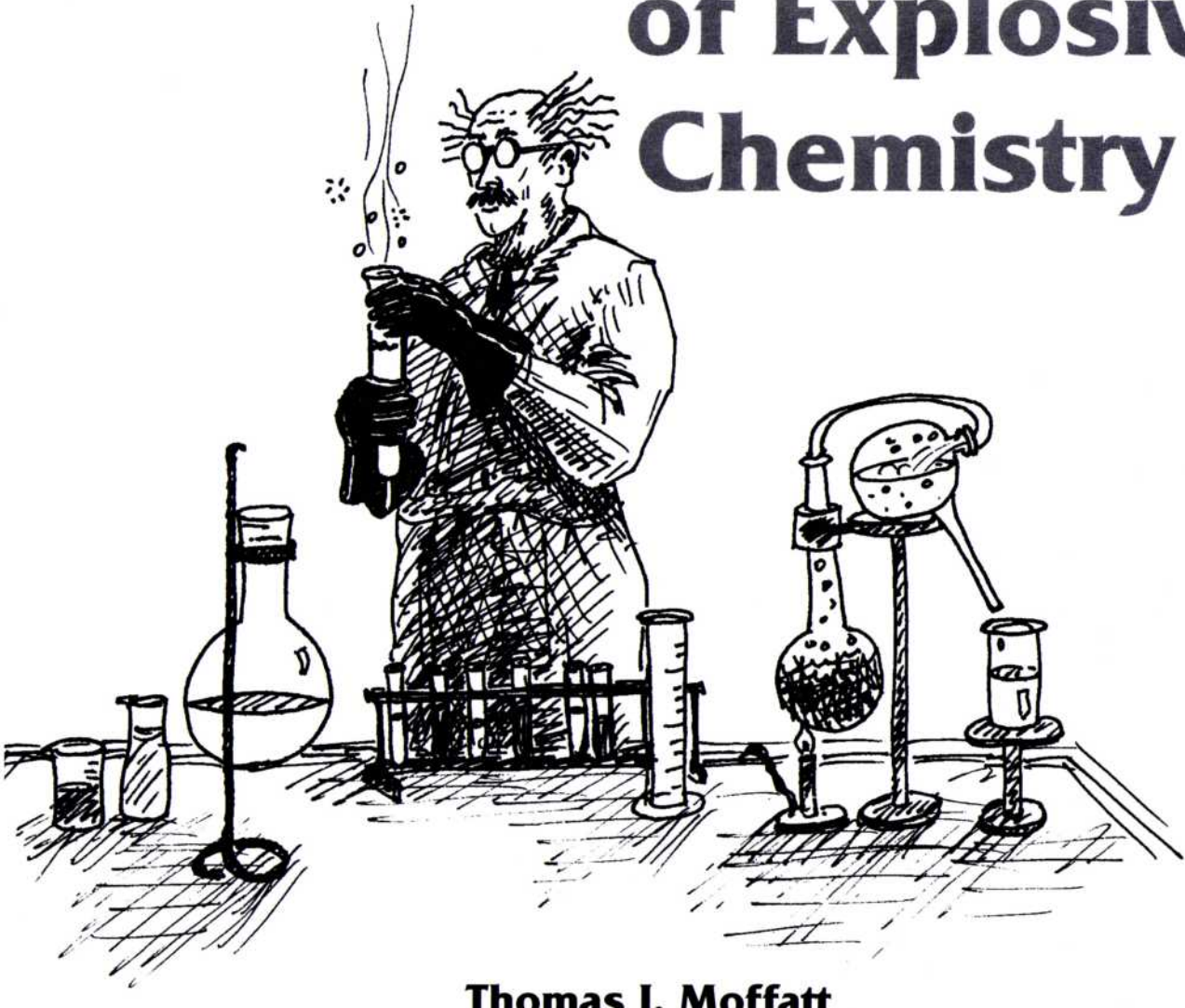

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by Thomas J. Moffatt

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WARNING

The manufacture, possession, and use of explosives and explosive devices is illegal without certification from and registration with the proper authorities. It is the reader's responsibility to research and comply with all local, state, and federal laws regarding the manufacture, possession, and use of explosives and explosive devices.

The procedures described are *extremely dangerous*. Whenever dealing with high explosives, special precautions must be followed in accordance with industry standards for experimentation and production of high explosives. Failure to strictly follow such industry standards may result in harm to life and limb.

Therefore, the author, publisher, and distributors of this book disclaim any liability from any damages or injuries of any type that a reader or user of information contained within this book may encounter from the use of said information. Use the material presented in this manual and any end product or by-product at your own risk.

This book is *for academic study only.*

1

EXPLOSIVES IN GENERAL TERMS

An explosive is a chemical mixture or compound that changes rapidly from a solid or liquid into a large amount of gas. An explosion is the combustion of an explosive that takes place very rapidly with a violent release of gases, light, and heat-producing shock waves.

There are two basic classifications of explosives: low velocity and high velocity. Velocity is measured in meters per second.

Low-velocity explosives, such as black powder, have less explosive power and burn when exposed to flame or spark. When low explosives are placed in a confined space (e.g., firecrackers), there is an increase in internal pressure and rate of combustion until the casing bursts, producing an explosion. Low explosives are also known as propellants because they have a tendency to throw or push objects rather than destroying them. These types of explosives are commonly used in rifle cartridges, rocket motors, firecrackers, and other pyrotechnic devices.

High-velocity explosives differ from low explosives in that, rather than burning, they detonate suddenly and violently. Detonation is a much faster chemical reaction than burning. Combustible gases are produced almost instantaneously, and although detonation is accompanied by flame, this process is not produced by burning.

High explosives are broken into two classes: primary high and secondary high. Primary explosives, or initiating explosives, are more sensitive than secondary explosives, and their use requires greater caution. When these compounds are exposed to friction, heat, flame, or shock, they will detonate with dangerous power.

Highly sensitive explosives of this type produce high pressure and intense shock. They are most commonly used in blasting caps and detonators. Primary high explosives do not require containment to facilitate explosion.

Examples of primary high explosives are mercury fulminate, lead azide, silver fulminate, lead picrate, lead styphnate, and diazodinitrophenol.

Secondary high explosives are rather insensitive and require a detonator or blasting cap to set them off. Some of these can be shot, burned, or even

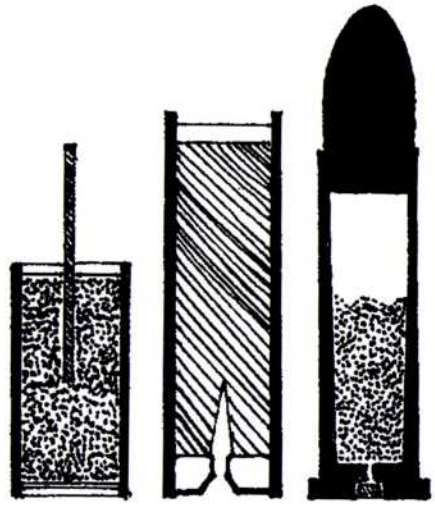


ILLUSTRATION 1
Common uses for low-explosive propellants: firecrackers, rocket motors, and ammunition.

melted without fear of explosion; however, when properly detonated, they produce tremendous power. They are used to shatter metal, destroy concrete, blast rock, and crater into soft earth.

Although various explosives share explosive properties, their characteristics are very different. Some are better suited for underwater work or use in wet climates, whereas others are better suited for use in military weapons and mining. One thing is certain: there are just as many types of explosives as there are uses for them.

The primary factors used to determine the safety and effectiveness of an explosive are as follows:

1. *Rate of detonation*. This is the speed at which a solid or liquid explosive turns into a gas and is determined by electronic measuring systems and measured in meters per second.
2. *Power*. Power is determined by the amount of gas and heat produced from the detonation of a standard weight of an explosive. This power is then compared with other explosive powers and rated accordingly.
3. *Sensitivity*. Sensitivity is determined by the amount of an explosive or fraction thereof that detonates when struck by force. Sensitivity is determined by testing various compounds and comparing these results to a standard.

Various other tests are conducted on explosive compounds to determine their individual characteristics. The hygroscopicity test is used to determine whether the chemical compound will absorb or repel water. The inflammability test is used to determine whether a sample will burn completely or only partially. The ignition temperature test is used to determine inflammability. A sample will be heated until decomposition or explosion occurs.

There are many more tests used to find explosive traits, and these could fill a book by themselves. So let's continue with other material.

TYPES OF EXPLOSIVES

Nitric Esters

Nitric esters are substances with a nitric acid base, such as nitroglycerin. Nitric acid is not an explosive by itself, but when mixed with other substances it becomes explosive. It interacts best with organic compounds containing alcohol (glycerol is a form of alcohol).

Nitric esters are prepared by adding organic material to a mixture of sulfuric acid and nitric acid. This is called the nitration process. Heat is produced when the two acids are mixed and again when the organic material is added. This is an exothermic reaction, and it can be very dangerous. If the temperature gets too high, an explosion will occur. To prevent these explosions, cooling systems are used during nitration. Nitric esters are chemically unstable by nature and are sensitive to heat, shock, and flame. Examples of nitric esters are nitroglycerin, nitrocellulose, nitroglycol, and nitro starch. **NOTE: These compounds are very dangerous!**

Chlorate Explosives

Chlorate explosives are made from perchloric acid or such chemical chlorates as potassium chlorate.

Perchloric acid is a colorless, volatile liquid that is very unstable. When mixed with other substances it may explode spontaneously, and when pure it will explode when its temperature rises above 92°C. (Unless otherwise noted, all temperatures will be given in Celsius.)

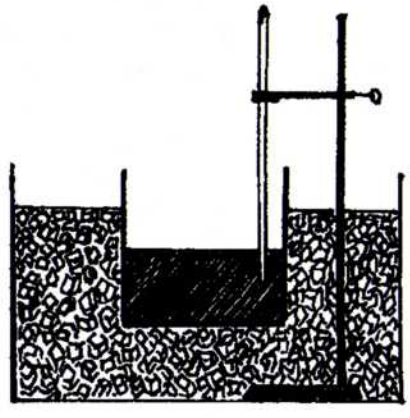


ILLUSTRATION 2
Nitration cooling system. The beaker containing the acid solution is kept in an ice bath. The temperature is monitored constantly to prevent an explosion.

Potassium chlorate is a strong oxidizer and is used in the manufacture of matches and pyrotechnics. Because of the great danger involved in production, no chlorate explosives have been manufactured for many years. **NOTE**: When chlorates come in contact with acid, they will ignite spontaneously. When mixed with acids, chlorates produce chlorine dioxide, an extremely violent gas that can be touched off by heat, spark, or flame. A spontaneous explosion may occur when potassium chlorate is mixed with red phosphorous, black antimony sulfide, or sulfur. Explosives of this type are very dangerous, and no attempt should ever be made to manufacture them. Even when stored, these substances are likely to explode. Examples of these explosive combinations are sugar-chlorate powder, barium chlorate-shellac, potassium chlorate-sulfuric acid, magnesium perchlorate-carbon, and perchloric acid-sulfur.

Explosive Powders

Explosive powders, or blasting powders, are low-explosive propellants that are usually based on the black-powder formula. Smokeless powders, or cellulose powders, also fall into this category. These have the advantage of not producing smoke signatures when used. Explosive powders are used mostly as propellants in rifle cartridges, mortars, and artillery, but they have also been used in mining, quarrying, and tunneling.

To produce an explosive powder, there must be both a substance that burns and combines readily with oxygen and a substance that produces oxygen. This can be seen in the formula for black powder; when the combustibles (charcoal and sulfur) are mixed with the oxidizer (potassium nitrate), an explosive mixture is the result. Explosive force is created during combustion from the production of gas in a confined space, and black powder, as an example, when ignited will produce 3,000 times its own volume in gas. This produces an explosion. Blasting powders must be contained to produce an explosion; if they are not, they will simply burn. The rate of combustion can be controlled, to some degree, by changing the ratio of combustible material and oxidizing agent. For example, quarrying powder has a reduced amount of potassium nitrate, thus slowing the rate of combustion and creating the necessary pressure gradually. This breaks the stone but reduces the amount of its scattering.

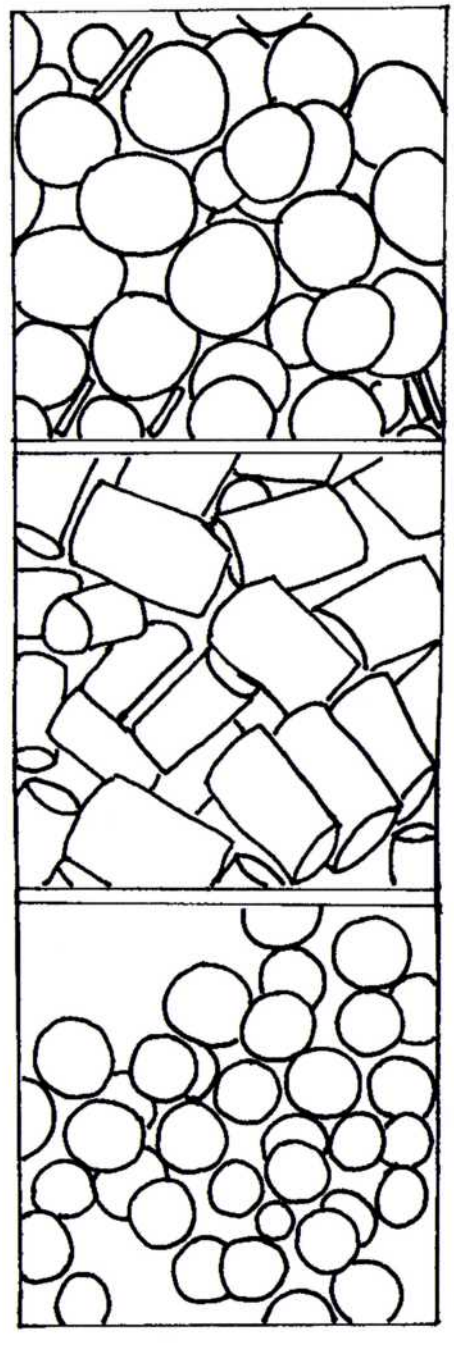


ILLUSTRATION 3
Explosive powders are produced in a variety of forms. The most common are (top to bottom) flakes, pellets, and grains.

Explosive powders are manufactured in various forms: powders, grains, flakes, and pellets. The size and density of the grains also determine the rate of combustion and the speed at which gas is produced. For instance, small grains will burn faster and produce volumes of gas more rapidly.

Blasting powders are not generally used in bombs or shells; the casings would burst before combustion is completed, wasting explosive energy and limiting the powders' effectiveness. This type of explosive is sensitive to excessive heat, spark, and flame. Examples of explosive powders are black powder, sugar chlorate, and smokeless powder.

Ammonium Nitrate Explosives

Ammonium nitrate (AN) is a white crystalline compound made from ammonium hydroxide and nitric acid. It is very hygroscopic, meaning that it absorbs moisture quickly and easily. AN is used as a fertilizer in agriculture as well in the manufacture of explosives.

AN explosives consist of a mixture of AN and a combustible material such as fuel oil or kerosene. This type of explosive is used in quarrying, mining, and construction because it is inexpensive and safer to handle than most explosives.

A common blasting formula is 95 percent of AN mixed thoroughly with 5 percent of fuel oil. These ingredients are most often mixed in a conveyor at the blasting site so that the mixture can be immediately delivered to the drill holes. A mixture of AN and sodium carbonate is used in coal mines because AN has a low explosive temperature, and by adding a cooling agent such as sodium carbonate the temperature can be further lowered. This reduces the risk of secondary explosions resulting from coal dust-air mixtures.

Explosives safe for use in coal mining, such as this one, are referred to as permissibles. These explosives are very stable and can be handled roughly. They will not detonate because of shock or impact. To initiate this kind of explosive, a booster charge of dynamite or trinitrotoluene (TNT) is required. AN can be made more sensitive to detonation by mixing it with such sensitizers as nitroglycerin, TNT, or nitromethane. When sensitized in this way these compounds will detonate easily with a blasting cap or detonator. These sensitized AN

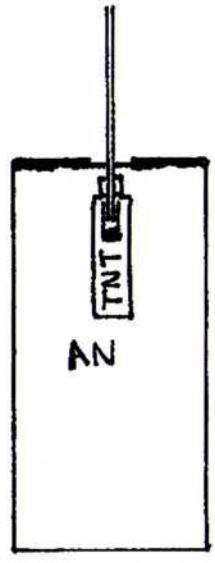


ILLUSTRATION 4
When blasting with AN, a booster charge of TNT is required to ensure detonation.

compounds are some times called slurry blasting agents. A typical mixture is 36 percent AN, 12 percent sodium nitrate, 2 percent fuel oil, 25 percent TNT, 10 percent aluminum powder, and 15 percent water. Slurry blasting agents are used primarily for blasting very hard rock like iron ore. Examples of AN explosives are ammonium nitrate-fuel oil (ANFO), ammonol, and amatol.

Sprengle Explosives

Sprengle explosives were patented in the late 1800s by Herman Sprengle. These explosives are combinations of oxidizing agents (such as chlorates, nitrates, and nitric acid) and combustible materials (such as benzene, nitro naphthalene, and oil of mirbane, also referred to as nitrobenzene).

Sprengle explosives are easy and cheap to make. Another advantage is that the components can be mixed just before use. An example of this type of explosive is rack-a-rock, a mixture of potassium chlorate and oil of mirbane, detonated with dynamite. This explosive was used to great effect in New York harbor to destroy Flood Rock, a navigational nightmare for ships. Historically, this event is known as the Hell Gate Blast of 1885.

A disadvantage of Sprengle explosives is that they

are very corrosive and must be kept in acid-resistant containers, such as glass. Examples of this type of explosive are nitric acid/oil of mirbane, rack-a-rock, and liquid oxygen/carbon black.

Fuel Air Explosives

Fuel air explosives (FAEs) are aerosol clouds of highly volatile fuel, such as ethylene oxide, which when detonated produce very powerful explosions. I know that this is more a description of an explosive effect that an explosive compound.

I have chosen to include this type of explosive because I believe it may one day replace conventional military explosives.

FAEs are delivered to their targets by artillery, rockets, missiles, and aerial bombardment. They produce a blast effect that is roughly five times more powerful than an equivalent weight of TNT. Because it is detonated as an aerosol cloud, the blast pressure is felt over a wide area. With conventional explosives, the blast is concentrated in the area of explosion, and explosive force is lost over distance. FAEs can generate pressures of more than 13 pounds per square inch (psi) over a radius as wide as 200 meters. The pressure is sufficient to collapse concrete buildings. The blast of an FAE has been described as being equivalent to that of a small nuclear weapon. This type of explosive is used to clear mine fields and destroy bunkers and such military equipment as tanks and aircraft.

Fuels used in FAEs are propylene oxide, methyl acetylene, propane, and acetic peroxide.

EXPLOSIVES IN INDUSTRY

Because of the their use in warfare and terrorism, explosives have become infamous, as can be seen routinely on television and in Hollywood films. But what we see at the movies is pure fantasy. Hollywood lives for the explosion—it looks great on film, adds excitement, and increases the suspense.

How many movies can be seen that don't have some sort of explosion? Whenever two cars touch in Hollywood films, there will be a huge explosion. Explosives are more often than not depicted in film as a tool of destruction used only by evil men. As the clock ticks, our hero tries to defuse the "evil" bomb. The suspense mounts as sweat drips down his forehead. He reaches down, unsure, with his wire cutters—is it the blue or the black wire? He quickly grits his teeth and cuts the black wire as the last seconds tick off the clock. Ring—buzz—the bomb is defused, and our hero lives to make a sequel or two.

I cannot count the number of times I have seen this on the silver screen. If this sounds a little sarcastic, I apologize. It was supposed to sound a lot sarcastic.

In this chapter, I hope to blast through the misunderstandings and fear that surround explosives. I would like to show you what many explosive experts already know: that explosives are a wonderfully useful tool and that in many ways they have made our lives easier and more profitable. To people who think that explosives are merely a device meant to kill or maim, this notion may seem a bit romantic or even harebrained, but let me assure readers that a lot of things we so easily take for granted would not have been possible without the use of explosives. I'd like to highlight the benefits that we all enjoy because of this powerful tool. I hope the reader will come to see explosives in a new light, one of appreciation for their usefulness.

To some it may come as a surprise to know that more explosives are employed for industrial purposes each year than are used in warfare. In fact, the variety and number of industries that use explosives may be surprising. But using explosives in industry makes perfect sense, e.g., in quarrying. One charge of high explosive can produce more stone in one minute, than 10 men could produce in hours of backbreaking manual labor.

Explosives are used in many industries, from agriculture to welding. So in order to present the broad picture, the true picture, let me mention briefly some of the industries that use explosives and summarize their use in these industries.

AGRICULTURE

Like a wrench to a mechanic, explosives help farmers do many jobs on the farm. When clearing acreage to be plowed, it is not uncommon for farmers to use dynamite to remove tree stumps or large rocks that lie below the surface of a promising field. These uses are well known in farm communities, and old-timers are full of fascinating stories about "Farmer John" blowing a stump into the next county.

Sometimes the soil in heavily farmed fields gets too old to produce much of a crop. When this

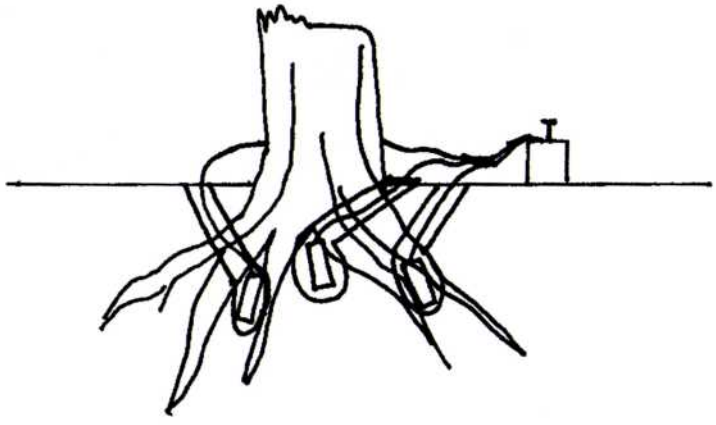


ILLUSTRATION 5
Stump removal is often necessary when clearing farmland.

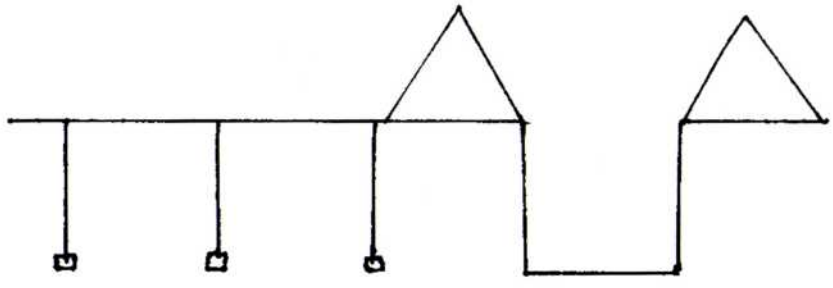


ILLUSTRATION 6
Subsoil blasting is accomplished when rows of soil are blasted, bringing up good soil from several feet below ground.

happens, a technique called subsoil blasting can be used to revitalize the soil. This is accomplished by placing charges of dynamite deep in the soil and blasting up fertile soil that lies several feet below the surface. Another benefit of this technique is that the explosives leave nitrates in the soil. This subsoil blasting also deals with certain unfriendly pests that farmers can surely live without.

Farmers also use explosives to excavate ditches and to level fields that have been potted by erosion.

Every fresh ear of corn a person bites into should be considered just one of the benefits of explosives.

TRANSPORTATION

Although explosives are not directly related to such transportation industries as shipping, trucking, or railroads, they are necessary to keep the arteries of transportation open and to create new ones.

Terrain, large rocks, or even trees can impede progress. To deal with this, explosives are used to remove or rearrange the obstacle and get things moving again. Transportation industries have used explosives to level ground, break up cumbersome

rocks, create terraces on steep slopes, and tunnel through mountains.

In shipping, however, the obstacles are a little different. Our rivers and oceans are always changing. Erosion deposits silt in areas that were once open to water traffic. Ocean reefs and rocky shores may cause ships to take less direct routes into port, or we may simply need a canal to connect waterways. These problems can all be solved with explosives. When salvaging a wrecked ship, explosives are used to blast away the rocks that have stranded an unfortunate vessel. Sometimes they are used to destroy sunken ships that have blocked waterways. The transportation industries have come a long way through the use of explosives.

CONSTRUCTION

The construction of new skyscrapers in urban areas is usually preceded by the demolition of old buildings. I have probably seen this done at least a thousand times, and I could never grow bored watching buildings fall. There is just something about hearing the crack of detonation, seeing the smoke rising skyward, and then watching the walls come tumbling down. Building demolition is a science of high precision that requires a great deal of care and a tremendous amount of skill. These skills are often found only in well-seasoned demolition experts.

Only after the site has been cleared, can the construction begin? Not yet. First the site must be excavated to make way for an underground garage or utility floors. So the blasting is not done yet.

There are a number of blasting techniques used to remove earth and rock in an urban area. And there are probably just as many government regulations for this as there are ways to do it! But, seriously, any use of explosives in urban areas is very dangerous: calculations for burden, blast, and throw must be figured with a high level of knowledge and skill. Miscalculations could mean having to redo the job or, worse yet, injuring nearby people or damaging surrounding property, neither option being desirable. The only correct way is to do it right the first time—attention to detail!

When smaller dwellings are built, the contractor may also need to use explosives for the excavation of basements, foundations, or swimming pools. He may also have to remove existing foundations, rocks, or trees. All these jobs can be done quickly and effectively with explosives. I should point out that the layperson should stay away from this type of blasting. An improperly placed charge could set off a natural gas line, cut buried phone cables, or produce some other horrible result.

ENTERTAINMENT/RECREATION

Entertainment/recreation is a broad category, so I would like to break this down into a few subheadings to show how explosives can make life more enjoyable: skiing, stage magic, and film.

Skiing

How can explosives be used in skiing, of all things? Well, in addition to their use in the general construction of the ski slopes and resorts, explosives are used to control avalanches. Keeping skiers safe from this danger requires a team of explosives technicians who not only have a knowledge of blasting, but who can also recognize when and where an avalanche is likely to occur. When a large formation of hanging snow is found, the avalanche bursters go to work, and packing the necessary equipment up to the blasting site is quite a job. There is the danger of causing an avalanche even before a team is in position. But when the charges are in place and everybody is in a safe location, the blasting begins sending tons of snow crashing down the mountain. After all has settled, the skiing can resume.

Stage Magic

Magicians are notorious for using flash paper and various pyrotechnic devices in their quest to thrill and amaze. Flash paper is made by nitrating paper, thereby creating "nitrocellulose." This novelty can be found in most magic shops for about $3 an envelope. The next time you see a magician produce a bright flame from the air you will see how flash paper is used. Flash paper burns very fast with almost no residue and is perfect for use in theaters where fire hazards are closely watched and regulated. Its use reduces the risk of fire but still allows magicians to use fire effects in their acts.

But magicians are not limited to just flash paper. Sometimes high explosives are used by would-be

Houdinis trying to free themselves from a locked trunk before an explosive charge blows them sky high. I have seen this escape performed several times, and it is very exciting watching the escape artist trying to free himself just in time, just barely escaping the blast!

Film

I have already mentioned Hollywood's fascination with explosives and how often they are used in films, so let's look at how explosives are actually used in movies and TV shows. Millions of gunshots occur in the movies, and an amazing amount of knowledge and skill is required to produce the desired effect. Thousands of explosive squibs have to be placed in many different surfaces, such as the ground, walls, and cars. Some are even attached to people. The process requires a great deal of care and can take many hours, but in the end, when a car is riddled with machine-gun fire, it has all been worth it.

I cannot emphasize enough the degree of skill required of Hollywood's explosives technicians. They not only have to figure out how to create the effect, but also have to figure out how to do this without injuring members of the cast or crew.

Sometimes it is necessary to give the effect of destroying something, like a hotel room, without doing any damage to the structure. This requires much preparation, protecting the structure with steel plates and sandbags and then strategically placing shaped charges to blast out the windows and direct most of the explosive force out the window.

The amount of explosive has to be carefully calculated to produce the best effect with the least amount of damage to the property. I do have to take my hat off to Hollywood's explosive experts.

MINING AND QUARRYING

Mines and quarries are probably the largest commercial users of explosives. When rock is quarried, a technique called bench blasting is used. A rock face is blown into small individual stones when drill holes are placed along a rock ledge behind the free face of a rock wall. Various factors determine how far from the free face the drill holes should be

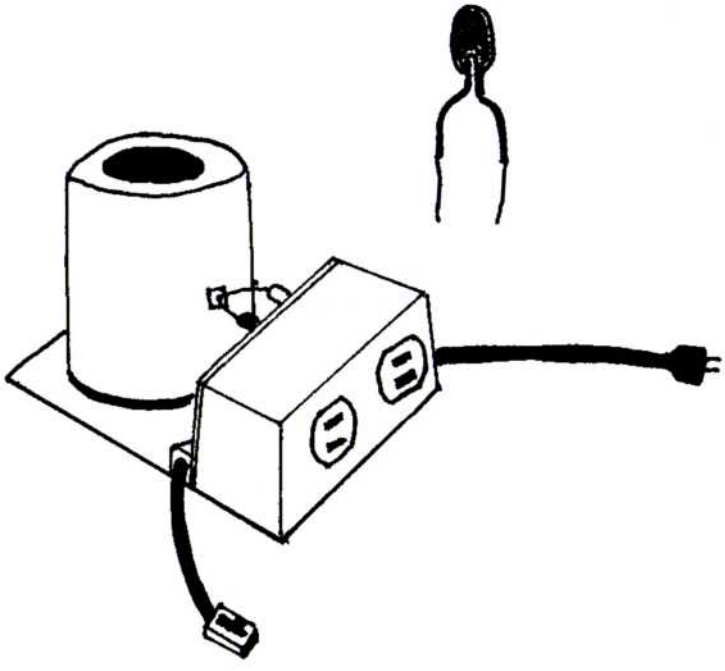


ILLUSTRATION 7
(Upper) Squibs are used to simulate gunfire in films.
(Lower) Flash pots are used to create pyrotechnic displays at concerts and to simulate explosions in film.

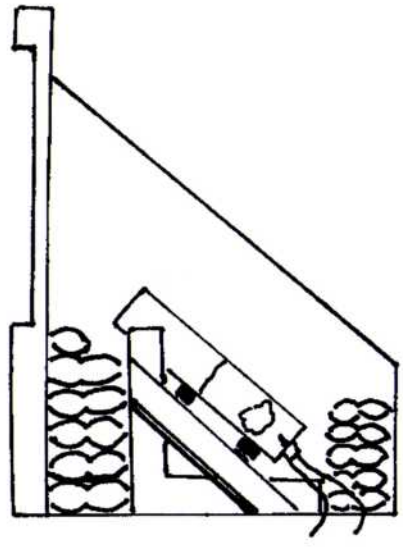


ILLUSTRATION 8
To simulate a structural explosion without causing actual damage requires the use of sandbags and a steel-enclosed frame so that the explosion can be directed out a window, causing little or no damage.

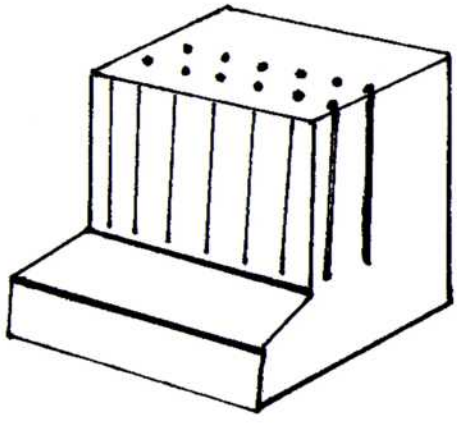


ILLUSTRATION 9
For bench blasting, holes are drilled down from the top of a rock wall and then packed with explosives. When detonated, the free face of the wall is broken into more manageable pieces.

placed and how far apart the drill holes should be.

These factors are determined by the type of rock being quarried. A great deal of calculation is required to determine how the rock will break, how much throw there will be, and whether the holes should be placed at an angle to prevent "stumping." Solving these problems effectively takes a great deal of knowledge and experience: quarry blasters have to be 50 percent powder monkey and 50 percent scientist to produce the most rock at the least cost.

Mining with explosives is fairly common, but when blasting underground the danger factor is increased. No one wants a cave-in or a secondary explosion. Blasting mine shafts underground requires an understanding of geology, physics, and mathematics, as well as a knowledge of explosives.

When all the factors are calculated, the explosive technician drills holes into the rock face where the shaft will be. He will choose a drill pattern that best suits the type of tunnel to be dug. He may choose to drill holes at various angles to ensure proper breakage of the rock face. The explosive technician will then load the drill holes with explosives and make final preparations for blasting. After the all-clear signal is given, blasting will begin. When all is done, the mineral ore is brought to the surface,

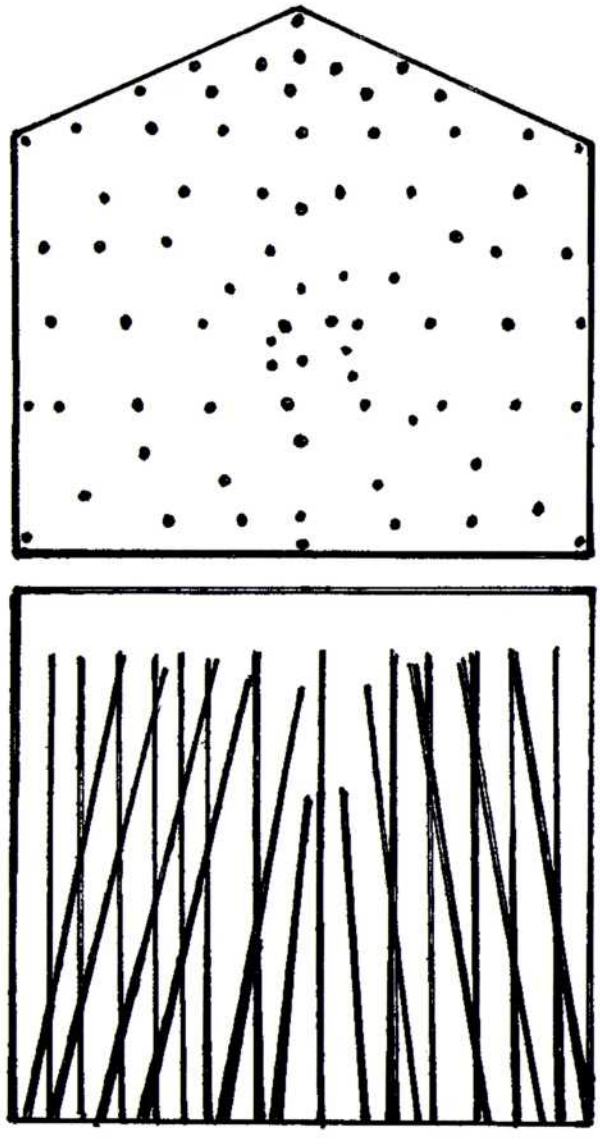


ILLUSTRATION 10
Precision drill holes are required for tunneling into solid rock so that the rock will fracture in the desired shape and at the proper depth.

where it can be processed and sold. Then the process starts all over again. One thing is certain, mining would be a lot more difficult and a lot less profitable without explosives.

MISCELLANEOUS USES IN INDUSTRY

Oil

Explosives are used in the oil industry to stop oil well fires. An explosive charge is lowered down on a boom into the heart of the fire and then detonated. The explosion robs the fire of oxygen, causing the fire to go out.

Art

The art world is occasionally rocked by a blast from high explosives. Some artists use explosives, such as det chord to produce wonderful pieces of art. The medium usually used with explosives is steel plate. The artist will create patterns on the steel plate by placing the det cord in the desired shapes, and then, BOOM! the design is forever marked on the steel.

Animal Control

Park services will sometimes use explosives to destroy the occasional beaver dam or to lower the population of some animals considered pests. One of these pesky critters is the crow, whose populations can at times grow so large that they endanger crops and the ecosystem of rural land. When a large flock of crows is scheduled to be removed, the roosting area is located and explosive charges are placed in the brush or trees that surround the offending creatures. Then they are blown to feathers. Another creature often controlled by explosives is the prairie dog, and it is dealt with in much the same way as the crow.

3

MILITARY APPLICATIONS OF EXPLOSIVES

The basic tactical principle of military operations is to inflict the maximum possible amount of damage on the enemy and to do it in as little time as possible.

Being true to this principle, the military has over the years created new ways to harm the enemy quickly and effectively, usually by blowing him and his equipment into tiny pieces.

We are all at least a little familiar with the use of explosives in warfare, thanks to seeing it on film or by actually seeing them used in the armed services. We may not be familiar with all their uses, but we do know that explosives play a large part in modern warfare. In fact, there could not be a war today without a large supply of many types of explosives.

Military explosives can be classified into three broad categories: propellants, initiating charges, and bursting charges.

Some weapons use explosives from all three categories, and some just use initiating and bursting charges. So that I can cover this subject effectively, I will break it down into three headings: weapons, demolitions, and special applications. This should provide a brief but broad overview of military applications of explosives.

WEAPONS

Small-Arms Cartridges

Small-arms cartridges have three basic components: the projectile, propellant charge, and priming charge to initiate the propellant charge. All of these components must be present to fire one round of ammunition.

Grenades

Grenades usually have a primer charge that initiates the delay fuse, a blasting cap that detonates the bursting charge, and the bursting charge, usually TNT. Certain other grenades differ from the basic. These are thermite (incendiary grenades), stun grenades ("flash bangs"), and CS gas grenades (chemical irritants).

Incendiary, chemical, and stun grenades are initiated in a similar fashion but differ from their high-explosive cousins. They are used for different

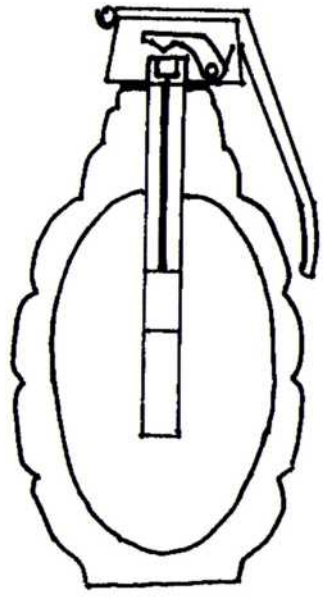


ILLUSTRATION 11
Grenades require a primer charge, a fuse delay, and a blasting cap to initiate the bursting charge.

tactical purposes, such as causing fires and disorienting the enemy.

Aerial Bombs

The first component of aerial bombs is an initiating system to start the explosive chain. It can work in various ways: time delays, percussion, inertial fuses, and combinations of these.

The next component is the detonating charge that sets off the bursting charge. Bursting charges can vary by the type of bomb used, but bursting charges in aerial bombs usually consist of TNT, amatol, tritonal, composition B, and picratol.

There are many types of aerial bombs used in the military today, certainly one for every type of target imaginable. There are bombs for demolitions, ones for piercing armor, and depth bombs for antisubmarine warfare, just to name a few. There are bombs of all shapes and sizes, and I am sure I have only scratched the surface. But these are the basics, so let's continue.

Mines

Mines can be broken down into two very basic categories: land mines and naval mines. Although these differ in their design and tactical use, the principle is still the same: when an object comes in contact with the mine, the mine detonates. Mines are usually detonated by the standard formula: initiation system, "fuse delay," blasting cap, and base charge. Detonation can be accomplished with or without a delay in the explosive train. Mines are detonated by applied pressure or released pressure, and some are detonated by remote control.

Types of mines include antipersonnel (AP), antitank (AT), and antiship (AS). Limpet mines are a variation of the antiship mine, and these must be placed on the hull of the ship and detonated by time delay or by remote control. Explosive fillers used in mines include C-4, tetrytol, and TNT.[1]

Missiles and Rockets

Excluding nuclear warheads, missiles and rockets use a standard explosive train that is usually initiated electronically. Rockets and missiles also have certain unique differences when compared with other weapons.

The first is that most are equipped with shaped charges, which cause greater penetration through armored targets. Some also have "smart systems" that allow them to acquire and home in on targets. Rockets and missiles can be very high tech, as exemplified by laser-guided, radar-guided, infrared, and wire-guided systems in use today.

They can also be low tech, as with the 66mm LAW and RPG-7 that require accurately aimed fire to be effective. Some rockets and missiles have delivery systems that can send explosive warheads over great

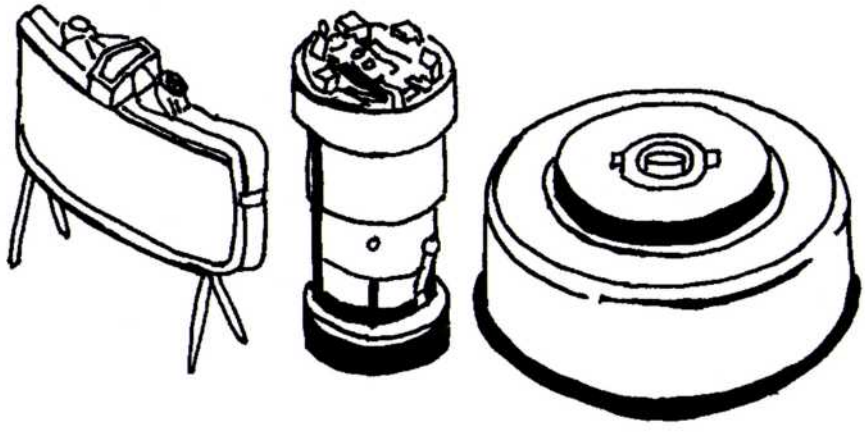


ILLUSTRATION 12
Mines play a big role in modern warfare to destroy personnel and equipment. Left to right: Claymore AP mine, pressure-activated AP mine, and pressure-activated AT mine.

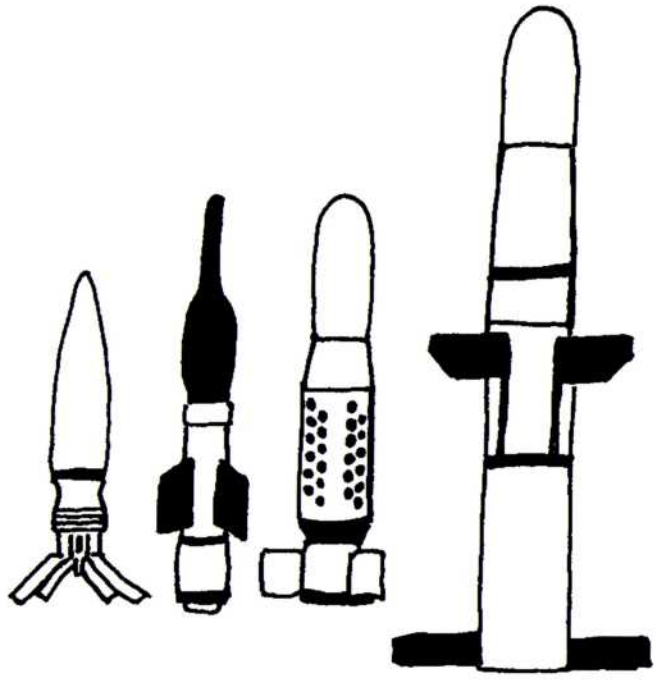


ILLUSTRATION 13
There are a wide variety of rockets and missiles in use today. Some are wire or laser guided, whereas others require accurately aimed fire to be effective.

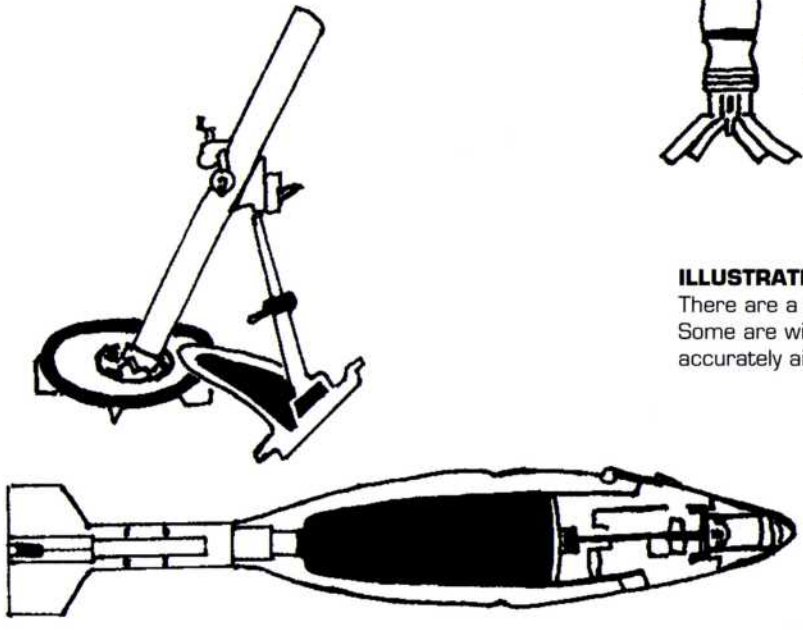


ILLUSTRATION 14
Mortar shells are delivered to the target through a mortar tube. When a round is dropped down the tube, a firing pin ignites a charge at the base of the round. This charge then expels the round from the launch tube to the target.

distances. This is accomplished with liquid- or solid-fuel rocket motors or jet engines.

Explosive charges used in rockets and missiles include nuclear warheads, tetrytol, C-4, and various other conventional explosives.[2]

Mortars

Mortar shells are very similar to air-dropped bombs in their functioning. What separates mortars from bombs is their size and how they are delivered to the target.

Mortar shells are much smaller than aerial bombs and are delivered through a mortar tube. When a shell is dropped down a mortar tube, a primer is ignited by a firing pin located at the bottom of the launch tube. This ignites a propellant charge in the base of a mortar round. When the propellant charge is being consumed, pressures at the base of the launch tube increase until the round is expelled from the tube. When the round is expelled, a bore-riding pin is ejected from the round, so that the round will become "live" and can detonate upon impact. There are many different sizes of mortars and many types of mortar rounds, but the principle of their functioning is the same.

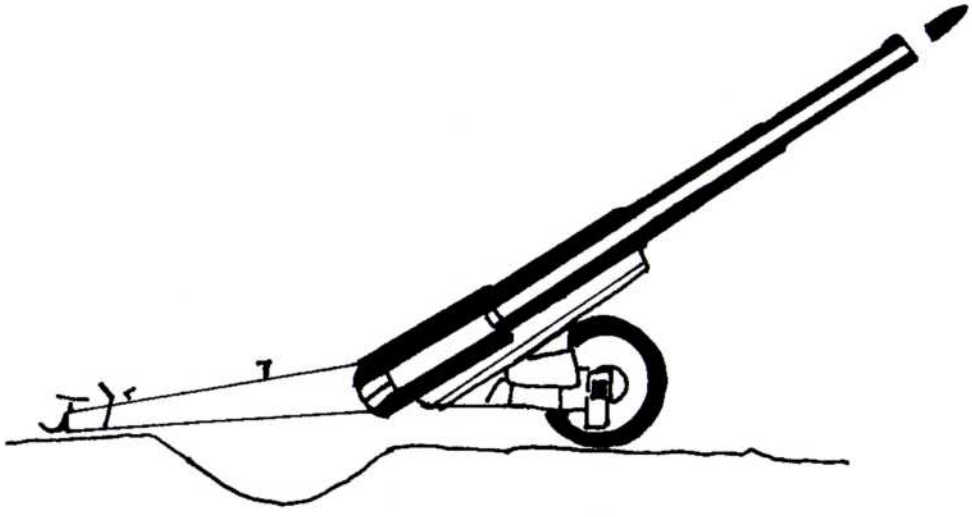


ILLUSTRATION 15
Artillery cannon are like very large rifles. They use the same explosive train and share similar design characteristics.

Artillery Cannon

Artillery can be described as very large rifles. Artillery cannon use the same explosive train as rifles do: a primer ignites the propellant charge, and chamber pressure expels the artillery shell. Artillery shells differ from rifle rounds in that, in most cases, artillery shells are explosive munitions designed to carry high-explosive charges over great distances, whereas the explosive force and shrapnel can destroy desired targets. To detonate the initiating charge, artillery shells use various types of fuses. There are inertial fuses that start the explosive train by friction caused from the centrifugal force of the spinning artillery shell. There are also fuses designed to ignite upon impact and fuses that ignite by time delay. High explosives used in artillery shells include TNT, amatol, and explosive D.

FAEs

I have already discussed FAEs in the section on types of explosives, but they also fall under the category of special weapons (see Types of Explosives, p. 2).

Explosive Bullets

Explosive bullets are manufactured for use in sniping, antiaircraft, and special warfare applications.

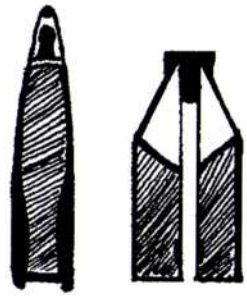


ILLUSTRATION 16
Explosive bullets: .50-caliber and 12-gauge.

They are commonly made for .50-caliber ammunition, but some are made for 20mm cannon rounds and 12-gauge shotgun cartridges. These rounds are used to destroy equipment, ignite fuel, and, in the case of 12-gauge ammo, to blast locks and hinges.

DEMOLITIONS

Military demolitions can also be described as the art of destruction—that is, the destruction of tactical military targets. But what exactly is a tactical military target? It is anything that aids the enemy (e.g., transportation, supply, fuel, or equipment).

It is the job of demolitions experts to destroy or render useless to the enemy a variety of targets. These targets can be made of various materials—concrete, steel, wood, or earth—so demolitions experts must

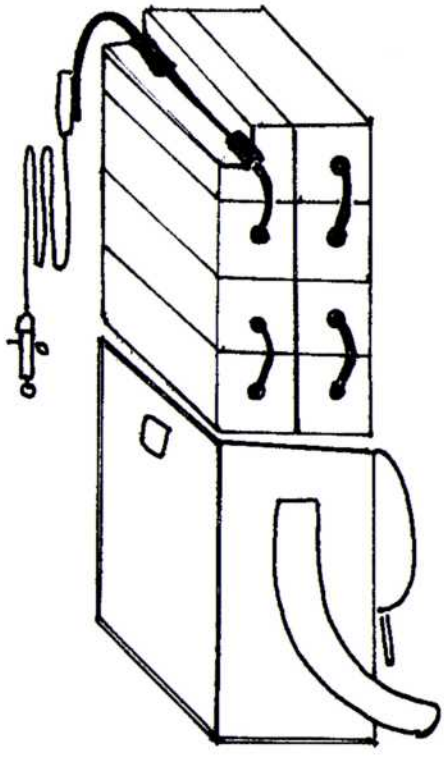


ILLUSTRATION 17
Satchel charges are used to destroy a wide variety of military targets, machine-gun emplacements, bunkers, and aircraft.

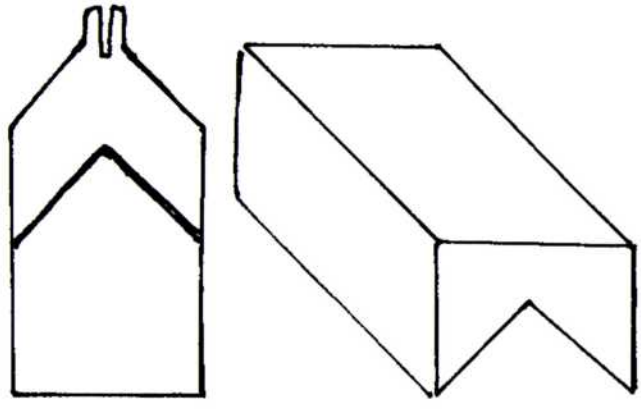


ILLUSTRATION 18
Shaped charges are molded to produce a greater explosive force in a desired direction. (Left) Conical charge. (Right) Linear charge.

possess a high degree of knowledge and be highly trained and very skilled at their trade. Describing military demolitions techniques can get very complicated, so I will just briefly describe certain techniques that apply to the various militaries' use of explosives in demolitions.

Satchel Charge

A multipurpose tool of demolitions is the satchel charge. A satchel charge is a haversack containing eight blocks of TNT laced together with det cord. It uses a time fuse and a pull igniter to produce detonation.

A satchel charge can be used to destroy many military targets by either placing it on or throwing it at the object to be destroyed. It is used commonly against bunkers, aircraft, fuel supplies, communications equipment, and defensive positions.

Shaped Charges

Shaped charges are explosive charges that are molded to produce a greater explosive force in a desired direction. This magnifies the explosive force and enhances the shattering or cutting abilities of high explosives. These charges are used to cut holes in concrete and steel. Some of these charges are small and used against such equipment as generators and engines. Whereas others are very large and used to destroy concrete pylons and underground bunkers.

Conical

A technique used to destroy bridges is called earmuffing. This is where conical-cavity shaped charges are placed on two sides of a concrete bridge support directly opposite each other and laced together with det cord. When detonated, the two charges direct great force into the supports, effectively destroying the column. **NOTE**: Shaped charges are

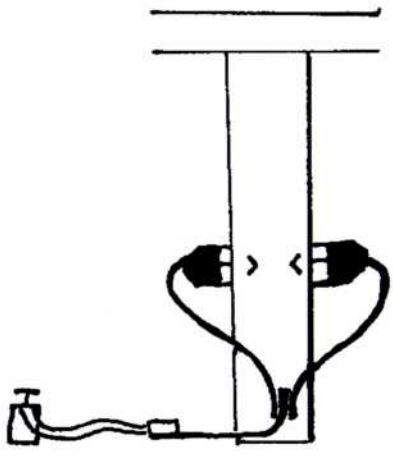


ILLUSTRATION 19
Earmuff charges are used to destroy concrete pilings by creating a counterforce that will shatter concrete.

ILLUSTRATION 20
Cratering charges are used to blast large holes into soft earth.

not always used for earmuffing, but they are more effective in this role.

Linear Cavity

Another type of shaped charge is the linear-cavity shaped charge. Linear charges are designed to cut across a length of steel, effectively cutting it in two.

Cratering

Cratering is a technique that produces large holes in soft earth surfaces. Cratering is used to deny an enemy the use of roadways and runways. Cratering charges are usually 40-pound cylinders containing an explosive with a TNT booster. These charges are placed in holes that are spaced 5 feet apart and have a depth of 4 to 5 feet. When charges are placed across a roadway 20 feet wide, five holes are made, and the charges are detonated simultaneously, producing a crater approximately 7 feet deep.

Delayed Cratering

The delayed cratering technique is used to produce larger, wider holes than the standard cratering technique. This method uses five 40-pound cratering charges placed at a depth of 8 feet. The hole pattern places three holes across a roadway 8 feet apart; the two remaining holes (of the five) are placed 8 feet to the right of the three previous holes. These two holes are placed across from the spaces in the three-hole pattern, the way

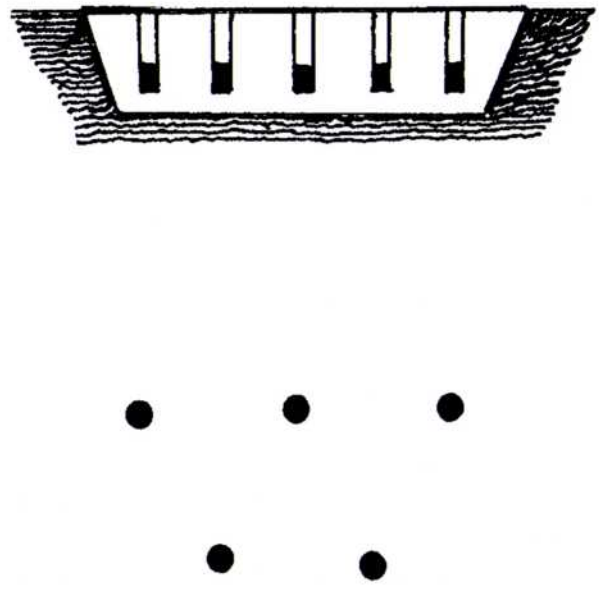


ILLUSTRATION 21
(Top) Straight-cratering pattern.
(Bottom) Delayed-cratering pattern.

bowling pins are placed. The set of two charges is detonated 1 to 3 seconds prior to the set of three charges. This causes the earth to be lifted and then thrown out of the desired crater. The crater that is produced is approximately 10 feet deep and 18 feet long. **NOTE:** This crater is triangular with both a wide and a narrow end.

To cut through steel cylinders, two types of charges are commonly used: the saddle charge and the diamond charge. These charges are made from blocks of plastic explosive. The explosive is rolled flat to a thickness of approximately 3/4 inch and then shaped into a triangle, in the case of the saddle charge, and a diamond for the diamond charge.

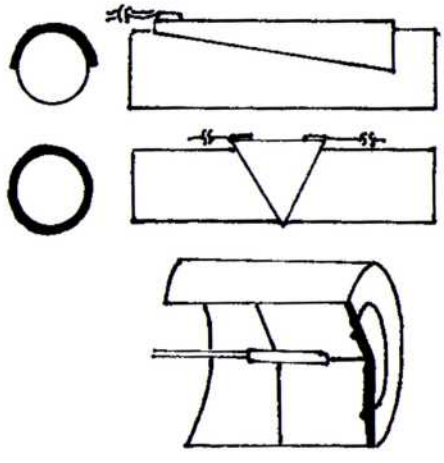


ILLUSTRATION 22
(Top) Saddle charge.
(Middle) Diamond charge.
(Bottom) Platter charge.

Saddle Charge

The saddle charge is placed along a length of pipe with the wide end of the triangle reaching down, to one-half the circumference of the pipe. The long axis is pointed down along the surface of the pipe. The blasting cap is placed at the apex of the triangle and then detonated, cutting the pipe.

Diamond Charge

The diamond charge is made to completely encircle the pipe to be cut. The wide axis of the charge should be one-half of the total circumference. This charge is placed with the ends of the long axis meeting at the bottom of the pipe and the short axis running along the top of the pipe. When detonating this charge, two blasting caps are used: one placed at each end of the short axis. The diamond charge is designed to cut heavier or thicker pipe, where a saddle charge would not be sufficient.

Platter Charge

To destroy fuel tanks, electrical transformers, and other such targets from a distance of up to 50 yards, a platter charge is used. A platter charge consists of a steel platter (like those used to hold a roast beef for carving) with plastic explosives packed against the total surface of the bottom of the platter. The amount of explosive should weigh the same as the platter itself.

Different sizes and shapes of platters can be used; however, the best type is round and made of steel. To destroy the desired target, the concave side of the platter must be aimed at the target and then a blasting cap placed at the center of the explosive charge. When detonated, metal shards will penetrate the target from up to 50 yards.

Derailment Charges

To prevent troops or supplies from reaching their

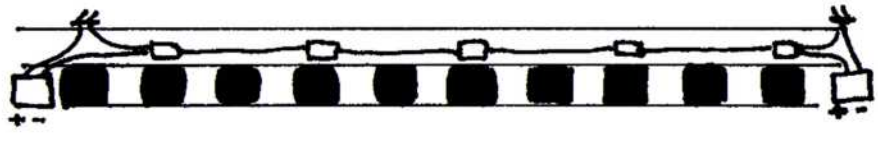


ILLUSTRATION 23
This type of derailment charge can be activated by a train moving in either direction along a track.

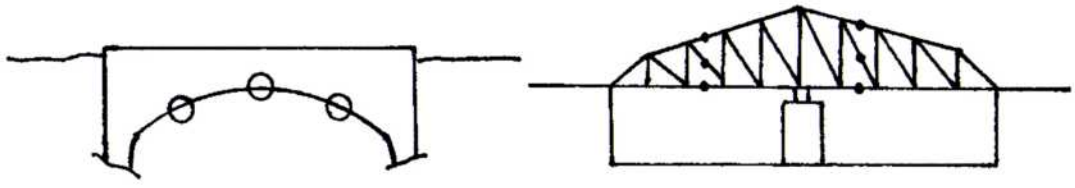


ILLUSTRATION 24
The circles on these diagrams indicate charge placement to destroy arch-style (left) and truss-style bridges.

destination by train, demolition experts use derailment charges. Derailment charges consist of 1/4-pound charges of C-4 laced with det cord. To be sure of derailment, the charges should remove a length of track at least equivalent to the train's wheelbase. The distance between charges should be the same as the distance from a rail tie to every second rail tie.

Bridges are commonly targeted for destruction by demolitions experts, because when bridges are destroyed, the enemy may be denied vital troop and supply routes, as well as access to tactically important territory. This could hinder the enemy for a long time if no other bridges are available at convenient distances. The enemy will have to travel greater distances to gain access to the adjoining area, or if they decide to rebuild, manpower would be diverted to rebuild and protect the new bridge.

To destroy an arch-style bridge, charges must be placed at the crown of the arch, as well as at the haunches on either side of the crown. When these charges are detonated, the right and left segments will collapse, making the bridge useless.

To destroy continuous-span truss bridges, it is necessary to cut the tresses into segments. This is accomplished by placing charges on the upper chord, the cross bar, and the lower chord of the bridge to be destroyed. Charges must be placed on both sides of the bridge directly across from each other. When these charges are detonated, those sections of bridge will break, causing the rest of the bridge to collapse.

There are other techniques for destroying bridges, and there are various other types of bridge designs. However, this should provide a general idea of how bridges are destroyed.

SPECIAL APPLICATIONS

Militaries have, over the years, found some unique uses for explosives that do do not fall into the usual or expected categories of explosives weapons or demolition uses. The explosives applications described are associated with special warfare and are not conventional uses for explosives. Although they can be perceived as improvised weapons and demolitions techniques, I've chosen to list these separately because they are "unique and special" even to conventional military forces. It must be remembered that most of these techniques are used primarily during wartime for offensive and defensive purposes. There are, however, some uses for explosives that can only be seen as helpful to the soldier. I will describe these first.

C-4

C-4 is a very effective and destructive plastic explosive. It possesses many fine explosive qualities such as high brisance and great explosive power, and it will not readily absorb water. One quality of C-4 that makes it a helpful item for the foot soldier is that it burns with an intense heat. It will also stay aflame during high winds and during rainstorms.

This unique quality makes C-4 a valuable tool for any unfortunate soldier stuck out in the boonies, subject to harsh living conditions. C-4 can be used to cook food, purify water, and start fires to give much needed warmth in cold weather. It is for these reasons that C-4 has become popular with many soldiers. I have heard and read many stories where C-4 has been used to prevent hypothermia and provide hot meals, and even one story where a block of C-4

was used to signal an evac helicopter. C-4 has proven itself as a helpful tool in many ways; it is not just used for its destructive capabilities.

On the flip side, C-4's burning qualities make it good as an incendiary weapon that can be used to burn down wooden structures, ignite fuel, or otherwise destroy property by fire.

Ambushes

An ambush is described as a surprise attack from a hidden position upon an unsuspecting target. This is one of the oldest military tactics and was used extensively in the jungles of Southeast Asia.

When springing an ambush, it is necessary to surprise the enemy, catching the soldiers unaware and launching the attack with tremendous force, thus allowing the ambushers to crush the enemy quickly and effectively in as little time as possible. This is the reason military forces engage in ambush-type operations and use explosives as an offensive weapon. Whether a supply convoy or an enemy unit is the target, explosives provide a clear advantage that can give the ambushers a quick victory even when greatly outnumbered.

Ambushing a Moving Convoy

When a moving convoy is targeted, it is sometimes necessary to create an obstacle that halts the convoy in the kill zone. This can be accomplished in many ways: cratering the roadway, blowing trees and rocks into the vehicle's path, or destroying the lead vehicle with an explosive charge planted in the path. After the vehicles are trapped, explosives can be used to destroy the remaining vehicles and injure or disorient enemy personnel.

Explosives can also aid the attack by blowing rocks and debris into or onto the enemy positions, effectively keeping the enemy at bay. When a column of troops is ambushed, explosives can be used to deny it escape routes or defensive positions. They can also be used to destroy whole columns when demolition blocks are laced together with det cord and the chain charge is buried beneath the path where enemy soldiers are expected. When the enemy troops arrive, they can be put down so quickly they won't know what hit them.

Sniper Ambush

Snipers have from time to time employed an ambush technique that uses their skill as expert marksmen and large quantities of high explosives. Sniper ambushes are made by hiding various explosives along an enemy trail. When the enemy appears, the sniper shoots at a target that, when destroyed, causes an electric circuit to close and detonate the charges. This can be accomplished from great distances, allowing a sniper to destroy the enemy in an explosive ambush.

Remote Ambush

Another ambush that can be safely launched from a distance by an individual or small group of combatants is the remote ambush. The remote ambush is similar to the sniper ambush because explosive munitions are placed in selected areas of enemy travel. Personnel are only needed to emplace the explosives. After this has been done, the ambushers can safely retreat to a concealed position. From this position they can, when the enemy arrives, detonate the explosives with a remote radio-detonation device. Such a device uses a coded radio signal sent to a receiver in place at the ambush site. When the correct code is received, the device electronically initiates the blasting caps and explosive charges, creating a high-explosive ambush.

During the Vietnam War, Special Forces personnel used various methods to defend their camps, often against great odds, and explosives played an important part in this defense. One technique used to defend a camp perimeter was to place a charge of high explosives against a 55-gallon drum of fuel. A white-phosphorous grenade

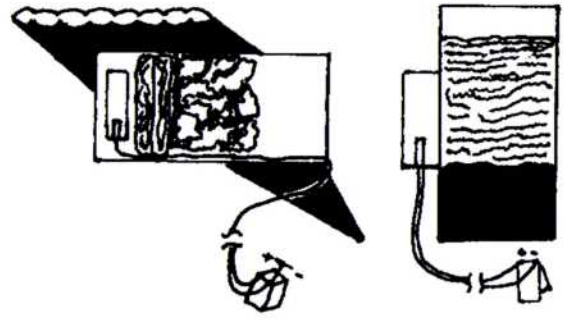


ILLUSTRATION 25
These items were used to defend Special Forces base camps in Vietnam: (left) improvised 55-gallon claymore and (right) improvised 55-gallon fuel bomb.

was added to ensure ignition of the fuel. When an attack was launched against the camp, the explosives were detonated, sending burning fuel onto the enemy soldiers.

Another method used was to place explosives in the bottom of a 55-gallon drum laid on its side. The drum was then filled with scrap metal, stones, broken glass, and other dangerous projectiles. This would also be detonated when the camp was under attack. This device is something like a jumbo claymore mine—very destructive.

When a camp was overrun and the enemy had gained control of key fighting positions (such as machine gun emplacements, mortar positions, and fighting trenches), the ability of the defenders to remove the enemy was enhanced by using charges of high explosives placed in key positions prior to battle. When these positions were captured by the enemy, the defenders would destroy the position by blowing the charges. Sometimes these charges would be set in such a way that the explosion would kill the enemy without destroying the weapons in the emplacement.

Booby Traps

Booby traps are designed to cause the injury or death of an unsuspecting person by luring him into disturbing a seemingly harmless object that is really a cleverly disguised destructive device.

Explosive booby traps fall into two basic categories: manufactured and improvised. Manufactured booby traps are made in factories and issued to soldiers. They usually look like common objects that are useful to soldiers or that may be collected as war souvenirs. An example of this type of booby trap is an exploding rifle cartridge. Booby-trapped cartridges are planted among enemy cartridges and left at the scene of conflict so that the ammo can be recovered by the enemy. When these cartridges are loaded and fired, they explode in the chamber of the rifle, destroying the rifle and injuring the unsuspecting enemy soldier. This causes the enemy to be suspicious of their own weapons and supplies.

The exploding wine bottle, produced by the Germans during World War II, is another such device. It was cleverly disguised as an ordinary bottle of wine, but in reality was filled with a dyed liquid explosive. The explosive was initiated by a pull igniter when the cork was removed. This device took advantage of human nature and curiosity, destroying many would-be winos and soldiers who thought that finding a bottle of wine was cause for celebration. Exploding booby traps were also disguised as canteens, food containers, and other harmless-appearing objects.

ILLUSTRATION 26
(Left) During World War II, the Germans left exploding wine bottles in strategic places for Allied troops to discover. When the corks were removed, a blasting cap would detonate the explosive liquid inside the bottle.
(Right) When placed in a weapon and fired, an exploding rifle cartridge kills or injures its user.

Improvised booby traps are constructed from available materials that have other everyday uses (e.g., books, irons, lamps, flashlights). These booby traps can be very effective if they are well concealed. They can be detonated electrically, mechanically, or by applied or released pressure.

An example of an improvised booby trap is the car bomb, which is constructed by taking a block of explosive and placing an electrical blasting cap in the explosive. Connected to the leads on the blasting cap are two lengths of wire, one at each leg wire on the cap. The ends opposite the blasting cap are stripped of insulation for 1 to 2 inches. These exposed ends can be hooked up to initiate detonation by connecting the wire ends to the ignition switch, the electrical coil, or the starter solenoid. Then when the targeted vehicle's ignition is turned over, the circuit will be completed, and the charge will destroy the vehicle.

A multipurpose booby trap can be constructed by

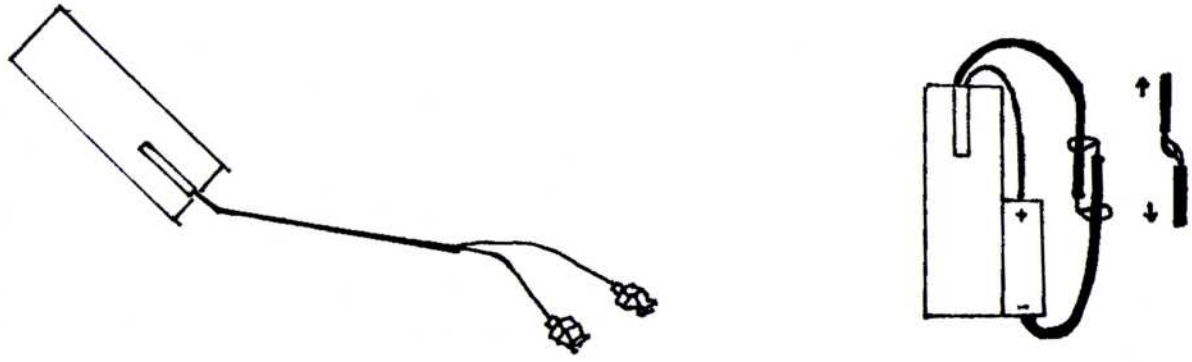


ILLUSTRATION 27
Improvised booby traps: (left) car bomb and (right) multipurpose booby trap.

taking a battery and connecting two lengths of wire, one each to the positive and negative terminals. One wire is connected to the negative terminal and at the opposite end to one of the wire leads of an electrical blasting cap. The wire connected to the positive terminal should have the free end stripped down about 1 inch. This bare wire should be made into a loop and twisted to secure the wire in a circular shape like a lasso. A third wire should have both ends stripped down about 1 inch. One end is placed through the wire loop of the previous wire and made into a loop as before around the body of the looped wire. This will hook the two lengths of wire together within their own loops. The interlocking loops should then be separated approximately 2 to 3 inches, so that the exposed ends do not make contact. They should encircle the insulated wires, so as not to make a complete electrical circuit. A piece of tape should be used to secure these wires and prevent the loops from making contact. When this is done, the end of the free wire without the loop should be connected to the blasting cap's loose leg wire. With this done, the firing circuit is completed. The unit can be detonated via a trip wire, or when hooked to opposing points on an object such as a door and frame. When the door is opened, the loops will make contact, and the device will explode.

To make this device safer to carry and transport, the battery should be removed until the device is in position. The firing loops should also be in a safe position (not touching). Devices like these are commonly improvised as booby traps, and its applications are only limited by an individual's imagination. An improvement on this design would be to place alligator clips at the wire ends connected to the battery and the blasting cap. This would allow quick placement. However, if detected, it could be easily defeated.

Counterterrorist units (CTUs) such as Delta Force and SEAL Team 6 use explosives for some very special work. Examples are blowing the doors to aircraft and blasting holes in walls to gain access to terrorist-held hostages or to provide a means of escape for the same. These tasks may seem pretty straightforward, but it is safe to say that they require a great deal of thought and planning. When the doors are being blown on a captured airliner, the charges have to be calculated so that the door will be blown open without igniting aircraft fuel or injuring hostages. The price of miscalculation is very high: if the charges do not breach the door or if too much explosive is used, the hostages may be killed.

The type of explosive charge used to breach aircraft doors is called a linear cutting tape charge. This is a flexible plastic tube with a notch placed along the inside face of the tube. This charge is held in place by magnets, and when fixed to the fuselage it will effectively cut through, allowing the CTU team to gain entry with little collateral damage.

A primary tactic used by CTU teams is "dynamic entry." The idea is to gain access to a terrorist-held position as quickly as possible and to dispatch the

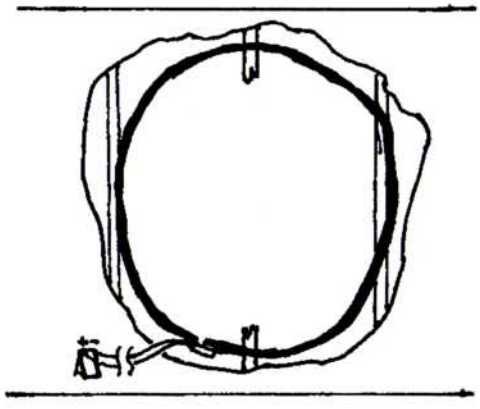


ILLUSTRATION 28
A dynamic entry charge is used to create an entry hole in a wall, giving CTUs immediate access and the element of surprise.

terrorists with lightning speed. A technique used to a gain entrance to a terrorist-held room is to make a hole in the face of a wall in an adjoining room and remove paneling, dry wall, etc., until the rear face of the interior wall is exposed. All of this must be done quickly and quietly, so as not to alert the terrorists. When this is accomplished, a charge of primer cord is made to encircle the hole in the wall, placing the charge on the interior face of the cavity. When the team is ready to make its dynamic entry, a hole is blown in the interior wall. The CTU team can rush the terrorists, having the benefit of a surprise attack. This technique allows CTU teams to enter rooms and buildings from a variety of positions, without the need for doors or windows.

It should also be noted that flash bangs (stun grenades) are also used to disorient terrorists prior to assaulting terrorist-held positions.

NOTES

1. Land mines are now manufactured so that they are undetectable by conventional metal detectors.
2. Missiles are being developed with remote-pilot and stealth technologies, and this is the type of weapons to watch for. The technology is improving daily.

COMMERCIAL EXPLOSIVES AND DESCRIPTIONS

BLACK POWDER

Black powder is a mixture of 75 parts potassium nitrate, 15 parts charcoal, and 10 parts sulfur. Commercial black powder is manufactured in pellets or grains. The size and density of the grains or pellets determine the rate of combustion.

Grains are produced by rubbing semidry black powder paste upon screens, the mesh size of which determines the grain size. Pellets are formed by the compression of black powder paste into small uniform pellets.

Black powder burns to produce 3,000 times its own volume of gas, and when contained, this will cause an explosion.

Black powder can be purchased in bulk 25- to 50-pound containers or at muzzle-loading or reloading supply stores in 1-, 5-, or 10-pound containers. Black powder is sensitive to flame and spark and does not require the use of a blasting cap or detonator to initiate explosion.

MERCURY FULMINATE

Mercury fulminate is manufactured by mixing liquid mercury with nitric acid and then pouring this mixture into alcohol. This produces heat and gray to white crystals. Mercury fulminate is very sensitive to impact, flame, friction, or spark. Mercury fulminate is used to produce detonators and blasting caps by compressing mercury fulminate crystals into a tube at 3,000 psi. If mercury fulminate is compressed beyond 30,000 psi, it will become dead pressed. At this point, it becomes rather insensitive and requires a blasting cap or high-explosive detonator to initiate explosion. When stored in bulk quantities, mercury fulminate is kept in drums of water; this does not reduce its effectiveness but prevents accidental explosions and enhances manufacturers' safety.

AMATOL

Amatol is a mixture of ammonium nitrate and TNT. Ratios for this mixture vary from 60 to 80 percent AN to 20 to 40 percent TNT. This mixture of explosives is more powerful than an equal amount of pure TNT. Amatol was used by the military as a high-explosive filler in bombs and artillery shells. A disadvantage of amatol is that it will readily absorb moisture, which reduces its effectiveness. Amatol should not be stored in copper or brass containers because it may react to form dangerous and unstable compounds.

AMMONIUM NITRATE

We have already discussed AN in some detail, but we will recap a bit here. AN is a white crystalline substance manufactured from a heated mixture of ammonia and nitric acid. This process produces fine white crystals that, when dried, are suitable for demolitions use. AN is also manufactured in prill (pellet) form for use in agriculture as a fertilizer, making it one of the most produced chemicals on the planet. By itself, AN is a low explosive that requires the use of a booster charge such as TNT to initiate detonation. It is for this reason that AN is often mixed

with other substances to make it more sensitive to detonation. A drawback to AN is that it is extremely water absorbent and must be stored in airtight containers. Copper and brass containers must not be used to store AN because it will react with these metals to form dangerously sensitive explosive compounds.

C-4

C-4, or plastic explosive, is a mixture of 91 percent cyclonite (RDX) to 9 percent plastic binder. C-4 has a high shattering power (brisance) and is well suited for demolitions work or as an explosive filler for munitions. C-4 will not readily absorb moisture and remains explosive even when underwater. To detonate C-4, a blasting cap or detonator is required.

DYNAMITE

Commercial Dynamite

Commercial dynamite is made by mixing nitroglycerin with absorbent materials and is graded by the content of nitroglycerin present—e.g., 40 percent, 60 percent, and 80 percent dynamite.

Dynamite is packed in sticks approximately 1 1/4 by 8 inches, and the approximate weight per stick is 1/2 pound. By increasing or decreasing the amount of nitroglycerin in the dynamite, the brisance can be carefully controlled and adapted for specific tasks such as cutting steel or blasting rock. The brisance can vary from 4,000 to 23,000 feet per second (fps).

Dynamite is sensitive to shock, heat, and flame, and when dynamite ages it can become even more sensitive and dangerous. Old dynamite can sweat out raw nitroglycerin, making handling very hazardous. Because it may detonate from the slightest shock, dynamite in this condition should be handled only if necessary and, if so, very carefully and then destroyed as soon as possible.

Military Dynamite

Military dynamite differs from commercial dynamite because it contains no nitroglycerin, making it safer to handle than commercial dynamite. Military dynamite is loaded in stick form, 1 1/4 by 8 inches and weighing about 1/2 pound per stick. It can also be stored safely for long periods without fear of accidental detonation.

Military dynamite requires a blasting cap or detonator to initiate explosion and detonates at a velocity of approximately 20,000 fps. This makes it perfect for demolitions or military construction projects.

LEAD AZIDE

Lead azide is a white crystalline explosive used as an initiating explosive in the manufacture of blasting caps and detonators.

This substance is more effective than mercury fulminate as a detonating agent, but to produce detonation reliably it requires a priming layer of lead styphnate. When lead azide is used in blasting caps or detonators, aluminum casings are required, because lead azide will form copper azide when brass or copper tubing is used. This substance is very sensitive, even more sensitive than lead styphnate, and much more dangerous to handle. Lead azide is sensitive to heat, flame, friction, and electrical discharge.

LEAD STYPHNATE

Lead styphnate is a crystal compound, orange to brown in color, used as an initiating explosive. That is sensitive to heat, friction, flame, and static discharge. Lead styphnate is also used as a priming charge in small-arms cartridges and in commercial blasting caps and detonators. Lead styphnate crystals are stored underwater for safety. When there is a danger of the compound's freezing, alcohol is added as a preventative.

NITRO STARCH

Nitro starch is a compound of sodium nitrate, barium nitrate, and starch nitrate. It is sensitive to flame, friction, and impact. Nitro starch will burn when exposed to flame, but it requires a blasting cap or detonator to initiate explosion. Nitro starch is packed in 1-pound blocks and in 150-pound cases.

PETN

Pentaerythrite tetranitrate (PETN) is a very powerful explosive. Its explosive force is almost equal to cyclonite (RDX) and nitroglycerin. Its

blasting velocity is approximately 26,000 fps. This explosive is primarily used in the manufacture of det cord and as a base charge in blasting caps. PETN is relatively insensitive to shock, heat, and friction; therefore, it can be handled and transported safely.

PICRIC ACID

Picric acid is a yellow high-explosive crystal manufactured through the nitration of phenol. Picric acid was used as a booster charge and a filler in munitions. It is rather insensitive to heat, shock, and flame but can be melted at 120°C and poured into shells. It is about as effective as TNT.

Materials made of lead should be kept away from picric acid because it will react with lead to form lead picrate, a highly sensitive and dangerously violent explosive. Picric acid requires a charge of mercury fulminate or other initiating explosive to produce detonation.

RDX

RDX is a white crystalline high explosive that has a high brisance and is odorless and tasteless. It melts at 200°C and requires even higher temperatures to produce detonation.

RDX is nonhygroscopic, meaning that it will not readily absorb moisture. RDX is manufactured by treating hexamethylenetetramine with nitric acid and stirring this mixture continuously during nitration. Crystals are formed when a solution diluted with water is added to acetone. RDX is very stable and insensitive to shock, friction, and heat. When ignited, it will burn slowly with a red flame, and when consumed by fire, it will leave no residue.

TETRYL

Tetryl is a very powerful yellow crystalline explosive used as a booster charge in blasting caps and detonators. Tetryl has a high brisance, and it will shatter targets easily. When tetryl is used in blasting caps and detonators, a priming charge of mercury fulminate or lead azide is used to initiate detonation. This explosive can be stored safely over long periods, while still retaining its explosive qualities. It has a tendency to exude liquid when stored at high temperatures. This is one of the reasons it has been replaced by RDX and PETN for most applications.

TNT

Trinitrotoluene is a very powerful high explosive. It is manufactured by nitrating toluene. It is a stable high explosive and is insensitive to shock, flame, spark, or heat. It can be melted at 84°C, and in this state it can be poured into molds or shaped charges. It is very shock sensitive when in its liquid form. To detonate TNT, a blasting cap or detonator is required. TNT is made in in 1/4-, 1/2-, and 1-pound blocks or 50-pound cases.

SAFE HANDLING PROCEDURES FOR EXPLOSIVES

All explosives should be handled with the care and respect they deserve. Some explosives are very unpredictable and may explode when exposed to shock, heat, or flame or react with other substances with which they have become contaminated.

When handling explosives, a little common sense goes a long way. All warnings should be heeded—they have been established for good reasons, usually because someone was killed or maimed doing what the warnings said not to do.

The following are some basic rules for the handling and storage of explosives:

1. Never, under any circumstances, should blasting caps, detonators, or other primary explosives be stored with or even near other low or high explosives. A minor accident could turn into a major disaster if this rule is not observed.
2. Explosives should be stored in cool, dry places located a safe distance from other structures. Never should explosives be stored at home or in cars.
3. Storage areas should be neat and clean at all times. Metal objects and tools should not be stored in the same area as explosives.
4. Under no circumstances should any type of open flame be allowed in the storage area. No lighted matches to read a label here.
5. Explosives should never be stored with gasoline, oil, or other combustibles.
6. Temperatures should be monitored in storage areas. In hot climates, this should be done frequently.
7. Some explosives become more dangerous with age; therefore, explosives should be inspected on a regular basis for signs of decomposition, and any explosives found to be unstable should be destroyed. Even if a problem is only suspected, the explosive should be disposed of safely.

The U.S. Department of Transportation regulates the transportation of explosives, and the guidelines it sets forth for the transportation of explosives should be studied and followed to the letter. Many regulations are common sense, but people who are involved in the handling or transportation of explosives should never be foolish or careless. It is better to be extremely cautious when transporting explosives. Auto accidents can happen at any time, for any reason, regardless of cargo. A minor fender bender could turn deadly, however, if the cargo has been handled improperly. For best results, the following recommendations should be heeded.

1. Vehicles used to transport explosives should be in excellent working order. Brakes should be checked to make sure that wires are properly insulated and not prone to sparking.
2. Explosives should be packed in wooden or plastic containers that can be secured to the vehicle and prevented from sliding, bouncing, or moving around in any unsafe manner.
3. The vehicle's storage area should not have any loose tools or combustible materials, such as gas or oil present. These items should be kept elsewhere.
4. Under no circumstances should explosives be exposed to open flame from matches, lighters, cigarettes, etc.

5. Explosives must be handled with extreme care when loading and unloading. Handling must be slow and very careful.
6. If it is necessary to transport blasting caps or detonators with other high explosives, they should be kept separate, and if possible some type of barrier should be created between the explosives and caps.

When explosives are used, for whatever reason, the user is exposing himself to the danger of being killed, blinded, or maimed. None of these things is very pleasant to think about and is even more unpleasant when experienced firsthand.

I have heard too many stories of experienced explosives experts losing their eyesight, their fingers, or even their lives. What all these stories have in common is carelessness. When people are accustomed to doing something, they tend to get careless and complacent. Working with explosives is not like driving a car, but accidents still occur that can be prevented if users follow the rules, pay attention to details, and know their limitations and state of mind.

People who handle explosives must always practice safe handling procedures and not relax their respect for safety. The danger is great. To be successful, users must be constantly on alert.

1. Explosives must not be exposed to open flame, heat sources, cigarettes, or electricity.
2. Explosives should not be used during electrical storms, and users should remain a safe distance from the storage site under these conditions.
3. All equipment must be inspected prior to use. When electrical blasting caps are used, it must be ensured that power supplies are unhooked and wires are well grounded before connecting the electrical blasting caps.
4. Blasting caps should never be disassembled or have their explosives removed from them. They are not toys and should be handled cautiously. When crimping blasting caps, the explosives handler must remain a safe distance away or at least be facing away from the main explosive charge.
5. Excess explosives should never be kept in the blasting area. They are to be placed at a safe distance.
6. When a misfire is being handled, it must be approached cautiously and only after enough time has passed to ensure that detonation will not occur.
7. Primed explosives should never be carried on the handler's person, and blasting caps and explosives must be kept separate until the charge is in place. Carrying primed explosives is not only very dangerous, it is stupid.
8. The blasting area must be kept clear. This means no children, no pets, no cars—NO PEOPLE, PERIOD! I don't care how curious they may be. They should not be there.
9. When the explosive is being tamped, care must be taken that the fuse or electrical wires are still intact and have not been damaged. Explosives should never be tamped in a violent manner.
10. When explosives are being detonated electrically, all the wire leads must be kept clean and the firing circuit completely insulated. No other conductors should be present, and under no circumstances should the power source be attached until ready.
11. When a fuse is being crimped into a blasting cap, care must be taken to ensure that the explosive filler is not being crimped. This could cost a finger or two. Short fuses should never be used, and the burn rate of the fuse should be tested before using it.
12. Explosives should be kept away from animals, children, and other innocents who lack a knowledge of explosives. This includes curious animals who may unknowingly cause an explosion.
13. When explosives are being put into bore holes, the temperature should not be high enough to cause detonation. When drilling is being done, care must be taken that the drill is not going into an explosive charge or another drill hole.

6

TOOLS AND TECHNIQUES

Blasting caps are small tubular shells filled with primary high explosives and a base charge. These blasting caps are approximately 1/4 inch in diameter and 1 1/2 to 2 1/2 inches long. There are two basic types of commercial blasting caps on the market today: electrical and non-el.

Electrical blasting caps are detonated when a Nichrome wire glows red hot (because of the addition of electricity). This initiates the primary charge, which in turn detonates the base charge. A waterproof plug holds the Nichrome wire and the wire leads, as well as the explosive charges, in place. To set an electrical cap, all that is required is that it be added to an electrical circuit. This electrical circuit requires a power source with enough power to detonate the blasting cap or caps.

Non-el blasting caps contain a flash charge as well as a primary charge and a base charge. The addition of the flash charge is necessary to ensure a good ignition by fuse or electric spark. When a fuse is used with a non-el cap, it must be fastened by crimping the neck (or skirt) of the cap around the fuse. This is accomplished by placing the fuse down into the cavity firmly against the flash charge. The neck of the cap is squeezed just below the opening with a pair of crimping pliers; care being taken that there is no contact with any primary explosives.

NOTE: If some primary explosive is crushed during crimping, the cap will most likely go off in the user's hand. This must be watched for closely!

Delay-type blasting caps are similar to the basic caps with one difference: they provide a delay from ignition of the cap to the actual detonation of the

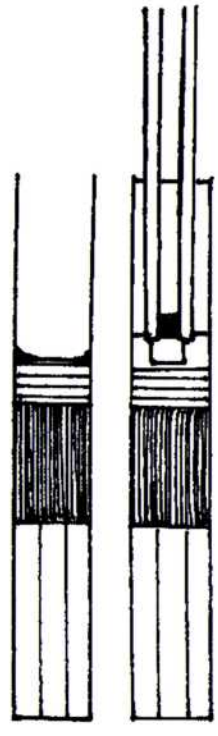


ILLUSTRATION 29
Blasting caps come in two types: electric (right) and non-el (left).

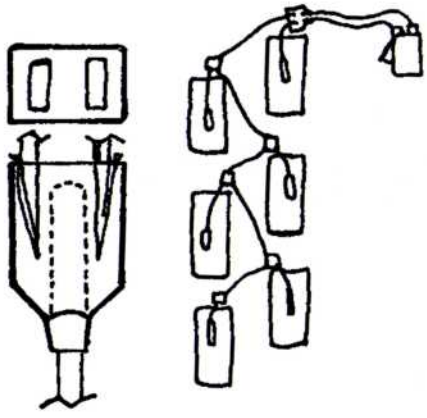


ILLUSTRATION 30
The non-el system uses connecting blocks and tubing for chain-detonating explosives without fuses or det cord.

priming charge. The detonation delays can be as long as 5.0 seconds or as short as a millisecond. Again there are two basic types of delay blasting caps: electric and non-el. The electric-type delay caps come packed with a label describing the length of the delay.

The delay codes for electric caps are as follows:

0 = .008 second
1 = .5 second
2 = 1.0 second
3 = 1.5 seconds
4 = 2.0 seconds
5 = 2.5 seconds
6 = 3.0 seconds
7 = 3.5 seconds
8 = 4.0 seconds
9 = 4.5 seconds
10 = 5.0 seconds

Rather than using a fuse, the non-el system employs a series of explosive-filled tubes and connecting blocks to channel the explosive force to the blasting cap with a delay element.

The delays are coded much the same as the electric caps. What sets this method apart are the ease and safety with which it can be emplaced. This method gives millisecond and decisecond delays and is very effective for controlled blasting techniques. The non-el system does not have the problems that electric systems have, such as the making of an electrical circuit, and the number of misfires is much fewer with the non-el system. The non-el system detonates like a chain reaction, or through the domino effect. The starter cap is detonated by a fuse cap or with a starter pistol. The starter cap is placed in a connecting block that looks similar to a well plug. The cap goes in the rear. Then, other non-el tubes are placed in the receiving holes at the front of the connecting block. These tubes will either go to a blasting cap in an explosive charge or to another blasting cap placed in another connecting block that will continue the explosive train through to the finale. This system is effective and can be used to detonate many charges. The amount of high-explosive charge used in the tubes is minuscule; in fact, it is too little to burst the tube. It transmits the detonation wave from the igniter to the cap

DETONATOR CORD

Detonator or primer cord is a 1/4-inch ropelike explosive charge that is made in rolls of 50-, 100-, and 500-foot lengths. The core is a primary high-explosive charge of PETN. This explosive core is covered by successive layers of cotton tubing, asphalt, rayon, and an external coating of polyethylene.

Primer cord has a detonation velocity of approximately 7,000 meters per second, which is more than sufficient to detonate high-explosive charges. Primer cord is used to connect high-explosive charges to be detonated. A booster charge, or a roll knot of det cord, is usually placed within the charge to ensure detonation.

When det cord is being used to initiate multiple charges that are in different locations (such as earmuff charges), a length of det cord should extend from each charge. These are connected to a separate length of det cord with friction tape or det cord clips so that the lengths of det cord connecting the charges will detonate simultaneously.

WARNING: When det cord is used, it should not be confused with a time fuse or safety fuse. That would be a disaster.

DETONATOR CORD CLIPS

Det cord clips are used to fasten lengths of det cord, whether they cross or run parallel. They are

also used to support det cord when it is run on or above an obstacle. They can also be used to secure blasting caps to a length of cord.

Det cord clips have two main features: the trough, which can be clipped to a length of det cord, and the tongue, which looks like a bent spatula with a hole at the center. To connect lengths of det cord in a parallel line, both lengths should be placed into the tongue and bent to "snug" in place. The trough can be used to hang the det cords that cross.

One length should be placed into the trough and through the hole. Then, the crossed length should be placed over the top of the first length, at the center of the tongue, and the tongue is bent down to fit it in place. If the connections fit loosely, some friction tape can be used to secure the connections. Det cord clips can be improvised by fashioning them from tin or aluminum cans.

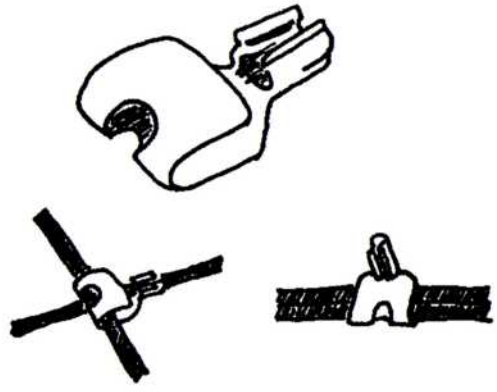


ILLUSTRATION 31
Det cord clips are used to secure lengths of det cord when they cross or run parallel.

FUSES

Commercial fuse comes in three types: blasting time fuse, safety fuse, and cannon fuse. All of these have a black-powder core, but they differ in reliability and application. A blasting time fuse is not reliably waterproof and must be tested. This is done by burning a 1-foot length to time its burn rate before use. The black-powder core of a time fuse is covered with a fiber wrap and a water-resistant outer covering. This fuse is sold by the roll and can be identified by its orange outer coating. Military time fuse has a higher degree of waterproofing and can be identified by a series of painted abrasive bands at 1-foot intervals. These abrasive bands are used to quickly determine a length of fuse by sight or touch. This fuse must also be tested to determine its burn rate, (approximately 40 seconds to the foot).

Cannon fuse is a small-diameter fuse usually used for black-powder cannons and pyrotechnic devices, such as firecrackers. Cannon fuse will burn under water but not reliably. It can be made more effective by rubbing wax on the outer covering or by spraying it with a heavy coating of varnish. This fuse can be purchased by the roll and can be identified by its small diameter and green color. This fuse must also be tested to determine its burn rate.

NOTE: If multiple lengths of cannon fuse are crimped into a blasting cap and secured with friction tape, this fuse can be used to effectively detonate blasting caps and detonators.

BLASTING MACHINES

There are several types of electric blasting machines available today. The most common is the condenser type. These machines come in many sizes and can detonate from 50 to 6,000 detonators at a time.

Condenser-style machines do not operate with net voltage or by battery power. To operate, a hand-cranked inductor is turned until the level of available power is enough to detonate the charges. The larger of these machines comes with a built-in voltmeter and the equipment necessary to test the blasting circuit. When a charge is built up, the circuit is made live by first turning the safety handle to close the safety. Then the charges can be detonated by turning the main blasting handle. The advantage of condenser-style blasting machines is that they are lightweight and very efficient when charging circuits for multiple-round blasting.

The hell box, or twist-handle machine, is a 10-cap-capacity electric blasting machine. It is roughly the size of a canteen cup and has a separate handle attached by a chain to the side. After the blasting circuit is prepared, the positive and negative wires are then hooked to the appropriate terminals at the top of the unit. When all is ready, the handle is attached.

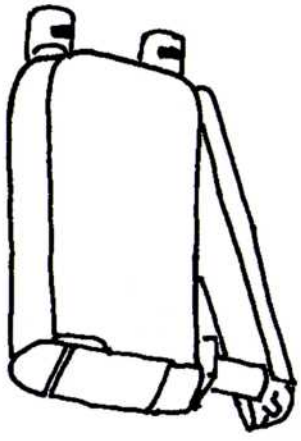


ILLUSTRATION 32
A hand-held 10-cap blasting machine.

To detonate the charge, all that is required is that the handle be twisted rapidly to produce the necessary current to detonate the blasting caps.

The T-handled push-down type of blasting machine is used when between 30 and 100 blasting caps are to be detonated. These machines are rated by the number of caps they can detonate reliably. They are manufactured in 30-, 50-, and 100-cap capacity. On the push-down machines, the electric circuit is connected to the positive and negative terminals. When the handle is depressed, the energy necessary to detonate the caps is produced. With this type of machine, the wires should never be hooked up until the charges are ready to be detonated. **THE POWER SHOULD ALWAYS BE HOOKED UP LAST!**

The M57 electrical firing device is a clacker-style unit that generates enough power to detonate a single blasting cap. This device can be operated by simply moving the safety to the rear position, allowing the firing lever to be completely depressed. This unit is most often used with the claymore mine. A test set to check the circuit is sometimes performed. The firing wires provided with this device have a plug-style adapter for connecting to the firing device. To test the circuit, the wire adapter plug is plugged into the test unit. The test unit is then connected to the firing device. For safety, the blasting cap should be in a position that will not cause injury to the user when testing.

The blasting cap may be placed in a hole or under a sandbag while testing. **UNDER NO CIRCUMSTANCES SHOULD THE BLASTING CAP BE IN OR NEAR THE EXPLOSIVES WHILE TESTING IS BEING DONE!** When all is safe and in place the test may begin. The firing lever should be pressed down firmly one time. This should (if the circuit is live) cause a red lamp to flash in the test unit. After the unit has been shown to be operational, the blasting cap may be placed into the explosive charge.

PULL FIRING DEVICES

Pull firing devices are tubular metal shells that contain a spring-driven plunger that detonates a percussion cap, causing the ignition of a length of time fuse or safety fuse. Devices of this type will reliably ignite fuses under harsh weather conditions and, in some cases, underwater. The basic principle of operation is as follows: a retaining pin holds the plunger in place, and when it is removed, the device is activated.

To prevent premature ignition of the fuse, the device has a couple of safety features. First, a cotter pin is used to hold the plunger in place. Second, a cotter pin is placed in front of the percussion cap to prevent ignition when the first pin is removed. These safety features should not be removed until the moment the fuse is to be initiated (for obvious reasons).

RADIO DETONATION DEVICES

Modern radio detonation devices are more sophisticated than earlier types that relied upon a single signal to be picked up by a receiver unit to detonate an explosive charge. Today's radio detonator uses multiple radio signals to form a radio code to initiate an explosion. Coded frequency units are safer because they cannot be accidentally detonated by the random radio signals that are everywhere in today's society.

MECHANICAL TIMING DEVICES

Since explosives first gained wide use, mechanical firing devices have been designed to allow time delays in minutes, hours, and even days. There are mechanical delays that use hammers to strike percussion caps, and there are those that use

batteries, which fire electrically after the desired time delay. Mechanical timing devices may be very simple, as with a watch or clock mechanism, or they may be as complex as the 72-hour timing mechanisms created for use in warfare. During World War II, many interesting time delays were introduced by both Axis and Allied powers. These delays were most often spring-driven clockworks that could, in some cases, provide both electrical and mechanical time delays. To set the times on these devices, a graduated ring with times marked on the clockwork base were turned to the appropriate delay time.

Improvised timing devices have been created for use by intelligence agencies and special forces. Improvised timers can be created from watches, clocks, egg timers, and even from beans in jars. These devices do not usually provide for extended time delays and are not as reliable as manufactured time delays, but they can be used effectively to delay explosives.

Other types of time delay are the chemical time delay systems. These use chemicals that either cause flames (through a chemical reaction) or chemicals that are corrosive and eat through wire. When the wire breaks, a hammer is released to strike a percussion cap and initiate detonation. An example of this type of delay is the pencil detonator, created for use by commandos. Its components consist of a glass vial of acid in a tubular assembly. A copper wire is used to hold back a spring-driven striker. To actuate this device, a screw is turned until the ampule containing the acid is broken, thus exposing the copper wire to the corrosive acid. After several hours, the copper wire will be dissolved enough to break, releasing the striker.

An improvised chemical delay can be created by putting sulfuric acid in a paper cup placed above a pile of potassium chlorate. When the acid eats through the cup and comes in contact with the potassium chlorate, a flame is produced that can ignite the time fuse.

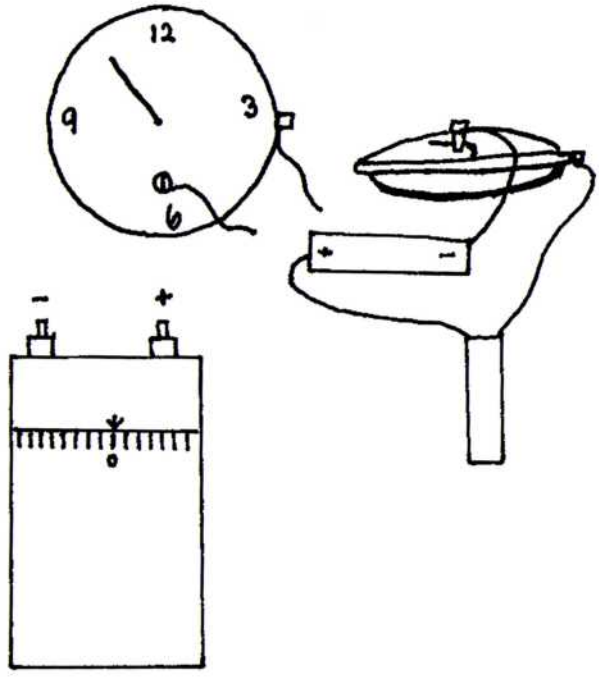


ILLUSTRATION 33
Mechanical timing devices may be as simple as an improvised watch time delay or as complex as a 72-hour time delay device common in wartime situations.

ILLUSTRATION 34
The pencil igniter. When acid from the broken vial eats through the retaining wire, the hammer will be driven forward into a percussion cap, igniting the fuse.

ELECTRICALLY FIRED EXPLOSIVES

To fire explosives electrically, all that is required is a blasting circuit, a battery (power source), and a switch to complete the circuit. But electric blasting is more complicated than this; there are some factors that must be considered, such as battery power, size, length of wire, and the number of caps to be detonated.

To calculate the number of caps that can be detonated electrically, the following factors must be known: the resistance (ohms) of the wire in the circuit, the voltage of the power source, and the amperes available along the blasting circuit. When the volts are divided by the ohms (resistance), the amperes (or rate of flow that is available to each cap) can be calculated. This principle is known as Ohm's law; the formulas associated with Ohm's law read as follows:

ILLUSTRATION 35
Improvised chemical delay timing device. When sulfuric acid eats through the cup, it will ignite the potassium chlorate, lighting the fuse.

Current (amperes) = electromotive force (volts) ÷ resistance (ohms)

Ohms (resistance) = electromotive force (volts) ÷ current (amperes)

Electromotive force (volts) = current (amperes) x resistance (ohms)

To better understand Ohm's law, it helps to use an analogy; the most common analogy is one that compares electrical flow to the flow of water in pipes. The amperes are compared to the quantity of water pumped. The resistance of water is compared to the resistance of electricity along a length of wire (ohms). The amount of force used to push water through a pipe is compared to the electromotive force, or volts. To put this more simply, the voltage must be sufficient to overcome the resistance of the wire in order to deliver the desired quantity of current to the blasting caps. These factors will vary from circuit to circuit, but with know-how and an ohmmeter, the power available can be reliably calculated. All that is

now required is to know how many amperes it requires to detonate an electrical blasting cap. The rule of thumb is that no fewer than 3.0 amps be used per cap. This has been established as a safety rule to make sure that all the blasting caps in a circuit can be detonated, thus reducing the chance of a misfire. It should be understood that blasting caps may detonate with less amperage than this, but it is not recommended. After the power, distance, and number of caps to be detonated have been calculated, an electric firing system can be constructed.

Single-Series Firing System

The first type of electric firing system we will look at is the simplest: the single-series firing system. It consists of primed charges, whose wires are spliced together in a row, creating a path for electrical current across the electrical blasting caps. Spliced to the free wires at each end of the row are two lengths of firing wire that lead to a prearranged "safe distance" site. This circuit can now be tested for faults, shorts, etc., using an ohmmeter or galvanometer. When the single-series system is shown to be free of faults, the ends of the firing wire can be connected to the power source. This system will detonate the charges, provided that the power supply is sufficient to detonate all the caps and providing that no shorts, breaks, or current leaks exist.

Dual-Firing System

The second type of electrifying system is the dual-firing system. This system is set up using two single-series systems, connected to separate charges, along the same row of charges. This allows the blaster to switch to a backup system in the event the first series fails to fire. **NOTE:** The second firing system does not need to be electric; time fuse or det cord can be substituted.

CRIMPING PLIERS

Crimping pliers are used to crimp blasting caps, cut wire, punch priming holes, and connect wires to screw terminals. This multipurpose tool consists of crimping jaws and wire cutters on a pliers-type head, with a screwdriver on one leg and a punch on the other. No blaster should be without a pair of crimping pliers.

BLASTING CAP CRIMPING

Before a non-el cap is crimped to the length of fuse, the cap must first be inspected to ensure that the charge is held in place. No dirt or debris should be present in the cavity at the top of the cap. If dirt or debris is present, it can be cleared out by the user holding the cap like a pencil, keeping the wrist bent up. Then any remaining dirt can be gently dislodged by the user lightly striking both wrists together. **CARE MUST BE TAKEN NOT TO STRIKE THE BLASTING CAP DIRECTLY!** Also a check must be made for any explosive material that might be stuck in the neck of the cap, since this could cause the cap to detonate when it is being crimped. After the cap has been inspected, a length of fuse is inserted into the neck of the cap until it comes in contact with the explosive charge. Then, with the fuse and cap held in one hand and the crimping tool held in the other, the user extends both arms out and away from his body.

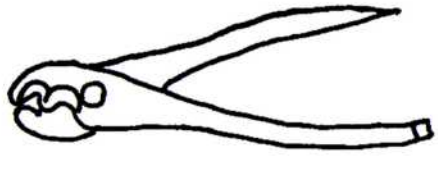


ILLUSTRATION 36
Crimping pliers have jaws for crimping, a pointed leg for priming, and a screwdriver for tightening screws.

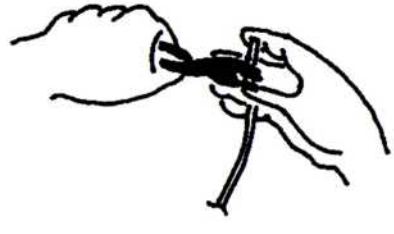


ILLUSTRATION 37
When a blasting cap is being crimped, it should always be held away from the body.

The crimping jaws are placed around the neck of the blasting cap, and pressure is applied until the neck of the cap is securely fastened to the fuse.

DYNAMITE PRIMING

To prime sticks of dynamite, the pointed arm of a pair of crimping pliers is used to make a hole by forcing the point into the stick. This hole should be large enough to accept the whole blasting cap and a small length of fuse. When this is done, the fuse and cap should be secured by tying or taping the fuse to the stick of dynamite. This will prevent the cap from falling out of the dynamite. This is done by tying string or some other material securely around the dynamite and then tying the other end snugly around the fuse, allowing little or no play.

Dynamite can be primed with det cord by punching a series of holes along the length of the stick and then snaking a length of det cord in and out of the holes. The det cord can then be secured by tying or taping it in place.

"Side priming" is another method used to prime dynamite. This is done by punching a hole in the side of the stick at an angle so that the cap sits at the center of the cartridge (care must be taken that a hole is not punched through the stick). The fuse can then be secured by tying or taping the fuse in place.

DEMOLITION BLOCK PRIMING

To prime demolition blocks, the priming hole located at one end of the block is found. This hole is large enough to accept an electric or a fuse-type blasting cap. At the top of the cap well is a paper cover used to keep dirt from entering the cap well. To prime the charge, a hole is punched through the paper cover and the blasting cap inserted so that it goes into the block completely. Then the fuse or wire to the block is secured by using string or tape. This is done by tying a length of string securely around the center of the demolition block and then securely tying the other end around the fuse or wire. This will prevent the cap from falling out of the block of explosive.

Another method for priming demolition blocks is using a priming adapter. It can be determined whether the block is compatible with a priming adapter by checking the priming hole for a threaded inner wall. A priming adapter is used to secure a blasting cap into a demolition block. It has a threaded end that attaches to the block and a slot along one side to allow the fuse or det cord to be secured within the adapter. When the adapter is threaded in this way and secured to the demolition block, it will hold the blasting cap and fuse/wire securely.

To prime demolition blocks with det cord, a length of det cord is laid along the block and the running end is then wrapped around the block four to five times. The cord's end is then slipped through the last turn and snugged down to secure the cord.

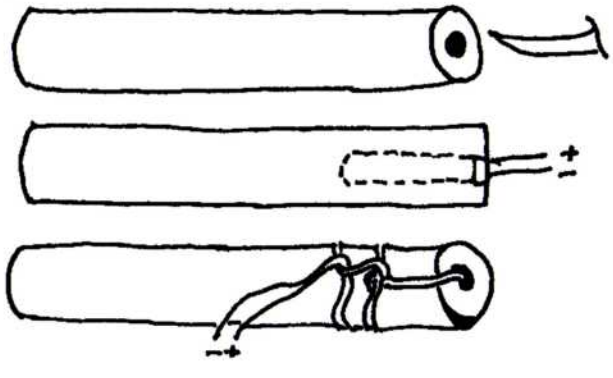


ILLUSTRATION 38
Priming dynamite is accomplished by creating a cap well with the pointed leg of a pair of crimping pliers, then inserting the blasting cap, and finally securing the leg wires to the stick.

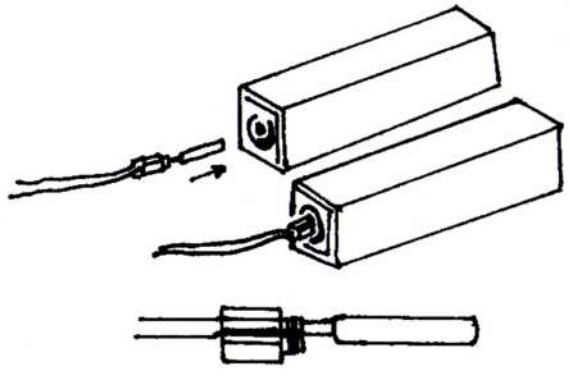


ILLUSTRATION 39
Priming adapters are used to secure blasting caps and leg wires to demolition blocks. This is to prevent loosening caused by movement.

PRIMING OF PLASTIC EXPLOSIVES WITH DET CORD

Plastic explosive is primed with det cord by placing a section of det cord at the desired location on the charge and tying one or two overhand knots in the det cord. Then, the plastic explosive is molded around the knot, and the charge is placed. Various other knots can be used, but this is the simplest. The important thing is that a sufficient amount of det cord be used to detonate the charge.

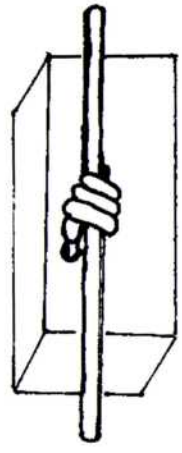


ILLUSTRATION 40
To prime plastic explosive with det cord, the explosive is molded around a roll knot or an overhand knot of det cord.

BLASTING CALCULATIONS AND TECHNIQUES

There are three basic charges to use to blast trees or cut timber: internal (charges placed in a drill hole), external (charges placed on the exposed face of timbers), and abatis. To create a defensive position, the trees are blown down with the upper pointed branch ends facing the enemy. Abatis charges are much like external charges, but their calculation differs slightly from those for external charges. Therefore, I will list them separately.

CALCULATIONS FOR INTERNAL CHARGES

Pounds TNT = $D^2 \div 250$ or pounds of TNT = Diameter (in inches) squared ÷ 250

For example: It would take 5 1/2 pounds of TNT to fell a tree or cut a timber 36 inches in diameter. This technique requires more work to place the charge but is beneficial because it requires fewer pounds of explosive to achieve comparable results. To place internal charges, a hole must be drilled into the tree. This hole should be large enough to accept the explosive charge and deep enough so that the charge is centered squarely in the tree or beam. When the charge is placed and capped, the hole should be filled with tamping material (e.g., clay, dirt). This charge can be detonated by the usual techniques.

CALCULATIONS FOR EXTERNAL CHARGES

Pounds TNT = $D^2 \div 40$ or pounds of TNT = Diameter (in inches) squared ÷ 40

For example: It would take 32 1/4 pounds of TNT to fell a beam 35 inches in diameter. External charges should be placed at the point where the timber is to be cut. It should be kept in mind that the timber will fall toward the side on which the charges are placed. These charges should be securely fastened to the surface of the beam. They can be detonated by the usual techniques.

CALCULATIONS FOR ABATIS CHARGES

Pounds TNT = $D^2 \div 50$ or pounds of TNT = Diameter (in inches) squared ÷ 50

For example: It would take 26 pounds of TNT to fell a tree 36 inches in diameter. The true figure would be 25.46 pounds, but this is rounded to 26 pounds (charges are always rounded up to ensure accomplishing the task). To properly position an abatis charge, it should be placed on the side of the tree that faces the direction the tree is to fall. This charge should be placed 1 to 2 yards up from the ground. It can be secured by rope, tape, or other means, as long as the charges are securely fastened. These charges can be detonated by fuse, electrical system, or improvised trip wire.

CALCULATIONS FOR STUMP REMOVAL

This is more a rule of thumb than an actual calculation: 1 pound of explosive for every 6 inches in diameter. For example: It would take 6 pounds of TNT to remove a stump 36 inches in diameter (this

amount should be doubled in clay or hard-packed earth). To properly place these charges, a hole must be dug beneath the stump as close to the center as possible. This hole should be dug to a depth of 3 to 4 feet below the main base of the stump. If there are large tap roots, some prefer to actually drill into the root to cut it, before proceeding to blow out the stump. It is sometimes necessary to cut large lateral roots before blasting out the stump.[1]

CALCULATIONS FOR CUTTING STEEL BEAMS

Pounds TNT = 3/8 of the surface area to be cut (in inches)

For example: It would take 10.6 pounds of TNT to cut an I-beam whose width is 8 inches and whose web is 18 inches. To calculate, the total rectangular area of each section is figured and then added to get the total area. The width and thickness of each area must be figured to get the total square inches. Then 3/8 of this total measure is calculated to get the pounds of TNT to be used. (To be assured of a proper cut, rounding up to the next nearest pound should be done.)

When cutting an I-beam, the explosives can be placed in two ways. The first is to place the whole charge on one side of the beam. The second is to place half the total charge on the right and half on the left of an I-beam. This is so they are set diagonally from each other at a distance of one to two times the thickness of the web apart. For example: If the web is 1 inch thick, the charges would be offset 1 to 2 inches.

When cutting a channel beam (C-shaped beam), the charge is placed inside the cavity in the area to be cut and against the inner wall. These charges can be detonated by standard methods. The charge is calculated in the same manner.

CALCULATIONS FOR CUTTING CABLES, CHAINS, RODS, AND BARS

Pounds TNT = D^2 or pounds of TNT equal to the diameter squared

For example: It would take 2 pounds of TNT to cut a cable 1 inch thick. If the thickness is greater than 3 inches, the previous formula of P = 3/8 area should be used. To cut cables or bars, the charge must be securely fastened to the surface with rope, tape, etc. Then the charge can be detonated in the usual manner.

CALCULATIONS FOR BREACHING CONCRETE STRUCTURES

Breaching concrete is much more complicated than the previous operations because there are many factors that must be considered, such as the tamping factor, the blast radius of the explosion, the placement of charges, the thickness of the wall, and the total number of charges needed to breach a length of wall.

For this equation the factors are referred to as follows:

P = Pounds of TNT
R = Breaching radius
K = Material hardness factor (0.1 for soft earth, 0.5 for mass only, timber earth construction, and 0.8 for reinforced concrete)
C = Tamping factor (3.6 for untamped base charges, 2.0 for tamped base charges, 1.0 for tamped midsection charges, and 1.8 for untamped midsection charges)

The calculation for breaching concrete reads like this:

Pounds of TNT = R^3 KC

or

Pounds of TNT = Blast radius cubed x Material factor x Tamping factor

For example: To breach a 4-foot-thick reinforced concrete wall with a charge placed at midlevel, that is untamped, it would require approximately 92.16 pounds of TNT (always rounded up, so 92.5 goes to 93 pounds).

To calculate this: Pounds of TNT = 4^3 (4 feet cubed) x .8 (reinforced concrete factor) x 1.8 (the untamped factor for midlevel charge).

Actual math = Pounds = 4^3 = 64 x .8 = 51.2 x 1.8 = 92.16 = Pounds of TNT.

CALCULATIONS FOR TOTAL NUMBER OF CHARGES NEEDED

Number of charges = Width ÷ 2 x R
(radius of blast doubled) or number of
charges = Width ÷ twice the blast radius

For example: It would take three charges of 92.5 pounds of explosives to blast down a wall 24 feet wide and 4 feet thick. For these charges to be positioned, they must be placed one times the blast radius from the end of the structure, and two times the blast radius between charges. So, the first charge would be placed 4 feet from the edge, and the second charge would be 12 feet from the edge. The third charge should be placed at 20 feet from the edge of the wall. To get maximum shattering effect, these charges should be detonated simultaneously.

Remember that when charges are being tamped, care must be taken to ensure that no damage is done to the electrical connections or fuse. Explosives should never be tamped violently by throwing material on the charges. These charges can be set off by standard techniques.

CALCULATIONS FOR THE MINIMUM SAFE DISTANCE FROM AN EXPLOSION

The calculation for minimum safe distance is as follows:

$$\text{Safe distance in meters} = 100 \times 3\sqrt{\text{pounds of explosives}}$$

The minimum safe distance is the distance that all people, animals, vehicles, and so forth should be away from the blast. If the minimum safe distance is unclear, the following rule can be used: The minimum safe distance for up to 100 pounds of explosives is 500 yards; for up to 200 pounds of explosives it is 600 yards.

NOTES

1. Mud capping is only used on large rocks and boulders.

THE IMPORTANCE OF SAFETY IN THE LABORATORY

Anyone working in a laboratory will be handling chemicals that are harmful to the human body. Whether these chemicals are corrosive, explosive, or poisonous, they can cause serious injury. Therefore, certain guidelines have been established to keep persons working in a laboratory environment safe from possible hazards. It is important to follow all the safety rules and procedures.

It is also important that all safety equipment be kept in working order and that it be placed within easy access to all persons working in the lab to ensure the quickest response in the event of an emergency. To help prepare for emergencies, signs may be placed around the lab, listing first aid methods, chemical hazards, and fire hazards. Anyone in a lab should be prepared to handle accidents at a moment's notice. Regular safety inspections should be required, and the lab should be kept clean. When a hazard is discovered, the problem should be handled immediately. Carelessness or laziness has no place in a lab.

When experiments are being conducted, it is very important that all personnel are aware of all the dangers involved. While working with other lab personnel or working alone, any person may be placing his life or the lives of others in danger. So the safety rules must always be strictly followed. All personnel must know where safety equipment is and how to use it and know first aid for poisonings, chemical burns, and other types of emergencies.

Most important, it must be remembered that just because dangerous experiments have been undertaken many times without an accident, it does not mean that mistakes won't happen. It takes only one careless mistake to kill, maim, blind, or disfigure someone. All people working in a lab must think twice before disregarding a safety rule, and they must heed all warnings!

SAFETY EQUIPMENT AND ITS USES

Rubber Gloves

Rubber gloves are used to insulate the hands from poisonous and corrosive chemicals. Certain types of chemicals can be absorbed through the skin, even to lethally toxic levels. Therefore, rubber gloves should be worn when working with known corrosives, poisons, or any unknown chemicals. The thicker the gloves, the better.

Goggles

Goggles are worn to protect the eyes from foreign material and such chemical accidents as a flask that bursts under pressure or a chemical reaction that produces an explosion. The best eye protection should shield the eyes from all directions and create a seal against the skin. When known explosives are being used, a full-face shield should be worn to protect against an explosion and the chemicals thrown by it.

Aprons

Aprons provide protection against chemical spills and will shield skin and clothing from corrosive and toxic chemicals. An apron provides little protection against explosion and flame, but the benefits of a lab apron are still apparent, and one should always be worn. The best type of lab apron is made of heavy

plastic or rubber. It should extend from just below the knee to the base of the neck, providing protection for the full front of the body.

Vapor Hood

A vapor hood is used to provide protection from poisonous or noxious vapors emitted during chemical reactions. A vapor hood provides an enclosed ventilated environment. When using a vapor hood, care should be taken that the ventilation system and seals are working.

Acid-Neutralizing Kit

An acid-neutralizing kit is used to treat spills or contamination by corrosive acids. This kit should contain powdered baking soda to neutralize and absorb acid spills, as well as a solution of baking soda and water to treat acid spills on absorbent materials and to flush skin that has been exposed to acids. The quantities of baking soda in the neutralizing kit should correspond to the amount of stored acid available in the lab. When acid is used in any experiments, this kit should be on hand to treat burns and contamination.

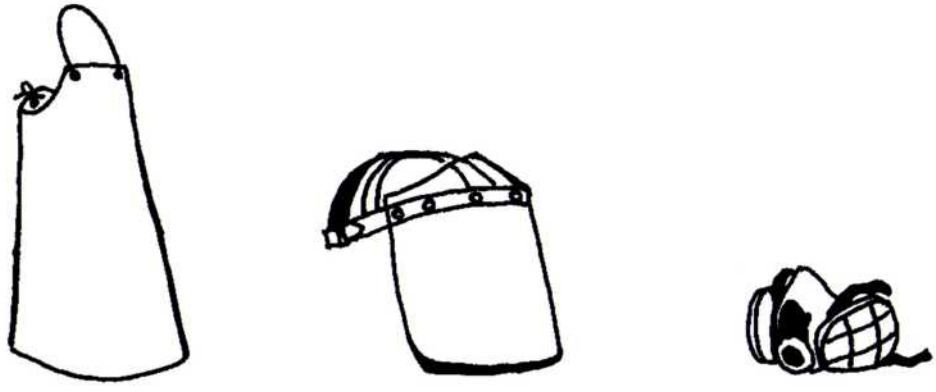


ILLUSTRATION 41
A laboratory should be equipped with safety uppermost in mind. Some of the equipment in a well-stocked lab includes (left to right) a rubber apron, face shield, and respirator.

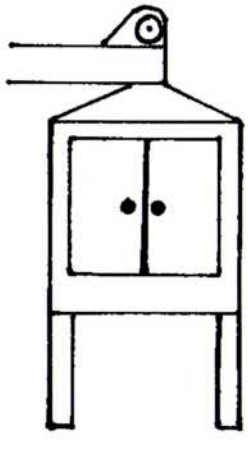


ILLUSTRATION 42
A vapor hood provides protection from poisonous or noxious vapors.

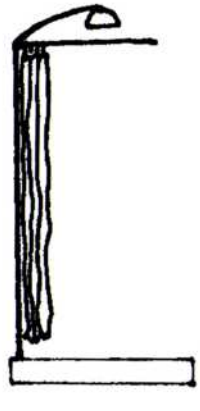


ILLUSTRATION 43
Every lab should have a safety shower to quickly clean areas that have been exposed to corrosive or harmful chemicals.

Spill Absorbers

Spill absorbers are available in many sizes and shapes. Some are like thick paper towels, and others are like giant sausages, but they all provide protection against spills. When liquid chemicals are being used, it is advisable to have spill absorbers available to aid in cleaning up and in preventing accidents. Sawdust and kitty litter may also provide low-cost protection from spills.

Safety Shower

Safety showers provide a quick source of water to flush areas of the body that have become contaminated by corrosive or harmful chemicals. Safety showers usually have large heads and are operated by pulling a chain connected to a water valve. Safety showers also provide a small degree of protection from fire when an exposed piece of clothing becomes engulfed in flames.

Eyewash

An eyewash bath should be a part of every lab. When chemical contaminants get in the eyes through spills, explosions, or other accidents, they can cause severe injury or even blinding. In the event of this type of emergency, the affected eye or eyes should be repeatedly flushed with the eyewash. The best type of eyewash operates much like a water fountain. When the water is turned on, a stream is projected up to the eye rest, where foreign material can be flushed out of the eyes. If a commercial eyewash is not available, a bath of water should be set aside for just such an emergency.

Fire Extinguisher

In the event of a laboratory fire, there is no more valuable tool than a fire extinguisher. Certain chemicals can react together to produce flames, and flammable gases may be produced through a chemical reaction. All of these add up to the potential for many fire hazards, so the fire extinguisher should be immediately visible and accessible and in working order in every laboratory.

First Aid Kit

All labs should be equipped with a well-stocked first aid kit capable of handling many types of emergencies. Also a first aid kit should contain a first aid manual and a list of emergency numbers for fire, ambulance, or hospital services. Emergencies that are more common in a laboratory include chemical burns, poisonings, and injuries from explosions. All lab personnel should know how to handle these emergencies and treat these injuries. This is for the benefit and safety of all lab personnel.

CHEMICAL DANGERS

Corrosive chemicals are chemicals that eat away or consume, for instance, wood, skin, or cloth. Corrosive chemicals used in explosives manufacture can be very dangerous. They will readily eat skin or burn eyes and may be highly toxic.

All applicable safety precautions should be taken when using corrosive chemicals—goggles, aprons, and gloves.

Nitric Acid

Nitric acid is a very corrosive liquid produced from a solution of sulfuric acid and potassium nitrate. This solution is heated to a vapor and then the vapor is condensed to form nitric acid. (This acid will eat skin and other nonresistant materials.)

Sulfuric Acid

Sulfuric acid is a highly corrosive liquid produced when sulfur dioxide reacts with water. (This acid will eat skin and other nonresistant materials.)

Phenol

Phenol or carbolic acid is a corrosive compound formed by distilling such organic substances as coal tar. Phenol is also very toxic, and lethal amounts can be absorbed through the skin.

These are some examples of corrosive chemicals and their properties. Rubber gloves, goggles, and an apron should be worn when corrosive chemicals are being worked with. An acid-neutralizing kit should be kept on hand. There are many other corrosive substances, so anyone in a lab should know the chemicals with which he is working and their properties.

CHEMICAL POISONS

Many chemicals used in the manufacture of explosives are toxic and can kill if ingested or absorbed through the skin. It should also be noted that some chemicals, although not toxic, may cause such harmful side effects as headaches, nausea, and vomiting. If any symptoms appear or ill effects are noticed, work should be stopped immediately and an inspection made for any signs of poisoning. Any such safety hazards as torn gloves or a broken vent seal or vent must also be noted. The dangers of chemical poisonings are ever present and can appear in the form of poison gas, a chemical spilled on skin, or contamination of skin or clothes by vapor, liquid, or gas.

The following measures help to prevent poisonings:

1. All laboratory equipment must be kept clean and in proper working order (this includes protective garments).
2. Anyone working in a lab should know all the chemicals with which he will be working; this familiarization should include chemical properties, poison danger treatments, effects, explosive dangers, what chemicals react with these known chemicals, and what the effects of these reactions are.
3. All protective gear available (e.g., gloves, apron, goggles) should be worn, and all safety equipment applicable to hazardous chemicals and known dangers that occur during experimentation should be readily available.
4. No food or drink should be consumed in a laboratory environment because of the risk of contamination and poisoning.

The following chemicals are just three of the chemical poisons commonly used in the manufacture of explosives.

Nitrobenzene

Highly toxic, nitrobenzene can be absorbed through the skin in doses sufficient to kill. This chemical is used in explosives combinations with nitric acid.

Aniline

Highly toxic aniline can be absorbed through the skin. This chemical is used to sensitize nitromethane.

Phenol

This highly toxic chemical can be absorbed through the skin. Phenol is used in nitro compounds such as picric acid.

To find out more about chemical poisons, write to your regional poison control center or chemical manufacturers for a poison symptom and treatment chart.

Another poison danger is from gases produced from chemical reactions. These poisonous gases include ammonia and chlorine, which are very dangerous. A ventilation hood or gas mask should always be used when working with chemicals that produce poisonous gases or vapors.

EXPLOSIVE CHEMICALS

Some chemicals by their very nature are explosive. These chemicals may explode either in pure form or when combined with other chemicals. Chemical explosives like these are dangerous to work with—and even more dangerous to produce. Only a skilled chemist with the proper equipment should handle or produce these chemicals.

Hydrogen Peroxide

Peroxides are strong oxidizing agents and when mixed with oxidizable substances may cause an explosion to occur. All peroxides have explosive potential, including hydrogen peroxide in concentrated solutions.

Hydrides

Hydrides, such as sodium hydride, will react violently when exposed to water. This is caused by the hydrogen gas and heat produced during this chemical reaction.

Hydrazine

Anhydrous hydrazine is a component used in astrolite explosives. Hydrazine is a colorless, corrosive chemical. It is explosive and becomes more dangerous when combined with oxidizing agents.

Perchloric Acid

Perchloric acid is a strong oxidizer. In its pure form it will explode violently if its temperature gets higher than 92°C. Perchloric acid is obtained through a decomposition of chloric acid.

Chlorates

Chlorates, such as potassium chlorate, are oxidizing agents used in manufacturing explosives. These chemicals are strong oxidizers and must be handled carefully. Chlorates may explode when contaminated and may explode spontaneously when left standing. When chlorates react with acids, they ignite on contact, producing chlorine dioxide, a flammable and explosive gas.

This brings us to explosive gases. Numerous chemical combinations may produce explosive gases. Therefore, it is important to know safe handling procedures for various chemicals, chemical combinations, and chemical reactions of metals, such as sodium or potassium. Such metals will produce violent explosions when mixed with water.

CHEMICAL EMERGENCIES

First, I would like to point out that this is in no way a medical or emergency manual. All the information contained in this book is based on my laboratory experiences with chemicals. Some procedures for treating chemical emergencies may differ from those currently in use. Persons handling chemicals are doing so at their own risk. Neither I nor the publisher accepts any responsibility or liability for chemicals being used or mishandled. Whatever the dangers or liabilities, they are the responsibility of the person handling the chemical!

The best advice I can give is to locate books on first aid, lab safety, and, if possible, material safety data sheets (MSDSs). These will provide a better knowledge of how to handle chemical emergencies. The MSDSs will provide specific information on chemicals, their hazards, and how to handle an accident or emergency with the chemical.

Chemical Burns

Chemical burns are caused by chemicals that are caustic or corrosive (such as acids, alkalis, and petroleum-based chemicals).

To treat a spill on exposed skin or clothing, the area should first be flushed with large amounts of water at a sink or, if available, a safety shower to dilute the corrosive substance and to remove it from the skin as quickly as possible.

The next step is to consult first aid directions for the specific chemical. These may be found on lab charts, MSDSs, or product labels. These must be followed to the letter. Third, if the condition of the injured person is serious, a physician should be consulted immediately.

Acid Burns

With acid burns, a solution of water and baking soda should be used to neutralize the acid. But there isn't time to prepare the solution after an accident. A water and baking soda solution should be on hand as part of an acid-neutralizing kit.

Alkali Burns

With alkali burns on skin, the affected area should be flushed thoroughly with water (do *not* use a baking soda solution) for 10 to 15 minutes. A final rinse, to be used after irrigation of the burned area, can be made by mixing a teaspoon of vinegar with water. A final rinse (to be used only after the burn has been irrigated) can be made by placing 1/2 teaspoon of vinegar into a 12-ounce glass of water. Rinsing the affected area with this solution will help neutralize any remaining chemical.

Chemical Burns in Eyes

NOTE: In this type of emergency, medical help should be sought immediately.

This type of burn should not happen if proper precautions (such as using goggles, face shields, and hoods) are taken. Remember, there wouldn't have to be precautions if accidents didn't occur.

When someone gets a corrosive chemical in his eyes, action must be taken immediately. The eyes are very sensitive and can be damaged quickly if the proper steps are not taken right away. First, using an eyewash or other flowing water source, the affected eye should be flushed thoroughly for 15 minutes. **NOTE:** The affected eye should be lower than the other eye so that the rinse water does not introduce

chemicals into the unaffected eye. For acids in the eye, a solution of 1 teaspoon of baking soda in 1 quart of water may be used as a neutralizing rinse.

An alkali burn of the eye should be watched very carefully. Alkali burns tend to penetrate tissue and can cause deep damage, even when they appear as minor surface injuries.

IMPORTANT: SOLUTIONS OF BAKING SODA OR VINEGAR SHOULD NOT BE USED IN THE EYES WITH ALKALI BURNS.

Chemical burns may also be a result of corrosive gases such as ammonia, chlorine, or sulfur dioxide. These gases can severely burn skin, eyes, lungs, and esophagus. If anyone becomes exposed to these types of gases, the following should be done:

1. The injured party should leave the contaminated area immediately.
2. The affected area should be immediately rinsed with water, and medical attention should be obtained promptly.

Some of these gases can cause injury hours after exposure unless medical attention is administered immediately. It may not even be realized that there was exposure until it's too late. Being smart means using safety gear!

POISONING EMERGENCIES

Many chemicals are toxic and can cause serious injury, even death. Because of the great variety of chemical poisons and their effects on the human body, CAUTION SHOULD ALWAYS BE USED!

A book of this nature can only address general treatments, so the best tool to have on hand is the phone number of the local poison control office. It can provide specific emergency treatments for poisonings and information on numerous toxins. This number should always be posted prominently in any area where any of these toxins are used or stored.

When a person has ingested a noncaustic chemical poison, he should be given as much water as he can drink to dilute the poisons and, in some cases, to induce vomiting. Caustic or corrosive poisons, on the other hand, may burn the throat, mouth, or lungs when regurgitated. Ipecac may also be given to induce vomiting. After vomiting, if the poisoned individual appears unharmed, he may be given burnt toast or 1 teaspoon of activated charcoal mixed with 1 glass of water to help absorb the poison. In some cases, laxatives are recommended after the poisoned individual has taken charcoal to help it through the body.

In any event, medical attention should be sought immediately and, if possible, the container of poison should be taken to the hospital. It may help diagnose treatment or provide valuable information to the medical professionals.

MISCELLANEOUS EMERGENCIES

Any accident that can take place in the home can take place in a laboratory. Common sense must be observed. Follow all laboratory safety rules no matter how strange they may sound. Such emergencies as cuts, broken bones, or sprains are very common. Because these are not related directly to a laboratory situation, I do not see the need to include them in this book. However, I recommend having a first aid kit and manual in any lab at all times. People who work in labs should also receive some kind of formal first aid training.

LABORATORY FIRST AID KIT

A fully stocked first aid kit made for industrial use should be included in all laboratories. Smaller kits made for camping or household use simply will not provide such items as burn sprays, tourniquets, stethoscopes, or even bandages for large wounds. The more prepared a person is for an emergency, the better he will handle one.

Here is a list of items that should be included in a first aid kit:

- Activated charcoal
- Baking soda (large container)
- Epsom salts
- Eyewash bottle containing a solution of baking soda and water
- Flashlight
- Milk of magnesia
- Phone numbers to use in an emergency (doctor, hospital, family members)
- Shears
- Splints
- Stretcher

SETTING UP A LABORATORY

LABORATORY ARRANGEMENT

Most amateur chemists work out of a kitchen or garage. Either may provide a good workplace if that's the only space available. I prefer to work in a remote shed or outbuilding that can provide a quiet place away from daily life. I feel a lab should be nicely laid out with everything within easy reach. Storage should be along the walls with the worktables in a central position. An open window with a great view may be nice, but not in my lab. I don't like distractions, especially when I'm working with dangerous chemicals.

There are no set rules for setting up a lab in terms of location or placement of tables or standard equipment to be included, but there are some basic rules that apply to all labs. A lab should be set up to provide the most effective arrangement for the following.

Cleanup and Safety

A lab should provide the means to clean glass and equipment, as well as providing for personal safety (e.g., a safety shower, eyewash).

Chemical Storage

Chemicals are dangerous to handle and should not be taken lightly or handled carelessly. All the rules that apply to a home medicine chest should apply to a lab. Keep all chemicals out of the reach of children. Keep all chemical bottles labeled by content, dangers, and applicable emergency information. Chemicals should also be kept in a locked storage cabinet or closet. The only time chemicals should be removed is when they are to be used or when they are being disposed of.

Fire Control

Fire extinguishers provide the ability to respond quickly to a fire. When anyone is working with a flame (e.g., a Bunsen burner) or flammable chemicals, there should always be a fire extinguisher at hand. All lab personnel should be familiar with its operation, and it should be properly charged and in good working order. A smoke alarm is also helpful.

Water

Water is a necessary part of all labs. It provides the means to clean lab glass and equipment, as well as providing for personal safety (e.g., safety shower, eyewash).

Ventilation

Ventilation is an important part of laboratory safety. Chemical reactions can produce noxious, toxic, and irritating gases and vapors. A laboratory should include a ventilation hood to handle chemical reactions that are known to produce harmful gases. But this is not enough. In the event of a hood failure, unforeseen chemical reaction, or chemical accident, it may be necessary to remove bad air and replace it with good air. For this reason a lab should have a ventilation system capable of venting the entire area. If the lab has large windows or a couple of doors opening to the outside, it would be a simple matter to place floor fans at doors or windows to allow air flow. But if that's not possible, a series of exhaust fans and

vents may be necessary to get proper air flow. The important thing is to be able to clear the area quickly of harmful gases and vapors.

LABORATORY EQUIPMENT

After the lab has been arranged for its most efficient use, the next step is to equip it. Again, not all labs are equipped in the same way, depending on the work that is to be done in them, but all should have the following basic equipment.

Sturdy Worktables

This may sound strange to some and sensible to others, but take it from the voice of experience: one good bump can destroy a lot of hard work. And if you are working with explosive chemicals, it may even be dangerous. A good lab table should be level, sturdy, acid resistant, and fixed to the floor. It may be hard to find a table with all of these qualities, but it at least should be level and sturdy.

Laboratory Safety Station

This is probably the most important requirement of all labs because it is necessary for the safety of all lab personnel. A lab safety station should include a first aid kit, protective gear, chemical spill kit, and fire extinguishers, as well as any other specific safety equipment that the chemicals being used call for. It should be kept in a place that is easily accessible to all lab personnel (e.g., closet, cabinet). When setting up a safety station, it is helpful to label all boxes, drawers, and so forth with the names of the items stored in them. This will facilitate monitoring or taking inventory, as well as save time in an emergency.

Scales

Scales are needed to measure chemicals by weight. The best type of scale is one that can zero out a container's weight and can weigh grams, ounces, and pounds. Balance scales also work well and are sometimes easier to come by. Balances can be improvised (see the segment on improvised lab equipment later in this chapter).

Stirring Rods

Stirring rods are used for mixing chemicals. They should be several inches long and made of glass or plastic. Glass pipettes and heavy thermometers can be used as stirring rods in a pinch, but I recommend having several stirrers on hand. **NOTE:** Always keep stirring rods clean to avoid contamination.

Mechanical Stirrers

There are two types of mechanical stirrers. The first is a motor-driven stirring rod that looks much like a milkshake mixer; the second uses a motor to spin a plastic-coated magnet placed in a beaker over a motor-driven magnet—in effect, stirring the liquids.

Funnels

Funnels are used for a variety of tasks, from filling containers to filtering liquids. Several sizes are available. At the least, a small (2-inch), medium (4-inch), and large (6-inch) funnel are required.

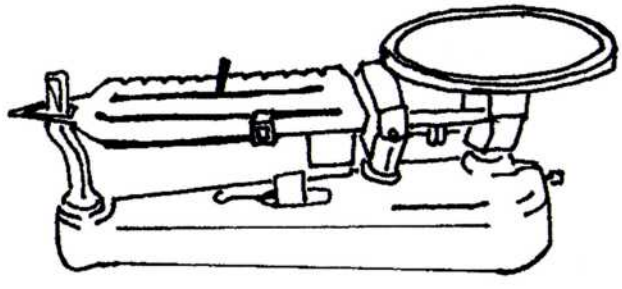


ILLUSTRATION 44
A good scale is essential in a home lab.

ILLUSTRATION 45
A well-stocked lab should have several funnels of both the long- and short-stemmed varieties.

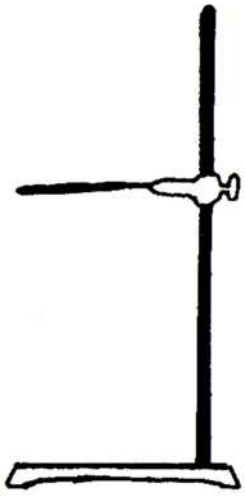


ILLUSTRATION 46
Ring stands are used to support glassware and other laboratory equipment.

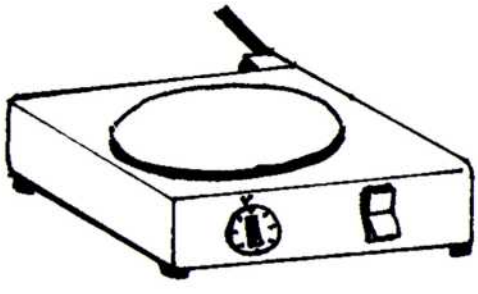


ILLUSTRATION 47
A hot plate provides a flameless heat source for the lab. Flames can be dangerous around the chemicals normally found in labs.

Filters

There are a number of filters on the market today, but I recommend the simple and widely available coffee-type filters. They can be used effectively for most tasks.

Ring Stands

Ring stands are used to support flasks and other laboratory apparatuses. They consist of a solid rectangular base with a rod sticking up at the rear. Utility clamps and ring-shaped flask holders are then attached to the support rod. Ring stands can be improvised by placing a metal rod into a securely fastened 2 x 4 block.

Rubber Stoppers

Rubber stoppers are used for many tasks, from merely corking a test tube to supporting thermometers placed in utility clamps. These are useful items, and any lab should have a good supply of the solid, single-hole, and double-hole varieties. These can be found at most laboratory supply houses.

Tubing

Plastic tubing is used to connect lengths of glass tubing, for vacuum lines, and as condensing tubes for stills. Tubing is available at hardware and auto part stores. There should be no trouble finding tubing in a variety of materials and sizes.

Hot Plates

Hot plates are used to provide a heat source without the danger of flame. The best type of hot plate is one whose temperature can be controlled and maintained by a dial. If one is not available, a simple coffee warmer hot plate will do just fine.

ILLUSTRATION 48
Two common types of lab burners are Bunsen (left) and alcohol (right).

ILLUSTRATION 49
A common mortar and pestle is handy for reducing solid chemicals to fine powders.

Test Papers

Test papers are used to check for the presence of chemicals such as acids, bases, and chlorine. A supply of litmus paper is needed to test for the presence of acids. This paper is available at laboratory supply houses, swimming pool supply stores, and some hardware stores.

Laboratory Burners

Alcohol lamps and Bunsen burners are used as sources of heat and flame to heat chemicals, distill liquids, and work glass tubing. Bunsen burners are available through lab supply houses. If none are available, alcohol lamps can be made easily at low cost. Improvised burners can be made from propane torches and kerosene lamps.

Eyedroppers

Eyedroppers are used to handle small amounts of liquid chemicals. They are available at low cost from drug, hardware, and grocery stores. The best type is graduated for measuring in teaspoons and milliliters. Eyedroppers can also be made from glass and rubber tubing.

Measuring Spoons

Measuring spoons are used to handle dry chemicals. Many types are available, but I recommend the plastic type with the conversions from teaspoon to milliliter on the handle.

Chemical Grinders

Chemical grinders are used to reduce solid chemicals to fine powders. The most commonly available are the mortar and pestle and the electric spice grinder. I recommend having both.

Cleaning Brushes

Brushes are used to clean lab equipment and are available in many shapes and sizes. I recommend having a variety, from small brushes for test tubes to large brushes for beakers and flasks. Toothbrushes and baby bottle brushes work well and are inexpensive.

Thermometer

A thermometer is used to check temperature changes during chemical reactions. I recommend having a large laboratory Celsius thermometer, which is sturdy and accurate. Laboratory thermometers are available through laboratory supply houses. If a lab thermometer cannot be found, a suitable substitute might be found at a hardware or grocery store. Thermometers should be tested for accuracy before use.

Screen Material

Screen material is used to support beakers and flasks on ring stands as well as to reduce clumps of chemicals to granules. Screen material should be heavy enough to provide support and be free of plastic castings. Screen material can be found at local hardware stores.

Test Tube Holders

Test tube holders are used to hold test tubes away from the hand when heating and when working with

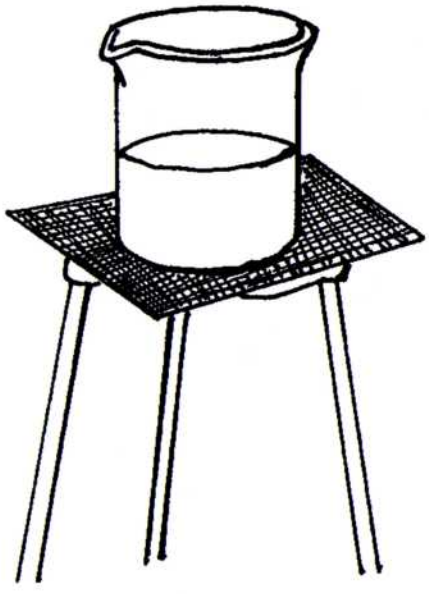


ILLUSTRATION 50
Screen material should be heavy enough to support beakers, flasks, and other lab equipment.

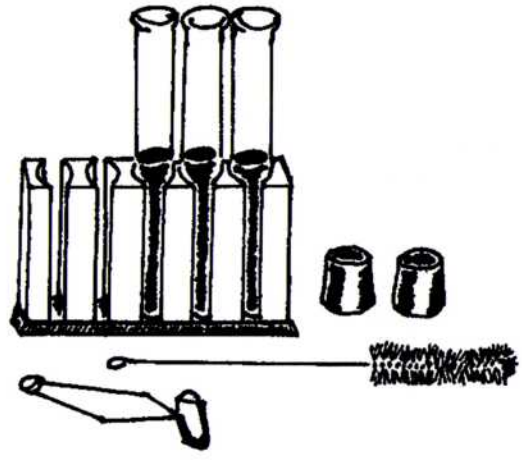


ILLUSTRATION 51
A well-equipped lab should have a variety of equipment to make handling chemicals safer and easier. From back to front: test tube rack, stoppers, cleaning brush, and tube holder.

dangerous or explosive chemicals. A laboratory supply house is the best source for test tube holders.

Test Tube Rack

Test tube racks are used to support test tubes in an upright position when in use and storage. I recommend having at least a couple of these. Test tube racks consist of a wooden or plastic stand with holes in the top and a solid bottom. Test tube racks should be solid and not easily knocked over. These can be made easily and at low cost.

Utility Clamps

Utility clamps are used to hold laboratory apparatuses on ring stands. They consist of a plastic-coated screw clamp to support glassware and a screw eye clamp to secure it to the post of a ring stand. Utility clamps can be purchased at laboratory supply houses. I recommend having several. For larger operations there should be at least one per ring stand.

Miscellaneous Vials and Canisters

Miscellaneous storage containers are needed to store chemicals, both solid and liquid. They should be clean and labeled to describe the contents. I recommend having a large quantity of various sizes with, if possible, tamperproof lids.

Utility Trays

Utility trays are used for a number of jobs in the lab, from handling chemical mixtures to providing a container for an ice bath. Several sizes should be on hand to provide for a wide range of uses. I recommend using plastic storage containers with lids and stainless-steel cake pans. These work well and are fairly inexpensive. Pyrex cake and casserole dishes also come in handy for many applications.

Glassware

Beakers

A beaker is a deep, wide-mouthed vessel used to handle chemical solids and solutions. Beakers are available in a few sizes. I recommend at least a couple of 100-, 250-, and 600-milliliter beakers. If beakers are unavailable, any wide-mouthed tempered-glass jar will do, such as a mason jar, glass coffeepot, Pyrex measuring cup, or clear-glass coffee cup.

Flasks

Flasks have a narrow neck and can have flat bottoms (as with Erlenmeyer flasks) or rounded bottoms (boiling flasks). Both are used for a variety of purposes, from boiling liquids to holding mixtures that will be stored for any length of time. Flasks are available from laboratory supply houses, but in some cases heavy glass liquor bottles may be substituted, providing that they don't have to be heated.

ILLUSTRATION 52
Beakers are wide-mouthed vessels used to handle solid and liquid chemicals.

Collecting Bottles

Collecting bottles are used to store a variety of solid and liquid chemicals. Several sizes and styles are available from laboratory supply houses, but any clean glass storage jars or bottles (such as spice bottles and baby food jars) may be substituted.

Separatory Funnels

Separatory funnels are narrow-mouthed bulbs of glass resembling an upside-down teardrop with a small valve at the bottom. They are used to separate chemicals that do not readily mix and to add liquids to chemical mixtures. I recommend having at least one of these with a capacity of 250 milliliters. If one cannot be obtained, separation may be done with an eyedropper. However, this is time consuming.

Glass Tubing

Glass tubing is used for handling liquids, connecting flasks and test tubes during distillation, and performing a multitude of other laboratory experiments. A lab should have a good quantity of glass tubing stoppers and connectors. Glass tubing can be purchased at laboratory supply houses.

Graduated Cylinders

Graduated cylinders are plastic or glass tubes

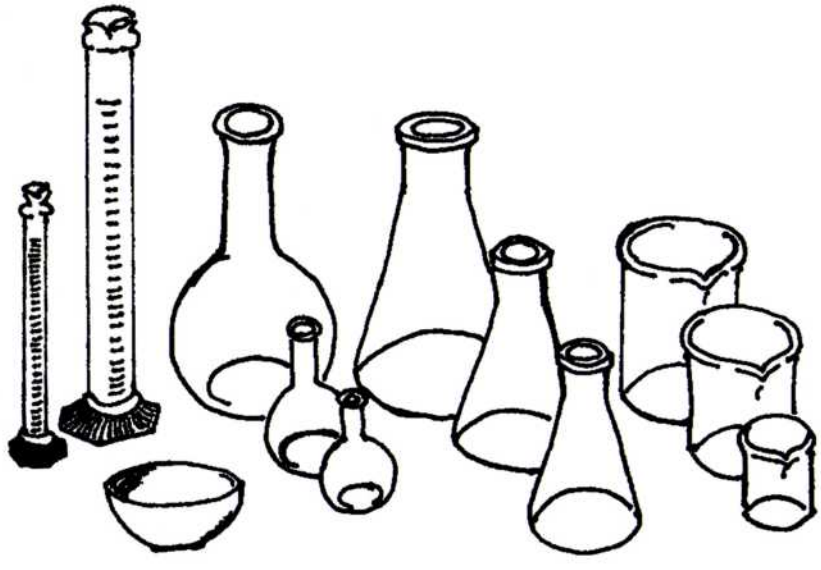


ILLUSTRATION 53
Lab glassware includes (right to left) beakers, flasks, and graduated cylinders.

ILLUSTRATION 54
Separatory funnels are used to separate chemical liquids that don't readily mix.

used to measure amounts of liquids, usually measured in milliliters. These come in various sizes. A lab should be equipped with at least three of each of the following sizes of graduated cylinders: small (10–50 milliliters), medium (50–100 milliliters), and large (100–250 milliliters). These sizes will provide for a wide variety of measures. If a source for graduated cylinders cannot be located, they may be made by placing a standard measure of a liquid into a glass vessel and then marking its position with a wax pen or permanent marker. By increasing the measures in like units and marking the vessel accordingly, an accurate measurement can be made.

Glass Bowls

Glass bowls are used to mix various quantities of solid and liquid chemicals. Three or four are recommended in various sizes. Sets can be purchased at local discount stores at little cost.

Test Tubes

Test tubes are used to conduct various chemical tests and to hold liquids to be added to beakers and flasks. Test tubes are valuable, and a well-equipped lab will have a good supply. These can be purchased from a laboratory supply outlet.

Retort

A retort consists of a bulbous body with a port in the top and a long neck on the top, at the side of the port, extending down below the base of the vessel. It looks something like the earless head of an elephant. Retorts are used to contain chemical reactions that

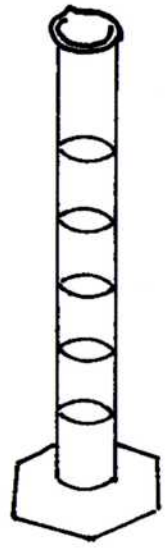


ILLUSTRATION 55
Graduated cylinders are used to measure liquids accurately.

produce gases (that must be bubbled through various liquids) and for distilling liquids. I recommend having one of medium size. They can be found at laboratory supply houses.

Miscellaneous Laboratory Equipment

Graduated Syringes

These can be found at most pharmacies for little cost.

Measuring Cups

These can be found at most grocery stores. Tempered glass is best.

Glass or Bottle Cutter

These will prove useful when making glassware and can be found at local hobby and discount stores.

Various Sizes of Wire

These may be useful to hold or restrain beakers or flasks, as well as to improvise stands.

Carbon Rods

These can be obtained from dry-cell batteries by removing the outer shell and removing the carbon rods at the center. Carbon rods are used in many experiments involving electricity.

ILLUSTRATION 56
Folding the filter paper for use with either the gravity or vacuum filtration systems.

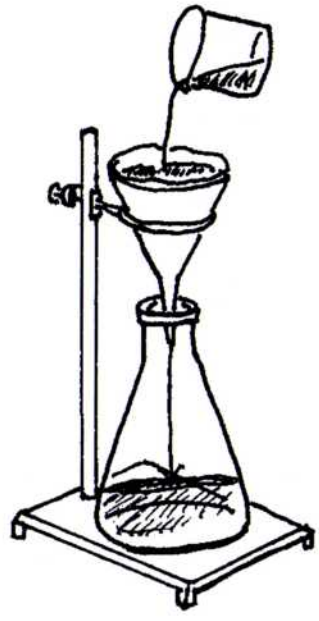


ILLUSTRATION 57
Gravity filtration is a simple and effective way to remove solid particles from liquids. This setup can also be used to wash crystals.

LABORATORY PROCEDURES

Filtering

Filtering is necessary to remove solid particles and precipitates from liquids. The two most common methods used are gravity filtration and vacuum filtration.

Gravity Filtration

Gravity filtration is accomplished by folding a piece of filter paper in half and then in half again so that it appears as a quarter of a circle. A slot is opened in the top of the filter paper to form a cone. This cone can then be placed into a funnel that is supported by either a ring clamp or the rim of a flask. Solutions can then be poured through the filter to remove solid particles. This is by far the easier method for filtering liquids.

Vacuum Filtration

Vacuum filtration is a bit more complex. First, the following equipment is required: a large flat-bottomed flask, a rubber stopper with two holes, a glass pipette approximately 4 inches long and bent at a 45-degree angle, a long-stemmed funnel, filter paper, and a vacuum pump.

These items should be set up as follows: the pipette is placed into the rubber stopper so that it fits snugly and faces away from the other hole. Next, the funnel is put through the second hole so that the bottom is lower in the flask than the pipette. Then the stopper is placed in the flask snugly. After this has been done, the vacuum line from the vacuum pump is attached to the pipette, in such a way that it seals completely. When this is done, the filtration may begin. The filter paper is placed into the funnel as was described in gravity filtration. Then when the vacuum is turned on and the solution is poured into the cone, the liquids will be sucked into the flask, leaving any solid particles.

The advantage of vacuum filtration is speed. Precipitates can be filtered faster, and filtered particles can be dried faster than by conventional means if the vacuum pump is allowed to remain on after the liquid has been drawn off. This allows air to pass through the particles, thus drying them. This is best done using a vacuum funnel. You can also wash the particles on the filter by pouring additional portions of the solvent over them.

Working with Glass Tubing

Glass tubing is used to set up various laboratory

equipment. However, because it doesn't always come in the right size and shape, it is necessary to know how to cut, bend, and polish glass tubing. To manipulate glass tubing, the following is needed: paper pad, triangle file, Bunsen burner (alcohol lamp), leather gloves, and Vaseline or glycerol.

Cutting Glass Tubing

To cut glass tubing, the tube is first placed on the paper pad. Then, at the desired place, the tube is scored once around the circumference with a triangle file. **NOTE:** The tube should be scored only once because uneven or jagged scratches make uneven breaks, and a clean break is needed. After the tube has been scored, the user should grasp one end in each hand and apply gentle pressure applied with the thumbs on both sides of the score mark. Then in one quick motion, the tubing is snapped in half.

Polishing Glass Tubing

After the tubing has been cut, the broken ends should be smoothed. This is accomplished by fire polishing. All that is needed are gloves and a Bunsen burner.

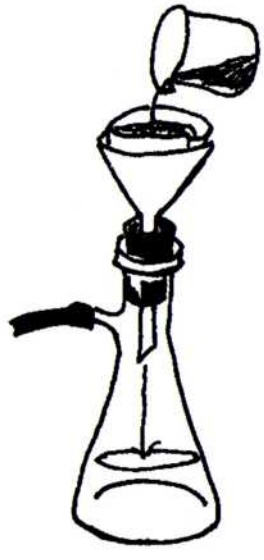


ILLUSTRATION 58
Vacuum filtration is more complex than gravity filtration, but it is quicker. Pulling air through the filtered chemicals will dry them more effectively and quickly.

The only thing remaining is for the rough scored end to be held in the blue flame of the Bunsen burner and gently rotated until the ends become smooth and rounded. **NOTE:** If left in the burner too long or if the tubing is not rotated, the ends may lose the straightness and roundness.

Bending Glass Tubing

Bending glass tubing is necessary to create certain lab equipment. It requires a degree of skill to make a good, even, and well-rounded bend, so practice is required. To start, a Bunsen burner (or alcohol lamp) and leather gloves are needed. The glass tubing is rolled back and forth in the blue flame of a Bunsen burner, while the glass is simultaneously moved from side to side over an area of 1 to 1 1/2 inches. When the glass becomes pliable, it is pulled from the flame and allowed to cool for a couple of seconds. Then when pressure is applied to the ends, the pliable center is bent down to the desired angle. When the pipette cools, the angle and evenness of the tubing should be checked. The bend should be even and provide a smooth channel.

NOTE: Uneven bends and bends that narrow too much at the center may break under pressure. Blowing air through the tube can help prevent flattening at the bend, but too much pressure can cause bulging. Bending glass tubing definitely takes practice.

Making an Eyedropper or Glass Nozzle

This can be accomplished with leather gloves, a Bunsen burner, and a triangle file. Begin by rotating a glass pipette in the flame of a Bunsen burner (as described in the section on bending glass tubing). When the glass becomes pliable, the ends of the pipette are gently pulled in opposite directions. As it is pulled, the heated center will begin to narrow. At this point, the pipette is allowed to cool. When the pipette has cooled, a cut is made in the center, at the narrowest part. This will produce jagged points, which can be removed by fire-polishing the ends. The finished product will function well as a nozzle.

To make an eyedropper, a rubber bulb is needed at the large end for suction. If a bulb is not available, a length of rubber tubing may be substituted. First, the large end of the pipette is placed into a snug-fitting piece of rubber tube about an inch long. Then by gluing a plug (e.g., a pencil eraser) into the free

end of the rubber tubing, an improvised suction bulb can be fashioned. The rubber tube end can also be flattened and sealed with rubber cement.

Grinding and Pulverizing

It is sometimes necessary to reduce chemicals to fine particles. This allows for better mixtures of both dry chemicals alone and dry chemicals in a solution. To reduce dry chemicals, a mortar and pestle or an electric spice grinder is needed. These should work for most tasks, except for very hard and large particles, which will quickly destroy a spice grinder. Grinding these large, hard particles with a mortar and pestle requires far too much work, but they can be reduced to a workable size by smashing them between two pieces of steel (e.g., rollers, hammer and anvil).

When grinding chemicals, a worker should always wear eye protection and follow all safety precautions that apply to the chemical should be carefully followed. A few important things to remember are that friction-sensitive chemicals should never be ground in a spice grinder, chemicals should never be ground together unless specified in the instructions, and grinding equipment must always be kept clean and free of contamination.

WEIGHING CHEMICALS

Procedures for weighing chemicals will vary from scale to scale, so the methods described for the type of scale being used must be followed. The best advice I can give is that the scale must be accurate. Here are a few helpful hints that may be useful for weighing:

- The scale must be on a level surface.
- The weight of the vessel must be accounted for.
- To make handling chemicals easier, a piece of paper folded in half to hold the chemicals on the scale can be used. This will aid in cleanup and will make chemicals easier to remove and pour.
- If counterbalance weights are needed, they can be improvised with pocket change:

  dime = 2 1/2 grams
  penny (copper) = 3 1/8 grams
  nickel = 5 grams
  quarter = 6 1/4 grams
  50-cent piece = 12 1/2 grams

  If other specific weights are needed, they can be fashioned from tin, aluminum foil, and fishing weights.
- A weight conversion card should always be on hand to convert grains, grams, ounces, drams, pounds, etc. This will speed up the chemist's ability to find various like measures when only grams or ounces are available on the scale.

DRYING CHEMICALS

It is often necessary to dry chemicals produced by reactions of liquids or chemicals that have been purified with various liquids. Some hygroscopic chemicals may even require drying after exposure to water vapor in the air.

There are a few common methods used in the lab to dry chemicals. Solid particles that are merely damp can be dried at room temperature by spreading them out on a piece of clean filter paper or other unbleached paper.

If the chemical is pasty or very wet, it may be placed between two sheets of paper, squeezed between wooden blocks, or run through rubber rollers.

A vacuum filter can be used to dry materials by allowing the vacuum pump to pull air through the material placed in the funnel. When extremely hygroscopic chemicals, such as ammonium nitrate, are to be dried, a heat source is required to completely remove water. A suitable heat source is an oven set at very low heat. It is best for the oven to be preheated and then turned off before the tray of chemicals is placed inside. The door should be left ajar for the water vapor to exit. This method allows air flow over material. Heat lamps are also used to dry chemicals. **NOTE:** When explosive chemicals are being dried, they should not be exposed to heat, unless specified by the formula.

WASHING CRYSTALS

When crystals are formed through chemical reactions, the solvents and impurities that are suspended in solutions must be removed. To do this, the crystals must be washed thoroughly. Here are two methods of washing crystals.

1. After crystals have been removed from precipitates through filtration, it is often

sufficient to pour the washing solvent over the crystals and allow the solvents and impurities to drain off. With two to three washings, crystals can often be purified to an acceptable level, except in specific cases.

2. When crystals form into solid cakes after filtration, it will not work to simply pour solvent over the crystals because the solidness of the cake will prevent a good, thorough washing. When this happens, the crystal cake must be removed from its filter and placed into a beaker containing a solvent. Then, a stirring rod is used to break up the cake and stir thoroughly until the crystals have been washed. These crystals must be filtered a second time. Note: Sometimes crystals will dissolve in solvents. When this happens, it may be necessary to use small amounts of solvents when washing, or crystals can be completely dissolved in solvents for purification and recrystallized later.

WEIGHTS AND MEASURES

Liquid Measures

1 teaspoon = 5 milliliters, 1/6 fluid ounce
1 tablespoon = 14.5 milliliters, 3 teaspoons, 1/2 fluid ounce
1 fluid ounce = 30 milliliters, 2 tablespoons, 6 teaspoons
1 cup = 237 milliliters, 16 tablespoons, 48 teaspoons, 8 fluid ounces
1 pint = 473 milliliters, 32 tablespoons, 96 teaspoons, 2 cups, 16 fluid ounces
1 quart = 946 milliliters, 2 pints, 64 tablespoons, 192 teaspoons, 4 cups, 32 fluid ounces
1 gallon = 3,784 milliliters, 4 quarts, 8 pints, 16 cups, 256 tablespoons, 768 teaspoons, 128 fluid ounces

Metric Measures (Volume)

10 milliliters = 1 centiliter
10 centiliters = 1 deciliter, 100 milliliters
10 deciliters = 1 liter, 1,000 milliliters
10 liters = 1 dekaliter

Metric Measures (Weight)

10 milligrams = 1 centigram
10 centigrams = 1 decigram, 100 milligrams
10 decigrams = 1 gram, 1,000 milligrams
10 grams = 1 dekagram
10 dekagrams = 1 hectogram, 100 grams

CONVERSION TABLE

To Change	Multiply the First By
Gallons to liters	3.785
Quart to liters	.9463
Pint to liters	.4732
Liters to gallons	.2642
Liters to pints	2.1134
Liters to quarts	1.0567
Grams to pounds	.002205
Pounds to ounces	16

TEMPERATURE SCALES

	C	F
Boiling point of H_20	100°	212°
Boiling point of alcohol	75°	167°
Freezing point of alcohol	37°	98°
Freezing point of H_20	0°	32°

To convert from Celsius to Fahrenheit, multiply the number of degrees C x 1.8 + 32

To convert Fahrenheit to Celsius, subtract 32 from F and multiply remainder by 0.556

COMPARATIVE TEMPERATURES

Celsius	Fahrenheit
100°	212°
90°	194°
85°	185°
75°	167°
70°	158°
60°	140°
55°	131°
50°	122°
40°	104°
37°	98°
30°	86°
25°	77°
20°	68°
10°	50°
5°	41°
0°	32°
-5°	23°
-10°	14°
-15°	5°
-17.8°	0°

HOME LABORATORY CHEMICALS

Common Name	Chemical	Source
Acetone	Methylethyl ketone	Hardware store
Ammonia	Ammonium hydroxide	Grocery store
Ammonia fertilizer	Ammonium nitrate	Garden supply store
Aqua regia	Nitric acid	Metal shops
Asbestos	Calcium or magnesium silicate	Chemical supply store
Aspirin	Acetylsalicylic acid	Most stores
Baking soda	Sodium bicarbonate	Most stores
Benzol	Benzene	Chemical supply store
Carbide	Calcium carbide	Chemical supply store
Carbolic acid	Phenol	Chemical supply store
Carbon tet	Carbon tetrachloride	Fire extinguisher repair (rarely used for this purpose today)
Caustic soda	Sodium hydroxide	Chemical supply store
Chalk	Calcium carbonate	Discount stores
Chile saltpeter	Sodium nitrate	Chemical supply store
Chloroform	Trichloromethane	Chemical supply store
Copper sulfate	Copper sulfate	Hardware store
Formalin	Formaldehyde	Chemical supply store
Fuel tabs	Hexamine	Camping supply store
Glycerin	Glycerin	Drugstore
Grain alcohol	Ethyl alcohol	Liquor store
Litharge	Lead monoxide	Chemical supply store
Muriatic acid	Hydrochloric acid	Chemical supply store
Niter	Potassium nitrate	Drugstore
Nitromethane	Nitromethane	Petroleum distributor
Oil of mirbane	Nitrobenzene	Chemical supply store
Oil of vitriol	Sulfuric acid	Auto store
Peroxide	Peroxide of hydrogen	Beauty supply store
Potash	Potassium carbonate	Chemical supply store
Quick lime	Calcium Oxide	Hardware store
Quick silver	Mercury	Mercury switches
Rust	Iron oxide	Rusted iron
Sour salts	Citric acid	Grocery store
Stop Leak	Aluminum powder	Auto supply store
Sulfur	Sulfur	Drugstore
Tetrachloroethylene	Tetrachloroethylene	Chemical supply store
Toluene	Toluene	Chemical supply store
Urine	Uric acid	Animal urine
Vaseline	Petroleum jelly	Drugstore
Wood alcohol	Methyl alcohol	Hardware store

PRODUCING CHEMICALS FOR EXPLOSIVES MANUFACTURE

NITRIC ACID

To produce nitric acid in the laboratory, the following items are needed.

Equipment

1 evaporation retort
1 small flask
1 bowl of ice
1 ring stand
1 alcohol lamp
1 stirring rod
1 roll of masking tape

Chemicals

4 tablespoons potassium nitrate
30 milliliters concentrated sulfuric acid

Setup

The retort should be placed on the ring stand high enough to allow an alcohol lamp to be placed beneath it. The bowl of ice is placed to one side of the retort. The small flask should be placed in the ice so as to cover two-thirds of the flask. When the flask has cooled, is it placed at an angle so that the neck of the retort reaches down into the flask. The exit end of the retort should almost touch the bottom of the flask. It should also be high enough from the lower edge of the flask so that when nitric acid is produced, it can drain to the lowest part of the flask and not be submerged. When the flask has been positioned, some tape should be used to cover the mouth of the flask completely. Now that the apparatus is in place, the procedure can begin.

Procedure

Step 1. 4 tablespoons of finely ground potassium nitrate are placed into the opening at the top of the retort.

Step 2. 30 milliliters of concentrated sulfuric acid are carefully added to the potassium nitrate.

NITRIC ACID

Step 3. A stirring rod is used to mix the contents of the retort thoroughly and the stopper is replaced at the top.

Step 4. Gentle heat is applied to the bottom of the retort. Soon red fumes will be generated, and as these fumes exit the stem of the retort, they will begin to condense into nitric acid. When the flask has collected approximately 4 tablespoons of nitric acid and fumes are no longer generated, the process has ended.

Note: Heat should be removed from time to time, if fumes are produced too rapidly or if the retort gets too hot.

This experiment should produce 60 milliliters of concentrated nitric acid. It should be noted that the volume of nitric acid produced is the same as the amount of potassium nitrate used in the experiment and twice the amount of sulfuric acid. When larger or smaller quantities than described are desired, the ratio is 2 to 1 by volume (for example, 2 tablespoons potassium nitrate to 1 tablespoon sulfuric acid). When a larger quantity is desired, care should be taken not to overfill the retort. About two-thirds of the volume of the retort should be air space and the other one-third potassium nitrate/sulfuric acid mixture.

NOTE: When this experiment is under way, the proper safety gear must be worn, and an acid-neutralizing kit should be at hand. Nitric acid and sulfuric acid are dangerous to skin and clothing.

SULFURIC ACID

Sulfuric acid is widely available and costs little, so rather than describing how to make sulfuric acid, I will describe how it can be concentrated for use in later experiments. For this experiment, the following items are required.

Equipment

1 ring stand
1 alcohol lamp or Bunsen burner
1 vent hood
1 medium-sized beaker
1 square of mesh screen (4 x 4)

Chemicals

Diluted sulfuric acid

Setup

The equipment should be set up as follows. First, a ring stand is placed under the vent hood, with the ring support high enough to allow an alcohol lamp to be placed beneath it. Next, a square of wire mesh is placed on top of the ring support. This will aid in supporting the beaker, as well as spreading the heat from the flame. Beneath the ring support, an alcohol lamp or Bunsen burner is positioned. Then the beaker is put on top of the wire mesh. Finally, the beaker is filled to about halfway with sulfuric acid (care should be taken not to spill or splash any acid). When everything is in place, the procedure can begin.

Procedure

Step 1. The alcohol lamp is lighted, and the flame must come in contact with the bottom of the beaker.

Step 2. The vent hood is turned on and the doors secured. This will remove any vapors produced during boiling.

After a few minutes the diluted sulfuric acid will begin to boil. As this happens, the water present in the acid will begin to boil off, leaving concentrated sulfuric acid. It can be determined that all the water has boiled off when white fumes are evolved from the acid. Now the lamp can be removed, allowing the remaining acid to cool. **NOTE: When this experiment is being performed, the proper safety gear must be worn and an acid-neutralizing kit should be at hand.**

URIC ACID

Concentrating uric acid, or animal urine, is accomplished by boiling, much like the method used to concentrate sulfuric acid. Although these methods are similar, urine has a higher percentage of water. Therefore, a large glass or ceramic vessel to reduce the uric acid to the proper volume is needed. This vessel should hold approximately 1 gallon of urine. An electric hot plate is also necessary because a vessel this size will not easily sit on top of a ring stand.

This process should also be done under a vent hood because the vapors produced are very unpleasant. The urine should be reduced to 1/16 its original volume. A gallon should produce approximately 240 milliliters or 8 fluid ounces. After the urine has been reduced, one last step is required: filtering out the impurities that are present in urine. After filtration, the product should be strong enough and pure enough to use in further experiments.

FERRIC OXIDE (RUST)

Ferric oxide, or rust, is the reddish product produced by the oxidation of iron. Rust can be commonly seen on exposed iron or steel objects (e.g., cars). In some cases, obtaining rust is merely a matter of scraping rusted surfaces with a file. This will yield large and small particles that must be screened to obtain a fine powder. All large particles that have not completely oxidized should be discarded. If going on rust-hunting expeditions is not practical, or if these expeditions have yielded little, iron oxide can be produced in the lab at little cost. To produce ferric oxide in the lab, the following are needed.

Equipment

Steel wool
Tin can (open at both ends)
Hair dryer
Screen material
Ring stand
Spray bottle
Stirring rod

Chemicals

Water

Setup

The equipment should be set up as follows. First, the ring stand is placed on the table at a low height so that the blow-dryer can be propped up next to it. Next, the screening material is secured to the rear of a tin tube. Then, steel wool is packed loosely into the open end, and the tin tube is placed on its side on the ring stand. Finally, the hair dryer is propped up so that it points into, and blows warm air through, the steel wool. NOTE: The hair dryer should be 3 to 4 inches from the tin tube to allow good air circulation. When setup is completed, the procedure can begin.

Procedure

Step 1. About a pint of warm water is poured through the open end of the tin tube, saturating the steel wool.

Step 2. The tin tube is placed on its side, on top of the ring stand, facing the open end toward the blow-dryer.

Step 3. The blow-dryer is turned on, and the steel wool allowed to warm up. This will also create an air flow through the steel wool. The dryer should be allowed to stay on for 5 to 10 minutes.

These steps should be repeated two to three times a day until iron oxide begins to appear. At this point, no more water should be poured through the can. Instead, the steel wool should be moistened by spraying lightly from a bottle of water. As the steel wool begins to decompose, it is poked lightly with a stirring rod or finger to deposit iron oxide into the bottom of the tube, exposing the remaining steel wool.

Step 4. The final step should begin when the steel wool is completely or almost completely reduced. The open end is turned up and the can shaken to screen out iron oxide. It may also be necessary to stir with a rod to completely screen out iron oxide.

POTASSIUM NITRATE

Potassium nitrate is a salt, also known as saltpeter. It is formed by decaying organic matter and found in natural deposits around the world. Potassium nitrate is easily available from drugstores and chemical supply houses. If a source of pure potassium nitrate is unavailable, it can be produced in the lab. The following are needed.

Equipment

2 collecting beakers
1 5-gallon plastic (pickle-style) bucket
1 cotton cloth
2 large stainless-steel pans, approximately 12 x 12 x 4 inches
1 electric hot plate
Drill
Paper
Razor blade
Tape
Oven rack or heavy metal rack to support bucket
1 strainer, extra fine
Coffee filters
Gravity filtration funnel and stand

Chemicals

3 1/2 gallons earth (obtain this from a compost bin or other source that contains decomposed animal or plant matter)
8 tablespoons white wood ash powder (from fireplace)
1 gallon (4 liters) ethyl alcohol
1 3/4 gallons water (6 3/4 liters)

Setup

Small holes are drilled into the bottom of a 5-gallon plastic bucket (to completely cover the bottom) to allow water to drain. Next, a stainless-steel collecting pan is placed beneath the bucket, with an oven rack on top of the pan to support the bucket.

After this has been done, a filter must be made. The cotton cloth is laid out, and using the plastic bucket as a template, two circles of cloth the size of the base of the bucket are cut out. Then, the cloth circles are placed together, making a double thickness of cloth. Next, the two circles are taped together around their edges, leaving a small opening of about 4 inches, which will allow 8 tablespoons of wood ashes to be poured between the layers of cloth. When this is done, the opening is taped shut, the filter is placed at the bottom of the plastic bucket, and the ash is smoothed to make an even layer between cloths. The bucket is placed on the oven rack over the collecting pan. When the apparatus is set up in this way, the procedure can begin.

Procedure

Step 1. The plastic bucket is filled to approximately four-fifths of its volume with loosely packed nitrate-bearing earth.

Step 2. On a hot plate, slightly more than 1 quart of water is boiled so that after evaporation, approximately 1 quart remains. The boiling water is poured over the earth and allowed to drain into the collecting pan.

POTASSIUM NITRATE

Step 3. Step 2 is repeated three more times, and the drained water is collected in the collecting pan. This water is allowed to cool and the suspended solids allowed to settle to the bottom.

Step 4. After the solids have settled to the bottom of the collecting tray, the water is poured slowly into the second stainless-steel pan, and the deposited materials should remain in the collecting pan.

Step 5. Again on the hot plate, the collected liquid is boiled until it is one-half its original volume.

NOTE: As the water boils off, salt crystals will be formed. These must be removed with a strainer as they are produced.

Step 6. The remaining liquid is allowed to cool, and an equal amount of alcohol is poured into the water. This will begin to produce small white crystals of potassium nitrate.

Step 7. The water-alcohol solution is poured through a coffee filter placed in a gravity filtration funnel. This will deposit potassium nitrate crystals in the filter. The liquid can be collected in a beaker and discarded.

Step 8. Potassium nitrate crystals are purified by dissolving the collected crystals in a small quantity of water.

Step 9. This solution is boiled and strained to remove any salt crystals produced. The solution is filtered again. The filtered solution is allowed to evaporate, leaving residual crystals. Any crystals collected by filtration should be allowed to dry completely. **NOTE:** This process will yield purified potassium nitrate crystals, but the amount produced will depend on the amount of nitrates present in the earth used.

HEXAMINE (HEXAMETHYLENETETRAMINE)

Hexamine is a versatile chemical. It is used in medicine as a urinary antiseptic (urotropine). It is also used to make hexamine fuel tabs for camping. Hexamine is also used in the manufacture of explosives. To produce hexamine, the following are needed.

Equipment

1 electric hot plate
1 stainless-steel pan (12x12x4-inches)
1 coffee pot
1 ventilation hood

Chemicals

Formalin (40 percent solution of formaldehyde)
Ammonium hydroxide water

Setup

An electric hot plate is placed in the ventilation hood. The stainless-steel pan filled halfway with water is placed on top of the hot plate. This will serve as a hot-water bath for the evaporation of liquids in the coffee pot. When the equipment is set up in this way, the procedure can begin.

Procedure

Step 1. The water is heated in the pan to simmering (below a boil, when bubbles start to form). The vent hood is turned on.

Step 2. 240 milliliters of formalin are put into the coffeepot.

Step 3. 720 milliliters of ammonium hydroxide are added to the coffeepot.

Step 4. The coffeepot is placed into the hot water bath, and the contents are allowed to completely evaporate. The white residual crystals left in the coffeepot are hexamine and can be used in further experiments. I should note that fuel tabs are cheap and will work as a source of hexamine. Hexamine tabs (not the trioxane bars sold for the same purpose in some surplus stores) should be used.

FORMULAS

GUNPOWDER (SIMPLEX)

Equipment

Grinder
Paper bag
Measuring cup and spoons

Chemicals

1 1/2 measures potassium nitrate
1/4 measure sulfur
1/4 measure charcoal (by volume)

Safety Equipment

Goggles
Apron
Gloves (leather)
Fire extinguisher

Safety Measures

There should be no open flames, sparks, etc. Chemicals should be ground individually, and equipment should be cleaned after each use.

Procedure

Step 1. Each chemical should be reduced to its finest possible powder, using a spice grinder or mortar and pestle.

Step 2. When all chemicals are powdered, they are placed in the proper amounts (teaspoons, cups, pounds) as indicated by measures into a paper bag.

NOTE: Measures should be consistent with the amount desired. For example, 1.5 cups potassium nitrate + .25 cup sulfur +.25 cup charcoal will yield approximately 1 pound of gunpowder.

GUNPOWDER (SIMPLEX)

Step 3. The bag is closed securely and shaken vigorously to mix the contents thoroughly. When the contents achieve a common gray color and no clumps of individual chemicals remain, it is mixed well enough. This gray powder is the finished product. It should be stored in a cool, dry place.

This product is of lesser quality than black powder, but it is easier to produce than other explosive powders.

BLACK POWDER (COMPLEX)

Equipment

Grinder
Paper bag
Measuring utensils (cup and spoons)
2 mixing bowls
Stirring rod
Screen material (as per grain size desired)
Cookie pan
Stainless-steel pan
Hot plate (electric)
Gravity filter set (filter material, funnel, ring stand)

Chemicals

1 1/2 measures potassium nitrate
1/4 measure charcoal
1/4 measure sulfur
1 1/2 measures water
5 measures alcohol

Safety Equipment

Goggles
Apron
Gloves (leather)
Fire extinguisher

Safety Measures

There should be no open flames, sparks, etc. Chemicals should be ground individually, and equipment should be cleaned after each use. During heating process, no dry chemicals should be present on the edges of the pan because these chemicals may be ignited by heat. Care should be taken to ensure that chemicals are damp. **CAUTION SHOULD BE USED WHEN HEATING!**

Procedure

Step 1. Reference should be made to the recipe for simplex powder to produce a quantity of powder equal in weight to the amount of black powder desired. The end product of black powder will be equal to the amount of simplex powder used.

Step 2. 1 1/2 measures of water should be placed into a stainless-steel pan and the simplex powder mixture added slowly, while the mixture is being stirred continuously until dissolved.

Step 3. The contents are heated by placing them on the hot plate. They are heated gradually until small bubbles appear.

Step 4. After the mixture has been heated, it is poured into another stainless-steel pan filled with 5 measures of alcohol. As the black powder mixture is added to the alcohol, it is stirred continuously for 3 to 5 minutes. This will ensure that the water has joined with the alcohol.

BLACK POWDER (COMPLEX)

Step 5. A funnel with filter material is put into the cone (which is in the ring stand) at a height that allows the proper funneling of the liquid into a container. The contents are slowly poured into the stainless-steel pan through the filter apparatus, and the residual powder is collected. For larger quantities, this may have to be repeated several times before all of the powder can be collected.

Step 6. The moist black powder is placed on a cookie pan and spread out evenly to form a thin layer of powder. This should then be placed in an area that is warm and has a warm draft blowing lightly over the black-powder cake.

Step 7. When the black-powder cake has almost dried but is still slightly moist, it is time to make grains of black powder. This is done by breaking the cake into small clumps and then lightly rubbing them over a piece of screen mesh material so that small grains are collected in a pan or on a cookie sheet. The grains should be small, separate particles. If they clump up or are sticky, the powder cake should be allowed to dry further. The size of the grains will determine the rate of combustion; therefore, when screen material is selected, the rule of thumb is the smaller the grain, the faster it will burn.

Step 8. The collected grains should once again be placed in a warm area and allowed to dry completely. There should be no moisture in the powder. The finished product should be kept in a metal or plastic container in a cool, dry place away from heat, flame, spark, etc.

Black powder is a more effective mixture than simple gunpowder because of the mixing process. Placing gunpowder into a solution creates a more intimate mixture, producing a product that will readily ignite and undergo rapid combustion (deflagration). This material is a suitable explosive filler for firecrackers.

Sometimes other chemical combinations are used to produce gunpowder-type mixtures.

PRODUCTION PARALLELS FOR BLACK POWDER

Following the same procedure as laid out for gunpowder or black powder can also yield a substitute (production parallel) for gunpowder. In some cases, a nonexplosive metal such as aluminum, magnesium, or oxide is added to increase heat and combustion. These mixtures should not be used as a substitute for black powder in black-powder firearms. They are suitable for use as a low-explosive filler in cherry bombs or as blasting powders. In this role, blasting powders are much more effective than black powder alone. Here are some combinations that have proven to be effective.

#1

1 measure potassium nitrate
1/4 measure charcoal
1/4 measure sulfur
1/4 measure iron oxide, magnesium, or aluminum

#2

1 1/2 measures potassium chlorate
1/4 measure charcoal
1/4 measure sulfur
1/4 measure iron oxide

#3

1 1/2 measures barium nitrate
1/4 measure sulfur
1/4 measure charcoal

#4

2 measures potassium nitrate
1 measure ammonium perchlorate
1/2 measure sulfur
1/2 measure charcoal
1/2 measure magnesium powder

#5

1 measure potassium nitrate
1 1/2 measures starch nitrate*
1/4 measure sulfur
1 measure charcoal
Mix by shaking in a paper bag
1/2 measure magnesium flakes*

(*__NOTE:__ Starch nitrate and magnesium flakes should be added to a premade black powder and then shaken in a paper bag.)

RED-IRON POWDER

Equipment

2 stainless-steel pans
1 beaker (graduated)
Large plastic stirring rod
Cookie sheet
Screen material
Hot plate (electric)

Chemicals

1 1/6 measures potassium nitrate
1 measure white sugar
1/6 measure powdered iron oxide
1 3/4 measures distilled water

Safety Equipment

Goggles
Apron
Gloves (leather)
Fire extinguisher

Safety Measures

There should be no open flames, sparks, etc. Chemicals should be ground immediately, and equipment should be cleaned after each use. **CAUTION SHOULD BE USED WHEN HEATING!** This mixture may ignite if allowed to dry while being heated. No particles should be allowed to dry on the edge of the pan. Although this mixture is made of sugar, it is not safe to eat!

Procedure

Step 1. The desired amount of chemicals is measured out for the amount of red-iron powder desired. For example: 1 1/6 pints potassium nitrate + 1 pint sugar + 1/16 pint iron oxide + 1 3/4 pints water = 2.5 pounds.

Step 2. Into a stainless-steel pan, 1 3/4 measures of water are poured and, using the hot plate, brought to a simmer. Slowly, 1 measure of granulated sugar is added and stirred until dissolved.

Step 3. When the sugar is dissolved and syrupy, 1 1/6 measures of potassium nitrate are slowly stirred in until all the potassium nitrate is dissolved.

Step 4. At this point, iron oxide may be added. This will give the mixture a red color. When the rust is completely mixed in, the mixture is allowed to sit on the hot plate, so that the water will evaporate. The mixture should be stirred periodically to remove any dry particles from the edges of the pan.

Step 5. When the mixture has been reduced to approximately one-third of its starting volume, it may be removed from the hot plate. Before it cools, slowly pour this mixture onto a cookie sheet and roll it out in a thin layer. It should now appear thick and heavy like fudge.

RED-IRON POWDER

Step 6. The mixture should be allowed to dry until it is soft but not sticky to the touch. At this point, grains can be made by rubbing the mixture across a screen. (The mesh size should be consistent with the size of grain desired.) The collected particles should not stick together but should remain as individual grains. If they begin to clump up or stick together, the mixture should be allowed to dry further.

This mixture is a low-explosive propellant that can be used as an explosive filler for firecrackers or cannon powder or to make improvised fuses.

PRODUCTION PARALLELS FOR RED-IRON POWDER

Using the same procedure, here are some other mixtures, all of which are about as effective as the original.

#1

1 1/6 measures potassium nitrate
1 measure sugar
1 1/2 measures water

#2

1 1/6 measures potassium nitrate
1 measure sugar
1/2 measure charcoal
1 1/2 measures water
1/16 measure aluminum

#3

1 1/16 measure sodium nitrate
1 measure sugar
1/16 measure aluminum
1 measure water
1/16 measure iron dioxide

#4

1 measure sodium nitrate
1 measure plain white syrup
1 measure water
1/16 measure iron dioxide

CHLORATE PUTTY (COMPOSITION M)

Equipment

Spice grinder or mortar and pestle
Mixing bowl
Beaker
Alcohol lamp
Stir rod
Ring stand
Screen material

Chemicals

9 measures potassium chlorate
1 measure castor oil

Safety Equipment

Goggles
Gloves
PVC
Apron

Safety Measures

The heating process should be handled with caution, and the apparatus should be securely set up and not be prone to tipping.

Procedure

Step 1. The ring stand should be set up so that it will support a beaker placed on a piece of screen material at a height that will facilitate ready heating of the contents of a beaker.

Step 2. The potassium chlorate should be reduced to the consistency of fine talcum powder and placed in an airtight container until ready to be used. There should be no moisture in the container.

Step 3. Using a ring stand, the chemist should heat a beaker containing 1 measure of castor oil until it is warm to the touch.

Step 4. When the castor oil has been heated, it should slowly be poured into the chlorate powder and mixed thoroughly. This product should have an even consistency with no lumps or dry spots. If these are present, the mixing should continue until the desired consistency is reached. This product is a low-powered high explosive with some of the qualities of other plastic explosive fillers, but it is not as reliable and may be difficult to initiate.

PRODUCTION PARALLELS FOR CHLORATE PUTTY

Through the use of the same procedure, other plastic explosives may be made with the following formulas. However, because of the sensitivity of these ingredients, the heating process should be discontinued and the ingredients mixed at room temperature.

#1

9 measures RDX
1 measure castor oil

#2

9 measures PETN
1 measure castor oil

#3

9 measures HMTD
1 measure castor oil-Vaseline (50-50)

#4

9 measures sodium chlorate
1/2 measure castor oil
1/2 measure Vaseline

NOTE: Petroleum jelly, cooking oil, and light machine oil may be used to replace castor oil.

ANFO (PASTE)

Equipment

Grinder
Oven
Glass bread pan
Stainless-steel pan
Stirring rod
Graduated beaker
Spoon (plastic)

Chemicals

16 measures AN
1 measure fuel oil

Safety Equipment

Goggles
Gloves
PVC
Apron
Fire extinguisher

Safety Measures

Caution must be used during the drying process; AN is an explosive and may detonate if heated at too high a temperature or if heated until it becomes brownish in color and has begun to melt. These are the danger signals to watch for.

SPECIAL NOTE: AN is extremely hygroscopic. If it becomes too wet, it will be ineffective.

Procedure

Step 1. The AN should be placed in a glass bread pan and heated at 125°C for 2 to 3 hours, or until most of the moisture has been removed (safety measures above should be heeded).

Step 2. While the AN is drying, 1 measure of fuel oil should be put into a stainless-steel pan and the grinder readied.

Step 3. This step requires a degree of dexterity and speed. When the AN has dried, the oven should be turned off and the door opened. A plastic spoon should be used to put a scoop of AN into the spice grinder and reduce it to a very fine powder. It must be ground evenly with no clumps.

AUTHOR'S NOTE: The drying and then grinding process is used because it allows air flow through the AN (when it is being heated). Therefore, it has a greater surface area, provided by the surface area of each prill. This causes a more rapid evaporation of water contained in each prill. I prefer this procedure because it produces a drier product (as tested). When a powdered form of AN is used, holes are poked in the mass with a glass rod for the same reason.

After the AN has been ground, it should be poured into the fuel oil and stirred until it is well mixed.

Step 4. Step 3 should be repeated until the proper amount of AN has been mixed into the fuel oil.

ANFO (PASTE)

This explosive can be used in mining and quarrying as well as a filler for explosive munitions. If larger quantities are desired, it is best to use an industrial AN manufactured for use in explosives. If all that is available is an AN fertilizer, it must be more than one-third or 34-percent nitrogen. It should also have a low moisture content. This explosive must be kept in an airtight container and is best used soon after it is produced.

Similar mixtures can be made using the same procedure and the following recipes.

PRODUCTION PARALLELS FOR ANFO

#1 (Wet Mixture)

16 measures AN
1/2 measure motor oil (heavy)
1/2 measure gasoline

#2 (Dry Mixture)

6 1/2 measures AN
1 measure charcoal powder

#3 (Dry Mixture)

6 measures AN
1 measure nitrocellulose
1 measure charcoal

#4 (Dry Mixture)

3 measures AN
1 measure aluminum powder

#5 (Dry Mixture)

50 measures AN
2 measures potassium nitrate (powdered)
1 measure aluminum powder

#6 (Wet Mixture)

6 measures AN
1 measure kerosene

#7 (Wet Mixture)

7 measures AN
1 measure naphthalene

#8 (Wet Mixture)

9 measures AN
1 measure fuel oil
1 measure ammonium perchlorate

ALUMINUM-CARBON TETRACHLORIDE (ACT)

Equipment

Large glass beaker (graduated)
Glass stirring rod
Measuring spoons

Chemicals

1 measure carbon tetrachloride
2 measures aluminum powder

Safety Equipment

Goggles
Gloves
Apron
Vent hood
Respirator

Safety Measures

This mixture will produce toxic fumes, which should be vented through an exhaust hood. Also, safe chemical-handling procedures should be observed because carbon tetrachloride is highly toxic. A respirator should also be used.

Procedure

Step 1. 2 measures of fine mesh aluminum powder is placed in a glass beaker, and the beaker is placed into the vent hood.

Step 2. The vent hood is turned on. When ventilation begins, 1 measure of carbon tetrachloride is stirred in slowly. This mixture is stirred until it thickens.

NOTE: This mixture should be used as soon as it is mixed. In storage it quickly loses its explosive qualities and effectiveness.

SUGAR CHLORATE

Equipment

Glass bread pan
Glass beaker (graduated)
Glass stirring rod
Hot plate
Screen material

Chemicals

3 measures sodium chlorate
2 measures sugar
1 measure water

Safety Equipment

Gloves (leather)
Goggles
Apron
Fire extinguisher

Safety Measures

There should be no open flames, sparks, etc. During the heating process, there is a danger of combustion. Caution must be used during heating to prevent any dried product on the edges of the container from igniting. This mixture will spontaneously combust when it comes into contact with sulfuric acid.

Procedure

Step 1. 2 measures of sugar are placed into a glass beaker, and then 1 measure of water is added. This mixture is put on a hot plate and stirred.

Step 2. When this mixture becomes more fluid, 3 measures of sodium chlorate should be stirred in. After all the sodium chlorate has been stirred in, the mixture is removed from the hot plate and stirred vigorously until it begins to harden.

Step 3. Before the mixture hardens, it should be placed in a bread pan and spread out to dry further.

Step 4. While the mixture is still slightly wet but not sticky, the cake should be broken into small chunks. Then it is further reduced to grains by sifting through a screen. These grains should be loose and not stick or clump.

This mixture can be used as a low-explosive filler, or it may be used to make such pyrotechnic devices as firecrackers, fountains, and incendiaries. **NOTE:** Heating is not necessary with sodium chlorate-aluminum mix.

PRODUCTION PARALLEL FOR SUGAR CHLORATE

A similar explosive may be produced by replacing the sugar with aluminum powder and leaving water out of the mixture. The recipe is as follows:

3 measures sodium chlorate
1 measure aluminum powder

NOTE: This mixture should not be heated. A fine mix is all that is required.

NITROCELLULOSE

Equipment

1 large bucket
Tongs or glass plate
1 ventilation hood
4 large beakers (500 milliliters)
Mixing bowl
3 thermometers (Celsius)
Eyedropper
Ring stand
Thermometer clamp
Stirring rods
Dry cotton batting
Litmus paper

Chemicals

1 measure nitric acid (NA) (50 milliliters)
Crushed ice (add 250 milliliters saline solution)
3 measures sulfuric acid (SA)
1 measure baking soda
Water
Salt
(sample measure: 50 milliliters NA, 100 milliliters SA, 10 grams cotton)

Safety Equipment

Goggles or face shield
Rubber gloves
Rubber apron
Fire extinguisher
Bucket 0°C water
Acid-neutralizing kit

Safety Procedures

Temperatures in this experiment are critical. If temperature exceeds safe level, anyone in the lab is in danger. In the event this happens, the mixture should be cooled immediately by pouring it into a bucket of cold water. All glassware must be kept clean, and all cotton should be free of dirt and debris. Medical-grade sterile cotton is best, but not the cotton found in pill bottles. Temperatures should not exceed 30°C during this experiment. If the temperature goes above 30°C, abandon the experiment.

Setup

The setup in this experiment is very important because it will allow for a quick reaction in the event safety measures must be implemented.

The ring stand should be placed under the vent hood. On top of the ring stand is placed a large mixing bowl of crushed ice with a 500-milliliter beaker in the center of the ice; the beaker must be surrounded completely by ice to cool the contents of the beaker. A thermometer is inserted in a thermometer clamp and attached to the ring

NITROCELLULOSE

stand to hold the thermometer at the rear of the beaker. The thermometer should not touch the beaker wall but should allow easy access. When this is done, a solution of salt and water can be made that will be added to the ice for cooling the nitration mixture.

The beaker is then three-fourths filled with water. Several teaspoons of salt are stirred in until no more salt will dissolve. An acid-neutralizing kit should be placed within arm's reach. A solution of water and baking soda will remove any residual acid from the nitrated cotton, the same procedure being used to produce this solution as for the saltwater solution. A large bucket of water (0°C) should be close at hand in case the mixture begins to overheat. If this happens, the nitration mix can be poured into the bucket. If all goes well, the water can be used to wash the final product and clear off any remaining baking soda solution. When all is ready, a nitration mixture can be prepared.

Procedure

Step 1. The vent hood is turned on. A nitrating mixture is prepared by placing 100 milliliters of sulfuric acid into the 500-milliliter beaker that is in the ice bath. At the same time that the mixture is being stirred, 50 milliliters of nitric acid is being added drop by drop. Careful attention must be paid to the temperature—if it rises too fast or gets too high, no more nitric acid should be added and the solution should be allowed to cool down. After the solution has cooled, begin adding nitric acid again. This should be done as often as necessary until all of the nitric acid is added. The solution should be allowed to cool before use. It can be refrigerated.

Step 2. The saltwater solution is poured into the bowl containing the ice to bring the temperature of the nitrating solution down. The temperature of the nitrating solution should be noted. When the temperature drops to 25°C, step 3 can begin.

Step 3. 10 grams of dry cotton batting should be slowly placed into the nitrating mixture, while the solution is being stirred. The cotton should be pulled apart into strands before adding. When the cotton is completely saturated, it should be allowed to stand for approximately 1 hour to complete the nitration. If the cotton turns to a kind of jelly, it has set too long. **NOTE:** If the cotton turns brown or if fumes are produced, the nitration should be discontinued because this means that the cotton contains moisture or other impurities.

Step 4. The cotton should be removed from the nitration solution and the acids allowed to drain back into the nitration bath. If possible, the cotton should be squeezed with tongs or between glass plates to remove more acid.

Step 5. Drained cotton should be placed in a beaker containing baking soda solution and stirred to remove excess acids. After 3 to 4 minutes, the cotton is removed and drained of baking soda solution.

Step 6. The cotton is placed in a large bucket of cold water and stirred for 3 to 4 minutes to remove excess acids and baking soda. When this is done, the cotton should be removed from the water and wrung dry.

Step 7. The cotton should be tested for acidity by using a piece of litmus paper. If acids are present, steps 5 and 6 should be repeated using a fresh solution of baking soda and fresh water. If no acids are present, step 8 can begin.

NITROCELLULOSE

Step 8. To dry the cotton, it should be squeezed to remove any moisture and then fluffed up by pulling it apart to allow air to flow through it. The cotton should be placed in an area where a warm breeze will slowly dry it. This nitrocellulose should be stored in a glass or plastic container in a cool, dry place. **NOTE:** It should not be allowed to dry in direct sunlight. Nitrocellulose may detonate spontaneously by friction, radiation, conduction, or convection, making it very dangerous to store. This product should be used soon after manufacture, but if long-term storage is desired, it would be best to store or transport it in water.

PRODUCTION PARALLELS FOR NITROCELLULOSE

Nitrostarch and various nitrates can be produced using the same procedure, with one additional step: powders must be filtered out of the acid. This is best done by pouring the nitrating mixture into a large bucket of cold water (1 to 2 gallons), thus diluting the acids. Nitro starch can then be removed by filtration. This prevents the reuse of the nitrating mix, as is possible with nitrocellulose.

The following products can be nitrated provided they are clean, dry, and free of unsuitable chemicals:

- String
- Paper
- Sawdust
- Cornstarch
- Cotton cloth

HEXAMETHYLENETRIPEROXIDEDIOMINE (HMTD)

Equipment

100-milliliter beaker (graduated)
Grinder
Mixing bowl
Filter material
Ring stand
Funnel
250-milliliter beaker
Thermometer
Glass stirring rod

Chemicals

Hexamethylenetetramine
Hydrogen peroxide (20-percent solution)
Citric acid
Ice water

Sample Measures

(This will produce 1.5 to 2.5 grams.)

Hexamine (12.5 milliliters, 2 1/2 teaspoons)
Peroxide (45 milliliters)
Citric acid (22.5 milliliters, 4.5 teaspoons)

Safety Equipment

Goggles
Gloves (rubber)
Apron (rubber)
Fire extinguisher

Safety Measures

Temperature is sensitive at the stage when hexamine is added to peroxide. If the temperature rises too quickly or if the mixture begins to froth, this means that impurities are present in the mixture. If this happens, the mixture must be discarded. The mixture must be kept away from flame, spark, etc. This explosive will become dangerously sensitive when exposed to copper or brass metals.

Procedure

Step 1. Hydrogen peroxide is placed in a 100-milliliter beaker, which is put into a mixing bowl full of ice water.

Step 2. Hexamethylenetetramine is ground to a fine powder and slowly added to the peroxide, which should be stirred continuously with a glass rod. When all is dissolved, this solution should sit for 30 minutes.

Step 3. The beaker is removed from the ice bath, and citric acid is added to the solution. The solution should be stirred until the citric acid has dissolved. When this is done, the mixture should sit in a cool place for 12 hours.

HEXAMETHYLENETRIPEROXIDEDIOMINE (HMTD)

Step 4. As the mixture sits, a white, cloudy precipitate should be noticeable. This is a primary explosive and should be handled with great care. After 12 hours the process should be complete, and the explosive can be filtered out. A ring stand should be positioned at a height where the liquid will drain into a beaker. A funnel should be fitted with the filtration material.

Step 5. The mixture is stirred with a glass rod to thoroughly mix the precipitate into the liquid and prevent suspended solids from remaining in the solution beaker. The liquid is slowly poured through the filter, thus removing explosive crystals. Next, 10 measures of cool water should be poured over the crystals to wash them free of any remaining peroxide solution. NOTE: Vacuum filtering works and will dry explosive crystals.

Step 6. The filter material and contents from the funnel should be removed and the filter paper spread out flat. Using a glass rod, the crystals should be spread out into a thin layer and be allowed to dry completely.

After drying, this chemical should be stored in a plastic container and kept in a cool, dry place away from heat, flame, sparks, etc.

METHYL ETHYL KETONE PEROXIDE

Equipment

100-milliliter flat-bottomed flask
250-milliliter beaker
Stainless-steel pan
Ring stand
Funnel
Filter paper
Refrigerator
Thermometer
Eyedropper
Glass stirring rod

Chemicals

6 measures methyl ethyl ketone (MEK)
10 measures hydrogen peroxide
1/2 measure concentrated sulfuric acid (CSA)
Salt
Ice
Ice water
Sample measures:
MEK 6 measures = 30 milliliters
Hydrogen peroxide 10 measures = 50 milliliters
CSA 1/2 measure = 2.5 milliliters

Safety Equipment

Goggles
Gloves (rubber)
Apron (rubber)
Fire extinguisher
Acid-neutralizing kit

Safety Measures

Temperature is critical during the addition of the sulfuric acid. If the temperature rises too fast, the liquid should be discarded by pouring it into the ice bath. The temperature of the mixed chemicals should be kept as low as possible.

Procedure

Step 1. A large stainless-steel pan is filled with ice water. At the center is placed a 100-milliliter flask. At the sides, the bottles of chemicals are put into the ice bath, keeping the mouths of the bottles clear of water. The chemicals should sit in the ice bath for 1 to 2 hours.

Step 2. The excess water should be scooped out and the bath filled with more ice. A cup of salt should be sprinkled over the ice, with no salt contaminating the flask or chemicals, to lower the temperature of the ice bath further. When this is done, the bottles of chemicals are removed and wiped dry.

METHYL ETHYL KETONE PEROXIDE

Step 3. 10 measures of hydrogen peroxide are added to the beaker. With the dropper, 6 measures of MEK are added to the peroxide, while the mixture is being stirred.

Step 4. While the mixture is being stirred, 1/2 measure of sulfuric acid is added drop by drop. After each drop, the mixture should be allowed to cool before the next is added. The mixture is being stirred all the time the drops are being added.

Step 5. This mixture must sit at a low temperature for 18 to 30 hours or until no more solids are formed in the precipitate. This is accomplished by periodically removing water and replacing it with fresh ice. Keep the ice bath at 0°C (+/- 10°). During the cooling precipitation phase, no water should be allowed to get into the mix.

Step 6. After precipitation is complete, a ring stand should be prepared for filtration; a funnel is inserted into the ring clamp, and filter paper is fitted into the funnel. The funnel should be placed at a height allowing a beaker to be positioned under it. Filtration begins as the contents of the beaker are stirred slowly to unsettle the explosive solids that have collected at the bottom. The liquid is poured slowly into the filter apparatus, thus removing the explosive crystals.

Step 7. These collected crystals must be washed free of any remaining peroxide solution by pouring a couple of teaspoons of water through the crystals. After the crystals have been washed, they must be dried. This is accomplished by removing the filter material from the funnel and laying it out flat. With a glass stirring rod, the crystals are spread into a flat layer for easier drying. The dried crystals should be stored in a glass or plastic container. This explosive reacts with various metals to produce a very unstable explosive capable of detonating spontaneously, so this explosive should NOT be stored in metal containers. Acetone peroxide can also be produced using this method by simply replacing the MEK with acetone.

PICRIC ACID #1 TRINITROPHENOL

Equipment

Petri dish
Hot plate
Stainless-steel pan
100-milliliter beaker
250-milliliter beaker
Thermometer
Funnel
Filter material
2 ring stands (clamps)
Electric stirrer
Eyedropper
Glass stirring rod
Litmus paper

Chemicals

1 measure phenol
4 measures sulfuric acid
4 measures nitric acid
4 measures distilled water
Cold water

Safety Equipment

Acid-neutralizing kit
Vent hood
Rubber gloves
Rubber apron
Goggles (face shield)
Fire extinguisher

Safety Measures

Phenol is toxic and can be readily absorbed through the skin. Noxious fumes will be produced by mixing the acids (use vent hood). **NOTE: Because picric acid reacts with metals to form unstable picrates, IT SHOULD NOT COME INTO CONTACT WITH METAL OBJECTS!**

Procedure

Step 1. A ring stand is placed under the vent hood and on top of this should stand a hot plate. An electric stirrer is clamped onto the post of the ring stand and turned so that it rests at an angle, keeping it out of the way until needed. The hot plate is turned on to a medium temperature. A shallow stainless-steel pan of water is placed on top of the hot plate to heat a bath for heating and drying. The water bath should be hot but not boiling. Water is added as needed. **NOTE:** *It should be remembered that all temperatures given are Celsius.*

Step 2. 1 measure of phenol is put into a 100-milliliter beaker and put in the hot-water bath. As the temperature rises to 84°C, the phenol will melt. This should be done while stirring with a glass rod.

PICRIC ACID #1 TRINITROPHENOL

Step 3. 4 measures of concentrated sulfuric acid are put into a 250-milliliter beaker, and the melted phenol is added slowly to the sulfuric acid, while the mixture is being stirred with a glass rod. Then the mixture is put on the hot plate, and the electric stirrer is lowered to maintain stirring. The temperature should be brought up to 95°C and maintained for 4 hours.

Step 4. 4 measures of distilled water (at room temperature) are placed into a separate beaker. To this are added 4 measures of concentrated nitric acid with an eyedropper while the mixture is being slowly stirred with a glass rod.

NOTE: As the nitric acid is added, the temperature of the solution will rise. If the temperature gets to 105°C, no more nitric acid should be added until the mixture cools. When it cools, the addition of nitric acid-water mixture can begin again. It is important that the temperature does not exceed 110°C.

Step 5. About 8 to 10 minutes after the nitric acid-water mix has been added, the picric acid will be fully formed and must be separated from the solution. First, a glass rod is placed across the top of the beaker so that it sits at the pour spout and the spot directly opposite. This is held in place with the index finger, away from the pour spout. The acid solutions are slowly poured off, leaving the picric acid and a small amount of acid in the beaker. When this is done, the beaker should be filled with cold (0°C) distilled water to wash out the acid.

Step 6. A funnel is positioned in a ring stand and fitted with filter material. The funnel is positioned at a height that will allow a collecting beaker to be placed underneath. Slowly, the picric acid/water is poured through the filter paper, collecting the picric acid. When this is done, a piece of litmus paper is used to test the picric acid. If acids are present, the wash with cold distilled water should continue until the test shows that no acids are present.

Step 7. To dry the picric acid, it is put into a petri dish and then into a hot-water bath. This will cause the moisture in the particles to evaporate. It should be stored in a plastic container and kept in a cool, dry place.

PICRIC ACID #2 TRINITROPHENOL (SIMPLEX)

Equipment

Vent hood
250-milliliter beaker
Petri dish
Small stainless-steel pan
Hot plate
Mortar and pestle
Funnel
Filter material
Ring stand
Measuring spoons
Thermometer
Glass stirring rod
Litmus paper

Chemicals

6 1/2 grams aspirin, powdered
100 milliliters alcohol (methyl, ethyl, or isopropyl)
Concentrated sulfuric acid
Potassium nitrate
Distilled water

Safety Equipment

Acid-neutralizing kit
Gloves (rubber)
Goggles (face shield)
Apron
Fire extinguisher

Safety Measures

Acid should be handled with care, and the fumes should not be inhaled. Picric acid will react to form metal picrates of an unstable nature if it comes into contact with metal, so it should come into no contact with metal during handling or storage.

Procedure

Step 1. In a clean mortar, 20 aspirin tablets are ground. The powder is put into a 250-milliliter beaker that has been half-filled with alcohol; it should be stirred for 1 to 2 minutes.

Step 2. A gravity filtration stand is made from a ring stand, funnel, and filter material and used to filter out any solid particles from this solution. The filter paper and solid particles should be discarded.

Step 3. A hot-water bath is made using the hot plate, stainless-steel pan, and water (water should be hot but not boiling). A petri dish should be put into the hot-water bath and filled about half-full with the liquid from the aspirin-alcohol solution. As the liquid in the dish evaporates, it should be replaced with any

PICRIC ACID #2 TRINITROPHENOL (SIMPLEX)

liquid remaining in the beaker. This should be done until all the liquid has evaporated, leaving only a white residue in the petri dish.

Step 4. The white residue should be placed into a 250-milliliter beaker, and 80 milliliters of concentrated sulfuric acid should be slowly added to it. When all the acid has been added, it should be stirred lightly for 1 to 2 minutes with a glass rod.

Step 5. The beaker goes into the hot-water bath, where it should be allowed to heat up for 10 to 15 minutes.

Step 6. The beaker is then removed from the water bath, and to it is slowly added 15 grams of finely powdered potassium nitrate, while the mixture is being stirred continuously. As this potassium nitrate is added, the mixture will turn blood red. Large quantities of red fumes will be generated. The process should be conducted under a vent hood. When the solution turns back to a yellow color, the stirring may be discontinued. The mixture should sit for 15 to 20 minutes.

Step 7. With a glass stirring rod, the acid solution is decanted as much as possible, and the solid particles are allowed to remain in the beaker. Decanting is done by placing a glass stirring rod across the mouth of the beaker, at the pour spout and the end opposite the pour spout. The glass rod is held with the index finger at the rear of the beaker, and the liquid is slowly poured out and allowed to run smoothly down the rod.

Step 8. Next, 200 milliliters of cold distilled water should be added to the remaining acid and picric acid particles, with the solution being stirred constantly. Again, by using the gravity filtration setup (with clean, fresh filtration paper), the solid particles are filtered out. A litmus paper test is conducted to check for the presence of acids. If acids are present, cold distilled water should be poured over the particles until the litmus paper shows that no acids are present.

Step 9. To dry the picric acid, the particles are placed in a petri dish and the petri dish is put into a hot-water bath. The picric acid will dry as did the aspirin-alcohol solution.

NOTE: Picric acid should be handled with care when hot. If it is contaminated with certain chemicals or metals, it may detonate. Picric acid should be kept in a plastic container and stored in a cool, dry place.

DIAZODINITROPHENOL

Equipment

250-milliliter flask
Two 250-milliliter beakers
Stir rods
Scale
Eyedropper
Hot plate
Gravity filtration system
Filter material

Chemicals

Picric acid
Powdered sulfur
Sodium hydroxide
Sulfuric acid
Potassium nitrate
Distilled water

Safety Equipment

Goggles
Gloves (rubber)
Apron (rubber)
Acid
Neutralizing kit
Fire extinguisher
Vent hood

Safety Measures

This explosive is very sensitive and should be made in small quantities. During the drying process, all explosives should be handled with great care. Safe handling procedures should be observed at all times.

Preparations

Solution A: 2 grams potassium nitrate dissolved in 85 milliliters distilled water. It should be placed in 250-milliliter flask.

Solution B: 1/2 gram sodium hydroxide and 3 grams picric acid dissolved in 30 milliliters of warm water and placed in 250-milliliter beaker.

Solution C: 2 1/2 grams of sulfur and 2 1/2 grams sodium hydroxide put in a beaker and 2 milliliters of water added and stirred.

Procedure

Step 1. Solution C is put on a hot plate and heated until dark red. When done, it is removed from the hot plate and allowed to cool to room temperature.

Step 2. Solution C is mixed slowly into solution B while constantly being stirred. This mixture is allowed to sit 4 to 5 minutes, while being stirred occasionally.

DIAZODINITROPHENOL

Step 3. Using a gravity filtration stand, the solid red particles are filtered out.

Step 4. In a clean beaker, 65 milliliters of water are brought to a boil on the hot plate. When the water is boiling at a good pace, the collected red particles from step 3 area added slowly. When the particles are completely dissolved, the beaker is removed from the hot plate.

Step 5. Using a gravity filtration stand, any solids left in the solution are filtered out, and the liquid is saved.

Step 6. Sulfuric acid is added by the drop to this solution. When it turns a ruddy orange color, it is almost done. After its color changes, 1 to 2 milliliters more of sulfuric acid should be added to the solution. This should be done while the mixture is being stirred lightly.

Step 7. When the solution is completely cool, solution A should be added, all while the solution is being continually stirred. When this is done, the new mixture should stand for 10 to 15 minutes.

Step 8. The solid particles are filtered out using a clean gravity filtration stand. These particles are diazodinitrophenol, and they must be washed by pouring 40 to 50 milliliters of distilled water over and through them.

Step 9. The filter paper and particles are laid out to allow the particles to dry completely. Drying can be speeded by occasionally breaking up the clumps to expose the moist center. These particles should be completely dry in about 24 hours. When dry, this explosive is placed in a clean glass or plastic container and stored in a cool, dry place.

AMMONIA IODINE CRYSTALS

Equipment

100-milliliter beaker
Gravity filtration stand
Filter material
Hot plate
Tweezers

Chemicals

Iodine crystals
Ammonia hydroxide (concentrated; store-bought cleaning solution won't work)

Safety Equipment

Goggles
Gloves
Apron

Safety Measures

This explosive is highly unstable and may detonate spontaneously at any time. It is sensitive to shock, heat, flame, spark, etc. This experiment should be done using small quantities, and, if storage is necessary, the explosive should be stored wet.

Procedure

Step 1. The desired amount of iodine crystals should be placed in a 100-milliliter beaker. Enough ammonium hydroxide to completely cover the crystals should be poured in the beaker. This should be allowed to stand overnight. **NOTE:** If any ammonia evaporates, add more, keeping the crystals completely submerged.

Step 2. Using a gravity filtration stand, the crystals are filtered out and allowed to dry at room temperature.

Step 3. One dried crystal should be very carefully removed with tweezers and placed on a cool hot plate. The hot plate should be turned on, and the time it takes to detonate the crystal should be noted. If this explosive is properly made, it will detonate when the crystal is picked up. It is possible that a very weak explosive can be made with store-bought ammonia, but it isn't as much fun. If it does not detonate rapidly, the previous step should be repeated.

TETRAMINE COPPER CHLORATE

Equipment

Hot plate
250-milliliter flask
1-hole stopper
250-milliliter beaker
Glass tubing
Rubber tubing
Stainless-steel pan
Measuring spoons
Filter material
Gravity filtration stand
Funnel
Ring stand
Scale
Petri dish

Chemicals

2 1/2 grams sodium chlorate
4 grams copper sulfate
250 milliliters ammonium hydroxide
250 milliliters alcohol (methyl, ethyl, or isopropyl)

Safety Equipment

Goggles
Gloves (rubber or leather)
Apron
Vent hood
Fire extinguisher
Beaker-handling device
Safety shield

Safety Measures

During this experiment, various harmful gases will be produced, and they should not be inhaled. After the tetramine copper chlorate has formed, there is a danger of spontaneous explosion due to heat. At this stage, it should be handled with care. There should be no flames, sparks, etc., present during this experiment.

Setup

First, 250 milliliters of ammonium hydroxide should be put in a 250-milliliter flask. Into a rubber stopper, a short length of glass tubing should be inserted so that it sits flush with the base of the stopper and protrudes approximately 1 inch from the top. A length of rubber tubing is attached to the glass tube at the top of the stopper. At the other end of the rubber tubing, a 6-inch length of glass tubing (for stirring) is inserted. A hot-water bath is made by placing a hot plate into the vent hood and putting a shallow stainless-steel pan of water on the hot plate to heat.

TETRAMINE COPPER CHLORATE

Procedure

Step 1. Into a 250-milliliter beaker containing 50 milliliters of alcohol, 2 1/2 grams of sodium chlorate and 4 grams of copper sulfate are slowly added (and the mixture is stirred constantly). This solution should then be placed in the hot-water bath for approximately 25 to 30 minutes. NOTE: The level of the solution should be maintained by replacing any alcohol that evaporates during heating (alcohol should be added while the mixture is being stirred). When this is done, the solution is removed from the hot bath and allowed to sit for 20 to 30 minutes.

Step 2. Using a gravity filtration stand, any solid particles left in the solution are filtered out. When this is done, the flask of ammonium hydroxide is put in the hot-water bath, and the stirring end of the rubber tubing is put into the prepared solution. It should be stirred gently as ammonia gas is bubbled through the solution. This should be done for 15 to 20 minutes. At the midpoint, the color will change from green to blue, and ammonia gas should be added for the same amount of time as as it took for the color change to occur. (For example, if it took 8 minutes for the color change to occur, the ammonia gas should be added for an additional 8 minutes.)

Step 3. This stage is dangerous. The solution may detonate spontaneously, so the following precautions should be taken. After the flask of ammonium hydroxide is removed and the hot plate turned off, a petri dish, mouth side down, is submerged in the hot-water bath, thus preventing the beaker from coming in contact with the bottom of the hot pan. A shield (e.g., Plexiglas, door, plywood) should be placed between the maker and the solution. When this is done, the beaker is carefully placed into the hot-water bath using a long handling device and heavy leather gloves. The solution must be allowed to evaporate down from 50 milliliters to approximately 15 to 20 milliliters. When this is done, the explosive particles should be removed by filtration, using a freshly cleaned gravity filtration stand.

Step 4. At this stage the collected crystals must be washed by slowly pouring 25 milliliters of alcohol over them. The crystals should now be ready for drying. This is done by laying out the filter paper where it can receive a warm draft. **NOTE:** This explosive is sensitive to heat, shock, flame, etc. Tetramine copper chlorate should be stored in an airtight glass or plastic container and kept in a cool, dry place.

LEAD PICRATE

Equipment

Glass stirring rod
Petri dish
Stainless-steel pan
100-milliliter beaker
Hot plate
Undyed, unbleached newsprint

Chemicals

2 grams picric acid
2 grams lead monoxide
10 milliliters methyl alcohol
Water

Safety Equipment

Goggles
Gloves (rubber or leather)
Apron
Fire extinguisher

Safety Measures

Picric acid is a primary high explosive and should be handled with great caution. The same thing applies to lead picrate. The lead picrate formed in this experiment is even more sensitive than picric acid. This explosive should only be made in small quantities.

Procedure

Step 1. To a petri dish containing 10 milliliters of methyl alcohol, 2 grams of picric acid should be added slowly (while the mixture is being stirred). When the picric acid is mixed in, 2 grams of lead monoxide should be added to the mixture while it is being stirred. When the mixture begins to solidify, clumps can be reduced by stirring and gently breaking them up with a stirring rod.

Step 2. Lead picrate is dried by spreading it into a thin layer on a sheet of undyed, unbleached newsprint and allowing it to air dry at room temperature. As mentioned, lead picrate is a very sensitive high explosive, capable of detonating by heat, spark, flame, or friction, and **IT MUST BE HANDLED WITH EXTREME CARE.** Lead picrate should be stored in a plastic or glass container and kept in a cool, dry place.

MERCURY FULMINATE

Equipment

250-milliliter beaker
Filter stand
Hot plate
Electric stirrer
Eyedropper
Ring stand
Graduated cylinders
Funnel
Filter paper

Chemicals

3/4 measure mercury (3/4 milliliter)
40 measures nitric acid (70 percent concentration)
50 measures alcohol (concentrated)

Safety Equipment

Vent hood
Acid-neutralizing kit
Rubber gloves
Goggles
Respirator
Gas mask
Rubber apron

Safety Measures

Volumes of toxic fumes are evolved from the production of mercury fulminate. A vent hood, gas mask, or respirator must be used, and inhalation of fumes must be avoided at all cost. Mercury fulminate is very sensitive. The rubber apron must be kept away from heat, flames, sparks, etc. **NOTE**: Mercury fulminate should be produced in small quantities, since larger quantities make this process even more dangerous.

Setup

A ring stand fixed at the top of its post is placed under a vent hood. An electric stirrer is hooked up so that the stirrer will sit near but not touch the bottom of the beaker. A hot plate is placed at the bottom of the ring stand. The stirrer should be turned to a 45-degree angle to allow easy access to the beaker.

Filter Stand Setup

A funnel is put in the ring stand, and filter paper is fitted into the filter and positioned at a height that will allow a beaker to be placed beneath the funnel.

Procedure

Step 1. 40 measures of nitric acid go into a 250-milliliter beaker. Slowly, 3/4 measure of mercury is added. The stirrer is carefully placed in the nitric acid-mercury mixture, and the mixture is stirred slowly. If some of the mercury remains undissolved, the hot plate should be turned on and the temperature raised until all

MERCURY FULMINATE

is dissolved. The hot plate is turned off when the mercury is dissolved. Toxic red vapors are produced during step 1, so the vent hood must be on and anyone in the room must wear a respirator.

Step 2. 50 measures of alcohol are slowly added to the nitric acid-mercury mixture. In a few minutes, dense white vapors will be produced. When these vapors stop, all mercury fulminate should form. At this point, no more stirring is necessary, and the electric stirrer can be removed.

Step 3. A filter stand is used to filter out mercury fulminate crystals. The collected crystals are washed with several measures of alcohol and placed in a warm, drafty area to dry. Mercury fulminate should be stored in a cool, dry place in a plastic or glass container and kept away from heat, spark, flame, or impact (shock).

Using this same procedure, silver fulminate can be produced by substituting a like quantity of silver filings.

LEAD AZIDE

Equipment

Hot plate
2,800-milliliter flask (flat-bottom)
Filter stand
Thermometer (Celsius)
Two 500-milliliter beakers
Ring stand
Thermometer clamp
Scale
Electric stirrer
Filter paper

Chemicals

Lead nitrate
Sodium azide
Sodium hydroxide
Cornstarch
Water

Safety Equipment

Goggles or face shield
2 pairs of gloves (rubber or leather)
Rubber apron
Safety shield

Safety Measures

Undissolved lead particles can be very dangerous. During this experiment, if undissolved lead particles come into contact with sodium azide, a spontaneous explosion may take place. If lead particles exist in the solution, they may be filtered out.

Preparations

Solution 1: In the flask 40 grams of lead nitrate are mixed with a pint of water, and the solution is stirred continuously. All of the crystals must dissolve completely.

Solution 2: 20 grams of sodium azide are put into a beaker with 1/2 pint of water and stirred continuously. The sodium azide must completely dissolve.

Procedure

Step 1. The flask containing solution 1 is put on a hot plate. Using a ring stand and thermometer clamp, a thermometer is hooked up so that it sits in the solution. Heat is added until the temperature reaches 55°C; 2 grams of cornstarch are added. As the temperature rises to 70°C, the mixture should be stirred continuously until all contents are completely dissolved.

Step 2. The hot plate and thermometer are removed. An electric stirrer is placed on the ring stand so that it is submerged in the solution. This stage is dangerous. If any particles come in contact with sodium azide,

spontaneous explosion may occur. The stirrer is turned on to medium speed, and VERY SLOWLY solution 2 is added to the flask. If available, a safety shield of wood or Plexiglas should be used as protection from a spontaneous explosion. As the contents mix, a white precipitate will form. This is lead azide, which should be kept away from flame, spark, heat, etc.

Step 3. Using a filter stand, the lead azide is filtered from the solution. When this is done, water is poured over the collected crystals to remove any remaining solution and impurities. The filter paper is laid out so that the crystals can dry at room temperature. When the crystals are completely dry, they should be stored in a clear glass or plastic container in a cool, dry place.

RDX (CYCLONITE)

Equipment

Hot plate
2 stainless-steel pans
3 large glass mixing bowls
Thermometer and clamp
Filter stand
Ring stand
Electric stirrer
Eyedropper

Chemicals

Ammonia nitrate
Acetic anhydride
Formalin (40 to 60 percent formaldehyde solution)
Acetone
Saltwater solution
Water
Ice

Safety Equipment

Goggles
Rubber gloves
Apron
Vent hood
Respirator

Safety Measures

During this experiment, toxic vapors will form—they should not be inhaled. **A RESPIRATOR AND VENT HOOD SHOULD BE USED.** Vapors are also flammable, so caution must be taken to keep away from flames or sparks.

Setup

A ring stand with a thermometer and a clamp are placed under a vent hood. A hot bath is prepared using the hot plate and stainless-steel pan filled with water. Next to this, a stainless-steel pan full of ice is strategically placed, as is a quart of saltwater solution.

Procedure

Step 1. 100 grams of AN are put into a glass mixing bowl filled with 250 milliliters of acetic anhydride, which is stirred continuously. When completely mixed, this solution is put in a hot-water bath and the temperature brought up to 90°C.

Step 2. From an eyedropper, 40 milliliters of formalin are slowly added to the solution, while the stirring continues. When this is done, the bowl is removed from the hot plate and placed in the pan of ice. The saltwater solution is poured over the ice to lower the temperature to below 0°C.

RDX (CYCLONITE)

Step 3. The cooled solution is poured into a pan of cold water (0°C) and allowed to sit for approximately 1 hour. This will cause RDX crystals to precipitate out of the solution. When this is done, the resulting crystals are filtered out by using a filter stand.

Step 4. A mixing bowl containing 1 liter of acetone is put into the warm water left over from the hot-water bath (providing it has cooled down to about 50°C). When the crystals have partially dissolved in the acetone, the bowl is removed from the warm water and put into the ice bath. This will recrystallize the RDX. This process produces a purer product.

Step 5. When all crystals have precipitated into the cooled acetone, a cleared filter stand is used to remove the purified crystals. When the crystals are removed, they should be allowed to dry completely at room temperature. RDX should be stored in a glass or plastic container and kept in a cool, dry place.

PENTAERYTHRITE TETRANITRATE (PETN)

Equipment

Two 5-gallon buckets
2 large glass mixing bowls
2 ring stands
Thermometer and clamp
Filter funnel and filter material
Hot plate
2-gallon plastic bucket
Two 500-milliliter beakers
2 stainless-steel pans
Glass rod
Electric stirrer

Chemicals

Nitric acid (concentrated)
Pentaerythritol
Soda lye
Acetone
Water (0°C)
Salt
Ice
Saltwater solution

Safety Equipment

Vent hood
Safety shield
Goggles or face shield
Gloves (rubber or leather)
Rubber apron

Safety Measures

This mixture will yield noxious vapors, so it should be prepared under a vent hood. It is also temperature sensitive, and all temperature warnings should be heeded.

Setup

A ring stand with a thermometer clamped on is put under the vent hood. Beside this is positioned a second ring stand with an electric stirrer attached. On top of the ring stand base a stainless-steel pan of ice is placed. Next to this should sit a 500-milliliter beaker of saltwater solution. At the side of the vent hood is one empty 5-gallon bucket and a bucket containing 4 gallons of cold water.

Procedure

Step 1. The vent hood is turned on. The saltwater solution is poured into the pan of ice. Enough time for the temperature to drop should be allowed and then a mixing bowl with 1 1/2 liters of nitric acid should be put in the ice and the thermometer placed in the nitric acid. The temperature of the nitric

PENTAERYTHRITE TETRANITRATE (PETN)

acid should drop to 20°C or below, and then the electric stirrer is put in the acid.

Step 2. The electric stirrer is turned on to medium speed, so that the acid doesn't spatter. Slowly, by spoonfuls, 8 ounces of pentaerythritol are added. During this stage, the temperature shouldn't exceed 20°C. When the temperature starts to rise, no more pentaerythritol should be added until the temperature falls below 20°C. When all of the chemical has been added, the mixture should sit in the ice bath for 25 minutes, while it is being stirred continuously.

Step 3. The nitric acid solution is added to 1 1/2 liters of cold water (0°C). This will cause the PETN crystals to precipitate out of the solution. These crystals should be filtered out of the liquid, using a filter stand, and the excess liquid should be discarded. When the crystals are collected, a solution of 5 gallons of water and 1 ounce of lye is prepared to wash the collected crystals. The lye solution wash should be followed by another couple of quarts of cold water poured over the crystals.

Step 4. The ice bath is taken from the vent hood and replaced with a hot plate and stainless-steel pan of warm water. The thermometer is put in the water, and the water heated until its temperature reaches 50°C. A glass bowl containing 1 1/2 liters of acetone is put in the warm-water bath, as are the collected crystals. After this has been done, the mixture is stirred with a glass rod until the crystals have been dissolved.

Step 5. The acetone solution is poured into 5 gallons of cold (0°C) water. This will recrystalize a purer PETN with better qualities than were previously produced. Once again, the PETN crystals must be filtered out and placed in a warm, drafty area to dry. When the crystals are completely dry, they should be stored in a plastic container in a cool, dry place. PETN is very sensitive to flame, spark, heat and shock, and should be handled with care.

SEMTEX

Semtex is a mixture of finely powdered RDX (cyclonite) and PETN (pentaerythrite tetranitrate). These are mixed 50–50 and held together with an additional 10 percent petroleum jelly. When the components are mixed together, there should be no clumping or lumping. Semtex should have a smooth, even texture. This explosive is placed in a plastic or waxed paper container (such as a milk carton) and used as a standard demolition block would be used.

NITROGLYCERIN

Equipment

Three 500-milliliter beakers
Stainless-steel pan
Ring stand
Thermometer and clamp
Stirring rod
2 Eyedroppers
Large glass pot
Glass mixing bowl
Litmus paper
Large plastic syringe

Chemicals

Nitric acid
Sulfuric acid
Glycerin
Baking soda solution
Water (0°C)
Saltwater solution
Ice

Safety Equipment

Acid-neutralizing kit
Vent hood
Safety shield
Goggles
Gloves (rubber or leather)
Rubber apron
Fire extinguisher
Bucket of ice water

Safety Measures

This explosive is very temperature sensitive. If the temperature gets too high, it may detonate spontaneously. **CAUTION IS ADVISED!** If the temperature rises too high or too rapidly, the mixture should be poured into a bucket of cold water (0°C). NOTE: Nitroglycerin, if allowed to come into contact with the skin, will cause severe headaches and nausea.

Setup

A ring stand with a thermometer clamped on is put in the vent hood, and a stainless-steel pan of ice is put on top of the ring stand. Next to the pan of ice, should be a beaker containing a saltwater solution and a bowl containing a baking soda solution.

Procedure

Step 1. 100 milliliters of concentrated nitric acid is put into a 500-milliliter beaker. While the acid is being

stirred, 200 milliliters of concentrated sulfuric acid are slowly added by the drop. The beaker is put in the ice, and the beaker of saltwater poured into the ice to lower the temperature of the acid mixture. The thermometer should be put in the acid to monitor the temperature (which should drop to below 20°C).

Step 2. 30 milliliters of glycerin are slowly added from an eyedropper while the acid solution is stirred gently. The temperature should be monitored and if it rises above 30°C, no more glycerin should be added (but the stirring should continue) until the temperature drops to 20°C. This should be done as often as necessary until all the glycerin has been added. If the temperature rises to between 40°C and 50°C, red vapors will appear. This is the signal to abandon the experiment by either pouring the contents of the beaker into the ice bath or a bucket of cold water. To be on the safe side, the contents should be dumped if the temperature goes above 30°C. The glycerin solution should sit for 20 minutes to complete nitration.

Step 3. After nitration is complete, the solution is carefully placed in a glass bowl or pitcher of cold water (approximately 2 liters) so as not to splash the acid or nitroglycerin. This will cause the nitroglycerin to settle to the bottom of the glass bowl, and a little gentle stirring will complete the separation. The nitro can now be drawn off with a syringe by submerging the tip of the syringe to the bottom of the bowl (into the nitro) and then drawing it up into the syringe. This collected nitro should be slowly and carefully placed into the beaker containing the baking soda solution (1 teaspoon per quart). When all the nitro has been transferred, the contents should be stirred lightly to allow the remaining acids to be neutralized. As an added measure, a quantity of water should be poured off and replaced with fresh, cool water. Light stirring should continue.

Step 4. The nitro should be removed from the beaker with a freshly cleaned syringe and placed into a clean beaker. Litmus paper should be used to test the nitro for any acids. If acids are present, step 3 should be repeated, using clean, fresh water, as often as necessary to remove any residual acid. If no acid is present, the nitroglycerin can be stored in a glass or plastic container and kept in a cool, dry place. Or it can be added to sawdust, porous earth, or nitro starch to produce a dynamite-type product. This experiment will yield approximately 75 milliliters of nitroglycerin.

To mix a 50-percent dynamite, twice the weight of absorbent material as the weight of a volume of nitroglycerin is used. For example, if the amount of nitro weighs 1 ounce, 2 ounces of porous material would be used. Using the same process, other substances may be nitrated much like nitroglycerin. These substances may have different characteristics, such as a lower brisance, but they will work well to produce various dynamites. These three chemicals nitrate well: methyl alcohol, ethylene glycol, and propylene glycol.

NOTE: Ethylene glycol and propylene glycol are toxic substances that should be handled with care.

UREA NITRATE

Equipment

500-milliliter beaker
Glass stirring rod
Filter stand
Eyedropper

Chemicals

1 measure concentrated uric acid
1/3 measure nitric acid
2 measures water

Safety Equipment

Acid-neutralizing kit
Goggles
Gloves
Apron
Vent hood

Safety Measures

Nitric acid is very corrosive and should be handled with care. Urea nitrate is sensitive to heat, flame, shock, etc.

Procedure

Step 1. A 500 milliliter-beaker containing 1 measure of concentrated uric acid is placed under a vent hood. With the dropper (and while it is being stirred continuously), 1/3 measure of concentrated nitric acid is added slowly. When this is done, the mixture should stand for 1 hour.

Step 2. The resulting crystals can be removed by filtering the solution through a filter stand. Pouring 2 measures of water over and through the crystals will clean them (the liquid should be thrown away). The crystals should be placed in a warm, well-ventilated area to dry. Storage should be in a clean glass or plastic container that is kept in a cool, dry place.

NITROMETHANE ANILINE LIQUID EXPLOSIVE

Equipment

Two 500-milliliter beakers
Glass stirring rod
Eyedropper

Chemicals

32 measures nitromethane
1 measure aniline

Safety Equipment

Goggles
Gloves (rubber)
Apron (rubber)
Respirator
Vent hood

Safety Measures

Although nitromethane becomes more sensitive to detonation when mixed with other chemicals, it is an explosive liquid by itself, so the dangers inherent in its use should not be overlooked. Aniline is toxic and can be absorbed in fatal doses through the skin. **PROTECTIVE CLOTHING SHOULD BE WORN AT ALL TIMES, AND VAPORS SHOULD NOT BE INHALED.**

Procedure

A beaker containing 32 measures of nitromethane is placed under a vent hood. With the eyedropper, 1 measure of aniline is added slowly. Stirring should continue until both chemicals are completely mixed. At this point, the mixture is a sensitive, highly explosive liquid and should be kept in a plastic or glass container and stored in a cool, dry place. **NOTE:** These chemicals should be mixed on site for safety. Nitromethane can be sensitized with other chemicals in this same way by merely substituting the sensitizer (aniline) with certain other chemicals. These chemicals include ammonium hydroxide, ethylenediomene, and triethylamine.

NITROMETHANE SOLID EXPLOSIVE

Equipment

Airtight container
Mixing bowl
Scale

Chemicals

1 measure nitromethane (by weight)
Aluminum powder (5 percent total weight)
2 1/2 measures AN (by weight)—powdered very dry

Safety Equipment

Gloves
Goggles
Apron

Safety Measures

Nitromethane is an explosive liquid by itself. Although it becomes more sensitive to detonation when mixed with other chemicals, its inherent danger should not be overlooked.

Procedure

Into a mixing bowl put 2 1/2 measures of finely powdered dry AN. **NOTE:** Ammonium nitrate will readily absorb moisture from the air, so it must be kept sealed in an airtight container until ready for use. Next, 5 percent of the total weight (AN plus nitromethane) of aluminum powder is added to the aluminum nitrate and mixed in completely. After this is done, 1 measure by weight of nitromethane is poured into the AN. Be sure to wear gloves. This mixture should now be kneaded like bread dough to ensure a thorough mixture. This explosive should be stored in an airtight plastic or glass container and kept in a cool, dry place.

AMMONIUM NITRATE LIQUID EXPLOSIVE

Equipment

500-milliliter beaker
Stirring rod
Scale

Chemicals

1 measure anhydrous hydrozine (by weight)
Aluminum powder (20 percent of total weight)
2 measures AN liquid (by weight)

Safety Equipment

Vent hood
Rubber gloves
Goggles
Rubber apron
Gas mask
Fire extinguisher

Safety Measures

Hydrozine is toxic and can be absorbed in lethal levels through the skin. **PROTECTIVE CLOTHING MUST BE WORN WHEN HANDLING OR USING THIS EXPLOSIVE.** Hydrozine is also flammable and should be kept away from flame, spark, etc.

Procedure

A 500-milliliter beaker containing 2 measures of ammonium nitrate is placed under a vent hood. While it is being stirred, 1 measure of hydrozine is slowly added. At this point, the mixture will begin to bubble and produce large volumes of poisonous gas. **NOTE:** The total amount of the mixture should not exceed one-half the volume of the beaker to prevent spillage at this stage. When the mixture stops bubbling and producing gas, the process is complete. While the liquid is being stirred, 20 percent of the total weight of aluminum powder should be added to the solution. This explosive should be stored in a shatter-resistant plastic container, in a cool, dry place, away from heat, spark, flame, etc.

NITROBENZOL

Equipment

Two 500-milliliter beakers
Glass stirring rod

Chemicals

Nitrobenzene
Nitric acid

Safety Equipment

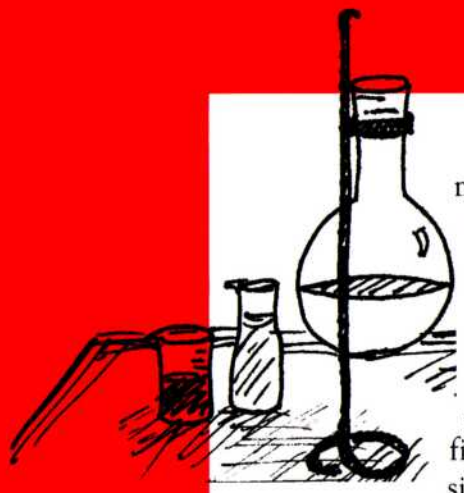
Acid-neutralizing kit
Goggles
Rubber gloves
Rubber apron
Respirator
Vent hood

Safety Measures

Nitrobenzene is toxic. It should not come into contact with exposed skin. These chemicals should be mixed under a vent hood. Because nitric acid is highly corrosive, it must be handled with care.

Procedure

A 500-milliliter beaker containing 1 measure of nitrobenzene is placed under the vent hood. To this, 2 measures of concentrated nitric acid are slowly added and stirred until all the nitrobenzene is completely mixed into the nitric acid. At this point, the mixture is a high explosive and should be stored in a glass or plastic container. It can be used to detonate: use a nonmetal, acid-resistant blasting cap, or compound detonator. If stored for long periods, nitrobenzol will lose some of its power, so a larger detonator must be used if this is the case. To be sure of detonation, these chemicals should be mixed just before use.



This book attempts to blast through the fear and misunderstanding that surround explosives and to give a more accurate and realistic portrayal of their uses. Explosives are a wonderfully useful tool that in many ways has made our lives easier and more profitable. Among other things, they are used to quarry stone, build roads, clear forests, stop oil fires, remove stumps, break up rocks in fields, control avalanches, excavate construction sites, tunnel through mountains, demolish old buildings, and make flash paper for magic acts. This is not to say, of course, that explosives do not have military applications. In fact, you could not have a war today without having a large supply of many types of explosives.

But before explosives can be used constructively or destructively, a thorough understanding of explosive chemistry is essential. Author Thomas Moffatt is a chemist with years of hands-on experience with explosive chemicals. In this book, he explains in precise and easily understandable language the types of explosives, their industrial and military uses, proper laboratory setup and safety procedures, tools and techniques, blasting calculations, and formulas for more than 50 commercial and improvised explosives, including C-4, PETN, RDX, Semtex, and gunpowder.

Warning: Explosives are used to inflict the maximum amount of force in the shortest amount of time. This makes them extremely dangerous and their possession and use heavily regulated by most nations, states, and municipalities. Therefore the information in this book is presented for *academic study only*.

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