BIC FARRELL

BACKYARD ROCKETRY

Converting Model Rockets into Explosive Missiles

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INTRODUCTION

This book contains extracts from the official constructor's handbook of the Dangerous Rocket Club, a completely fictitious organization that I made up in order to start this introduction.

It will show you how to build short- and medium-range surface-to-surface and surface-to-air missiles using off-the-shelf components and no tools (well, hardly any). Also included are designs for shoulder-launched rockets and warheads.

At last, those hard-to-reach targets are yours for the taking. City Hall, the local IRS offices, that damned polluting nuclear facility, whatever. You might even want to take a few to the next paintball game.

Using the techniques shown, it is also possible to make fully operational replicas of those neat multiple rocket launchers you've seen in Gulf War footage on TV. Using these (and assuming a suitable Iraqi target), you and your friends can re-enact the operation to your hearts' content. If you don't have a nearby Iraqi/Muslim community or can't locate a handy mosque, don't fret; you can find the addresses of relevant embassies in the Yellow Pages. These make great secondary targets.

The devices described here are based on flying model rocket components of the type available from hobby shops. Complete kits—which include engines, electrical igniters, launch pads, etc.—can be purchased over the counter.

A "Model Rocket Safety Code" exists, which, if followed, ensures clean, safe fun for kids of all ages. A copy of the code will be supplied with most store-bought flying rocket kits or suppliers' catalogs. The Dangerous Rocket Club's version of this code appears in **Appendix III**. If followed, you will probably go to prison.

The engines and rocket kits themselves are supplied in configurations that ensure that altitude/distance and payload capabilities are kept within safe parameters. By modifying and adapting engines and rockets, however, it is possible to create missiles that have a far more "useful" range and capacity!

Disregarding established Model Rocket Safety Code rules and experimenting with model rocket engines can be dangerous. Installing explosive components into such rockets is definitely dangerous and also illegal. Only persons with a sound and proven knowledge of explosives handling and use should ever experiment with such substances, and even then, industry standard guidelines must be followed.

In any event, neither the author nor the publisher advocate or seek to encourage any breaches of the *Model Rocket Safety Code* or explosives laws and offer this book for information purposes only.

CHAPTER 1

OVERVIEW

Flying model rockets are constructed from lightweight materials such as cardboard tubes, plastic, and balsa wood. Despite this, the completed devices are surprisingly resilient.

Kits are available in a variety of styles, ranging from simple, relatively inexpensive firework-size units to expensive scale replicas. Once the basic principles are understood, all component parts can be improvised easily, and the instructions provided with one kit can be used to make more rockets from components obtained elsewhere.

Assembly can take minutes or hours, depending on the level of complexity of the model. The tools required are a hobby knife, sandpaper, and some wood glue. Balsa wood sealer may be used prior to painting for a smoother and slightly more resilient finish. Enamel spray paint can be used for finishing, and this, too, helps "harden" the rocket.

The majority of commercial rocket kits include a parachute or streamer assembly that deploys at the end of the propellant burn period (more on this later) to facilitate safe recovery of the rocket. In the context of this book, parachutes or streamers would probably only be used as part of air-burst projects and during testing.

As supplied by the manufacturers, the rocket engines are completely safe. They are so safe, in fact, that the U.S. Department of Transportation (DOT) classifies them as "Toy Propellant Devices," and they may thus be shipped through the mail without problem under DOT exemption 7887 as "Flammable Solids." (It is interesting to note that fireworks must be shipped as "Class C Explosives.") Even the British government (notorious for its anti-things-that-contain-propellant laws) has determined that the current range of engines may be used without restrictions, save those pertaining to general safety.

As supplied, the model rocket engines comply with U.S. Consumer Product Safety Commission standards, and the launching of model rockets has been exempted from regulation by the Federal Aviation Agency. This relates to "unmodified" rockets, of course!

The techniques discussed in this manual are cheap and cheerful. They have been found to work but are not necessarily the "correct" or established way of doing things.

CHAPTER 2

PRINCIPLES OF OPERATION

Rockets are propelled according to Newton's third law of motion: for every action there is an equal and opposite reaction.

The burning fuel creates gases much greater in volume than the fuel itself. As gas escapes through the engine nozzle, it exerts an equal force in the opposite direction, thrusting the rocket forward. The rocket is not (as one might at first think) propelled by the gas pushing against the air.

The supply of gas is provided by a small "solid-fuel" engine mounted in the base of the rocket. The propellants most typically used will be either black powder or ammonium perchlorate. Typical percentage-by-weight mixes of both propellants are:

Black powder: 74 percent KNO_3 (oxidizer), 15.6 percent C, 10.4 percent S (fuel plus binder).
Ammonium perchlorate: 82 percent NH_4ClO_4, 17 percent synthetic rubber (fuel/binder), 1 percent burn-rate enhancers.

In addition to the propellant, most commercial engines incorporate a smoke charge (to help track the rocket during its nonpowered coast phase) and an ejection charge. Thus there is a delay—the length of which is determined by the amount of smoke charge present—between the end of the propellant burn period and the ejecting of the nose cone and parachute.

The rocket engine is fired by means of an electrical igniter. This is inserted into the engine nozzle so as to contact the propellant therein. It is initiated via a 6-volt battery pack and is, essentially, a "slow"-burning electrical match.

The most commonly available engines are rated by the manufacturers by total power produced, average thrust in newtons (4.45 newtons = 1 pound), and the number of seconds between the end of the thrust and (where applicable) the ejection charge. The rating takes the form of a three-character alphanumeric "serial number."

Thus, a "B6-4" engine will have twice the total power of an "A" designated engine (and half that of a "C" engine), will have an average thrust of 6 newtons, and will incorporate a delay of four seconds between the end of the thrust period and the firing of the ejection charge. Engines with a "0" suffix have no smoke or ejection charge and can be coupled directly to other engines to provide a multistage rocket.

Engines are available in the ranges "A" to "D." Important applicable specifications are given for various engines in subsequent chapters.

The engine is installed in a simple cylindrical mount which itself is affixed to the inside base of the rocket. The mount may incorporate a small, spring-steel quick-release device, or it may simply be held on a friction-fit basis. The securing technique need not be complex, as the tendency of the engine's, once ignited, is to push upward anyway.

The centering/support rings of the engine mount have an external diameter similar to the internal diameter of the rocket body and are secured with adhesive. The engine tube has an internal diameter very slightly larger than that of the engine it is intended to carry.

A washerlike stop piece is installed inside the tube, and it is against this that the shoulders of the engine rest when inserted. Gases from the ejection charge are free to pass through its hollow center.

LAUNCHING

The rockets are launched (conventionally) from a com-

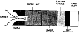

Figure 1. *Typical model rocket engine.*

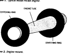

Figure 2. *Engine mount.*

mercially available launch pad. The pad is comprised of a stand, a metal deflector plate, and a vertical launch rod. The stand has an adjustable head to facilitate aiming and will not permit tilting in excess of 30 degrees from the vertical for safety reasons.

A cylindrical standoff piece is used to hold the rocket base/igniter wires clear of the deflector plate during firing. This can be improvised by wrapping tape around the launch rod.

The rod engages with rocket-mounted launch lugs and provides stability during the first couple of feet of flight. The

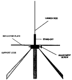

Figure 3. Typical commercial launch pad.

deflector plate merely serves to prevent ground fires being caused by the engine exhaust.

When firing explosive pad-launched rockets, the type of pad shown in Figure 4 should be used. It incorporates two launch rods and weighted or staked support legs for far greater stability.

The extra launch rod requires an additional set of launch lugs affixed to the rocket body. These should be attached 180 degrees from and exactly opposite the originals.

TYPICAL ROCKET

In a commercial rocket, the shock cord is a length of elastic

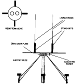

Figure 4. Improvised launch pad.

connected between the rocket body tube and the parachute lug. It takes the shock during nose-cone ejection and keeps the nose cone and rocket body together for recovery.

When preparing the rocket for a launch, recovery wadding is packed loosely into the body tube to a depth approximately three times the body diameter. The fire-resistant wadding protects the chute from damage from the ejection charge and provides some additional pressure resistance to ensure the chute and cone are ejected cleanly.

With the wadding in place, the parachute canopy is fold-

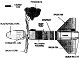

Figure 5. Typical rocket.

ed and the lines wrapped loosely around it. The chute and shock cord are placed in the body tube and the nose cone installed. The nose cone normally will be a sliding fit in the body tube.

In the case of modified rockets not intended for recovery, the chute, shock cord, and recovery wadding will be discarded and the nose cone secured with adhesive. Where an explosive warhead is to be ejected, however, the wadding will be retained and the nose cone installed on the usual friction-fit basis. Note again that when firing explosive missiles, additional launch lugs should be attached and the improvised launch pad with its two launch rods used.

LAUNCH CONTROLLER

A launch controller enabling remote launches should always be used, regardless of whether conventional or modified rockets are being fired. The system should be based around a switch that returns to "off" automatically when

released and should include a removable safety key (which can be as simple as a bent nail) that must be inserted manually into the controller to render the electrical circuit complete.

A visual indication that the circuit is complete should also be included, and a bulb in series with the safety lock achieves this. A commercial controller is available that meets these requirements; it can be purchased separately or as part of a "starter kit" that also comes with a launch pad.

To launch a rocket, an engine of the required size is installed in the base of the rocket and an igniter inserted into the nozzle. The igniter may be secured with masking tape.

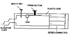

Figure 6. Typical launch controller.

The rocket is now lowered onto the launch pad rod until it rests upon the standoff piece.

It is worth noting that the vast majority of misfires are caused by either a faulty or poorly installed igniter. Therefore, the igniter should be physically checked for damage before installation. If it is okay, it is inserted into the nozzle until resistance (from the solid propellant) is felt.

If the controller safety key is not in place, the controller wires may be attached to the igniter.

The safety key may now be inserted (at which point the indicator light should glow). With the immediate area clear of personnel, the rocket can be fired. Four 1.5-volt AA cells are sufficient to fire the igniter.

TYPICAL FLIGHT PROFILE, SINGLE STAGE AND MULTISTAGE

The flight profile of an unmodified model rocket commences when the igniter fires. When this happens, the rocket engine begins to burn and the rocket lifts off.

The rocket accelerates skyward at great speed. Speeds of several hundred miles per hour can be reached in a matter of seconds, depending on the power/weight ratio of the engine/rocket.

Having consumed the available propellant, the rocket continues toward its peak altitude under its own momentum, discharging smoke for observation purposes. Several seconds later the smoke charge ignites the ejection charge. The nose cone is blown off and the chute pulled free. The chute fills with air and the rocket body and nose cone drift back to earth.

In a multistage rocket, the first-stage engine will have no smoke or ejection charge. Instead, it provides the initial liftoff and thrust power and then ignites the second stage engine. As each subsequent engine fires, the previous one, complete with its mount and body tube/fin section, is jettisoned. The final (upper) stage engine is the only one with an ejection charge, and when this is reached, the sequence of events is as per the single-stage rocket.

As can be seen from the chart (a more complete version of which is found in engine manufacturers' catalogs), each engine has a lift capacity determined, other things being equal, by the amount of propellant vs. smoke charge (delay time = smoke charge) it contains.

Note that when selecting engines for use in a specific project, the engine weight should be added to that of the rocket and payload to determine total launch weight.

Other things being equal, the greater the "headroom" between the maximum lift capacity of a given engine and the actual weight of the rocket, the greater the height/range achieved.

Always test for height/range capabilities in an isolated area using inert components of the same weight and in the same position/configuration as any explosive material/firing-

ENGINE SPECIFICATIONS

TYPE	DELAY	MAX LIFT WEIGHT	THRUST DURATION	WEIGHT
B6-2	2.00 sec.	4.50 oz.	0.85 sec.	0.60 oz.
B6-4	4.00 sec.	4.00 oz.	0.85 sec.	0.71 oz.
B8-5	5.00 sec.	5.00 oz.	0.60 sec.	0.68 oz.
C5-3	3.00 sec.	8.00 oz.	2.10 sec.	0.90 oz.
C6-5	5.00 sec.	4.00 oz.	1.70 sec.	0.91 oz.
B6-0	0.00 sec.	6.00 oz.	0.80 sec.	0.58 oz.
C6-0	0.00 sec.	4.00 oz.	1.68 sec.	0.80 oz.
D12-0	0.00 sec.	14.00 oz.	1.70 sec.	1.44 oz.
D12-3	3.00 sec.	14.00 oz.	1.70 sec.	1.49 oz.
D12-5	5.00 sec.	10.00 oz.	1.70 sec.	1.52 oz.
D12-7	7.00 sec.	8.00 oz.	1.70 sec.	1.55 oz.

"B" and "C" engines are 2.75 inches long, 0.690 inch in diameter.
"D" engines are 2.75 inches long, 0.945 inch in diameter.

chain components that will be used subsequently.

Always fire modified/explosive rockets from behind cover.

IMPROVISED MISSILES

The designs that follow (Chapter 5) are based on commercially available, preformed rocket kit parts. These are available from most hobby/model shops and via mail order. If you are unfamiliar with the field, a visit to the local hobby/toy store is a must.

Specific brand names have not been given for legal reasons, but the reader should have no trouble determining (via reference to available catalogs, kits, and components) those which meet the parameters outlined in subsequent pages.

In any event, all the parts can be improvised easily. Cardboard tubes can be salvaged from many sources, balsa fin stock can be purchased in sheets from craft and hobby shops, and plastic nose cones can be improvised from the caps of aerosol spray cans and bathroom products.

TESTING FOR FLIGHT STABILITY

The stability of all improvised rockets—or commercial rockets into which extra parts have been added—must be checked and alterations made as required before firing. Flight stability can be determined by installing all components and engines (in the case of explosive rockets, inert components of the same weight and installed as per the explosive and fuze items should be used) and then locating the rocket's center of gravity.

A simple way of doing this is to find the point along the

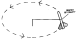

Figure 7. Testing for flight stability.

body at which the rocket can be balanced on the edge of a ruler and attach a thin cord some 6 feet in length to this point. Whirl the rocket around by the cord at eye level and confirm that the rocket "flight path" is straight and true. Make small adjustments to the fin positions and/or the distribution of internal components as required.

Accurate fin placement is made easier if glue is applied to both the fin edge and the appropriate part of the body tube and left to dry for about five minutes before assembling. A commercial device is available that holds fins in position while the glue dries.

ENGINE MODIFICATION TECHNIQUES

The simplest modification that can be made to commercial rockets in order to obtain greater ranges and/or a higher payload capability is to utilize a much more powerful engine than is recommended by the manufacturers. For example, one can install a "D" engine in a rocket intended to use only "B" or "C" engines. This will require replacement of the supplied engine-mount assembly with one of a larger diameter, although often the engine-mount requirement can be ignored completely and the engine secured on a friction-fit basis by wrapping it with tape.

As long as the engine can be mounted securely, centrally, and in such a manner that the stability of the rocket in flight is

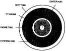

Figure 8. Rear view of conventional "C" engine installation. The engine will be either a "0" suffix type or one that incorporates a delay, according to the project requirements.

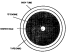

Figure 9. Rear view of "D" engine replacement. The existing engine, centering/support rings, and engine tube have been removed, and the "D" engine's diameter has been increased to create a friction fit within the rocket body itself.

not adversely affected, then any form of improvisation may be used to accomplish the modification. Thus tape, adhesive, and silicone sealant may all be pressed into service.

Another technique is to install an additional "0" suffix engine (or more than one, of course) to provide a longer burn time, affixing it to the top of the first engine with wood glue applied to the card rim only (more on card adapters later). Cut off and discard the empty end sections of both engine bodies, and rotate the second engine 180 degrees, as shown in Figure 10.

The uppermost nozzle may now be removed by scraping with a plastic or wooden tool, or the nozzle hole can be enlarged to accommodate a fuse, black powder, etc.

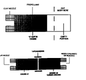

Figure 10. Adding extra engines.

The lengthened engine can be installed by extending the original engine mounting tube or discarding the engine mount and wrapping tape around the engine bodies to obtain a friction fit.

A higher initial thrust can be obtained from any flat-ended engine by carefully boring out a central cavity from the propellant material. The cavity should be around one-third the diameter of the propellant block and extend inward some five times that diameter. Never use any high-speed drill or other tool or technique that will generate excessive heat. A small hand reamer works well.

MULTISTAGING

Ranges can be increased by using multistage rockets. These incorporate individual engine, body section, and fin assemblies that are jettisoned when the next engine in the series fires.

Stage coupling is accomplished by using card adapters. These take the form of a collar with an external diameter slightly less than the internal diameter of the body tubes themselves, thus allowing a sliding fit. An adapter is secured with adhesive at the base of all the stages (except the first) in such a manner that half of its length remains exposed, and the preceding stage is simply slid on.

Prior to installation, the engines are coupled using cellophane tape. As the engine in the next stage ignites, the

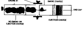

Figure 11. Engine connection technique.

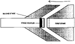

Figure 12. Two-stage rocket.

resulting fire and pressure simply burn the tape through and jettison the entire lower engine/body/fin assembly.

All engines except the final (upper stage) one are to be of the "0" suffix type. The upper-stage engine is selected according to the constructor's requirements.

Existing single-stage rockets can be converted into multi-stage devices by adding extra body tube sections, each of which contains an engine mount assembly, or by segmenting an existing length of body tube and turning the sections into separate stages. Some commercial multistage rockets are available.

The fins on each additional body piece can be designed to mate and thereby form a continuation of those on the subsequent stage, or they may be duplicates of the existing fins. In either case, they should be aligned during fitting.

The stage couplers must have a diameter that produces a friction fit inside the appropriate body tube, and a length of approximately .75 to 3.9 inches, depending on the rocket body diameter. The larger the diameter, the larger the coupler.

"POWER-IN" MODIFICATION

This variation on standard techniques causes the rocket to power downward into the ground at tremendous speed

rather than falling under the force of gravity. It has to be seen to be believed!

Couple two engines as per Figure 10, except that here the first-stage engine incorporates a delay rather than being a "0" suffix unit. Other things being equal, best effects are obtained when the delay selected is the maximum available.

Remove the clay retaining cap and ejection charge material from the lower engine by scraping with a plastic or wooden tool, leaving only the solid propellant and smoke charges. There is only a tiny amount of ejection charge compared to smoke charge, and the smoke charge itself is of a lighter, gray color. Shake out all loose material before attaching to the other engine.

Upon launching, the rocket travels under the power of the first engine until the propellant is exhausted. At this point the smoke charge fires and the rocket slows. After a few seconds the rocket begins to fall nose down. The smoke charge now ignites the second engine, which fires, causing the rocket to accelerate again.

Depending on the height that the rocket achieved initially, the second engine frequently will still be burning propellant when the rocket hits. It will almost certainly still have

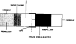

Figure 13. "Power-in" engine connection technique.

unburned smoke and ejection charges. These can be incorporated into the firing chain of an explosive missile with great effect.

ULTRA-POWER CUSTOM ENGINE

All work on this modification is to be undertaken outside. Protective goggles and gloves must be worn. Have water or an extinguisher on hand in case of fire.

Disassemble seven "0" suffix engines by cutting lengthwise into each card body in such a manner that the card can be peeled away and the propellant block removed.

The clay nozzles are now broken away and discarded. It does not matter if small bits of the clay remain, as all but one of the sticks (use this one as the central stick) will be rotated

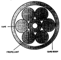

Figure 14. Custom engine viewed from below.

prior to assembly so that the nozzle ends become the top of the engine pack.

Assemble the propellant blocks into a bundle as shown in Figure 14 and secure with tape. Install the bundle in a card tube having a diameter that facilitates a friction fit and a length that produces a gap of about 1 inch at either end. The wall thickness of the tube should be about be 3 to 5 millimeters.

An improvised nozzle can now be prepared and installed in one end of the tube. Prior to installation, sprinkle a small amount of black or smokeless powder onto the propellant sticks simply to help ensure ignition.

For once-only use, the nozzle can be made from modeling clay or a "plastic metal" type material, or a hardwood nozzle of the required dimensions can be made and sprayed

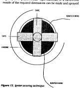

Figure 15. Igniter securing technique.

Figure 16. *Improvised nozzle in cross-section.*

over with high-temperature paint available from vehicle accessory shops. The burn time of most improvised engines will be so short anyway that by the time the nozzle has been destroyed, its job will have been done.

Whatever method is employed, the nozzle should be pressed home firmly against the propellant sticks and, if necessary, secured with adhesive applied to the outer wall of the nozzle only.

With the nozzle in place, pour a very small amount of black or smokeless powder into the nozzle opening and install an igniter. Secure the igniter with masking tape in such a manner that neither it, nor any of the powder, can fall out. The best technique is shown in Figure 15.

The choke point at the center of the nozzle is half of the mouth diameter, and the angle of divergence/convergence of the nozzle mouths is around 30 degrees.

Custom engines may also be coupled in-line to provide both greater lift capability and range.

CHAPTER 4

WARHEAD SAFETY

Having *first* determined through test firing with nonexplosive components the optimum warhead/payload weight that the rocket will carry over the required distance, the material used for test purposes can be replaced with an equivalent weight of similarly distributed explosive/firing-chain components and the recovery system components discarded. The precise specifications of firing-chain components and the weight/type of explosive material used will vary according to the type of rocket employed.

In direct contrast to the safety considerations outlined in the "Model Rocket Safety Code" (which are intended to prevent rockets from traveling horizontally), it is recommended that the *minimum* angle of launch when firing improvised missiles be *10 degrees from the vertical*. The *maximum* angle of launch, applicable especially to shoulder-fired devices, should be slightly less than *90 degrees from the vertical* to allow for any drop when the missile leaves the tube.

In the designs in the following chapter, the nose cones are of the commercial plastic type. It can be assumed that, where necessary, the bottom sections of these have been removed to facilitate access. Similarly, where a reference appears to, for example, the smoke charge lighting a fuse, it can be assumed that the retaining cap and ejection charge material have first been removed.

That said, the following improvised safety features (or some other variants serving the same purpose) must be incorporated into all explosive rocket configurations. These systems are not shown on the warhead/rocket designs themselves for reasons of clarity.

ELECTRICAL SAFETY

This device provides for safer handling and protects against premature detonation in the event that an explosive impact-firing missile is dropped. The firing circuit is not actually armed until the missile is safely on the pad or in the tube.

The switch employed is of the subminiature release-to-make/release-to-break type. This type of switch is turned "on" by depressing and then releasing the button and turned "off" in the same manner. The release action is the one that actually causes the state of the switch to alter. These are readily available from the usual outlets.

The switch is installed in the rocket body in the "off" position in such a manner that it can be operated externally via a small piece of dowel inserted through an access hole in the rocket body and, where applicable, launching tube wall. In the case of tube-launched missiles, the access holes will align if, during construction, the rocket is installed in the tube and a hole drilled simultaneously through both launcher and rocket walls.

After loading, the dowel piece is inserted and the switch depressed and released. The system is now live.

Figure 17. Manual electrical safety.

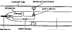

Figure 18. Automatic electrical safety.

For tube-launched missiles, the dowel piece may instead be incorporated into the inner face of a discarding support piece in such a manner that it depresses the switch when installed during loading (see Figure 18). The switch remains depressed until the support piece is discarded when the missile leaves the tube, at which point the switch springs out to the "on" position.

MECHANICAL SAFETY

This safety feature can be incorporated into striker/plunger-

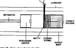

Figure 19. Manual mechanical safety.

type firing mechanisms. It consists, simply, of a wooden or plastic pin inserted through the missile wall in such a manner that it prevents the striker/plunger from contacting the primer or completing an electrical circuit.

In the case of pad-launched missiles, this safety is removed manually immediately prior to launching. For tube-

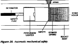

Figure 20. Automatic mechanical safety.

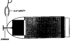

Figure 21. Clip-type safety.

launched missiles, the safety may incorporate a spring that is compressed during loading and kept under tension by the launcher walls. Upon leaving the tube, the spring throws the safety pin free (see Figure 20).

A clip safety takes the form of a simple split-washer or such that fits between a nose-mounted plunger and the nose cone proper, preventing the former from being depressed.

CHAPTER 5

WARHEAD DESIGNS

The percussion fuzes shown in several of the following designs operate only when the missile strikes an object at speed. When this occurs, the sudden loss of momentum causes the striker (which is free to slide within its housing) to be thrown forward. This forward movement overcomes the tension in the spring and the striker pin hits the primer. The spring must be of sufficient strength to prevent the striker pin from contacting the primer when the missile is inverted during normal handling.

As a matter of prudence, safety fuze should be used in the firing chain of nonelectric, impact-firing devices.

Improvised explosive warheads should only be assembled immediately prior to use.

IMPACT FIRING I

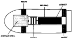

Figure 22.

Upon impact, the striker flies forward and hits the shell primer, causing the shell to fire.

IMPACT FIRING II

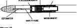

Figure 23.

Upon impact, the striker hits the primer, lighting the percussion igniter and thereby the safety fuse. After a few seconds, the burning fuse reaches the blasting cap, which explodes and detonates the warhead.

IMPACT FIRING III

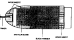

Figure 24.

Upon impact, the striker sets off the shotgun blank, igniting the black powder and producing a low-level explosion.

IMPACT FIRING IV

Figure 25.

Upon impact, the striker shatters the glass vial, causing the acid to contact the potassium chlorate/sugar mixture. The resulting heat and flame fire the detonator.

IMPACT FIRING V

Figure 26.

The charged capacitor is used, as its weight is far less than that of a battery. It is charged immediately prior to installation.

Upon impact, the switch, which is of the press-to-make/press-to-break type, is depressed and the electrical circuit completed. Current flows from the capacitor to the detonator and the device explodes.

IMPACT FIRING VI (SHAPED CHARGE)

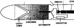

Figure 27.

Ideally, the nose cone should be of a lightweight metal having a thickness 1 millimeter or so greater than the thickness of the internal cone. Similarly, the distance between the front of the nose cone and the face of the cavity should be one to two times the diameter of the cone (cavity) face.

The cavity liner is made of copper or tin sheet, 1 to 3 millimeters thick, formed into a cone (as shown in Figure 27), with an angle of between 30 and 60 degrees.

The electrical detonator is positioned at the top center of the explosive. The capacitor is of the electrolytic type.

Upon impact, the sliding plunger hits the switch, which closes, completing the circuit and firing the detonator. The cavity/liner "focuses" the explosion, creating a highly penetrating effect.

The cone can also be improvised from a wine glass or funnel. If a cavity liner can not be improvised, lesser shaped-charge effects may be obtained by simply cutting the cavity directly out of the explosive material itself.

IMPACT FIRING VII (SMOKE)

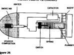

Figure 28.

Upon impact, the sliding weight is thrown against the switch, completing the electrical circuit and firing the smoke charge.