



4-H ROCKETRY

Member's Guide

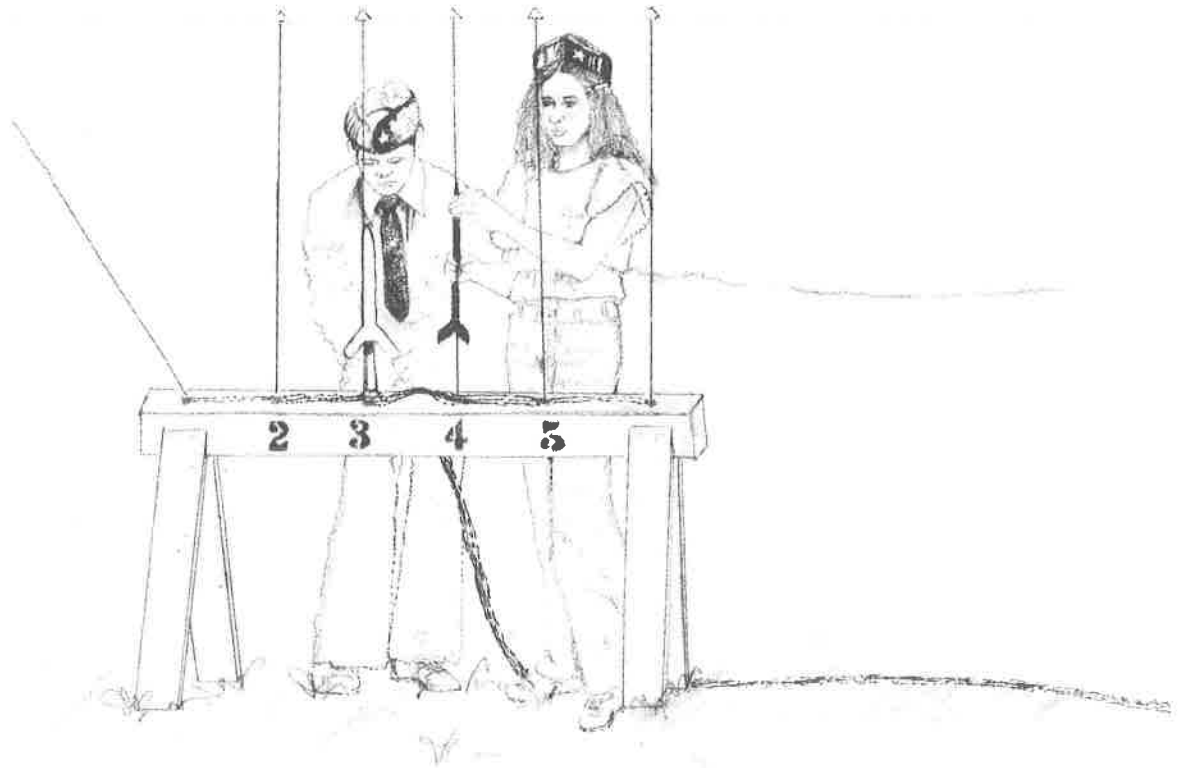
Cooperative Extension **University of California**
Division of Agriculture and Natural Resources

4-H-3002

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This 4-H Member's Guide was developed by a committee composed of 4-H Teen Leaders Jon Schmitz of Humboldt County and James Marshall of Del Norte County; and 4-H Youth Advisor Charles Hilgeman of Humboldt County in cooperation with Kathryn Cirincione-Coles, 4-H Specialist: Curriculum/Publications, U.C., Berkeley.

Some of the material is adapted from a publication prepared by Humboldt County 4-H All-Star Mark Bent in 1973. The authors are grateful for information provided by Estes Industries, Inc., and the National Rocket Association.



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4-H Rocketry Member's Guide

Safety for yourself and others should be your first concern as a member of a 4-H rocketry program. Without safety precautions, someone is bound to get hurt. A single slip-up might cause a serious accident. If you build your rocket with care and follow the rules, you will have a project that is highly successful through completion.

To stay within legal boundaries, check with your local or state fire marshall's office or fire department safety officer for regulations covering the use of model rockets in your area. You can learn the basics of rocketry by starting out with simple-to-build Level I rockets. Learning the names of all the rocket parts is a good beginning. The names are part of the special terminology and language you will need to know for communicating with professionals in the field.

4-H Rocketeer's Pledge

I am proud to be a model rocketeer. I will uphold the outstanding safety record of model rocketry by following the Rocketeer's Code of Safety and by acting with maturity in all my rocket activities. I will always strive to be considerate of other people and their property.

Rockets are not toys. Those whose career is with rockets in the space program, or missiles in the military, treat them with a great deal of respect. You can learn about responsibility and respect—the two "Rs" of model rocketry—by learning and practicing the Model Rocketry Safety Code (p. 4). 4-H model rocketry members should always respect the equipment with which they are working...and always respect their fellow 4-H rocketeers.

Skill levels

There are five skill levels for members in the rocket project.

- Level I. The beginner with no previous experience with models will build models that are simple to build.
- Level II. The rocketeer with other experience with models, or who has built the simple rocket of Level I, can build a model that is easy to build.
- Level III. Intermediate skills. Build and fly more complex rockets.
- Level IV. Participating in staging, boost glider, or scale model rockets.
- Level V. Advanced challenge. Designing rockets.

Tools and materials

You do not need a large number of tools to be involved in the 4-H rocketry project. You will need: an X-ACTO or small hobby knife, scissors, a ruler or straight edge, balsa wood, white wood glue, paint, rubber bands, clothes pins, straight pins, sandpaper,

wax paper, and cellophane tape. Rocket kits purchased from local hobby stores or by mail contain most of the materials necessary to complete each rocket. Only in the advanced unit of this project will you work without a kit.

Reaching new heights

4-H offers the opportunity for you to progress as fast and go as far as you wish. Giving the project your best effort, see how far you can go. After you have mastered the elementary levels of rocketry, look for challenges requiring additional learning. Level II and III rockets introduce you to the concepts of staging, multiple engines, or larger rockets with larger payloads. Bring science and math into your rocket launches and learn how to accurately measure the height of each of your launches. You may want to challenge other members to see who can build a rocket that goes the highest with the biggest payload. In case you haven't noticed, for nearly 30 years some nations also have

been flexing their missile might to impress each other.

In Level IV and V rocketry you may want to explore the world of astrophotography and include a camera as part of the payload. If you are really interested in rockets and space you may be able to have a career in that industry.

As you become older and more experienced in 4-H rocketry you may wish to contact companies associated with the space industry, NASA, or the military about careers in rocketry.

In case of accident

Accidents can happen, even when we follow the safety codes. Be prepared. Be sure your rocketry group has a first aid kit. Each member should know the basics of first aid. When you go on your launches, appoint a range "safety officer" who will find out where the nearest phone is and bring the phone number of the nearest emergency aid service, such as a fire department or an ambulance service. Put that

number with the first aid kit. If someone does get hurt, DON'T PANIC. Keep calm and keep the injured person calm. Water carried in a plastic gallon jug is useful for treating heat and acid burns that could occur. Flooding with cold, clean water is the best treatment. Puncture wounds can be treated by flushing with cold water, applying pressure to stop the bleeding, then getting proper medical attention.

Ever want to be a teacher?

Make a presentation about 4-H rocketry, covering what model rockets are, how they work, how to launch them, where to buy them, and what supplies are needed. Learning something well enough to teach it gives a feeling of pride and accomplishment.

Your leaders can help you learn how to put together a 4-H presentation. Your county has 4-H events where you can share your knowledge and compare how well you did with others in giving 4-H presentations.

Model Rocketry Safety Code*

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 preloaded, 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 ounces) at liftoff, and the engines will contain no more than 113 grams (4 ounces) 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 anyone 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, or low-flying aircraft, or under any conditions that 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 use only non-flammable recovery wadding in my rockets.
10. **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.
11. **Power lines.** I will never attempt to recover my rocket from a power line or other dangerous places.
12. **Launch targets and 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.
13. **Prelaunch test.** When conducting research activities with unproven designs or methods, I will, when possible, determine their reliability through prelaunch tests. I will conduct launchings of unproven designs in complete isolation from persons not participating in the actual launching.

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Date completed

Leader's initials

Unit I _____

Have your leader initial and date each objective as you complete it:

- 1. List at least five parts of a rocket.
- 2. List at least five sections of the model rocketry safety code.
- 3. Assemble a Skill Level I rocket.
- 4. Prepare a presentation showing the steps in building a Skill Level I rocket.
- 5. Write an evaluation of another member's rocket presentation using 4-H Presentation Evaluation (4-H 8017).
- 6. Attend a rocket launching.
- 7. List at least five contents of a first aid kit and explain the use of each item.

Unit II _____

Have your leader initial and date each objective as you complete it:

- 1. List the seven parts of a rocket.
- 2. Assemble your own rocket launching system.
- 3. Assemble a Skill Level II rocket.
- 4. Prepare and present a talk for first-year members about the Rocketry Safety code which includes all 13 points.
- 5. Prepare a demonstration about rocketry and present it in your county contest.
- 6. Launch a rocket that you have assembled.

Date completed

Leader's initials

Unit III

Have your leader initial and date each objective as you complete it:

- _____ 1. Name the three rocket recovery systems.
- _____ 2. Assemble a Skill Level III or IV rocket.
- _____ 3. Prepare a report about a two-stage rocket for a club meeting.
- _____ 4. Prepare a report about a rocket with a payload for a club meeting.
- _____ 5. Build an altitude measuring device and explain to club members at a meeting how it works.
- _____ 6. Describe one possible cause for failure of a rocket to launch.
- _____ 7. Prepare a list of ten questions first-year members have about rocketry and, through research, find the answers to those questions.

Unit IV

Have your leader initial and date each objective as you complete it:

- _____ 1. Assemble a Skill Level V rocket.
- _____ 2. Prepare a plan for being a junior/teen leader in rocketry using 4-H 8034 Leadership Project Plan and Report.
- _____ 3. Make a list of sources for visual aids on rockets.
- _____ 4. Assemble a rocket with a camera.
- _____ 5. Assemble a rocket without using a kit.
- _____ 6. Describe one way to test a rocket for stability.
- _____ 7. Prepare an educational display about rockets for a fair or other public event.
- _____ 8. Prepare a report about careers related to rocketry and present the report at a 4-H club.

IMPORTANT!

COUNTY _____

Here are my suggestions for improving this 4-H publication 4-H-3002 Title 4-H ROCKETRY - Member's Guide

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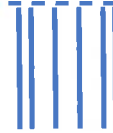
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4-H ROCKETRY

Leader's Manual

Cooperative Extension **University of California**
Division of Agriculture and Natural Resources

4-H-3001

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The 4-H Leader's Manual was developed by a committee composed of 4-H Teen Leaders Jon Schmitz of Humboldt County and James Marshall of Del Norte County; and 4-H Youth Advisor Charles Hilgeman of Humboldt County in cooperation with Kathryn Cirincione-Coles, 4-H Specialist: Curriculum/Publications, UC, Berkeley.

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Learning objectives

In the 4-H Rocketry Program some of the more important objectives that can be achieved include being able to:

Unit I

- list five parts of a rocket;
- list five sections of the Model Rocketry Safety Code;
- assemble a Skill Level I rocket;
- prepare a presentation showing the steps in building a Skill Level I rocket;
- write an evaluation of another member's rocket presentation using *4-H Presentation Evaluation (4-H 8017)*;
- attend a rocket launching.

Unit II

- list seven parts of a rocket;
- assemble a rocket launching system;
- assemble a Skill Level II rocket;
- prepare and present a talk about the Rocketry Safety Code which covers all 13 points;
- prepare a demonstration about rocketry and present it in your county contest;
- launch a rocket that the member has assembled.

Unit III

- name the three rocket recovery systems;
- assemble a Skill Level III or IV rocket;
- prepare a report about a two-stage rocket for a club meeting;

- prepare a report about a rocket with a payload for a club meeting;
- list at least five components of a first aid kit and explain their use;
- build an altitude measuring device and explain to club members at a meeting how it works;
- describe one possible cause of failure for a rocket to launch;
- prepare a list of ten questions first-year members have about rocketry and, through research, find the answers to those questions.

Unit IV

- assemble a Skill Level V rocket;
- prepare a plan for being a junior/teen leader in rocketry using *4-H 8034 Leadership Project Plan and Report*;
- make a list of sources for visual aids on rockets;
- assemble a rocket with a camera;
- assemble a rocket without using a kit;
- describe one way to test a rocket for stability;
- prepare an educational display about rockets for a fair or other public event;
- prepare a report about careers related to rocketry and present the report at a 4-H club.

On being a rocketry leader

This resource guide is designed to help you succeed as a 4-H rocketry leader. Planning ahead is important. Bring one or two sample rockets to the first meeting with your group to show the members what may be accomplished as members of the rocketry project. Talk with your members about what they can learn and accomplish, then help them develop a plan for their personal achievement during the year.

As leader you should clearly communicate to the members and receive their support. Members and leaders who successfully meet their goals are more likely to return to 4-H the following year.

The 4-H Project Leader is crucial to the 4-H program. Many members drop out of 4-H because they are not having a meaningful learning experience in their 4-H project groups. You can learn further about being a

successful 4-H Project Leader by reading *The Volunteer's 4-H Handbook (4-H 1111)*, available from your local 4-H office. This handbook contains a section on how to work with members. Material presented there can lead to a better understanding of the various characteristics of the growth and development of youth as they pass through various life stages.

Record keeping is an integral part of 4-H and one of the life skills taught in the program. Details on what records to keep and how to encourage members to keep them are also included in the handbook.

Individual recognition is important in developing a healthy self-image. Individual recognition can be as simple as a pat on the back or a word of praise at a project meeting, or as complex as being a national winner and taking a trip across the country. Lack of

recognition can cause members to leave the 4-H program. Project leaders have a key role in providing recognition, and leaders should plan to recognize members during local project meetings. Project leaders

also can guide members toward opportunities for recognition beyond the project group. An explanation of the 4-H recognition and awards system is another feature of *The Volunteer's 4-H Handbook*.

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. Figure 1 shows the basic construction of the solid-fuel rocket. Note the small size of the engine compared with the whole rocket.

Solid-fuel engines use a propellant similar to micro-grain powder or gunpowder. Because such engines can be explosive if not properly used, some states have an age requirement for their purchase.

Solid-fuel engines come in various sizes and in thrusts ranging from 22 ounces to 7 pounds. Static test engines for testing rocket performances are also available. However, they should not be used in an actual launching. You can use a solid-fuel engine only once and then you have to buy a replacement.

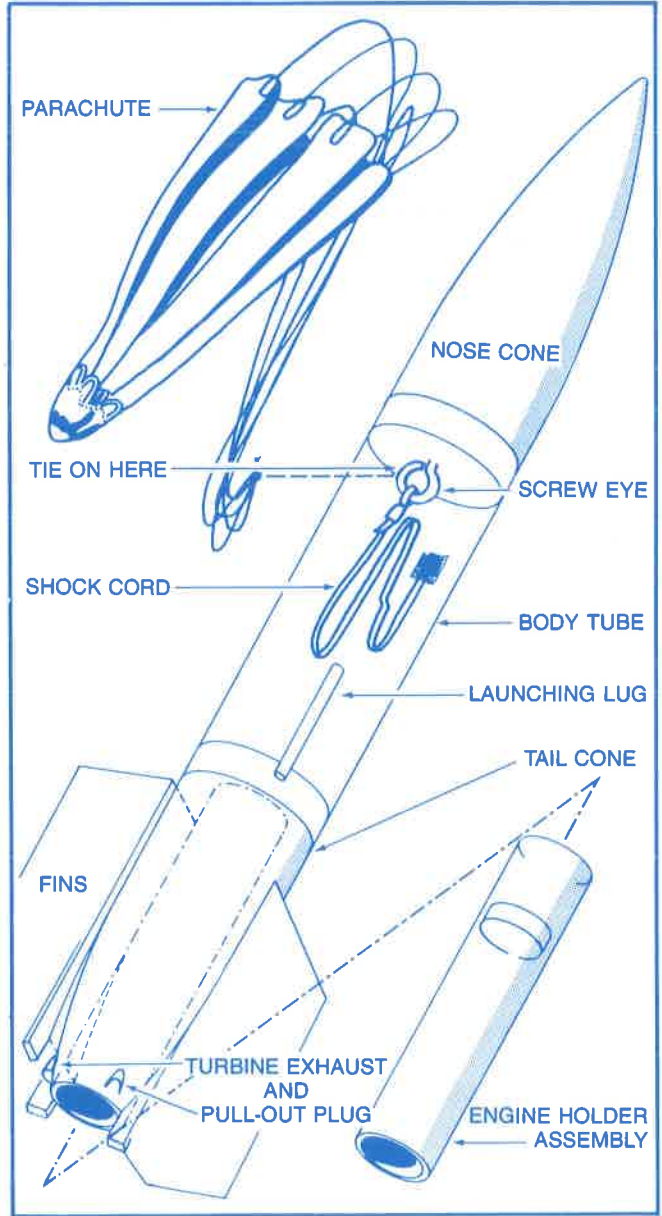


Fig. 1. Solid-fuel rocket.

Rocket safety

Safety is very important. Follow the Model Rocketry Safety Code. Some of the dangers to avoid include burns from the rocket engine thrust; eye injuries from launch rods that are left uncapped; and bruises and lacerations from chasing rockets after launch over uneven terrain. Include a basic lesson in first aid at one of the early rocketry meetings. It could be taught by a nurse or paramedic attached to your local fire or ambulance service.

Have your rocketry group carry at all times a basic first aid kit. A kit can be purchased, or assembled

from individual parts. The Red Cross can supply a list of items that should be included in such a kit, and preparation of the kit can be the subject for another rocketry project meeting.

When field trips are planned away from the members' home area, leaders should obtain from each member's parents a *Medical Treatment Form* (4-H 1109) and carry it with the group.

Starting out

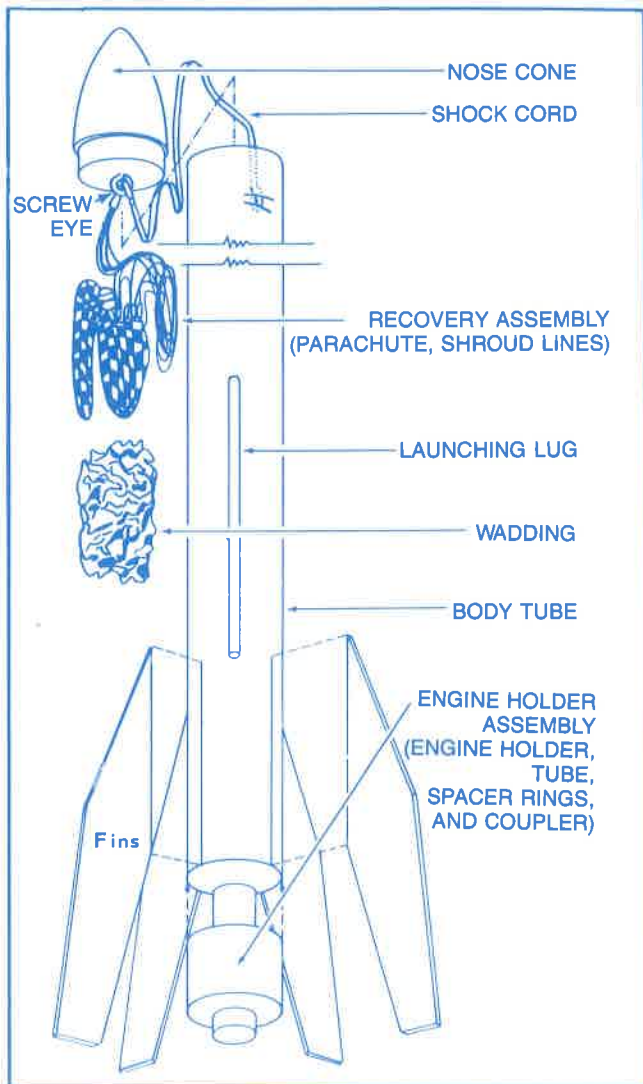


Fig. 2. A typical model rocket.

It is best to start with a small, single-stage rocket. Most kits supply instructions for building the rockets. The typical model rocket (shown in fig. 2) gives good results if carefully built.

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

Construction techniques

Rockets have at least four main parts: fins, engine mount, recovery system, and launching lug. (See fig. 2.)

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 lower wind resistance. On a high-speed high-altitude rocket, both the leading and the trailing edges are sanded sharp.

The recovery system safely returns the rocket to the ground. It may be a parachute cluster or simply a single streamer. 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.

The launching lug is a small tube attached to the outside of the rocket which guides the rocket during the initial acceleration and take-off. It should be small to reduce wind resistance, but it must be strong enough to bear 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 rockets have no body at all.

Fins. Make the rocket's fins of thin balsa-wood sheets, available from most hobby and hardware stores. Most fins are made of 1/16-inch stock, a size

that is easy to cut and sand. Always start by cutting a pattern out of a stiff piece of card stock so that all the fins will be the same size. Keep the pattern for making a replacement if necessary. 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 fig. 3.)

When cutting the fins, make sure the leading edge is parallel to the grain of the wood. Use a sharp hobby knife to cut the balsa. If the tool is not sharp the balsa will tear and the fin will be ruined. Where possible, use a metal straightedge to make cuts. Make a few practice cuts on a scrap piece of wood.

Round all the fin edges except the root edge with sandpaper. Sand both the leading and the trailing edges of a high-performance rocket to a sharp edge and coat them with a layer of glue to strengthen them.

After sanding the fins, seal 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, such as white glue. After marking the body 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 before adding the next. Try to prop up the rocket on its nose while the fins are drying.

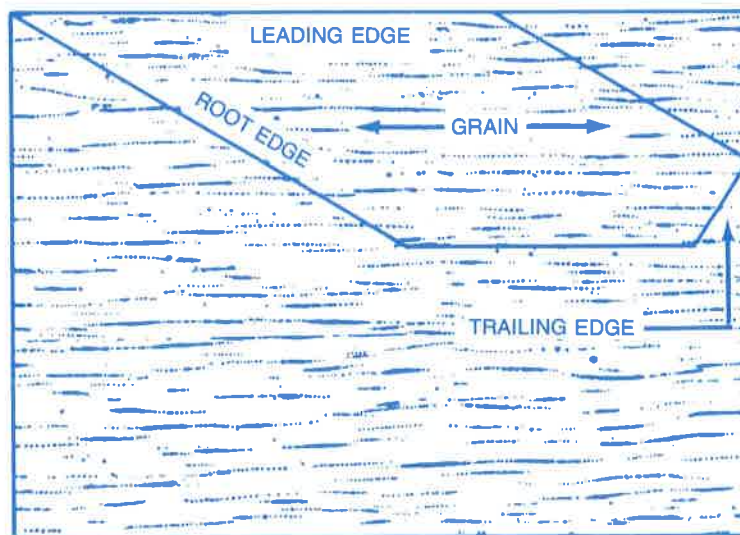


Fig. 3. Rocket fin.

After the glue has set, apply a fillet of glue to the joints that need to be reinforced (see fig. 4.) You can build up the fillets by applying three or four thin coats of glue. Lay the rocket on its side when filleting so the glue will not drip.

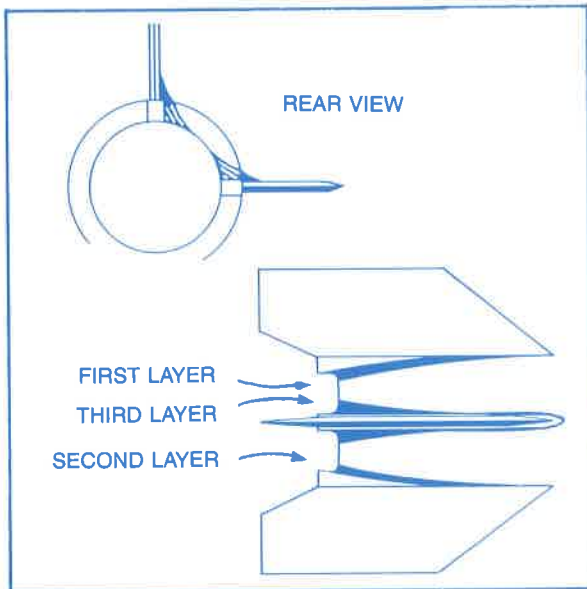


Fig. 4. Build-up of fillets in layers.

Engine mounts. The engine mount is the most important part 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. Because the engine mount takes such stress, 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 the engine tube can be reinforced with small pieces of balsa wood.

To keep the engine from traveling too far forward in the tube an engine block or clip can be used. Engine blocks are used mostly in tumble-recovery models. It is easy to glue them into place, as shown in Figure 5. Use an old engine casing to position the engine block in the tube. An engine clip can facilitate 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 (fig. 6). With an engine clip (fig. 7), however, just lift the end of the clip and slip the engine into place. The engine igniters can be kept in place with masking tape. Be sure to read the instructions included in the engine packet.

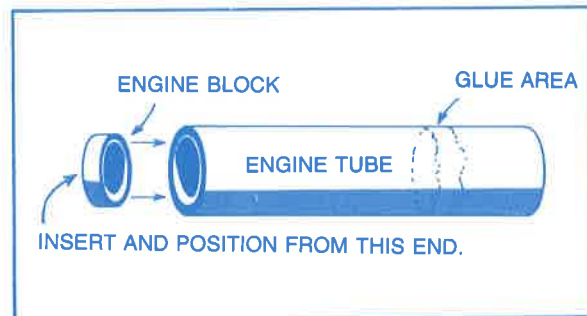


Fig. 5. The engine block is easily glued into place.

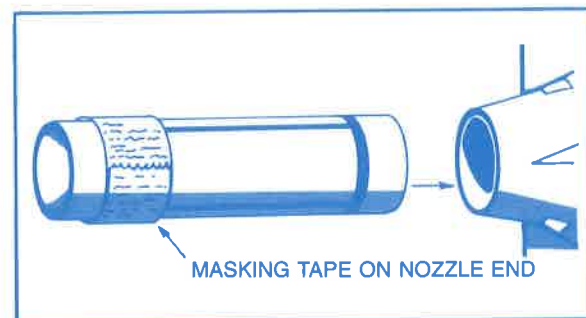


Fig. 6. On a rocket with an engine block, masking tape gives the engine a snug fit.

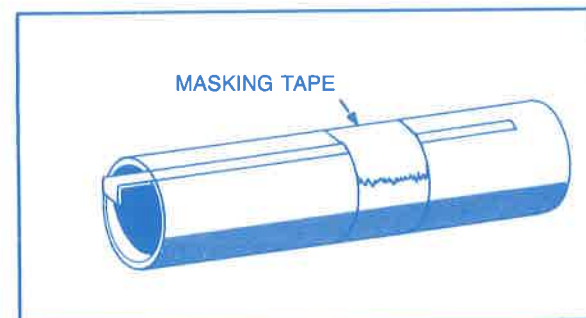
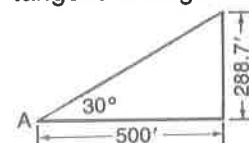


Fig. 7. Engine clip.

Basic tracking. To help your members determine how high their rockets went, buy a simple altitude measuring device at a hobby store or construct one from a nail, yardstick, screw eye, protractor, string, and weight.

To figure the rocket's apogee, multiply the distance from the launch site by the tangent of angle A. For example:

$$\begin{aligned} \text{Distance} &= 500 \text{ feet} \\ \text{Tangent of } 30^\circ &= .5774 \\ 500 \times .5774 &= 288.7 \text{ feet} \end{aligned}$$



A table of sines and tangents is included in the back of this manual.

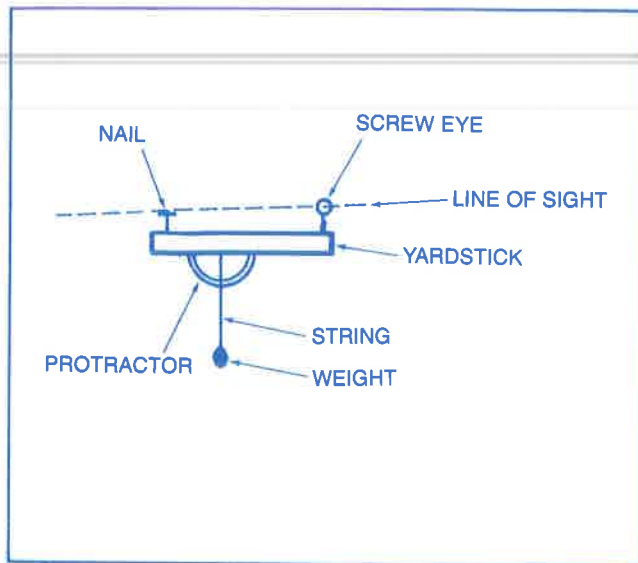


Fig. 8. Tracking instrument.

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

- The feather-weight system is used only on small, light-weight rockets. These rockets float to the ground in about the same way a feather falls.
- Tumble recovery is used on medium-weight rockets of 4 to 6 ounces. After reaching peak altitude in its powered flight, the rocket 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. The streamer develops enough drag by fluttering to slow the rocket's 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 (see fig. 9), 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 to the rocket with a short, 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 1/2 inch long and 3/4 inch below the end with the nose cone.

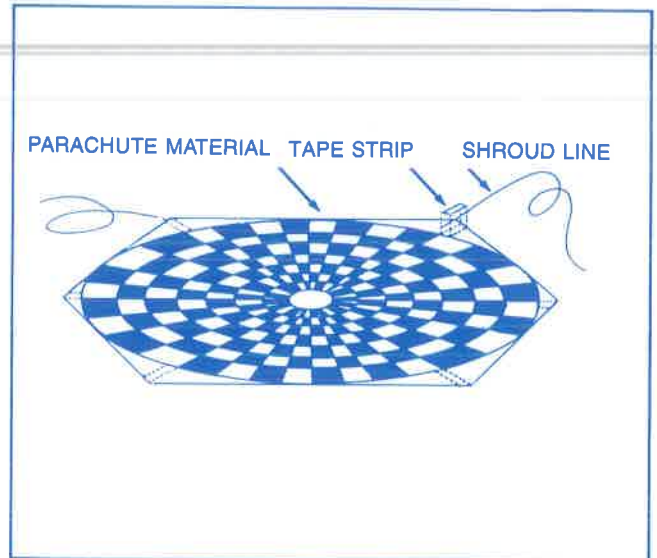


Fig. 9. Parachute.

(See fig. 10.) 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.

The second method of mounting the shock cord is easier and makes a more durable rocket body. (See fig. 11.) First, trace the pattern on typing paper and cut it out. Apply glue to section 1. Lay the end of the shock cord in place. Fold the first section over the second one, as shown in Figure 11. Apply glue over the back of the first section and over the top of section 2. Position the shock cord as shown in Figure 11 and fold the cord and section 2 over section 3. Then press into place.

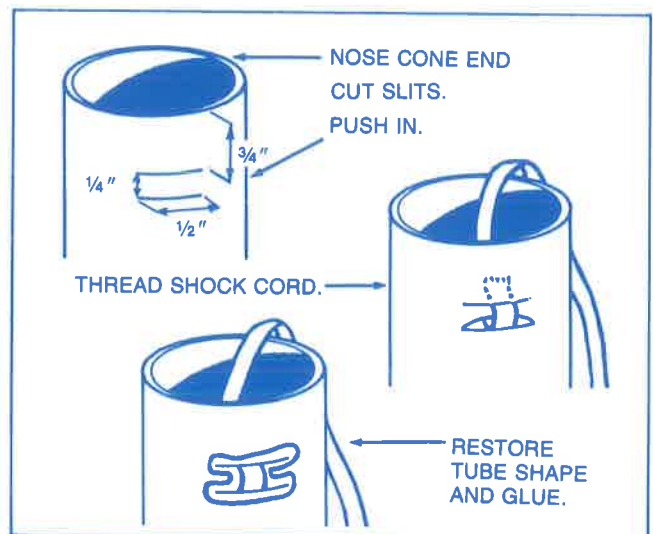


Fig. 10. One method of mounting the shock cord.

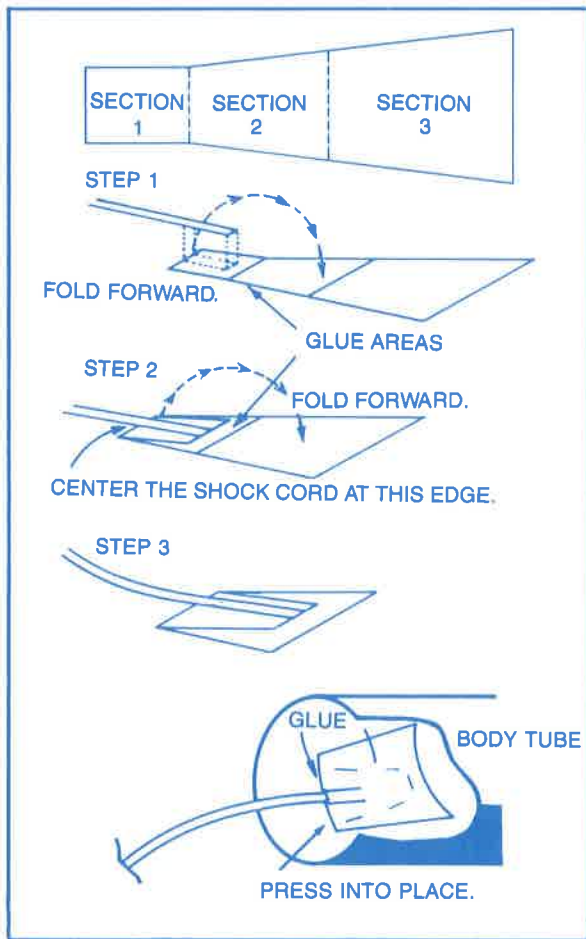


Fig. 11. Another method of mounting the shock cord.

Launching lug. Attach the launching lug the same way the fins were attached. To reduce wind resistance, cut the tube ends at a 45° angle. A stand-off (see fig. 12) can be used for an extra large payload. 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, which comes in many colors and textures. Most modelers use enamel paint because of its durability. Several thin coats of spray paint give the best results. Paint thickens quickly and you can ruin a good paint job by putting on too much either by spray or paint brush.

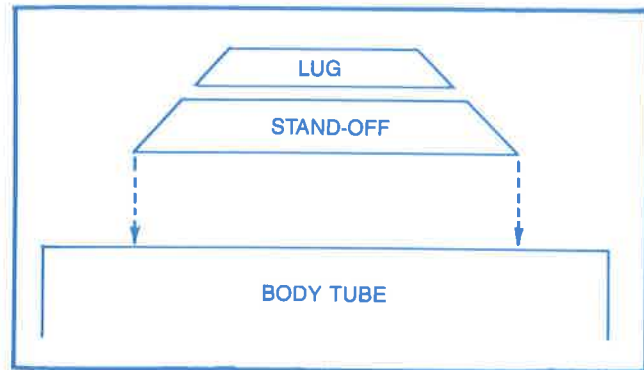


Fig. 12. Launching lug attached first to a stand-off, then to the body tube.

Launching systems

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 no ranges are available, select a place that has no trees or structures and is large enough so that rockets will not fly out of the area. The field should be no less than 300 by 500 feet, and the launcher should be set up in the middle of the area. A larger field—as long as 2,000 feet on each side—would be better, if available. Some larger rocket clubs use a multiple launching stand that can accommodate up to 10 rockets at a time. This is usually a 2-by-4 board, with holes drilled in the 4-inch side, and placed flat on supporting legs.

Insert a 3-foot-long, 1/8-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, 1-1/2 inches in diameter, every 11 inches down the center of the 12-inch side. About 1-1/4 inches from each hole, drill

another hole, 1/8 inch in diameter, to insert the launching rod into. 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 Styrofoam safety caps and place them on the tips of the launching rods before use to aid visibility and prevent eye injury.

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 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. You may be able to obtain an excellent cable from your local telephone

company with up to 40 strands of wire in a single length.

If only a few rockets are to be launched, a simple launching system (fig. 13) can be constructed or purchased.

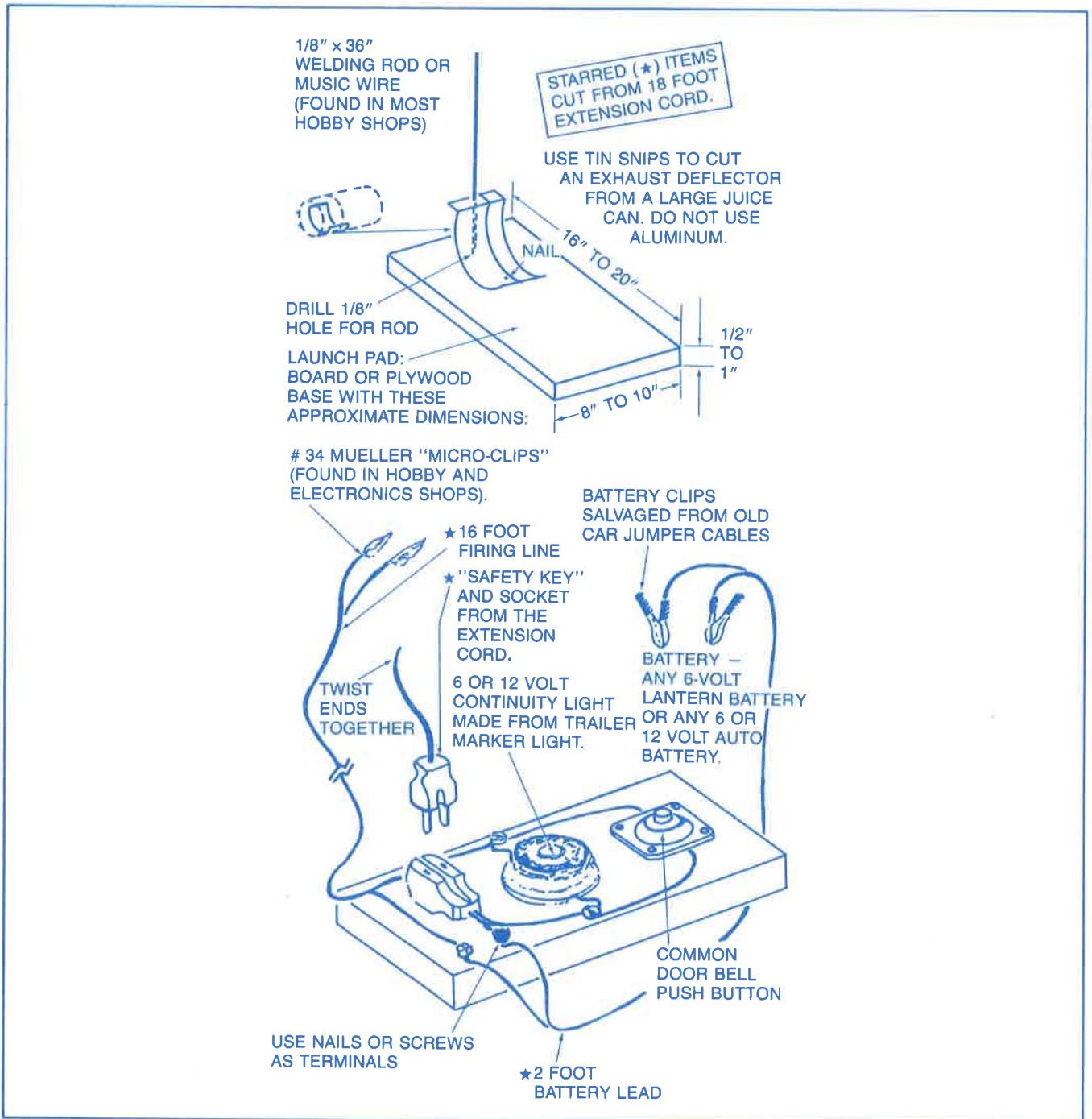


Fig. 13. Simple rocket launcher.

Launching your rocket

After you locate your launching site and set up your equipment, put up a rope beyond which spectators cannot go—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. 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 spectators' rope is clear, with no one between the rope and the launch platform. Insert the safety interlock in the launcher and check for low-flying aircraft. When all is clear, count down from 10 to 0, and launch.

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.

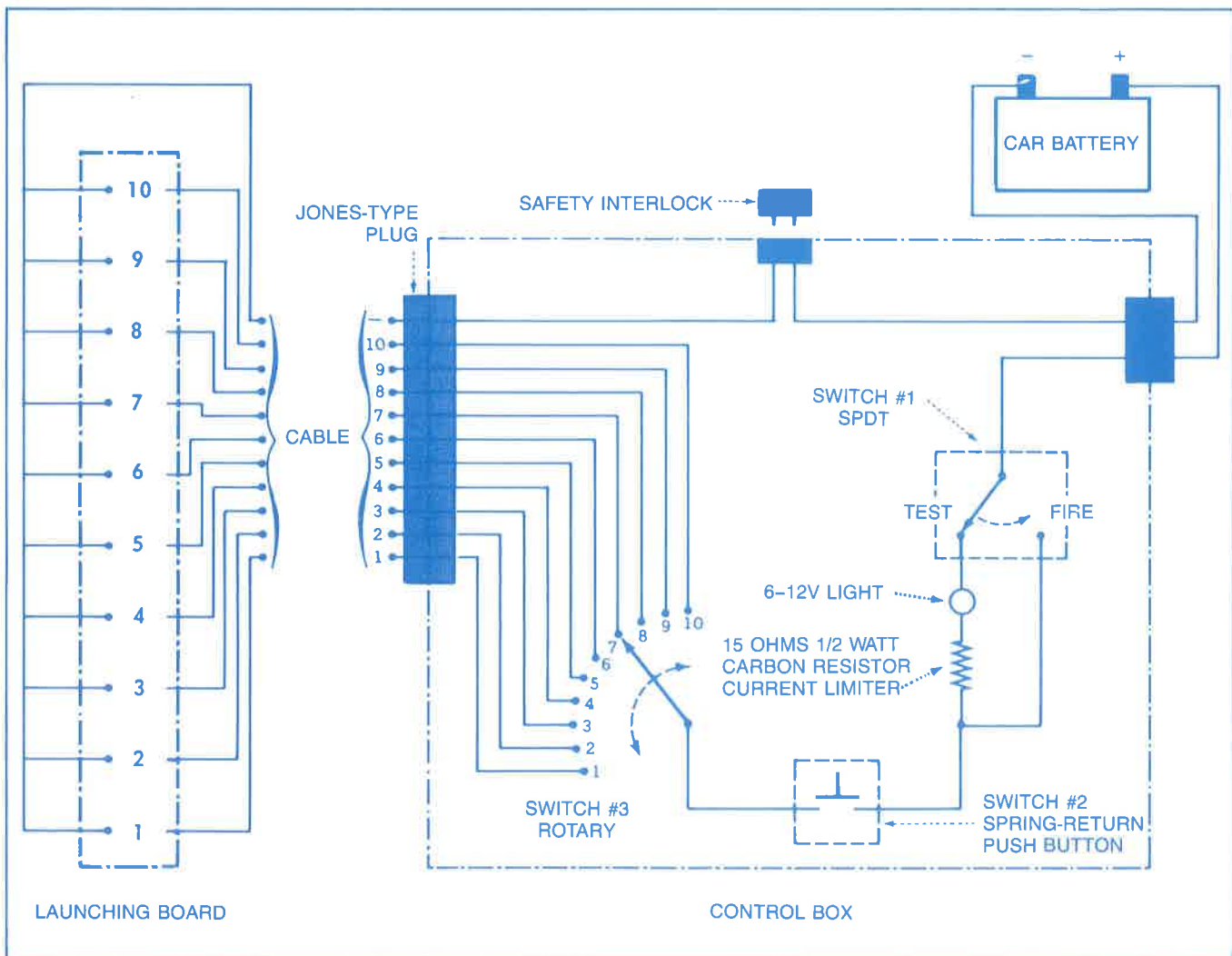


Fig. 14. Multiple rocket launcher.

Trouble shooting

The most likely reason for the rocket not firing is an incomplete connection with the power source (battery). If it does not fire, disconnect at the power source and work back along the connecting wire until reaching the rocket, checking each connection carefully. Another possibility is that the power source may have become discharged and may not have had enough strength to power a launch. Or the ignition was not placed properly in the engine and fastened with a small piece of masking tape.

Failure of the rocket to follow a true path after launching generally indicates a defect in design. Improper

weight balance can cause irregular flight patterns. Fins that are not of equal weight and size also can result in flight problems.

Model rocket companies publish detailed booklets containing discussions on the various causes of rocket malfunction and these booklets should be added to the club's resource library so that members can participate in research to determine what is wrong.

The 4-H rocket club

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. Safety consciousness is the most important qualification for a potential rocket club member.

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 that members can learn new construction techniques and safety precautions. Every 2 months, hold a club launching where members can launch their rockets under adult supervision. At such events, you can hold a contest and offer prizes. Remember to follow the safety rules and the Model Rocketry Safety Code at these launchings.

To establish a 4-H rocket club, be sure to recruit leaders and junior/teen leaders to help members construct their models and equipment. A training forum can be held to instruct the leaders and junior/teen leaders in the basic applications of model rocketry.

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

Some companies offer bonus kits with minimum purchases, 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 little money to spend on rockets.

Advanced rocketry

After the club members have successfully constructed and launched Level I and II rockets, they are ready to advance to the multi-stage, cluster, payload, glider, and original-design rockets. These require more patience, time, and checking for stability. Each step in construction should be monitored in order that the finished rocket be a success.

Another aspect of advanced rocketry might be the inclusion, if possible, of the use of a computer to do altitude simulations and rocket design. There are excellent sources for designing computer programs. If your club has a computer project, you might ask a representative to attend one of your meetings.

Educational presentations

An important and effective 4-H teaching technique is learning by doing. When a member learns something well enough to teach it to others, the person has learned it well. The *4-H Presentation Program* presents members with the opportunity to focus on one part of the project they are learning.

Most of the day, youngsters sit in their classrooms and are taught by others. At 4-H meetings they can reverse the role and become the teacher for the day. For further help getting your members involved refer to *4-H Presentations—Leader's Manual* (4-H 8046), available from your local 4-H office.

For more challenges, try constructing an educational display. Advanced members learn more about rocketry by researching and planning what should go into the display. An educational display will tell others what is involved in the 4-H rocketry project. The display may be the work of an individual or of a committee of members. A booklet—*Planning and Judging Posters and Displays* (4-H 8018)—is available from your local 4-H office.

Careers

Brainstorming is a good technique for learning about careers. Brainstorming is accepting in rapid-fire order all ideas brought forth by a group and quickly recording them on a blackboard or poster paper. Then they can be sorted through with the most interesting career ideas given to members or groups of members

to gather data on each. Of course, a whole industry has grown up around our nation's space program and the National Aeronautics and Space Administration has films and other materials available to groups covering aerospace and space-related careers.

Helpful resources

There are various companies that manufacture rockets and associated supplies which will furnish catalogs and other written materials upon request. Those include:

Celestial Enterprises
5205 Highgate Plane
Rowlett, Texas 75088

Centuri Engineering Co.
P.O. Box 1988
Phoenix, Arizona 85001

**Competition Model
Rockets**
P.O. Box 7022
Alexandria, Virginia 22307

CNA Systems
P.O. Box 1252
Lewiston, Maine 04240

Estes Industries, Inc.
P.O. Box 227
Penrose, Colorado 81240

Logix Enterprises
3810 St. Patrick Street
Montreal, Canada
("Science Fun/
Experiments in
Aeronautics")

Flight Systems, Inc.
9300 East 68th St.
Raytown, Missouri 64133

**National Association of
Rocketry**
182 Madison Drive
Elizabeth, Pennsylvania
15037

**Small Sounding
Rocket Systems**
P.O. Box 341
Mountlake Terrace,
Washington 98043

Some audio visual aids are available from the NASA Ames Research Center, Educational Services Officer, Moffett Field, CA 94035. Write to them for the list of latest available materials. They also can arrange tours of their non-classified operations area with advance reservations.



SINES AND TANGENTS

ANGLE	SINE	TANGENT	ANGLE	SINE	TANGENT	ANGLE	SINE	TANGENT
1	.01745	.01746	31	.5150	.6009	61	.8746	1.804
2	.03490	.03492	32	.5299	.6249	62	.8829	1.881
3	.05234	.05241	33	.5446	.6494	63	.8910	1.963
4	.06976	.06993	34	.5592	.6745	64	.8988	2.050
5	.08716	.08749	35	.5736	.7002	65	.9063	2.145
6	.10453	.10510	36	.5878	.7265	66	.9135	2.246
7	.12187	.12278	37	.6018	.7536	67	.9205	2.356
8	.13917	.14054	38	.6157	.7813	68	.9272	2.475
9	.15643	.15838	39	.6293	.8098	69	.9336	2.605
10	.1736	.1763	40	.6428	.8391	70	.9397	2.747
11	.1908	.1944	41	.6561	.8693	71	.9455	2.904
12	.2079	.2126	42	.6691	.9004	72	.9511	3.078
13	.2250	.2309	43	.6820	.9325	73	.9563	3.271
14	.2419	.2493	44	.6947	.9657	74	.9613	3.487
15	.2588	.2679	45	.7071	1.0000	75	.9659	3.732
16	.2756	.2867	46	.7193	1.0355	76	.9703	4.011
17	.2924	.3057	47	.7314	1.0724	77	.9744	4.331
18	.3090	.3249	48	.7431	1.1106	78	.9781	4.705
19	.3256	.3443	49	.7547	1.1504	79	.9816	5.145
20	.3420	.3640	50	.7660	1.1918	80	.9848	5.671
21	.3584	.3839	51	.7771	1.2349	81	.9877	6.314
22	.3746	.4040	52	.7880	1.2799	82	.9903	7.115
23	.3907	.4245	53	.7986	1.3270	83	.9925	8.144
24	.4067	.4452	54	.8090	1.3764	84	.9945	9.514
25	.4226	.4663	55	.8192	1.4281	85	.9962	11.430
26	.4384	.4877	56	.8290	1.4826	86	.9976	14.301
27	.4540	.5095	57	.8387	1.5399	87	.9986	19.081
28	.4695	.5317	58	.8480	1.6003	88	.9994	28.64
29	.4848	.5543	59	.8572	1.6643	89	.9998	57.29
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IMPORTANT!

COUNTY _____

Here are my suggestions for improving this 4-H publication 4-H-3001 Title 4-H ROCKETRY - Leader's Manual

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MODEL

AIRPLANES

LEADERS' GUIDE

Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

Reprinted from a University of Minnesota publication

4-H AEROSPACE PROGRAM LEADERS' GUIDE

Objectives

1. Create an awareness in youth of the basic concepts of space science and aeronautics.
2. Develop in youth interest and awareness of the impact of the aerospace program on society.
3. Give youth the opportunity to develop skills and explore areas of interest in the aerospace program.
4. Provide youth with the opportunity to explore various aerospace careers.
5. Help youth realize the growing interdependence of people through aerospace developments and related fields.
6. Provide experiences in aerospace science that will enhance the responsible growth of the individual and lead to productive citizenship.

YOUR JOB AS A LEADER

The Challenge

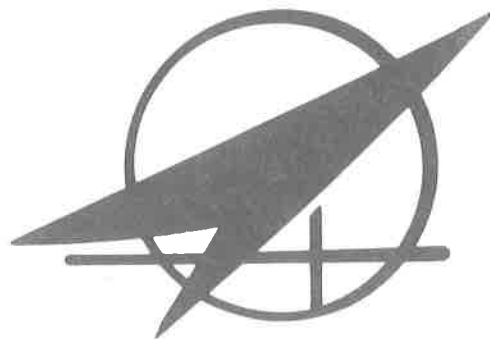
Your responsibility as a leader is both a challenge and an op-

portunity. Yours is a key position in the 4-H program. If you enjoy working with young people, you will find that working with the aerospace program is most rewarding. You'll find great satisfaction in watching boys and girls develop new knowledge and skills under your guidance.

Today's generation has accepted the importance of aerospace. This acceptance, however, has caused many changes in the social, economic, and political environment of the entire world. These changes provide an opportunity for educational institutions to create learning experiences within the many segments of aerospace education and its related sciences.

The 4-H aerospace program gives youth an opportunity to become interested in and aware of aerospace experiences. These experiences lead to further development of the individual's interest, skills, and career goals. This development enhances the responsible growth of the individual helping him or her become a productive citizen in society.

A successful leader is the person who has the confidence of the group; keeps ahead of them, yet seems always with them and understands their viewpoint; and is tolerant, patient, and sym-



4-H AEROSPACE PROGRAM

pathetic in working with them. He recognizes work well done in such a way that young people will be encouraged to do even better, makes friendly suggestions instead of displaying authority, and provides situations that will increase responsibilities as they become more experienced. Each boy or girl is an individual with his or her own background, personality, talents, experience, and aspirations. Your own activity will be varied as you help members plan their own programs, attend their meetings, give guidance to their training, help plan tours and field trips, and help members have fun.

You don't have to do the job without help. Others in your community will be glad to assist. In addition, older club members can serve as teen leaders and junior leaders.

GETTING ORGANIZED

The first step is to get several individuals interested in model airplanes. These individuals could: meet together to form a formal 4-H club, be a part of an existing 4-H club, join together merely for a special interest group, or serve as individuals with a leader for assistance. The informal activity of a few persons can serve as a basis for getting more members interested.

When the individual members are enrolled in your club or group, you must remember that the primary purpose of the meeting is for development of skills. Any good organization will function best when some activity keeps the group together above and beyond the club's primary purpose. Club meetings should be well planned. The first ones will set the pattern for the group's future success. The prospective leader, parent, committee, or other interested persons should assist in planning the first meeting and making sure that it becomes an exciting experience for all involved.

Some basic ideas for planning a get-acquainted meeting and following meetings are:

- * Arrange for a suitable time and place for the meeting.
- * Invite families, prospective members, and parents.
- * Check plans with others concerned.
- * Announce the meeting at community gatherings, schools, in newspapers, on radio or posters, or by invitation.
- * Outline the first meeting carefully. This key meeting will set the example for all the following meetings.
- * If you are not experienced in working with youth, get help from experienced 4-H club members and leaders or an extension agent, if possible.
- * If you are organizing a 4-H club, briefly review what 4-H club work is, what the 4-H member does, and the role of the parent, leader, and extension agent. If this is a special interest group only, it would still be best to know what each member should do and how the parents and others can assist.
- * Explain the value of having the group involved in aviation. Discuss projects that fit the needs, interests, time, and abilities of the individuals. Encourage them to take on no more than what they feel they can handle adequately.

On follow-up meetings, planning is very important. Discuss club activities, events, meetings, tours to be taken, and what the members will do. The group members should be involved in planning future meetings and activities. In a special interest group, the members may be interested only in attending and working on their models and then later flying them. The group should participate in other activities related to aviation to broaden the outlook and education of the members.

TEACHING AND SUPERVISING

You can use various teaching methods. Choose the one that is suited to the subject and allows the members to participate

actively in the learning process. If you arrange for an outsider to teach at a meeting, be sure he understands that boys and girls learn more by doing something than by just sitting and listening. It is easier to get help teaching if you can give your volunteer a concise outline, including the degree of learning desired by the club members.

As you lead, you also must be aware and create an awareness in your members of safety. Maintain that "Safety First" attitude in model flying. Without good safety built into this system, your program will be in trouble. You must supervise your members constantly throughout all phases of their model construction and flying.

ACTIVITIES

Many activities, from the first handling of the model under construction to the actual flying and observation in flight, will enhance the learning. The wide range of activities possible in aviation gives every member a chance to experience real achievement and success.

The imagination and ability of the group will determine the activity possibilities. The members must be given an opportunity to organize and carry out the activity without depending on others.

Field Trips—Field trips to military bases and private and commercial airports are informative. Tours of manufacturing plants, tracking stations, or other interesting facilities could prove useful.

Demonstration Days—These actual flying demonstrations may be opportunities for the club to sponsor programs.

Duration Events—involves how high, how long it stays up.

Scale Events—judge how well the contestants were able to keep their models within scale.

Special Events—are races, exhibits, dog fights, or shows.

Design Contests—determine the best design in various categories.

Other activities include research programs. This is limited only by the imagination and ambition of the member.

The club could begin to establish a library of assorted materials dealing with aviation. These are available from many sources such as:

- * American Institute of Aeronautics and Astronautics, 1290 Avenue of the Americas, New York, New York 10010.
- * National Aerospace Education Council, Suite 310, Shorham Building, 806 15th Street N.W., Washington, D.C. 20005.
- * Paul K. Guillow Company, Wakefield, Massachusetts 01880.
- * Model Airplane News.
- * Local Hobby Shop.

This educational material has been prepared under the guidance of the National 4-H Aerospace Development Committee.

Special acknowledgment is given to the General Aviation Manufacturers Association for financial support of the 4-H Aerospace Program and to Estes Industries for their consultation help.

Mention, by name, of mail order companies is solely for the reader's convenience and does not imply endorsement, nor does failure to mention a company imply criticism by the extension services of state land-grant universities.

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4-H AEROSPACE PROJECT



ROCKET

INTO THE FUTURE

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

ACKNOWLEDGMENT

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The University of California's Agricultural Extension programs are available to all, without regard to race, color, or national origin.

To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products which are not mentioned.

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 marshal'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.

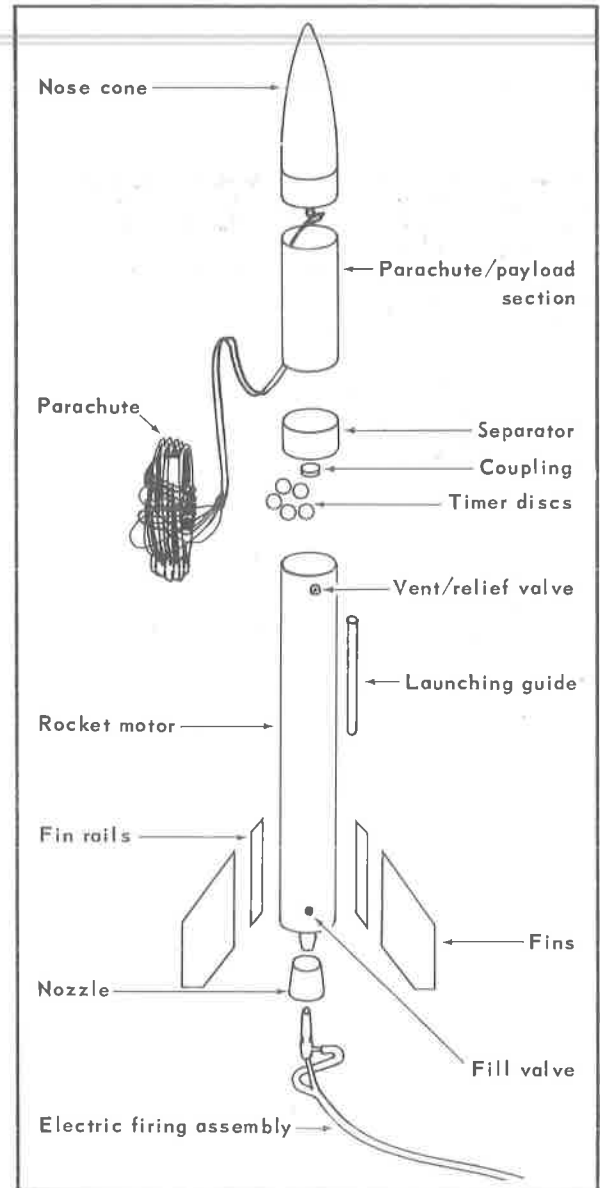
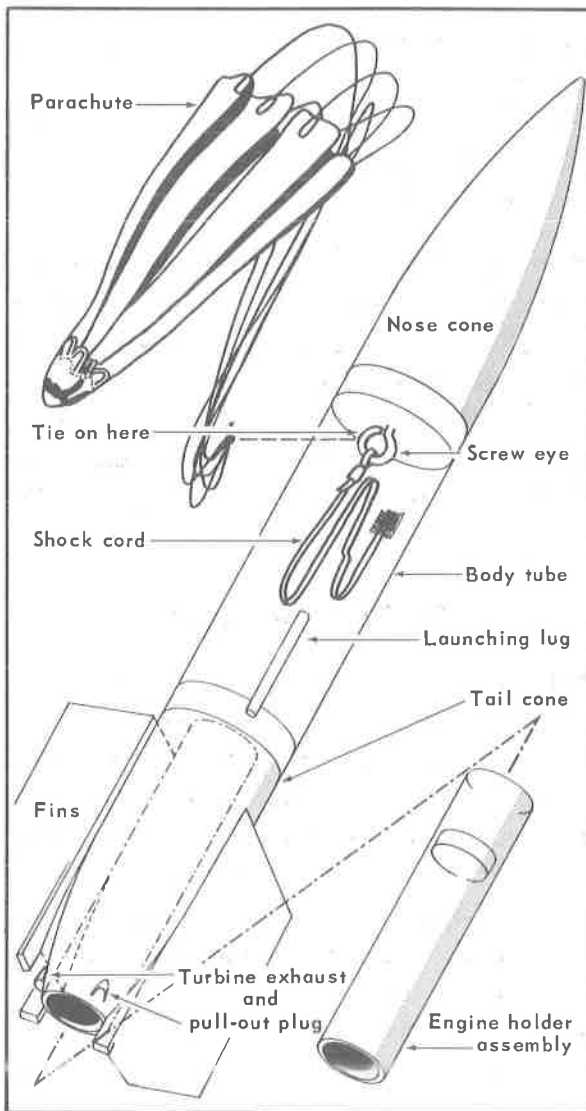


Figure 2. Liquid-fuel rocket.

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.

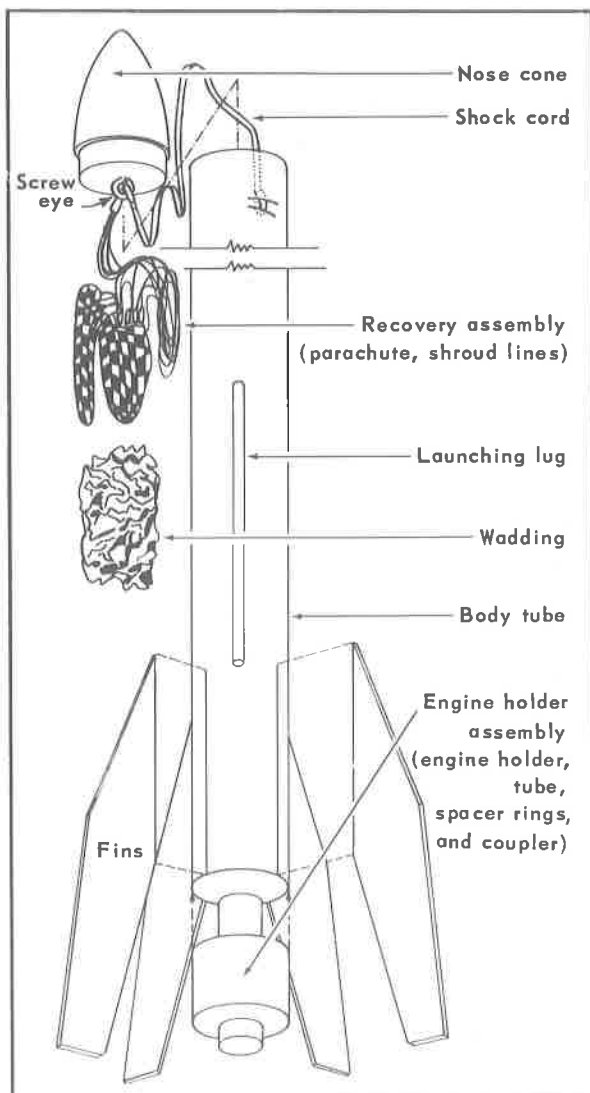
YOUR FIRST ROCKET

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.)

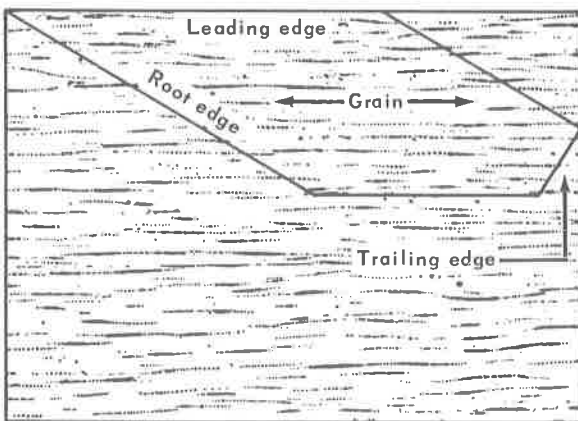


Figure 4. Rocket fin.

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.

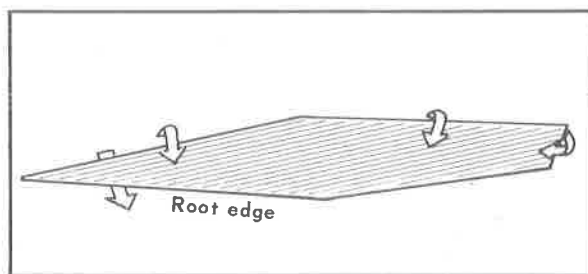


Figure 5. Sand all but root edge to a round shape, as shown.

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.

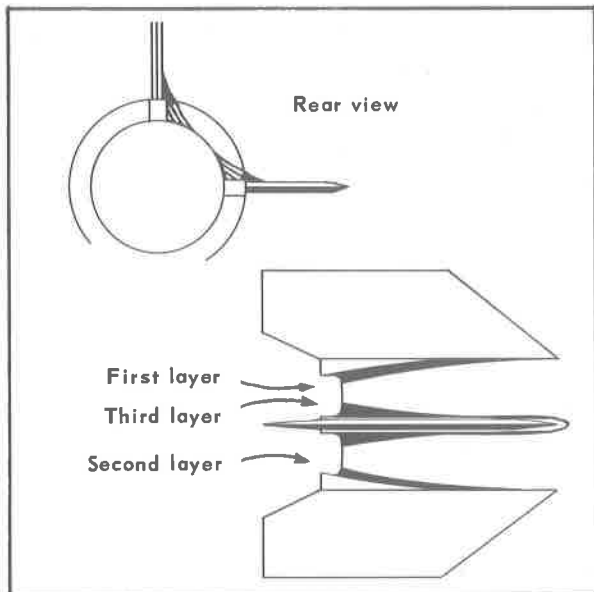


Figure 6. Build up fillets in layers.

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.

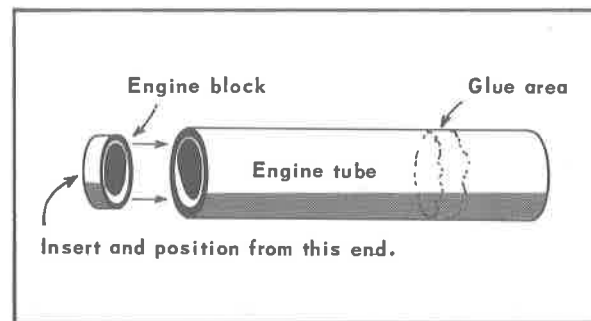


Figure 7. Engine block is easily glued into place.

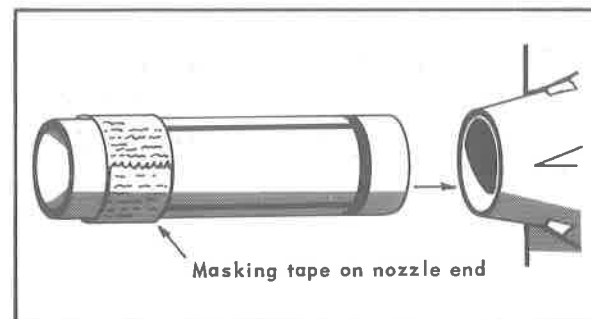


Figure 8. On a rocket with an engine block, masking tape gives the engine a snug fit.

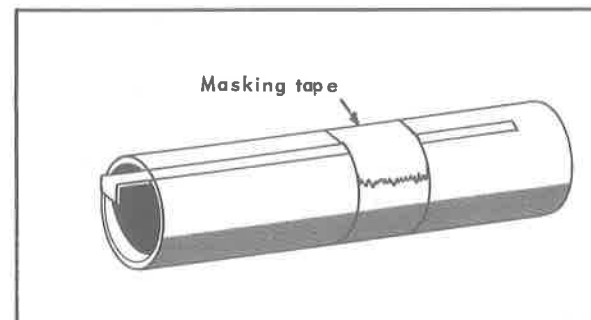


Figure 9. Engine clip.

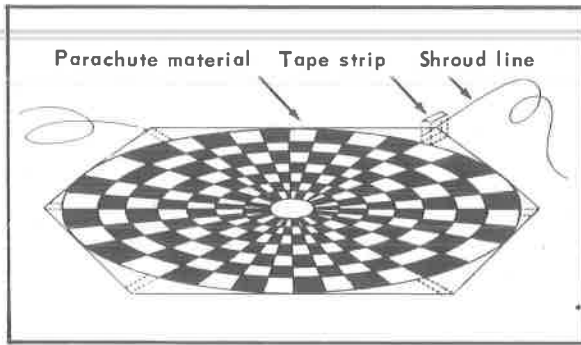


Figure 10. Parachute.

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.)

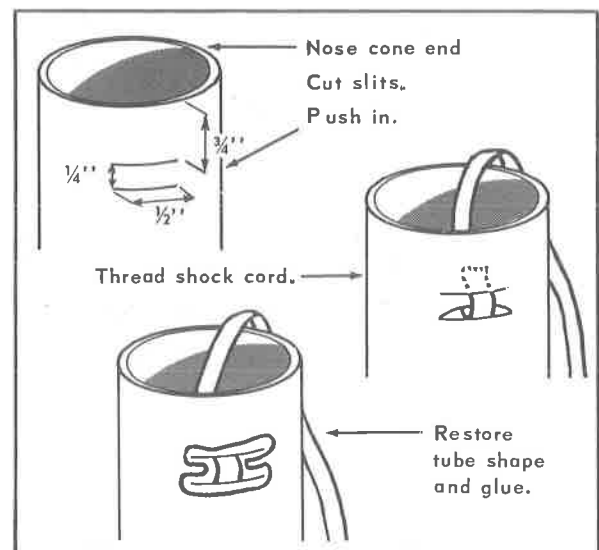


Figure 11. One method of mounting the shock cord.

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

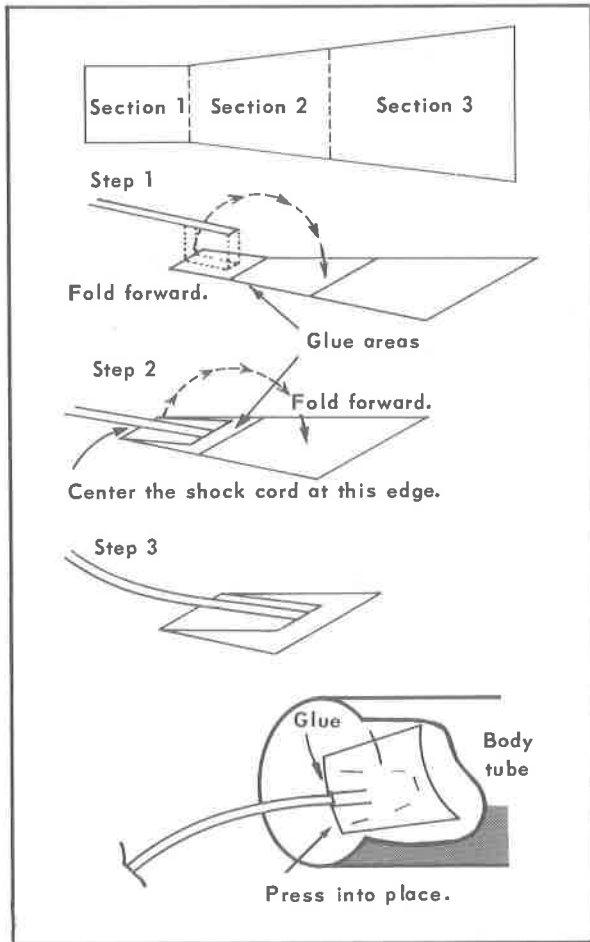


Figure 12. Second method of mounting the shock cord. First, trace the pattern on typing paper and cut it out. Then follow steps 1 through 3.

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.

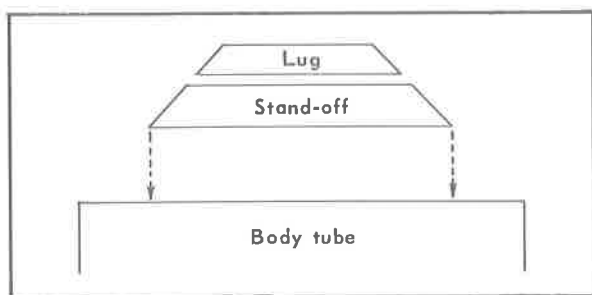


Figure 13. Launching lug attached first to a stand-off, then to body tube.

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).

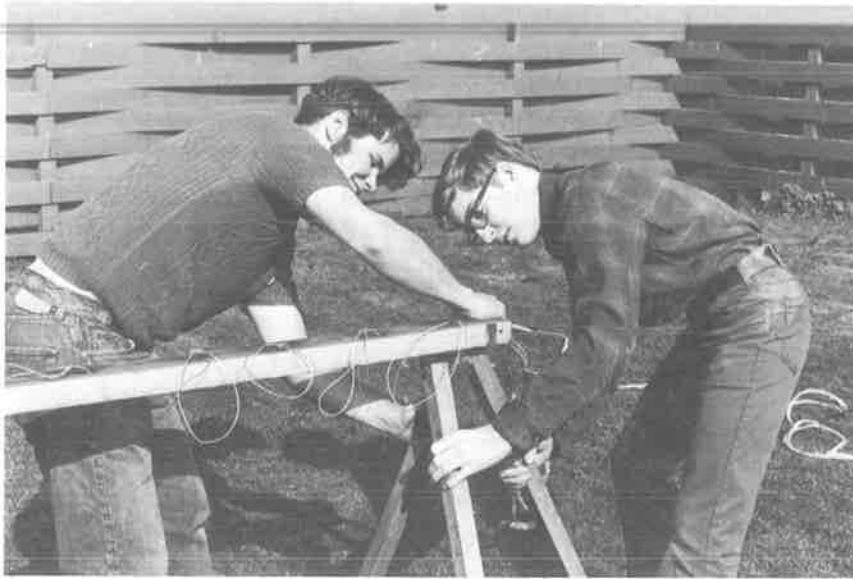


Figure 14.

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, $\frac{1}{8}$ -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, $1\frac{1}{2}$ inches in diameter, every 11 inches down the center of the 12-inch side. About $1\frac{1}{4}$ inches from each hole, drill another one, $\frac{1}{8}$ 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.

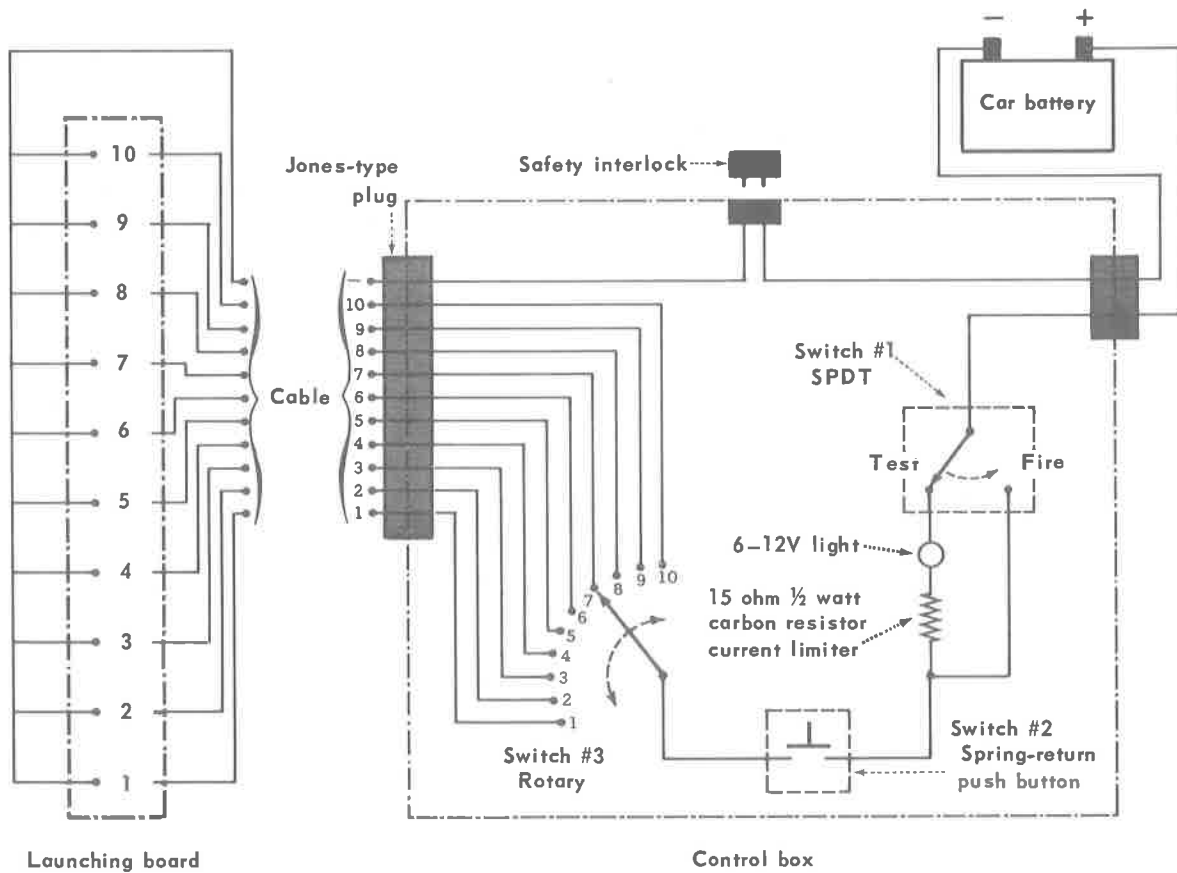


Figure 15. Launch control plan.

MODEL ROCKETRY SAFETY CODE¹

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.

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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 PLEDGE¹

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.

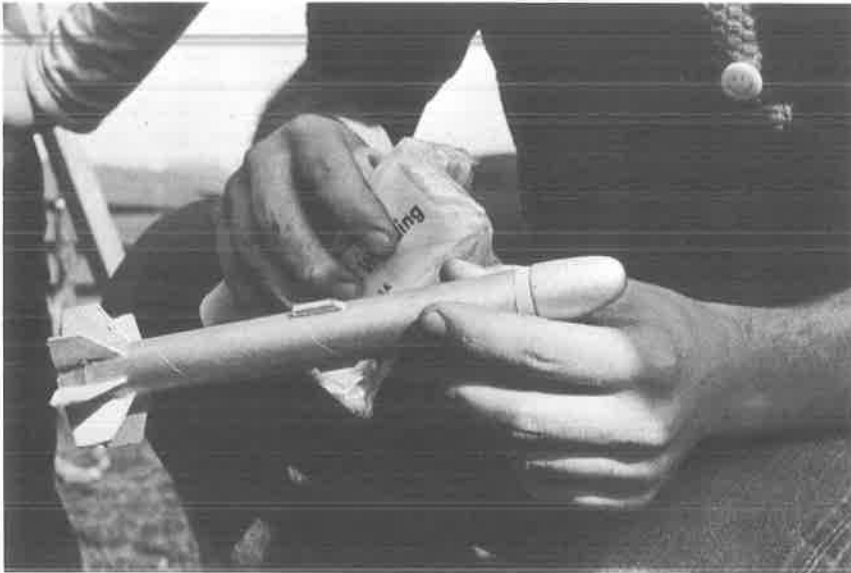


Figure 17.

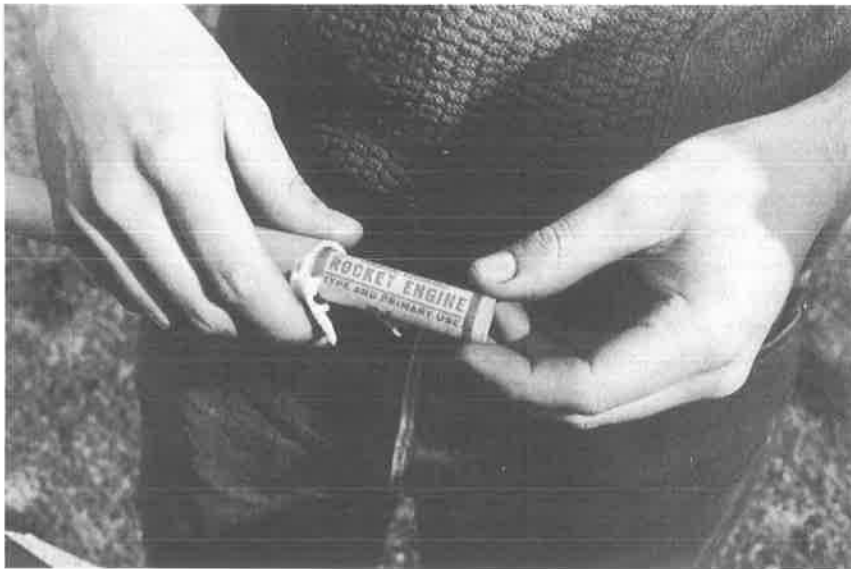
You can carry several rockets in the gear box. Other gear includes wadding and parachutes for recovery.

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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.



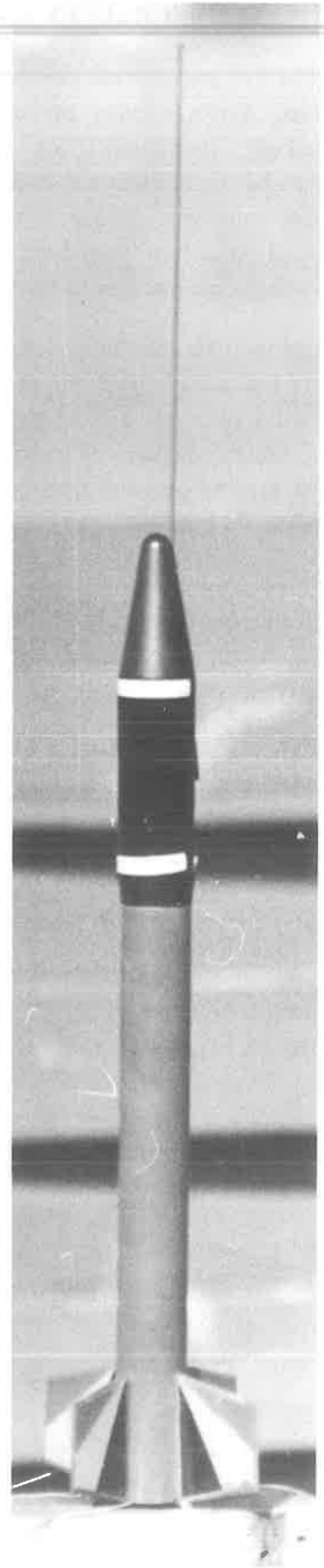
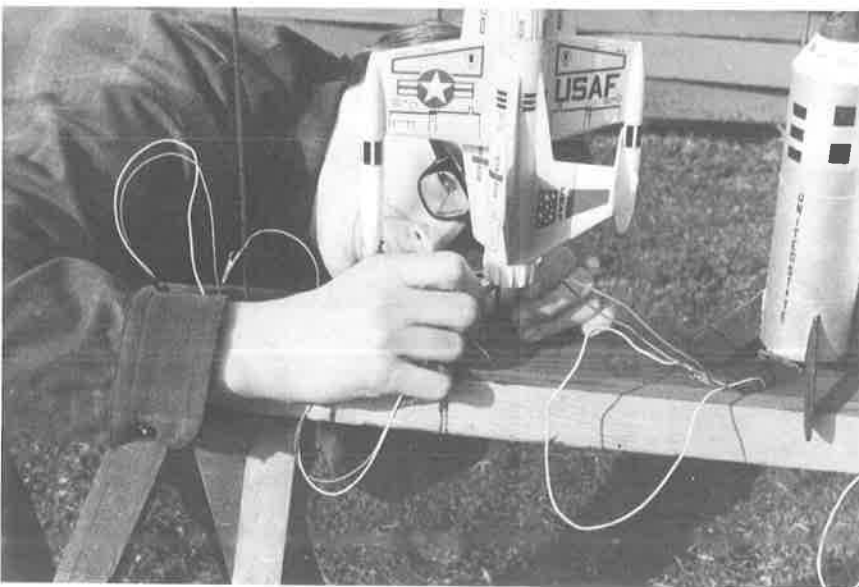
Figure 19. a) In assembling the rocket launch pad, make sure that launch rods are straight and that they make a good connection with the launcher circuitry.
b) Then place the rocket on the launching rod.
c) Take care not to break the rocket or the launching-rod lug and make sure you do not disrupt the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

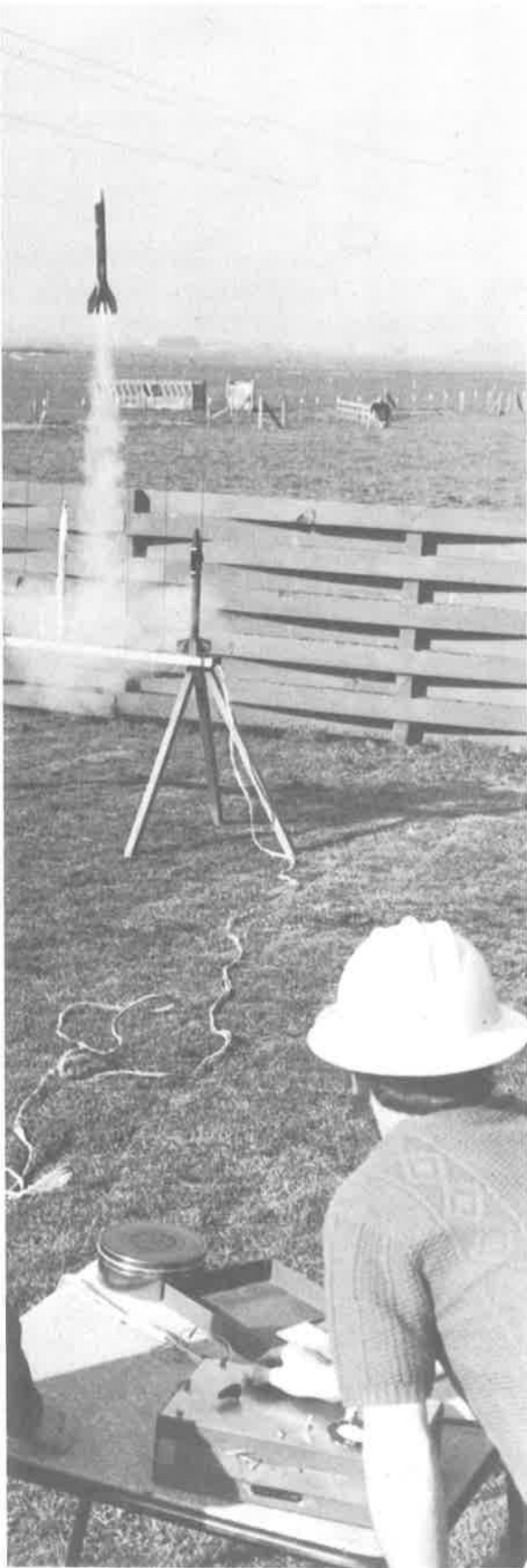


Figure 23. 5 - 4 - 3 - 2 - 1 - BLAST OFF! And the rocket heads skyward in another safe and successful launch. Note that the rocket launching pad is placed well away from the launch control area to give maximum safety.



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!

