B16

Orders?

ROCKET INTO THE FUTURE

COOPERATIVE EXTENSION
UNIVERSITY OF CALIFORNIA

4-H AEROSPACE PROJECT

4-H-Ag210
2/73

This manual was compiled by Mark Bent, 4-H All-Star, Kneeland Community 4-H Club, Humboldt County.

ACKNOWLEDGMENT

The author wishes to acknowledge the assistance of Charles R. Hilgeman, 4-H – Youth Advisor, Humboldt County. He is also grateful for information provided by Estes Industries, Inc., Penrose, Colorado, and the National Rocket Association.

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Co-operative Extension work in Agriculture and Home Economics, College of Agriculture, University of California, and United States Department of Agriculture co-operating.
Distributed in furtherance of the Acts of Congress of May 8, and June 30, 1914.
George B. Alcorn, Director, California Agricultural Extension Service.

ROCKET INTO THE FUTURE

ABOUT MODEL ROCKETRY

Safety should be your first concern as a member of a 4-H rocketry program. Safety for yourself and others is of the utmost importance. Without safety precautions, someone is bound to get hurt. A single slip-up or accident can ruin a whole project. If you build your rocket carefully and follow the rules, you can have a continuing, highly successful project.

To stay within legal boundaries, write to your local or state government for a copy of the state's model rocketry regulations before you start your project. Check with your local fire marshall's office or fire department safety officer for regulations covering the use of model rockets in your area.

When you have a leader—and perhaps some junior leaders—and have complied with state regulations, write to some of the well-known companies that supply model rockets and engines. Most of these companies offer a wide range of model rockets and supplies. Some also sell supplies for building oddball-design rockets and rockets of your own design.

TYPES OF ROCKETS

Model rockets come in many sizes and shapes. Most are single stage, but there are also multiple-stage rockets that lift large payloads. There are two basic types—solid-fuel and liquid-fuel model rockets. Liquid-fuel rockets use a nonflammable, completely safe liquid similar to Freon®. Solid-fuel rockets, on the other hand, resemble sky rockets in design and construction. Figure 1 shows the basic construction of the solid-fuel rocket. Note the relatively small size of the engine compared to the whole rocket.

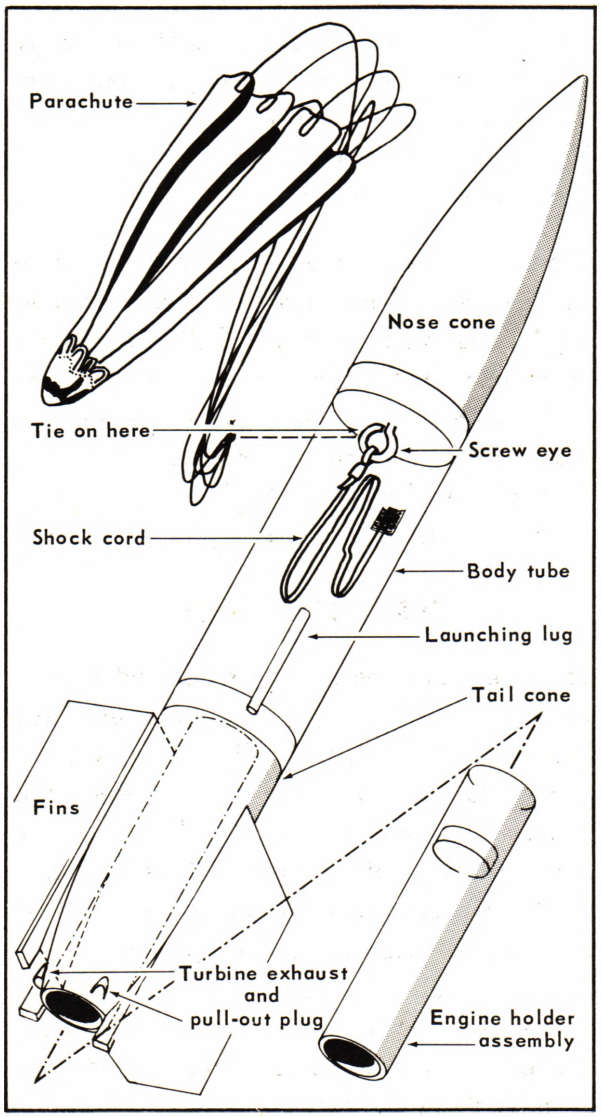
®Registered trade name.

Solid-Fuel Rockets

Solid-fuel engines use a propellant similar to micrograin powder or gunpowder. Since these engines can be explosive if not properly used, some states require that the person purchasing them be 18 years old or older.

Solid-fuel engines are in various sizes and in thrusts ranging from 22 ounces to 7 pounds. Static test engines for testing rocket performance are also available. However, they should not be used in an actual launching. You can use solid-fuel engines only once and then you have to buy new ones. (The cost is low.)

Figure 1. Solid-fuel rocket.



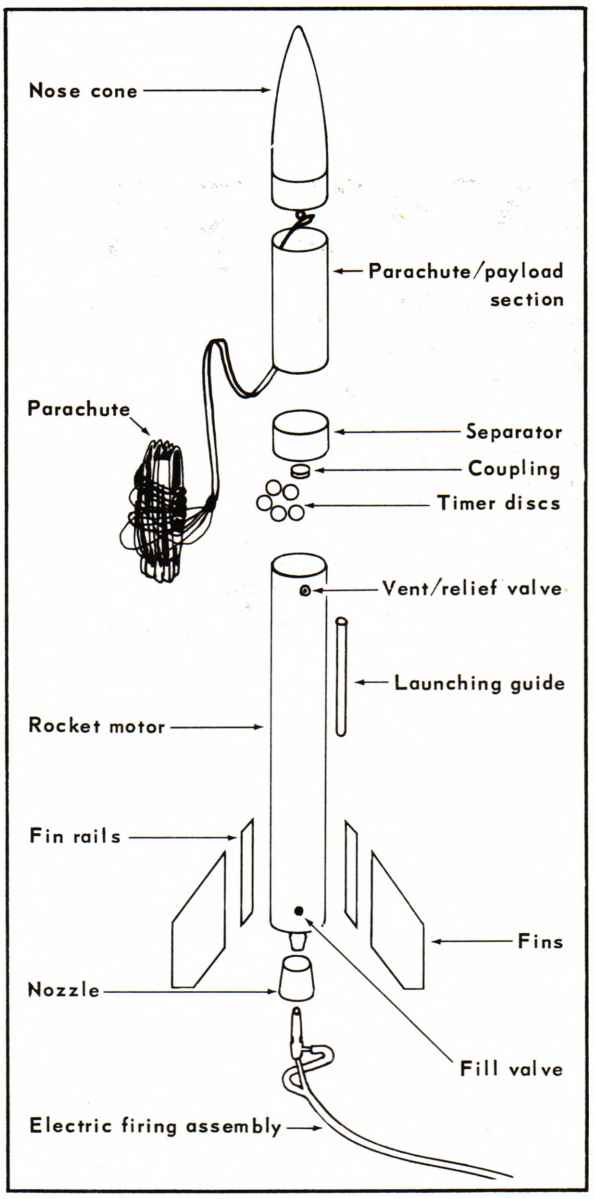


Figure 2. Liquid-fuel rocket.

Liquid-Fuel Rockets

Because this other type of rocket uses a non-flammable, harmless liquid fuel, you do not need a permit to purchase either the fuel or the rocket engine. You can fly the rocket without creating a fire hazard. The engine is re-usable and is made of a high-strength aluminum alloy.

You can adapt liquid-fuel engines to solid-fuel rockets so that you can launch a variety of rockets with just one engine.

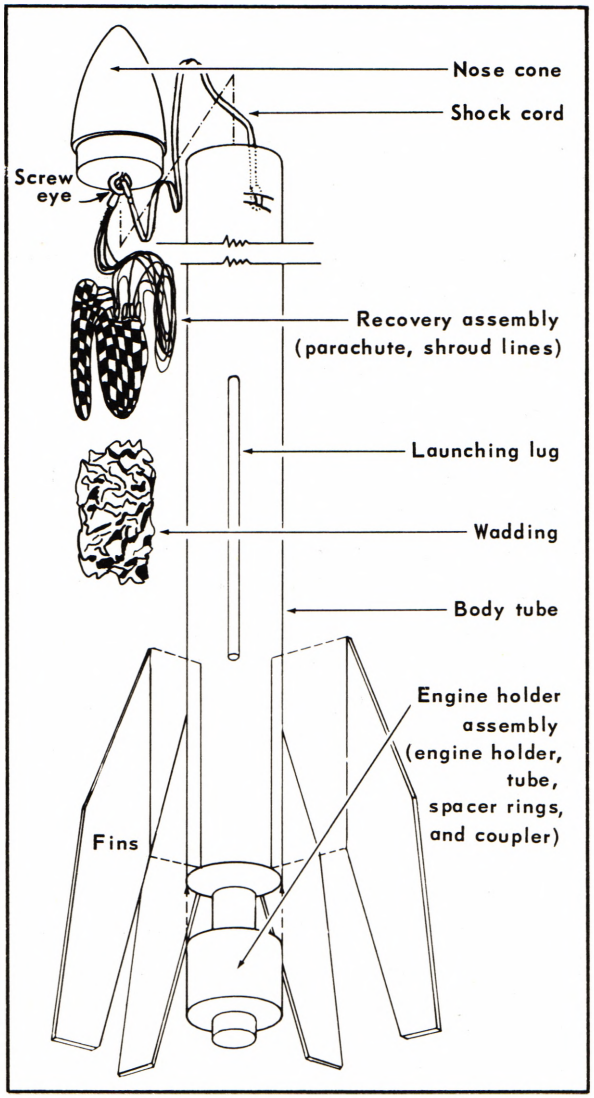
YOUR FIRST ROCKET

It is best to start with a small, single-stage rocket. This is your first rocket and you need to learn all about the materials you will be using.

Most kits supply instructions for building the rockets. To have a good model, follow the instructions and you can't go wrong. The typical model rocket, shown in figure 3, gives good results if carefully built.

Remember—don't rush! The more care and time you spend building a rocket, the more durable it will be and, therefore, the more flights it will make.

Figure 3. A typical model rocket.



CONSTRUCTION TECHNIQUES

Rockets have at least four main parts. These are the fins, engine mount, recovery system, and launching lug. (See figure 3.)

The fins guide the rocket in flight and, in most rockets, act as a stand to support the rocket while it is on display. The fin's front, or leading, edge is sanded smooth to cut wind resistance. On a high-speed, high-altitude rocket, both the leading and the trailing edges are sanded to a sharp finish.

All power for flight is applied through the engine mount, so this assembly has to be strong. There are two ways to hold the engine in the engine tube. One is the engine block, a round paper ring that fits inside the engine tube. The other is the engine clip, a metal clip that holds the engine in place. Spacing rings position the engine tube inside the rocket body.

The recovery system safely returns the rocket to the ground. It may be a parachute cluster or simply a single streamer. You pack either one inside the body tube and insert a piece of wadding to protect the recovery system from the ejection charge. Some light-weight rockets have neither parachute nor streamer, but are designed to float or tumble safely to the ground.

Last of all is the launching lug, a small tube attached to the outside of the rocket. This guides the rocket during the initial acceleration and take-off. It should be small to reduce wind resistance, but it must be strong to take the launching stress.

Most rockets have an outer shell, or body tube, to which the fins, launching lug, parachute, and engine mount are attached. Some smaller rockets use the engine tube as the body tube, and some special-design, oddball rockets have no body at all!

Now you know the basic parts of a rocket. The following details will show you how to get the most out of your rocket when you build it. Try to remember that model rockets are like any other model; take your time and do a good job. It will pay off!

Fins

Make your rocket's fins of thin balsa wood sheets, available from most hobby and hardware stores. Most fins are made of $\frac{1}{16}$-inch stock. This size is easy to cut and to sand.

When you make the fins, always start by cutting a pattern out of a stiff piece of card stock. This will help you make the fins all the same size, and if you ever have to make a replacement, you will have a handy pattern to work from.

Fins have three edges: the root edge, which is left flat and is the edge glued to the body tube; the leading edge, which is sanded to reduce wind resistance; and the trailing edge, on the back end of the fin. (See figure 4.)

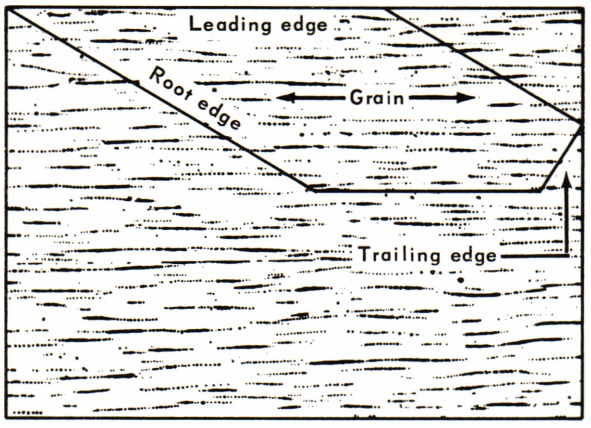


Figure 4. Rocket fin.

When you cut the fins, make sure the leading edge is parallel to the grain of the wood. Use a modeler's knife or a single-edge razor blade to cut the balsa. Be sure the cutting tool is sharp, or you will tear the balsa and ruin the fin. Where possible, use a metal straightedge to make your cuts. Make a few practice cuts on a scrap piece of wood.

Sand all the fin edges except the root edge to a round shape (figure 5). However, if you are making a high-performance rocket, sand both the leading and the trailing edges to a sharp edge and coat them with a layer of glue to strengthen them.

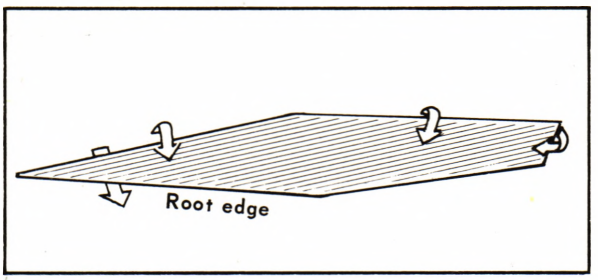


Figure 5. Sand all but root edge to a round shape, as shown.

After sanding the fins, seal them with balsa wood sealer. Apply two coats, sanding lightly between each coat. Then apply a prime coat of paint, being careful not to get any on the root edge.

The fins are usually attached to the body tube with a high-strength adhesive, like white glue. After marking the tube, apply a line of glue to the root edge of one fin. Let the glue dry for a minute or two. Then press the fin into place, being sure to keep it aligned with the tube. Attach the other fins the same way, allowing time for each fin to dry sufficiently. If possible, stand the rocket on its nose while the fins are drying.

After the glue has set, apply a fillet of glue to the joints that need to be reinforced (figure 6). You can build up the fillets by applying three or four thin coats of glue. Lay the rocket on its side when filleting so that the glue will not drip.

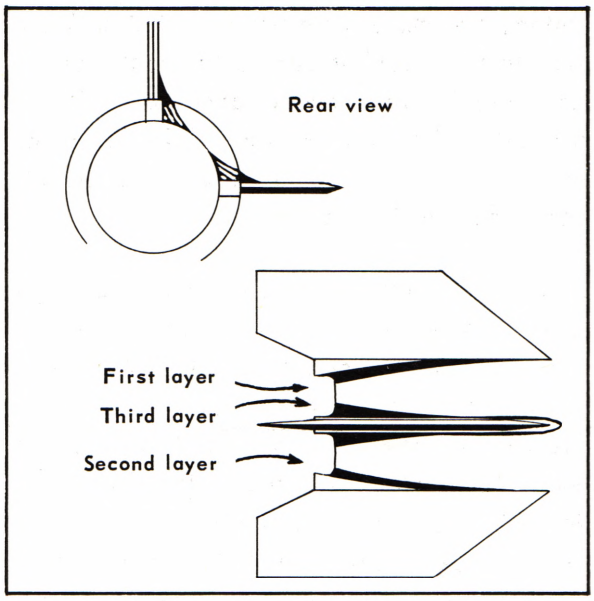


Figure 6. Build up fillets in layers.

Engine Mounts

The engine mount is the heart of a model rocket. It holds the engine during loading and keeps it in place while the rocket is in flight. It also has to keep the engine from coming loose when the ejection charge activates the recovery system. Since the engine mount takes all this use, it should be as strong as possible.

Most engine mounts have three basic parts: the engine tube; the engine block or clip; and spacing rings. The spacing rings position the engine tube inside the body tube. In some cases, you can reinforce the rings with small bits of balsa wood.

To keep the engine from traveling too far forward in the tube, you can use an engine block or clip. Engine blocks are used mostly in tumble-recovery models. It is easy to glue them into place, as shown in figure 7. Use an old engine casing to position the engine block in the tube. One advantage of using an engine clip is the ease of loading and unloading the engine.

In a rocket with an engine block, use a small piece of masking tape to give the engine a snug fit (figure 8). With an engine clip (figure 9), however, just lift the end of the clip and slip the engine into place. You can keep the engine igniters in place with a little recovery wadding or masking tape. Be sure to read the instructions included in the engine packet.

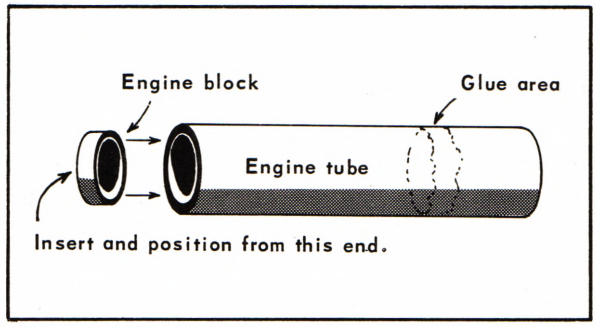


Figure 7. Engine block is easily glued into place.

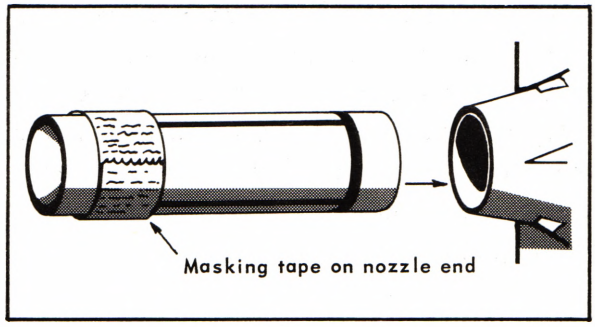


Figure 8. On a rocket with an engine block, masking tape gives the engine a snug fit.

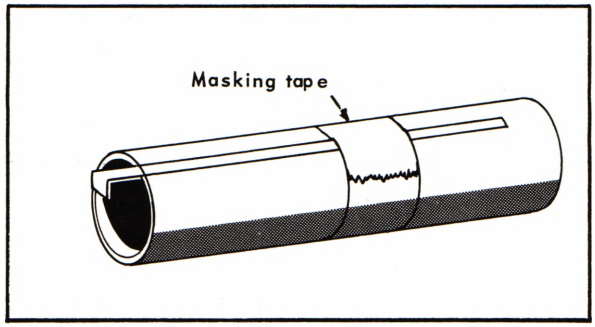


Figure 9. Engine clip.

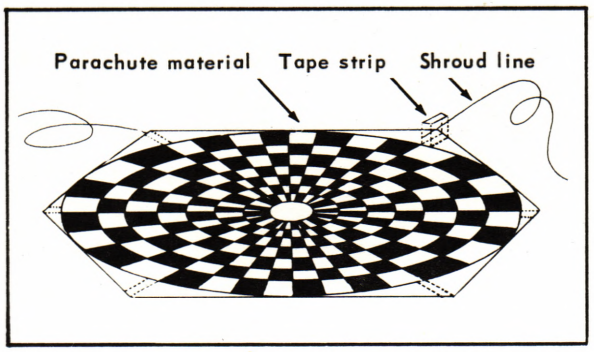


Figure 10. Parachute.

Recovery Systems

There are four main types of recovery systems to ensure the rocket's safe return and to prevent possible damage to people or property.

The first type is the feather-weight system, which is used only on small, light-weight rockets. These rockets float to the ground in about the same way as a feather falls.

The second type, called tumble recovery, is used on medium-weight rockets of 4 to 6 ounces. The rocket, after reaching peak altitude in its powered flight, becomes unstable and starts to flutter. This causes a great amount of drag and slows the rocket's descent to the ground.

Larger medium-weight model rockets use a streamer for recovery. The engine ejection charge deploys the streamer by means of a time-delay release mechanism. A sufficiently large streamer develops enough drag by fluttering to hold the rocket back in its descent so that it lands gently. The average streamer is twice the length of the rocket. Make it of paper that is bright colored and preferably flame proof.

In the parachute recovery system (figure 10), a timed charge deploys a small parachute, which gently lowers the rocket to the ground. Most large rockets use this type of recovery system, and many have two parachutes. When you fold the parachute, grasp the center of the parachute between two fingers and pull the material back to form a spike. Fold this spike into a rectangular bundle and wrap the attached shroud lines around it.

Connect the parachute or streamer recovery system to the rocket with a short, $\frac{1}{8}$-inch-diameter rubber shock cord. This eliminates the violent jerk when the parachute or the streamer deploys. There are two ways to mount the shock cord to the model rocket tube. One is to cut two small slits in the tube, each approximately $\frac{1}{2}$ inch long and $\frac{3}{4}$ inch below the end with the nose cone. Pass one end of the shock cord through the bottom slit and insert the end in the top slit so that the cord end is inside the rocket body tube. Restore the body tube to its original shape and apply glue inside and outside the tube at the slits. (See figure 11.)

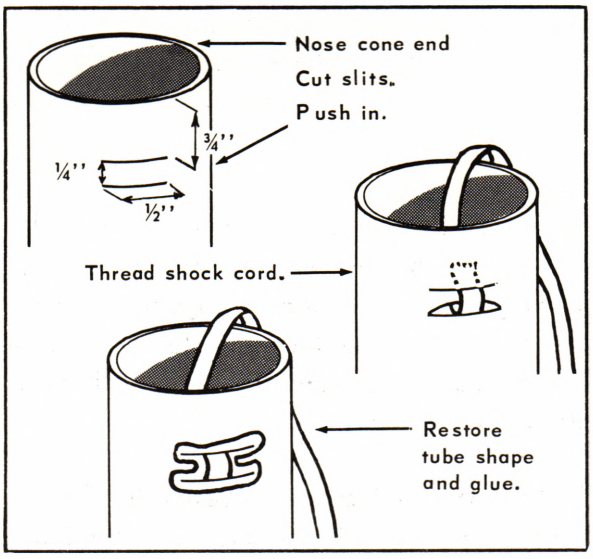


Figure 11. One method of mounting the shock cord.

The second method of mounting the shock cord is neater and makes a more durable rocket body. Figure 12 gives complete instructions.

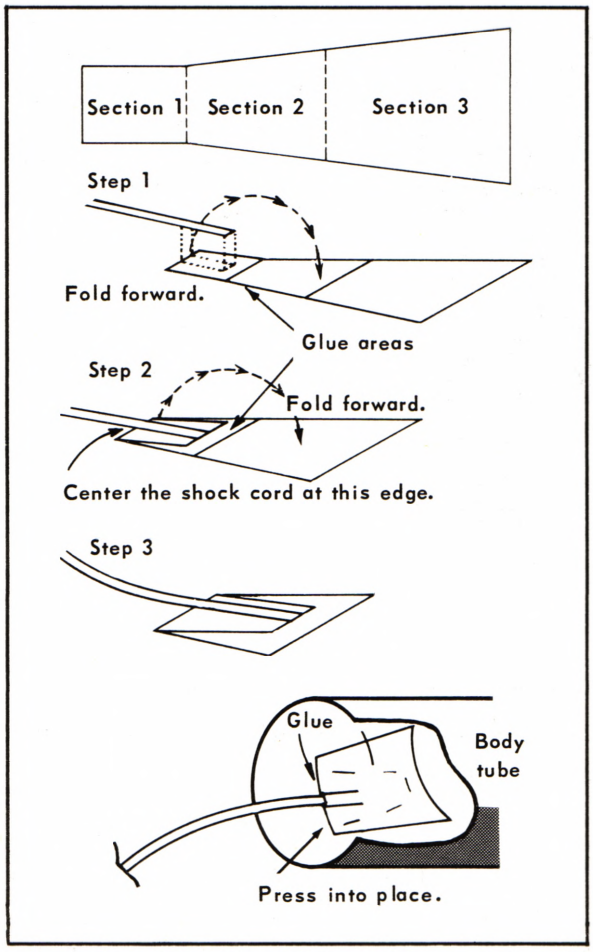


Figure 12. Second method of mounting the shock cord. First, trace the pattern on typing paper and cut it out. Then follow steps 1 through 3.

Step 1: Apply glue to section 1. Lay the end of the shock cord in place. Fold the first section over the second one, as shown.

Step 2: Apply glue over the back of the first section and over the top of section 2. Position the shock cord as shown and fold the cord and section 2 over section 3.

Step 3: Press into place.

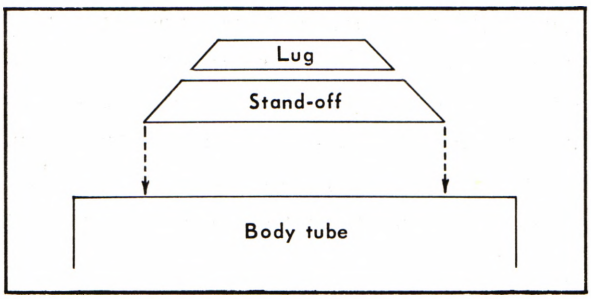


Figure 13. Launching lug attached first to a stand-off, then to body tube.

Launching Lug

Attach the launching lug the way you attached the fins. To reduce wind resistance, cut the tube ends at a 45° angle. You can use a stand-off (figure 13) when you have an extra large payload. If you use one, glue the lug to the stand-off first, then glue the whole unit to the body tube.

Painting

After assembly is complete and all the glue is dry, protect the rocket with modeling paint. These paints come in many colors and textures. Most modelers use enamel paint because of its durability. Several thin coats of spray paint give the best results. If you use a brush, paint the rocket, using two coats, if necessary. Then leave it! The paint thickens quickly and you can ruin a good paint job by brushing over it too much.

LAUNCHING SITES AND EQUIPMENT

A model rocket range is the best place to fly your rocket. Organized groups of rocket enthusiasts have set up many such ranges. However, if there is none available, it is best to select a place that has no trees or houses and is large enough so that you can recover the rockets within the area. The field should be no less than 300 by 500 feet, and you should set up the launcher in the middle of the area. A larger field would be better, if available. The best size would be 2,000 feet on each side.

Now about launchers. Most clubs use a multiple launching stand that can hold up to 10 rockets at a time. This is usually a 2-by-4 with holes drilled in the 4-inch side and placed flat on supporting legs (figure 14).

Figure 14.

You can use scrap wood to build a model rocket launcher that fires up to 10 rockets. Build it so it can be broken down into pieces and easily stored between launches.

Insert a 3-foot-long, ⅛-inch-diameter welding rod in each drilled hole. For a more elaborate set-up, you can buy a 2-by-12 board and drill holes, 1½ inches in diameter, every 11 inches down the center of the 12-inch side. About 1¼ inches from each hole, drill another one, ⅛ inch in diameter, to insert the launching rod. The larger hole allows the exhaust gases to pass through without burning the board.

An aluminum sheet spread over the board (with the exhaust holes and launching rod holes cut out) and tacked to the board provides an excellent blast deflector and keeps the blast from scorching the wood.

Make safety caps of white polyurethane (Styrofoam®) and place them on the tips of the launching rods before use. This aids visibility and prevents eye injury.

Various companies sell launch control panels. However, if you wish to construct your own, they are easy to make and the cost is nominal. A high school electronics instructor could be a valuable resource person if you build your own launcher.

A safety interlock is a must for every launch control panel. This is a keyed switch or a special plug that can be made to complete a circuit in the launcher. Some rocket launch control panels have batteries to supply the power; others have special hookups for car batteries. These systems are available in either 6, 12, or 24 volts.

Another must is a cable to connect the launch control panel to the launching stand. For most uses, this cable should be 50 feet long or longer. When you make your own cable, use number 22-type wire, and remember to use 11 strands. This enables you to launch 10 rockets in succession. In some cases, you may be able to obtain a length of cable from your local telephone company. This is an excellent cable, and there are up to 40 strands of wire in a single length.

LAUNCHING YOUR ROCKET

After you locate your launching site and set up your equipment, erect a spectator retaining line at least 100 feet behind the launcher. Then go to the launch panel, remove the safety interlock, and disconnect the cable from the launch panel. This is a safety precaution to prevent accidental firings while the rockets are being set up.

Now install the engine in the model rocket and connect the two electrical leads to the end of the igniter. On liquid-fuel rockets you will have to load the engine with propellant. Check all connections on the launching platform. Then go back to the launch control panel and connect the cable. Be sure the area in front of the retaining line is clear, with no one between the retaining line and the launch platform. Insert the safety interlock in the launcher and check for low-flying aircraft. When all is clear, push the button.

Remember—do **not** launch on windy days.

Have several people standing by to recover rockets after the launch. Before the launch, ask them to remove any combustible materials that would be fire hazards on the launching site.

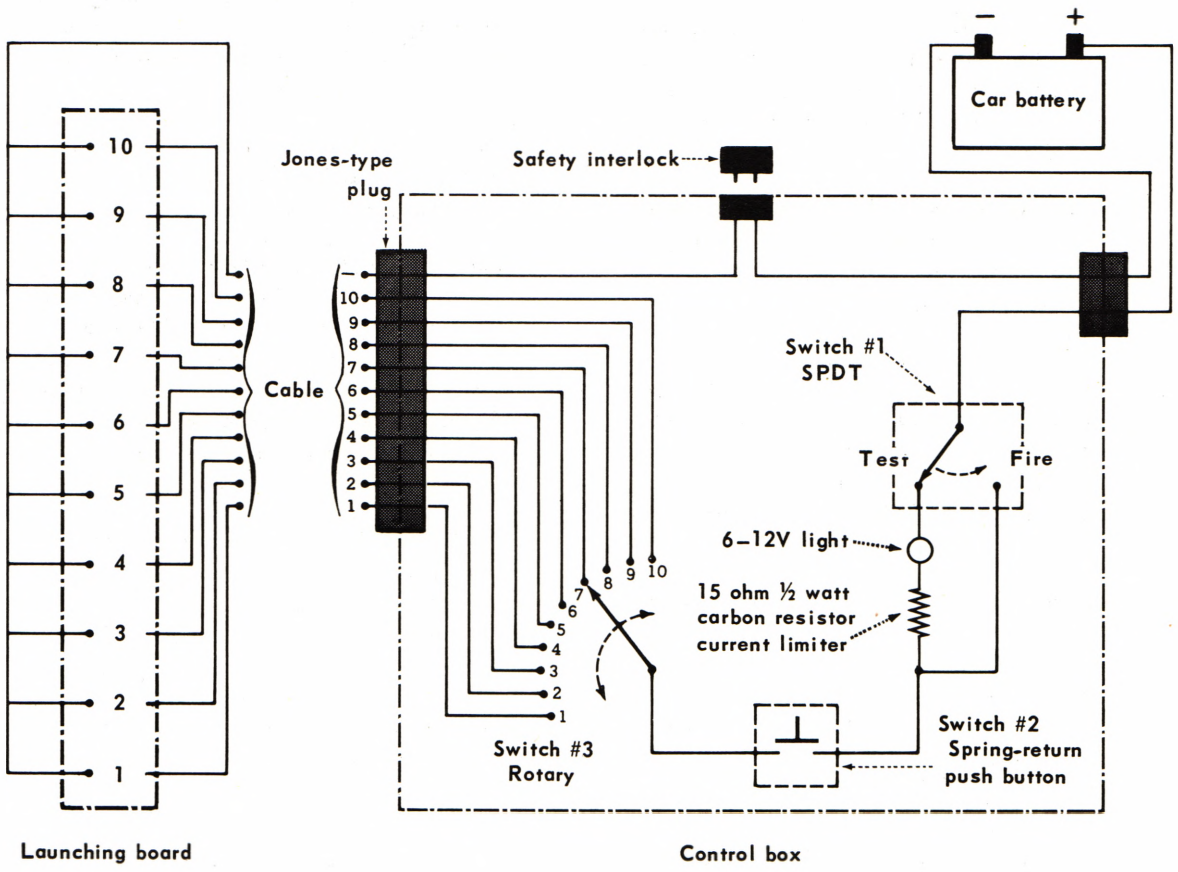


Figure 15. Launch control plan.

MODEL ROCKETRY SAFETY CODE[1]

1. **Construction** – My model rockets will be made of lightweight materials such as paper, wood, plastic and rubber, without any metal as structural parts.

2. **Engines** – I will use only pre-loaded factory made model rocket engines in the manner recommended by the manufacturer. I will not change in any way nor attempt to reload these engines.

3. **Recovery** – I will always use a recovery system in my model rockets that will return them safely to the ground so that they may be flown again.

4. **Weight Limits** – My model rocket will weigh no more than 453 grams (16 ozs.) at liftoff, and the engines will contain no more than 113 grams (4 ozs.) of propellant.

5. **Stability** – I will check the stability of my model rockets before their first flight, except when launching models of already proven stability.

6. **Launching System** – The system I use to launch my model rockets must be remotely controlled and electrically operated, and will contain a switch that will return to "off" when released. I will remain at least 10 feet away from any rocket that is being launched.

7. **Launch Safety** – I will not let any one approach a model rocket on a launcher until I have made sure that either the safety interlock key has been removed or the battery has been disconnected from my launcher.

8. **Flying Conditions** – I will not launch my model rocket in high winds, near buildings, power lines, tall trees, low flying aircraft, or under any conditions which might be dangerous to people or property.

9. **Launch Area** – My model rockets will always be launched from a cleared area, free of any easy to burn materials, and I will only use non-flammable recovery wadding in my rockets.

* * * * *

11. **Launch Rod** – To prevent accidental eye injury I will always place the launcher so the end of the rod is above eye level or cap the end of the rod with my hand when approaching it. I will never place my head or body over the launching rod. When my launcher is not in use I will always store it so that the launch rod is **not** in an upright position.

12. **Power Lines** – I will never attempt to recover my rocket from a power line or other dangerous places.

13. **Launch Targets & Angle** – I will not launch rockets so their flight path will carry them against targets on the ground, and will never use an explosive warhead nor a payload that is intended to be flammable. My launching device will always be pointed within 30 degrees of vertical.

14. **Pre-Launch Test** – When conducting research activities with unproven designs or methods, I will, when possible, determine their reliability through pre-launch tests. I will conduct launchings of unproven designs in complete isolation from persons not participating in the actual launching.

[1]This is copyrighted material, reprinted with the permission of Estes Industries, Inc.

Figure 16.

Carry model rockets and other gear to the launch site in a sturdy, well-constructed gear box. This protects the rockets from damage, and everything is easily accessible in one container.

ROCKETEER'S PLEDGE[1]

I am proud to be a model rocketeer. I feel it is important to do my part in upholding the outstanding safety record that model rocketry has gained. In all my rocket activities I will act in a mature manner and will always be considerate of other people and property rights. I pledge to follow the Rocketeer's code of safety.

Figure 17.

You can carry several rockets in the gear box. Other gear includes wadding and parachutes for recovery.

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Figure 18.

a) Pack wadding between the rocket engine and parachute assembly.

b) Then the rocket engine is inserted into the rocket housing, and

c) the rocket is ready for a journey into space.

THE 4-H ROCKET CLUB MEMBER

The 4-H rocket club member should be a serious, safety-minded person who is able to accept responsibilities. An irresponsible member can cause accidents and injury to all the members. Safety consciousness is the most important qualification for a potential rocket club member to have.

Before new members join a 4-H rocket club, they should attend a meeting to learn about model rocketry and what it can be used for. At this meeting, new members should also be briefed on what will be expected of them when they participate in club activities.

Have project meetings at least once a month, preferably every 2 weeks, so members can learn new construction techniques and safety precautions.

Every 2 months, hold a club launching where members can launch their rockets with adult supervision. At such meets, you can hold competitions and offer prizes. Remember to follow the safety rules and the Model Rocketry Safety Code at these launchings.

Figure 19. a) In assembling the rocket launch pad, make sure that launch rods are straight and that they make a good connection with the launcher circuitry.
b) Then place the rocket on the launching rod.
c) Take care not to break the rocket or the launching-rod lug and make sure you do not disrupt the launching-rod circuit.

Figure 20. Set up rockets on the launcher. Rockets come in all sizes and shapes. They can be inexpensive homemade jobs or very sophisticated ones developed from kits.

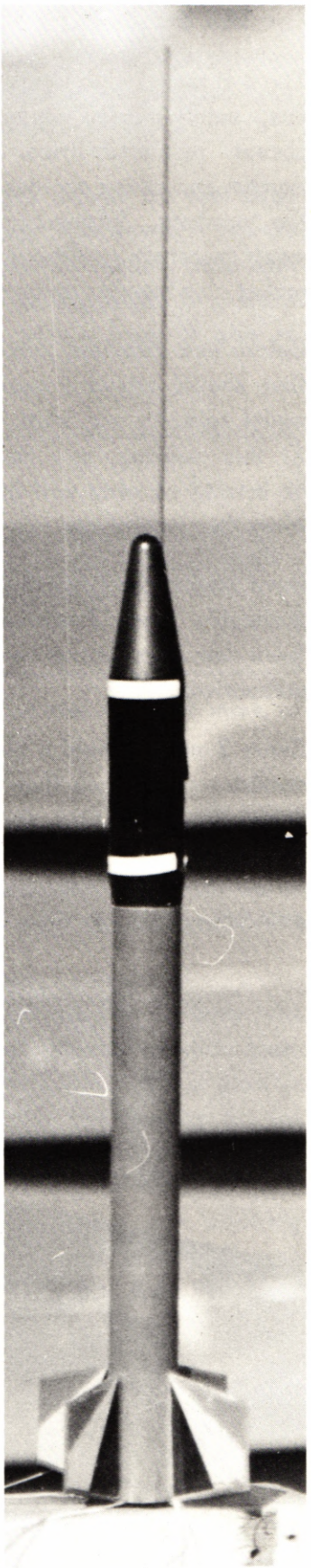
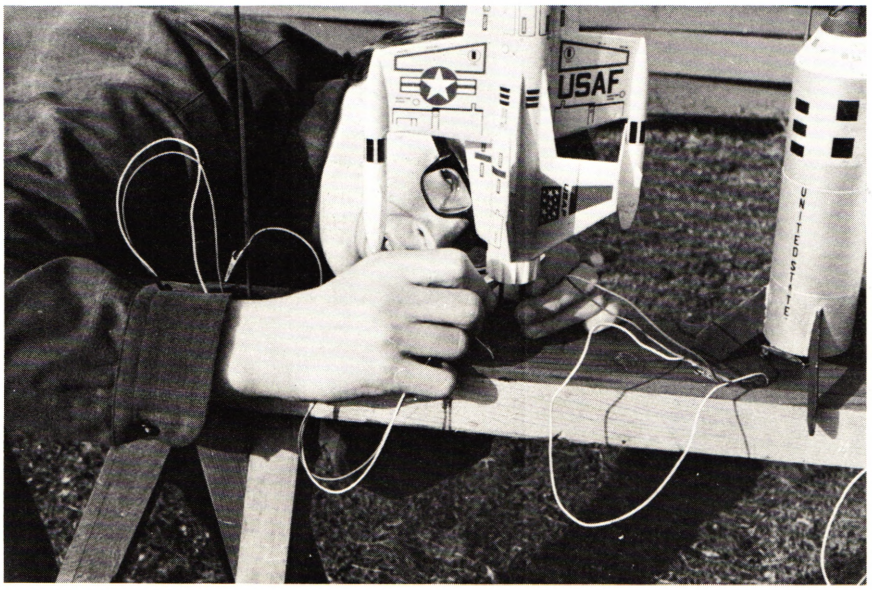
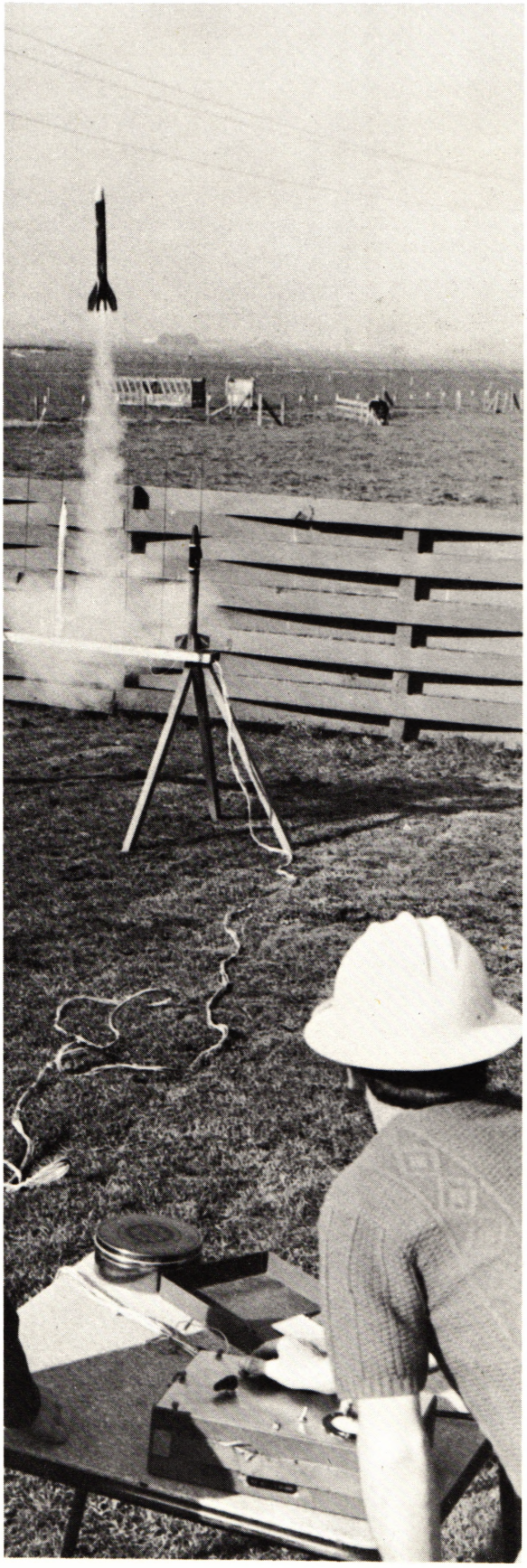


Figure 21. This rocket, poised ready to be sent skyward, has a camera in its nose cone. Two types of camera units are available. One takes a single shot as the rocket heads earthward. The other begins to take pictures immediately at the launch and takes a sequence similar to movie film as the rocket goes up.

Figure 22. The final step before launching is to connect the engine igniter wires to the launch circuit.





4-H ROCKET CLUBS

To form a 4-H rocket club, be sure to recruit leaders and junior leaders to help members construct their models and equipment. A training forum could be held to instruct the leaders and junior leaders in the basic applications of model rocketry. These forums could be held during the weekend, on holidays, or whenever convenient.

Clubs should be small enough so that each member receives adequate attention. Average club size should range from 10 to 15 members at the very most.

Some companies offer bonus kits with orders of $5 or more, so all members should place orders with the club's secretary and give the treasurer the money for the orders. This way, the bonus kits become the club's property and can be given to members who have less money to spend on rockets.

Club officers should include:

President	Treasurer
Vice-President	Club Reporter
Secretary	Common Supply Officer

Figure 23. 5 – 4 – 3 – 2 – 1 – BLAST OFF! And the rocket heads skyward in another safe and successful launch. Note that the rocket launching pad is placed well away from the launch control area to give maximum safety.

Figure 24. Bright-colored parachutes are used to slow the rocket's descent back to earth. It is easy to spot them, and so recovery is easier. Make launches well away from power lines and in clear, open spaces. This helps you recover rockets so that you can use them again and again.

Now you are ready to begin your 4-H project
in Model Rocketry.

HAVE FUN!