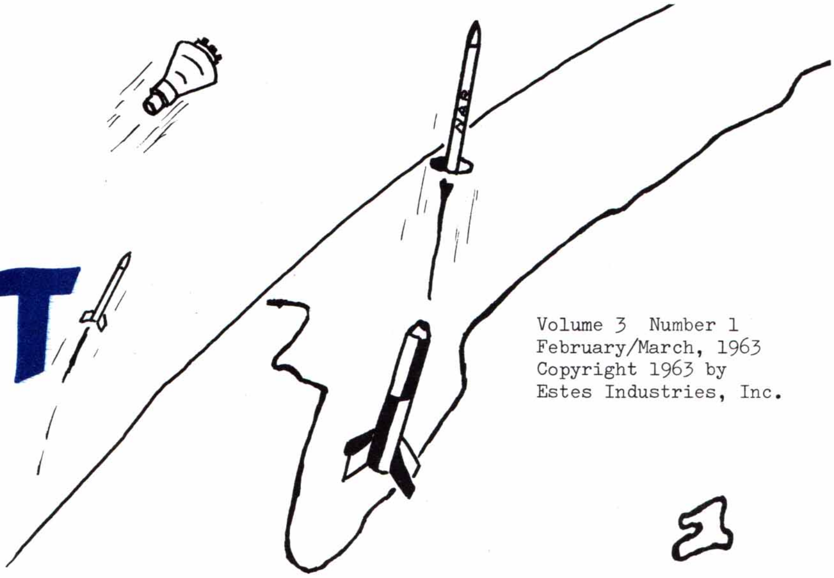
MODEL ROCKET NEWS



Volume 3 Number 1
February/March, 1963

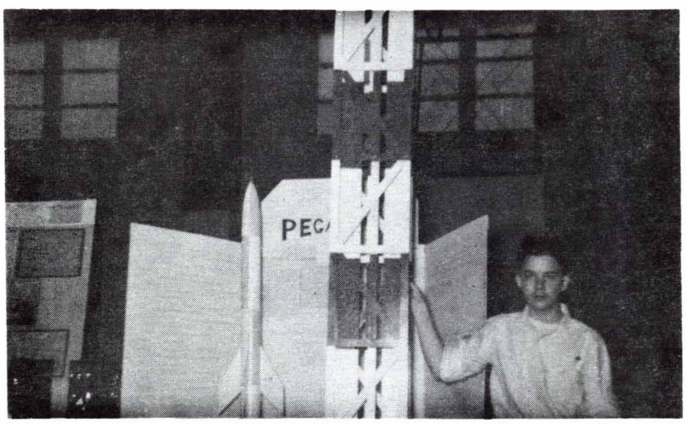
Model Rocketry and the Science Fair

Model rocketry, because of its safety and because of the reliability of the propellant means used, has shown in the past an excellent record for application to science fair projects. The repeatability of performance obtained from model rocket engines permits close comparison between one flight and the next, and variable factors, such as rocket weight, atmospheric conditions, or rocket stability margin can be measured with a high degree of confidence that the changes in results are actually due to changes made in the rocket or in the flight conditions, and not due to changes in the engine's performance.

Controlled conditions are necessary for any scientific experiment. For any reliable data to be gained, only one condition should be changed from one stage of the experiment to the next. For example, if an investigation into the effect of nose cone design on rocket altitude were being made, it would serve no useful purpose to make one flight with a 3 ounce rocket, powered by a B 3-5, and with a BNC-20B, make the next flight with a 4 ounce rocket powered by an A.8-3, and with a BNC-20A, and then attempt to compare results. Instead, the proper thing to do, if the first flight were made with the first rocket described above, would be to make the second flight with the same rocket, at the same weight, and with the same type engine, but substituting the BNC-20A for the BNC-20B used in the first flight. In this way it is possible to determine what effect, if any, the change in nose cones had on the rocket's performance.

In any science fair project extreme care and thoroughness in the gathering of data is necessary. To prevent the possibility of fruitless repetition of steps and the performance of unnecessary experiments, it is necessary to keep complete, clear, and accurate notes on each step of each experiment. This recording of data is of extreme importance in all phases of science--an experiment which is not recorded might just as well not have been made, since the results are completely committed to a single person's often faulty memory.

The usual procedure in any scientific work is to first collect data by observation and experiment. After sufficient data has been collected, a hypothesis or preliminary generalization is made based on the data. The validity of deductions that follow logically from the generalization is then tested by further observation and experimentation. If the generalization withstands further testing, it is considered a scientific theory or law; but if contradictory facts arise, the theory may be modified to include the new facts, or it may be replaced by a new concept. It is extremely important that this procedure be used, as it is the only proven method for producing valid information for science. It should be followed in any science fair project to insure that the work in the project will produce results which are reliable.



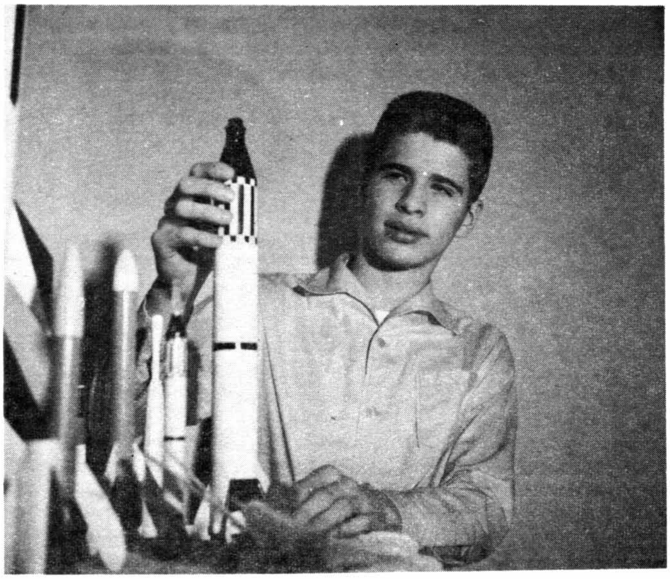
Gordon Mandell, Great Neck, N.Y., with an early science fair project employing model rocketry. This entry placed in the junior division in the competition.

The projects below are by no means the only ones which can be made using model rocketry. These projects are, in fact, intended to serve as an idea guide so the rocketeer can develop his own project independently. Simply building a rocket and displaying it is not likely to win anything. In any science fair project there is no substitute for independent thinking, and any project must be an original contribution to science if it is to place high in competition.

If you desire additional information on any of these projects, do not write to Estes Industries, but go to your local library or consult your teachers. In this way you will obtain your information more readily, and will learn more in the process. Also, we are not in a position to provide the charts, photos, etc., for a few thousand different projects. However, as more information becomes available, it will be published in the Model Rocket News.

(Continued on page 10)

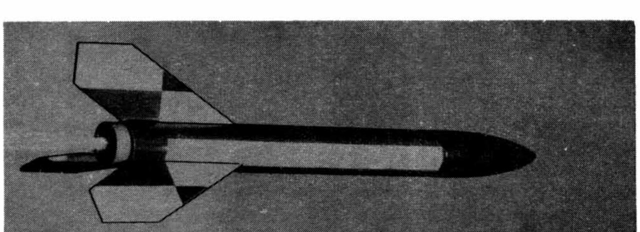
Rocketeer of the Month



You've seen his work on the pages of this publication; now meet the man: Bob Coon, Model Rocket News cartoon editor and Rocketeer of the Month. Bob is 14 years old, and a ninth grade student in Colorado Springs, Colorado, where he lives. In school, Bob is taking the normal ninth grade subjects, such as Algebra, English, Spanish, etc., and is maintaining a good grade average, in addition to being very active in outside affairs. He isn't taking ninth grade science this year, as he took that class last year, and maintained an "A" average in the course.

Outside of school, Bob is an active member of the Peak City Section of the NAR, which he joined about three years ago. In the time since he became interested in model rocketry, he has built between 50 and 75 models, and has won such events as parachute duration, spot landing, and B payload, and is always a top competitor in any event. In addition to his rocketry and cartooning interests, Bob is a paper carrier for the Colorado Springs Free Press.

When asked about his plans for the future, Bob stated that he intends to continue his education through college, hoping to become an engineer in one of the aerospace fields. The Model Rocket News is especially proud to name this active and forward-looking modeler the "Rocketeer of the Month."



In this re-print of a past issue of the Model Rocket News many of the engines mentioned in letters and articles are referred to by the old classifications in effect at that time. Since many of the articles would be misleading if we simply changed the engine designations, we have left these articles as they were originally printed and are printing the chart below to provide engine classification comparisons. You may use these new engines, obtain the specifications from the current catalog, and rework the problems.

On all plans and kit specifications the new engine classifications for "Recommended Engines" have been used.

MEMO

NEW ENGINE DESIGNATIONS

The N.A.R. and other major model rocketry organizations throughout the world have recently adopted new model rocket engine standards and classifications. Estes Industries is currently engaged in changing its products and literature to match these new international standards. Since it is not possible to change all items at the same time, some items which you will receive may bear engine designations based on the old system while other items will carry the new designations.

In the conversion table below the new engine designations are shown next to the old engine types which they most closely replace. If one engine type is recommended for flying a model, the type shown next to it in the table may also be used in that model.

Old Engine Type	New Engine Type	Old Engine Type	New Engine Type
1/4A.8-0	1/2A6-0	A.8-4	A5-4
1/4A.8-0S	1/2A6-0S	----	A8-5
1/4A.8-2	1/4A3-1	B.8-0(P)	B4-0(P)
1/4A.8-2S	1/4A3-1S	B.8-0	B6-0
----	1/4A3-2	B.8-2	B4-2
----	1/4A3-2S	B.8-4	B4-4
1/4A.8-4	1/4A3-4	B.8-4	B6-4
1/4A.8-4S	1/4A3-4S	B.8-6	B4-6
1/2A.8-0	1/2A6-0	B.8-6	B6-6
1/2A.8-0S	1/2A6-0S	C.8-0	C6-0
1/2A.8-2	1/2A6-2	----	C6-5
1/2A.8-2S	1/2A6-2S	----	C6-7
1/2A.8-4	1/2A6-4	B3-0	B14-0
1/2A.8-4S	1/2A6-4S	B3-5	B14-5
A.8-0	A8-0	B3-6	B14-6
----	A5-2	B3-7	B14-7
A.8-3	A8-3		

These new engine classifications are based on the metric system. They show average thrust in newtons and total impulse in newton-seconds. The old designations give average thrust in pounds and total impulse in pound seconds. One newton, the metric measure of thrust, is equal to 0.224 pounds. Thus 4.46 newtons equal one pound.

The Model Rocket News

Volume 3 Number 1, February/March, 1963

Vernon Estes, Publisher — William Simon, Editor

The Model Rocket News is published approximately 6 times annually by Estes Industries Inc., Box 227, Penrose, Colorado. It is distributed free of charge to all of our mail order customers from whom we have received substantial orders within a period of one year. The Model Rocket News is distributed for the purpose of advertising and promoting a safe form of YOUTH rocketry, and for informing you of new products and services available from our firm. You rocketeers can contribute in three ways to help us in advancing this scientific hobby.

(1). Write us concerning things you and your club are doing in this field which you think would be of interest to others.

(2). Keep supporting us in our development program by purchasing your rocket supplies from us. We are working as fast as we can. Every spare dime we get goes back into research and development, but it takes a heck of a lot of dimes to develop a new kit or a new rocket engine.

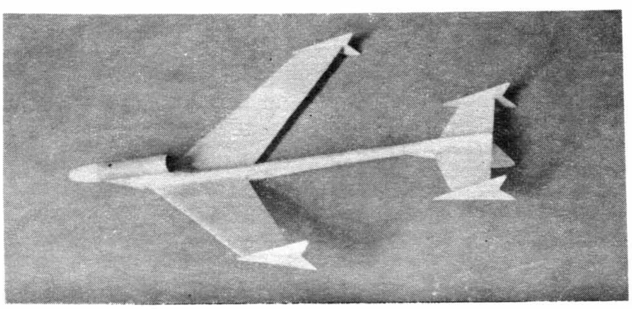
(3). Write us about our products, what you like, what you don't like, new ideas, suggestions, etc. We may not have time to answer all of you personally, but we will read every word.

Sky Slash II Named Top Glider

The Sky Slash II, a novel design by Larry Renger, was selected for first place in the recent Boost-Glide design contest held by Estes Industries. The design was chosen as the most original and significant contribution to the field of any of the entries.

Renger, a Los Angeles resident, is now a Senior in Aeronautical and Astronautical Engineering at M.I.T., and has been a serious modeler for seven years. In designing the Sky Slash II, he applied the knowledge of model aeronautics which had previously given him three National Indoor model records (AMA). The result was a very skillful blend of model airplane and model rocket practice.

Some special advice for those interested in developing their skill in boost-glide was given by Renger. He suggested that the rocketeer build several simple hand-launch gliders to learn about proper trim for maximum time, and that by throwing a glider time and again for several hours (fun in itself) quite a good feel for proper trim is obtained. To minimize chasing, early morning or evening is recommended.



ODD BALL CONTEST

Send us your own Odd Ball model rocket design and win one of these great prizes!

1st Prize--$50 in merchandise credit
2nd Prize--$25 in merchandise credit
3rd Prize--$10 in merchandise credit
4th Prize-- $5 in merchandise credit

Winners will be notified by mail

The object in this contest is to design a rocket which is as far as possible in appearance from a normal rocket, but which performs in an acceptable manner. The rocket must be stable, and must be designed so that it will deploy its recovery system at least 50 feet from the ground. The Buchanan Buster rocket plan carried in this issue is only meant to illustrate the idea of an Odd Ball: Entries will be judged heavily on originality, practicality, performance (not overall altitude), and soundness of design. By designing and building an Odd Ball rocket, the modeler will gain a better insight into the principles involved in rocket flight, and will be better able to design and fly conventional rockets.

CONTEST RULES

1) All plans must be drawn to scale. Pencil or ink drawings are acceptable.

2) A parts list must accompany entry.

3) All entries must be flight tested to assure that they have suitable flight characteristics.

4) Only Odd Ball designs will be qualified.

5) The center of pressure and center of gravity of the design must be marked on the plans.

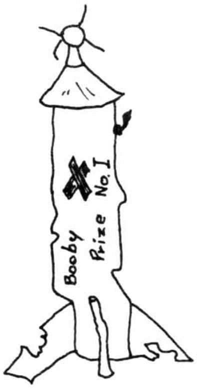
6) Sufficient information must accompany entry to allow judges to build an exact duplicate of the original model.

7) The decision of the judges is final.

8) Entries must be postmarked no later than midnight, April 30, 1963.

9) All plans submitted become the property of Estes Industries, Inc., and no plans or designs will be returned.

10) Design must use no more than one engine per flight.



Due to space limitations, the Sky Slash II design is not carried in this issue, but is available on the Clip 'N' Mail page in a separate, large size plan.

Second place in the contest was taken by Gordon Mandell, Great Neck, New York, with his Oberon XBG-47 design, a canard wing glider. Third place went to Wesley Wada of Denver, Colorado, with his Dyna - Sour III, a more conventional delta wing design, while fourth place went to three rocketeers, Kenneth Bradford, Bill Bleak, and Larry Derrick, all of Salt Lake City, Utah, for their Para-Beta folding wing design.

Judging in the contest was performed by members of the Astron Rocket Society of Penrose, with the better-appearing designs built and flown by the group. In summing up the contest, Vern Estes, President of Estes Industries, stated that special congratulations were in order for the contest winners, and that the many others who produced good, though non-placing designs deserve the highest compliments on their work also.

NOTES FROM THE BOSS

These last few months have seen things especially busy around here, and it looks like the next few months will be just as busy. Our special project for this year is to develop the kits and information you need for your scientific programs. The section on science fair projects in this issue is just a beginning: We hope to publish several new technical reports during the year, develop some more kits which will be especially useful for science fairs, and publish some special information on astronautics. We're looking forward to an especially exciting year, and we hope you are too.

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FOR THOSE WHO want to get a club started, a new model rocket club guide has been prepared, covering subjects such as organizing the club, conducting meetings, and holding contests and research programs. The guide includes a sample constitution for a model rocket club and a copy of the Astron Rocket Society Safety Code. We hope that this guide will answer some of your questions and help you get a very active group going. For your copy, see the Clip 'n' Mail section on the wrapper of this issue.

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THERE HAVE BEEN a number of questions asked about the B.8-0(P) engines for static testing. To set the record straight, a static test stand is a device which measures the thrust and thrust duration of a rocket engine, producing a chart which shows the thrust level of the engine at every instant of its duration. This chart will be quite similar to the ones shown in the catalog in the engine section. The B.8-0(P) engine has been made for use in static test stands, and has a plug in the upper end of the engine to seal it, eliminating the discharge of upper stage ignition gases found in normal B.8-0 engines. This makes the engine especially useful, since the lack of forward discharge prevents the build-up of deposits and burning of the test stand mechanism. In addition, the use of the plug makes all the propellant develop thrust, and all that burns is propellant, thus permitting more accurate measurement.

A static test stand is often quite useful in educational programs, where it can be used to demonstrate, on the ground, the performance of a rocket engine. Static test stands can also be used to advantage in determining the effectiveness of special propulsion systems, such as the jet pump system employed in the Li'l Augie rocket. We hope to have a test stand kit ready within the next few months, but we aren't making any promises, and aren't in a position to supply any information on test stand construction other than that in the section of this issue on science fair projects.

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THERE WERE A FEW mistakes, errors, omissions, etc., in the latest catalog, mainly due to working on it into the wee early hours of the morning. In some copies of Catalog 631, masking tape has no catalog number or price, in other copies it has the number T-1. The correct catalog number for masking tape is #631-MT-1, and the price is 30¢ a roll. In some copies of the catalog both screw eyes, the 1 inch and the 3/4 inch, are listed as SE-1. The correct number for the 3/4 inch eye is #631-SE-2.

Although nobody remembers the time, it must have been especially late when the next page was set up, since three entirely different items got the same number. The one ounce payload weight has the correct number, but the lead nose cone weight should be NCW-1, and the brass nose cone weight should be NCW-2.

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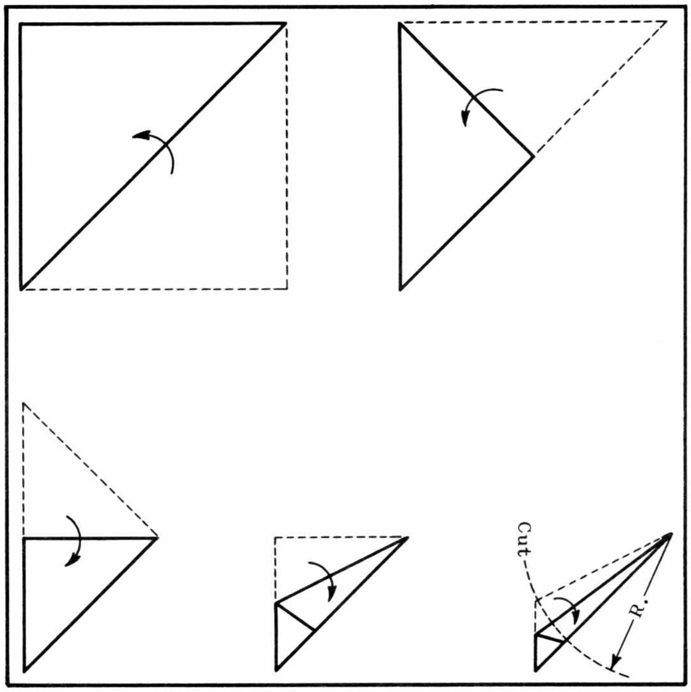
IF YOU TRIED cutting your parachute by following the diagrams in the catalog or in the Ranger instructions, you may have ended up with a doily. Steps four and five should be taken so the small end (center) of the sheet remains the center. If that sounds confusing, take a look at the corrected drawings below.



WE HATE TO BREAK anybody's heart, but there are no engines included with any rocket kits except the beginners specials. This is a practice which has been in effect in the model airplane hobby for many years now, but there are special reasons for not including engines with model rocket kits. Of course one is that model rocketeers operate with different kinds of flying conditions, and one type of engine will be suitable in one area, while another will be best for another area. Also there is the slight matter that Canada will not allow the import of rocket engines, and if we were to include engines with the kits, the Canadian modelers wouldn't be able to buy any kits either.

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BECAUSE OF POSTAL restrictions, the butyrate dope listed in the catalog can no longer be shipped by mail. If you include any on a parcel post order, we will have to refund your money. If your order is fairly large, however, and if it is shipped by express, we can include the dope. We're looking for a suitable paint to stock in place of the dope, and will let you know when it is available.

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IF YOU WERE WONDERING about the change in Series II engines from B 16 to B 3, whether the two were the same engine, or if there is a difference, you are entitled to a bit of explanation. The two engines are the same. The change came about for several reasons. The original B 16 engines had a slightly higher peak thrust, but were less reliable, and so they were slowed down a little. The rest of the change came about by using static test equipment which was designed to handle the thrust given by the Series II engines. The original tests were made with the stand designed for Series I engines, and it just couldn't react fast enough to tell us exactly what the engine was doing. When you consider that the thrust rises to over nine pounds and then drops back to zero in less than .35 second, the problem in measuring is understandable.

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ONE ITEM LISTED in the catalog should be of special interest to those who are multi-stage bugs. These are the stage couplers, which are short sections of a strong tubing in exact diameters to slip fit inside the regular body tubes. They are not cut-off pieces of engine casing, but a special lightweight spiral tube. Stage couplers are ideal for the transition block and collar systems described in TR-2. In addition, when used with BT-50 and some paper tube adapters, they permit the engines of the upper and lower stages to sit flush against each other as shown in the Idea Box.

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THE PLAN EXCHANGE program seems to be quite popular with you rocketeers. So popular, in fact, that we'll be continuing it through at least the next several months. Some of the designs which have come in, however, haven't met the standards set up for participation, and we have had to send them back to the person who submitted them. We can't always tell at a glance whether a rocket is any good or not, but there were some designs which obviously weren't test-flown, because they couldn't be stable by any stretch of the imagination. As a result of this, we are asking that every design submitted have its center of pressure and center of gravity for each distinct portion of flight marked. In other words, CP and CG should be marked for the rocket at take-off, just after second stage ignition, etc. If you're not sure how to determine CP and CG, better read TR-1 again, because it isn't a very good rocketeer who designs unstable birds. The form for the program is printed on the wrapper, but if you take care of all the requirements listed, the form isn't necessary. And don't forget the dime, as it costs money to handle and mail the plans.

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THERE'S A LITTLE NUMBER along with your address that has made a few rocketeers wonder. This is a code number which helps speed the handling of orders. The first digit represents the postal zone, based on the distance from Penrose to your city. The second three-digit number is your unit or area zone, as found on postal maps of the United States. This helps us to pin point exactly where you live. The next digit(s) or letter is an origin number. This tells us how you found out about us, whether it was by a magazine or newspaper ad, friend, etc. The last two digits indicate the approximate date on which we first heard from you. The application of this coding system is just another step in Estes Industries' continuing effort to provide the fastest possible service to you rocketeers. You can help by letting us know if you are receiving duplicate copies of the Model Rocket News and by letting us know right away when you move.

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IF YOU THINK you're really good at designing rockets, try the latest contest, announced elsewhere in this issue. The trick is to build a rocket that looks as different from a conventional model rocket as possible and then get it to fly. It might sound easy, but it isn't. For example, there were the elaborate loops made by our shop foreman's special twelve-body rocket. It was intended to go like a flying pipe organ, but it ended up more like a pinwheel.

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IF YOUR NEWSPAPER comes out with an article pertaining to model or amateur rocketry, we'd certainly appreciate your sending a copy of the clipping to us. Not only do we like to find out about the things you rocketeers are doing, but these clippings are also very valuable in presenting model rocketry to politicians, educators, etc.

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WE TOO GET LETTERS. . . Several young rocketeers would like to know how high a certain engine will take their rockets. We'd like to know too. It is actually completely impossible to tell how high a rocket will go unless certain things like frontal area, coefficient of drag, surface finish, rocket weight, air pressure, and air temperature are known. The best way to find out how high your model will go is to haul out the Altiscopes, stick a 1/4A or 1/2A engine into it, fire it, and figure it out for that size of engine. The rocket will go about twice as high with a B engine as it will with a 1/2A, and about 3/5 as high with a 1/4A as it will with a 1/2A. The reason for this is that drag on a rocket increases with the square of the speed, and so the faster a rocket goes, the more wind resistance it has to overcome to keep going. It takes about four times the power to double the speed of a rocket. You might sit down with a physics book some time and try to figure out just what performance can be expected from a rocket with other engines when its performance with one type is known. When you have it all figured out and have tested the results thoroughly with a reasonably accurate optical tracking system, let us know, because we'd like to know how to do it too. As a matter of fact, that might make a very good science fair project.

LETTER SECTION

I am writing in accordance with your offer to exchange plans for a model rocket. I would prefer a one stage rocket diagram.

I would like to congratulate you on your fine engines. Before I started to use them I made engines out of old plastic bottles, using sodium bicarbonate and 3% acetic acid, which really is vinegar and baking soda. The rocket I first put an engine into weighed about one pound and reached an altitude of over 1/4 inch, thus giving a small grasshopper a very graceful ride.

David Pusateri
Hillside, Illinois

I have now got a rocketeering pen pal. His name is Bob Kaynor, and he lives in Connecticut. I owe this to your company, as I got his design in the plan exchange program. I think this program is a great idea! . . .

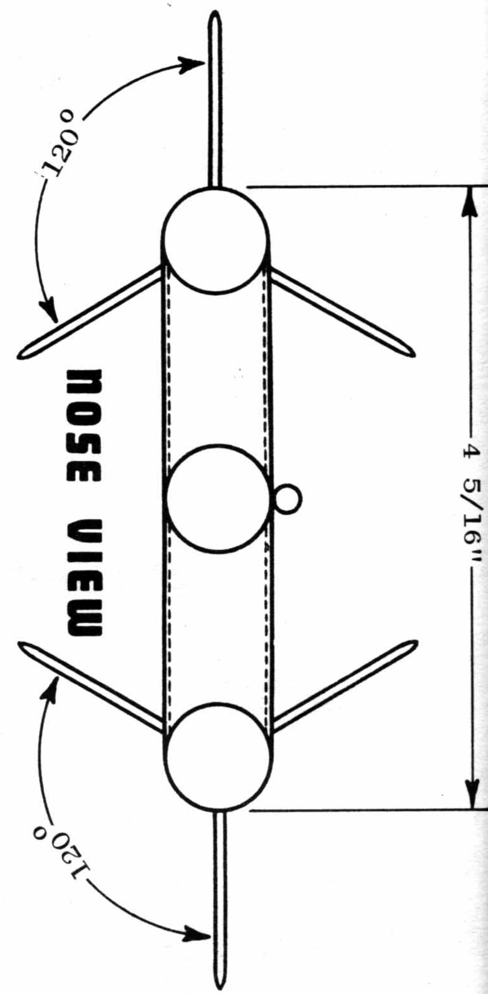
Tommy Herring
Waco, Texas

. . .I have been asked to represent Albert Lea ninth grade students at the N.A.S.A. space exhibit during Thanksgiving week. My science project is involved with the mathematics and applications of aerodynamic principles in rockets, airplanes, and gliders (especially the Dyna-soar). When I undertook the project I didn't realize what I was getting into, but now that I'm in the middle of it I find it extremely interesting. My program of work has me studying rocket mathematics until 1963, and from then until April (the day for our science project) I'll be working on gliders and airplanes. Although my teacher thinks I'm getting too involved (some of the problems I have to solve involve calculus), I am glad I am digging into it so deep because I am really learning a lot.

Wayne Sumner
Albert Lea, Minn.

THE BUCHANAN BUSTER

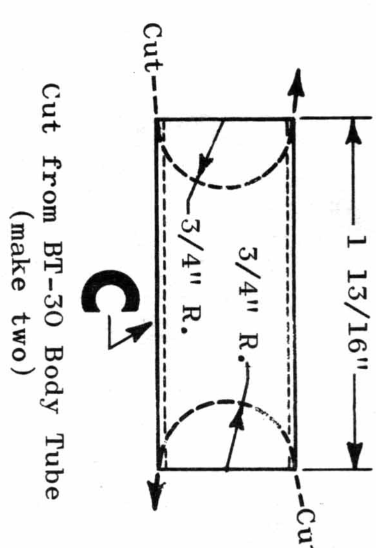
This rocket, designed by Delbert Buchanan, Shop Foreman at Estes Industries, is the classical Odd Ball design. A well constructed Buchanan Buster is a very impressive model in flight. When assembled correctly, it can give many highly enjoyable flights, and is always good for a few laughs, some conversation, and lots of fun. It is a sport model, designed to lift a maximum of rocket with a minimum of engines.



To build the Buchanan Buster, first trace out six fins on the fin stock by placing carbon paper between the pattern and the balsa, then tracing along the pattern. Cut out the fins and sand them to a smooth finish. Cut the three body tubes to length, two of them 6" long and one 6 3/4" long. Cut two 1 13/16" lengths from the left-over pieces of body tube, and cut them so that they will fit against the main body tubes as at C. Glue these cross pieces to the longer body tube as shown in the plans. Be sure that the joints are straight. When this glue has dried, glue the remaining body tubes on the other ends of the cross pieces.

Glue the fins in place, and after the glue has dried, reinforce the body tube/cross piece joints with gauze. Glue the engine block in place in the center body tube by applying a small amount of glue to the end of your little finger and spreading it around the inside of the tube as far up as you can reach. Put the engine block into the tube, and using an expended engine casing, quickly push the block forward into position. Do not pause during this operation, or the glue may set with the block in the wrong position.

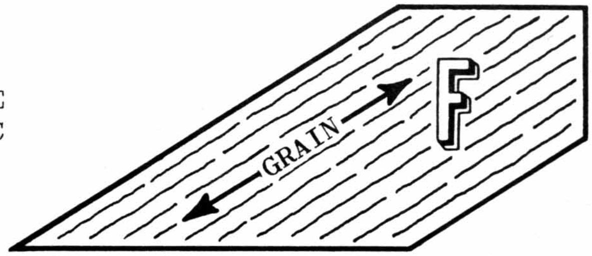
Glue the nose blocks into the rear of the two outside tubes, and glue the nose cones on the outside tubes in place. Cut two slits in the center tube approximately 3/4" from the front end of the tube, pass a shock cord through the two slits, and glue the end of the shock cord in place. Assemble a square parachute (PM-1), insert the screw eye into the center tube nose cone, and tie the remaining ends of the shock cord and the shroud lines to the screw eye. Glue a launching lug on the center tube. After the rocket has been painted, it is ready for flight.

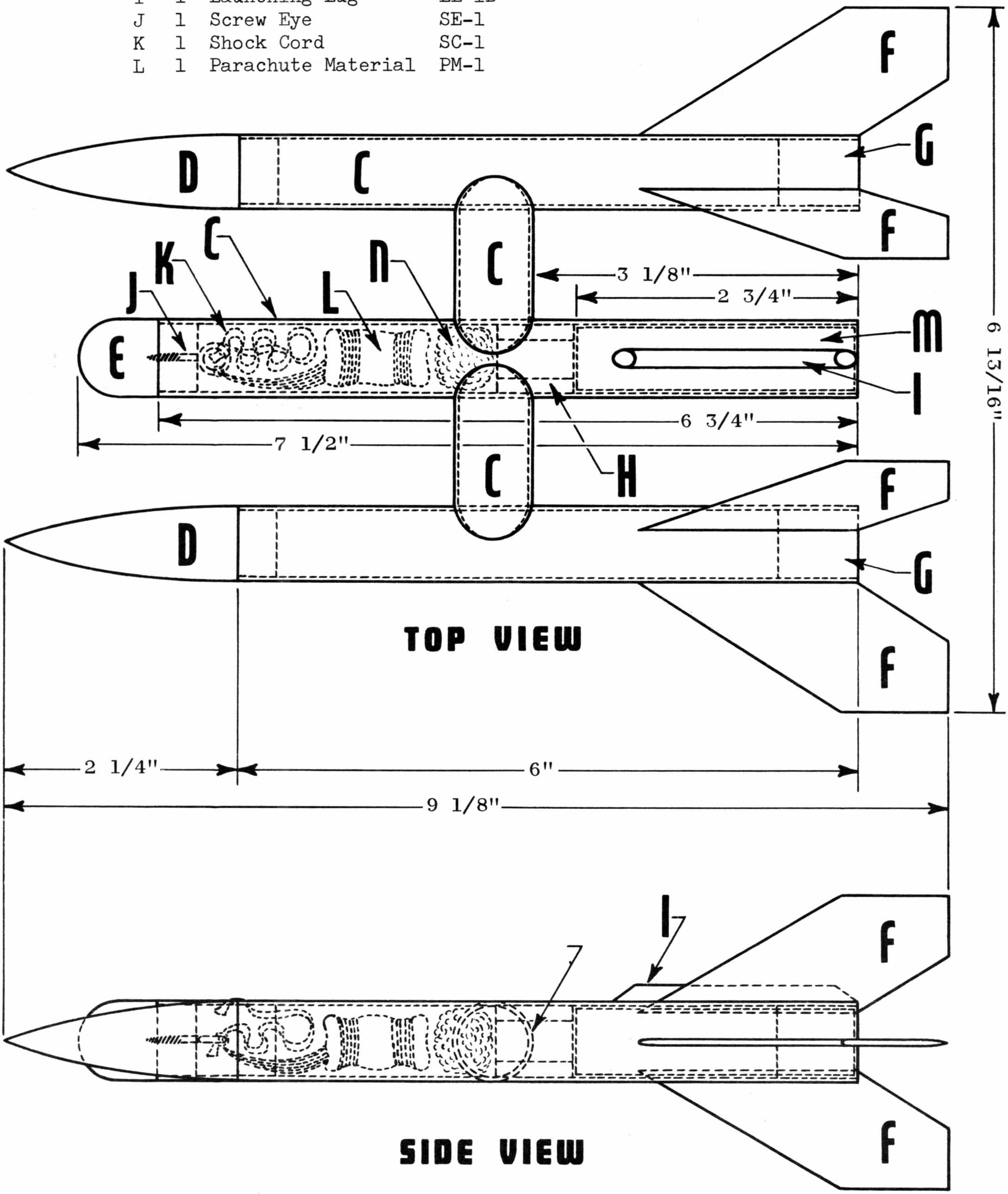


In flying the Buchanan Buster, only one engine is used. Do not attempt to fly this design with engines in the two outer tubes, as it will not be stable. The only engines recommended for use with this rocket are the A8-3, the B4-4, and the B4-2. Never use an upper stage engine in the Buster. Launchings should be carried out on fairly calm days, using the standard electrical ignition and countdown. If the Buster ever busts, it can be glued back together, with no loss in performance.

PARTS LIST

C	3	Body Tubes	BT-30
D	2	Balsa Nose Cones	BNC-30E
E	1	Balsa Nose Cone	BNC-30C
F	1	Balsa Fin Stock	BFS-20
G	2	Balsa Nose Blocks	NB-30
H	1	Balsa Engine Block	EB-30
I	1	Launching Lug	LL-1B
J	1	Screw Eye	SE-1
K	1	Shock Cord	SC-1
L	1	Parachute Material	PM-1

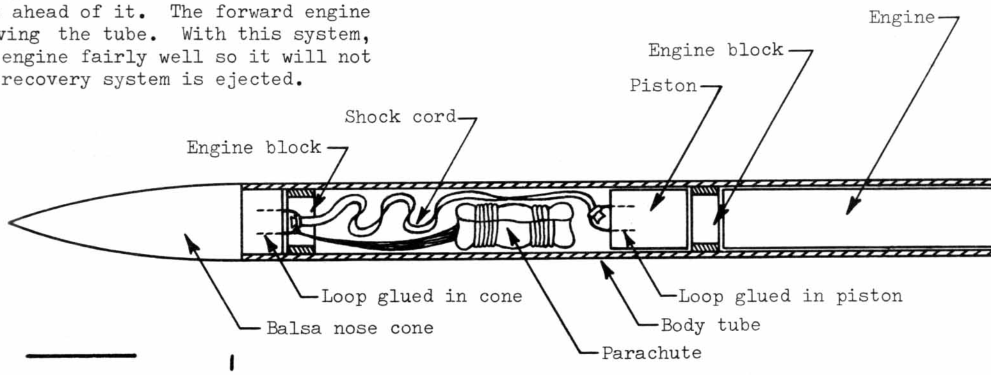




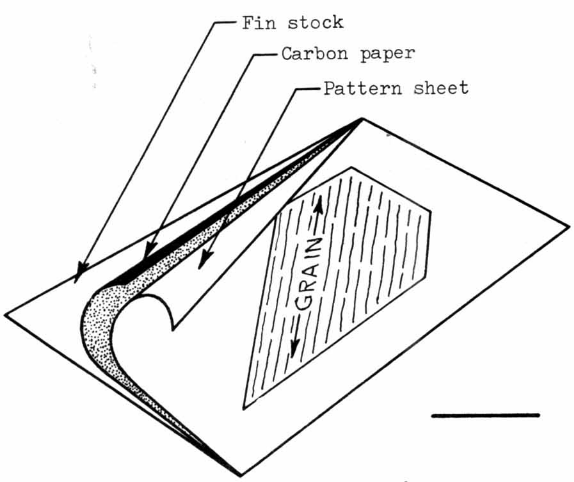
The Idea Box

If you are getting tired of replacing parachute or streamer protectors after each flight, try this permanent protector system. The nose block is left to slide free in the body tube to act as a piston, and when the ejection charge goes, the piston moves forward in the body tube, forcing the recovery system out ahead of it. The forward engine block prevents the piston from leaving the tube. With this system, though, it's necessary to tape the engine fairly well so it will not be kicked out of the tube before the recovery system is ejected.

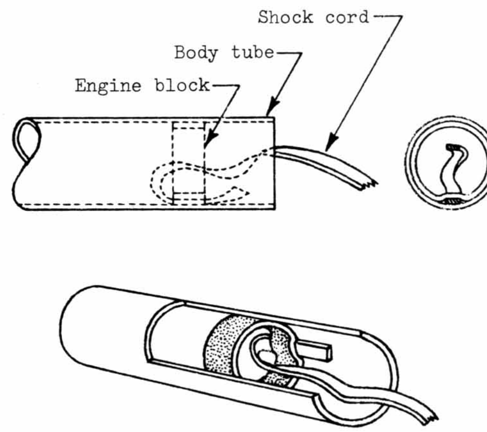
To insure smooth operation and to prevent the parachute from catching on the forward engine block, sand the rear end of the block so that it is smooth before inserting it into the tube. In operation, the parachute should be packed as far forward in the body tube as possible.

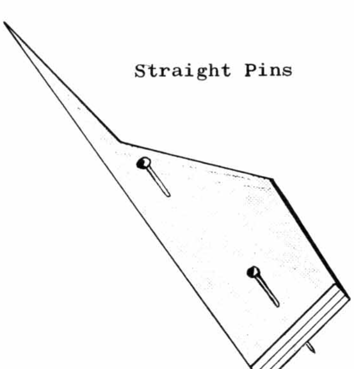


When building a rocket from plans, to eliminate the need for cutting out the fin pattern, try placing a sheet of carbon paper on the balsa under the plan sheet, and then tracing along the outline of the fin. If you want to have a permanent pattern for your range kit, try tracing the pattern onto heavy paper instead of balsa. Cut the pattern out of the cardboard, and draw around it for cutting the balsa.

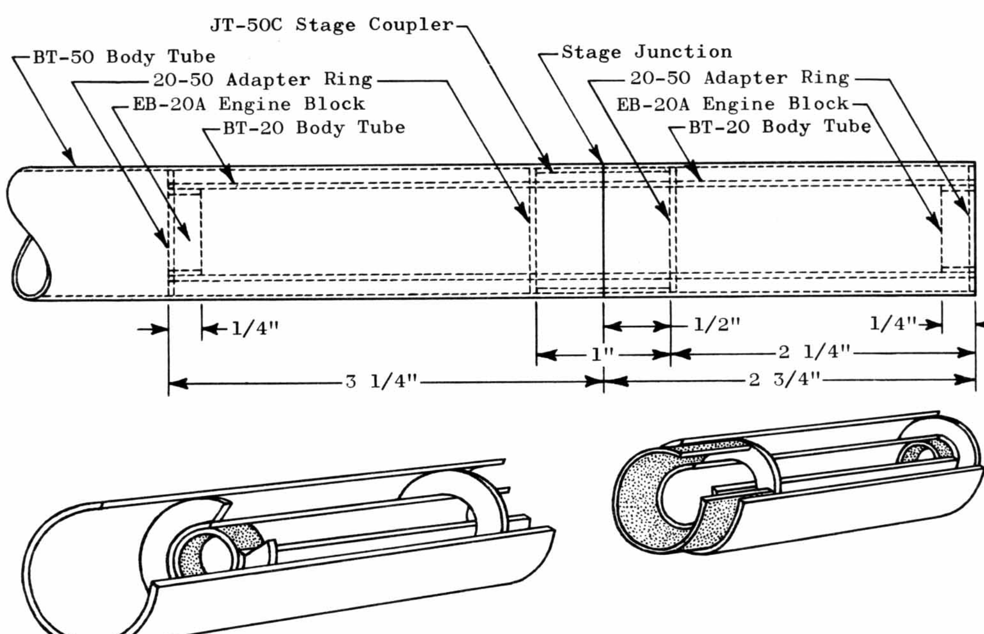


When you don't want to mark up the outside of your rocket with the shock cord attachment, try using a paper engine block with the cord looped under it and glued in place. It holds it firmly, and is easy to put together.





Straight pins help you to flat-sand all fin edges to a common shape at one time. Stack 'em together and push a pair of pins through them all. When sanded, remove the pins and sand each fin to its final airfoil shape.



This stage coupler system provides for both the centering of the engines in the larger body tube sizes, and the positive separation of stages. It has a few other advantages, too, which you'll find when you build a rocket employing the system. But when you build the rocket, make sure the adapter rings are securely glued in place, and make sure that you position the parts so everything fits in place. Otherwise, it won't work properly.

ESTES INDUSTRIES TECHNICAL REPORT

Altitude Tracking Part II

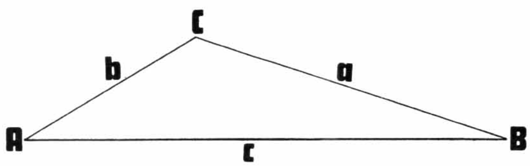
A higher degree of accuracy is possible when two elevation tracking stations are employed. In such a case, we will have triangles with 2 angles and 1 side given, enabling us to determine the other parts of the triangle without guesswork.

When using two trackers without azimuth readings the tracking stations are set up on opposite sides of the launcher. Preferably, to obtain the greatest accuracy, the stations should be in line with the wind, unlike the system used in single station tracking. Thus, if the wind is blowing to the south, one station will be north and the other south of the launch area.

The distance between the two trackers is not critical. One might be 100 feet from the launcher and the other 500 feet away. However, for the greatest ease in data reduction, the distances should be equal. For the greatest accuracy, they should be as far apart as possible. A general rule is that the distance from the stations to the launcher should be equal to the altitude the rocket is expected to achieve.

Some provision should be made to insure that the trackers lock their instruments at the same time. This is one of the greatest problems with any system using more than one station: The one tracker may lock his 'scope when the rocket appears to him to have ceased rising while the other tracker is still following the rocket. If a phone system is used, one of the trackers or a third party should call "mark," and the trackers should lock their 'scopes immediately. In the system described here this is especially important, as the elevation readings from the two trackers must be taken at the same point or the altitude computed will be somewhat incorrect.

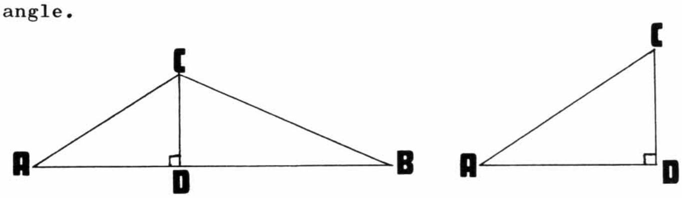
In this more accurate system we will work with sines instead of tangents. To determine altitude, then, we will first have to find the unknown sides of the triangle, as we have no right angles with which to work.



For example, stations A and B are located on a 1000' baseline with the launcher between them. Station A calls in an elevation of 34°, and station B calls in an elevation of 22°. The total of these two angles is 56°, so angle C, located at the peak of the rocket's flight, is equal to 180° - 56°, or 124 degrees. We now have 3 angles and one side to work with. Our first step will be to list the angles and their sines. Since the sine of any angle greater than 90° is equal to the sine of the supplement of the angle, the sine of 124° is equal to the sine of 180° - 124°, or 56°.

Angle A = 34°	Sine A = .5592
Angle B = 22°	Sine B = .3746
Angle C = 124°	Sine C = .8290

The law of sines states that $\frac{c}{\text{SinC}} = \frac{b}{\text{SinB}} = \frac{a}{\text{SinA}}$. $c = 1000'$, SinC = .8290 Therefore, $\frac{1000}{.8290} = \frac{b}{.3746} = \frac{a}{.5592}$ Pulling out the slide rule, we determine that $\frac{1000}{.8290} = 1205$. So we have a dividend, divisor, and quotient. In solving for side b, our dividend is b, our divisor .3746, and our quotient 1205. To find the dividend we multiply the divisor times the quotient. Now .3746 times 1205 = b, and pulling out the slide rule again, we find that b = 451'. The same process is repeated to find side a: $1205 = \frac{a}{.5592}$, a = 1205 x .5592, a = 674'. So we now have the three sides of the triangle.



The altitude of the rocket is then the distance from C to D in the diagram above. The angle formed by the meeting of lines AB and CD is a right angle. Since the sine of an angle in a right triangle is the relation of the opposite side to the hypotenuse, and since we wish to determine the value of the opposite side, we find that the sine of A (34°) is .5592. Hence $.5592 = \frac{CD}{451}$, since $\text{SinA} = \frac{\text{opposite side}}{\text{hypotenuse}}$. .5592 x 451 = 252, hence CD = 252', and we now know that the altitude reached by the rocket was 252 feet.

Fortunately, our computations to determine the altitude of the rocket can be simplified. To find the altitude we need only determine one of the unknown sides of the original triangle. So if we find the distance BC (side a) on the triangle, we can multiply it times the sine of B to find the height CD.

So $\frac{c}{\text{SinC}} = \frac{a}{\text{SinA}}$. Since we have found $\frac{c}{\text{SinC}}$ equal to 1205 when C = 124°, $\frac{a}{\text{SinA}} = 1205$. Then 1205 x SinA = side a = 674'. Now we have the one needed side of the triangle, so we can solve for distance CD in the right triangle BCD. The sine of an angle is equal to its opposite side divided by the hypotenuse, so we take the sine of B, which is .3746, times the hypotenuse, or 674', to find the opposite side CD. Thus .3746 x 674 = 252'.

The complete series of computations then would be $\frac{c}{\text{SinC}} \times \text{SinA} = a$, and a x SinB = CD. However, if we can combine the formulas to make one formula, we can speed up our work considerably. Now $\frac{c}{\text{SinC}} \times \text{SinA} = a$, so we can substitute the expression $(\frac{c}{\text{SinC}} \times \text{SinA})$ for (a) in the formula a x SinB = CD. Our formula then becomes $\frac{c}{\text{SinC}} \times \text{SinA} \times \text{SinB} = CD$. One of the basic rules of algebra tells us that if the dividend is multiplied by a number and the result divided by the divisor, the result is the same as if the division were carried out first and the quotient multiplied by the number. For example, $\frac{10 \times 4}{5} = 8$, and $\frac{10}{5} \times 4 = 8$.

So we can change the expression $\frac{c}{\text{SinC}} \times \text{SinA} \times \text{SinB} = CD$ to read $\frac{c \times \text{SinA} \times \text{SinB}}{\text{SinC}} = CD$. By performing only two multiplications and one division, we can find the altitude of the rocket. The division of SinC into the expression (c x SinA x SinB) can occur at any point, as $\frac{c \times \text{SinA}}{\text{SinC}} \times \text{SinB} = CD$, and $c \times \frac{\text{SinA} \times \text{SinB}}{\text{SinC}} = CD$ also. This last form of the equation will give the same result as the first, and actually involves the same steps, but is generally easier to use.

SUMMARY

(1) In two station tracking without the use of azimuth readings we station the trackers on a base line approximately equal to twice the altitude the rocket is expected to reach.

TRACKING continued from page 9

(2) The trackers are located in line with the wind.

(3) The 'scopes are locked at the rocket's maximum altitude, the angles read, and the sines of the angles found.

(4) The altitude is computed by the formula: $\text{Height} = \frac{c \times \text{Sin}A \times \text{Sin}B}{\text{Sin}C}$, when A and B are the angles read by the trackers, c is the baseline distance, and C is the third angle formed by the meeting of the lines of sight of the two trackers.

Sines and Tangents

∠	sin	tan	∠	sin	tan	∠	sin	tan
1	.02	.02	28	.47	.53	54	.81	1.38
2	.03	.03	29	.48	.55	55	.82	1.43
3	.05	.05	30	.50	.58	56	.83	1.48
4	.07	.07	31	.52	.60	57	.84	1.54
5	.09	.09	32	.53	.62	58	.85	1.60
6	.10	.11	33	.54	.65	59	.86	1.66
7	.12	.12	34	.56	.67	60	.87	1.73
8	.14	.14	35	.57	.70	61	.87	1.80
9	.16	.16	36	.59	.73	62	.88	1.88
10	.17	.18	37	.60	.75	63	,89	1.96
11	.19	.19	38	.62	.78	64	.90	2.05
12	.21	.21	39	.63	.81	65	.91	2.14
13	.22	.23	40	.64	.84	66	.91	2.25
14	.24	.25	41	.66	.87	67	.92	2.36
15	.26	.27	42	.67	.90	68	.93	2.48
16	.28	.29	43	.68	.93	69	.93	2.61
17	.29	.31	44	.69	.97	70	.94	2.75
18	.31	.32	45	.71	1.00	71	.95	2.90
19	.33	.34	46	.72	1.04	72	.95	3.08
20	.34	.36	47	.73	1.07	73	.96	3.27
21	.36	.38	48	.74	1.11	74	.96	3.49
22	.37	.40	49	.75	1.15	75	.97	3.73
23	.39	.42	50	.77	1.19	76	.97	4.01
24	.41	.45	51	.78	1.23	77	.97	4.33
25	.42	.47	52	.79	1.28	78	.98	4.70
26	.44	.49	53	.80	1.33	79	.98	5.14
27	.45	.51				80	.98	5.67

For angles of 81° through 89° the sine is .99, the sine of 90° is 1.00. Tangents over 80° are not given, as no sensible data reduction is possible for angles that great.

SCIENCE FAIR continued from page 1

PROJECT I: ROCKET STABILITY

Every designer of airborne vehicles such as jet aircraft and rockets must become familiar with the principles involved in their stability under flight conditions. There has never been any other object or instrument available which so clearly and dramatically demonstrates these principles as model rocketry. This project is quite suitable for the beginner in model rocketry, and offers possibilities for further development for the experienced rocketeer.

Before beginning work on this project, study and master Technical Report TR-1 on Rocket Stability. When this report is fully understood, a series of rockets should be built:

(1) The Astron Scout, which by shifting its center of gravity upsets its aerodynamic balance and returns safely to earth without the use of a parachute or other retarding device.

(2) Two rockets similar to those shown in plans A and B. Rocket A is a conventional model, while B is designed so that it will fly only when a one ounce weight is placed in the payload compartment. When the payload weight is placed in the compartment of the rocket, its center of gravity is moved forward of its center of pressure, and it will be stable.

Tests on all of these rockets except the loaded payload rocket should be made using 1/4A.8-2 The rocket with the payload, however, will be too heavy to lift high enough for the parachute to deploy before the rocket descends back to the launch area unless a larger engine is used. An A.8-3 engine is recommended for this flight.

In the exhibit all test rockets should be displayed. Indicate which will fly, which will not, and tell why. Show how a rocket is checked for balance using a cardboard cutout, and show how a rocket should be designed for stability.

Show how an improperly balanced rocket will turn away from the wind. A large electric fan may be employed as a wind tunnel, with the rocket suspended in the air stream in the manner described in TR-1. Show how a rocket changes its balance when weight is added to the nose and how an unstable rocket may be made stable. Take pictures of the actual flights and have them on display. Explain why an Astron Scout will not fly down in its recovery. Demonstrate this in your wind tunnel.

For additional information, read the Aerodynamics section in as many different encyclopedias as you can locate, and search the local libraries for all related material.

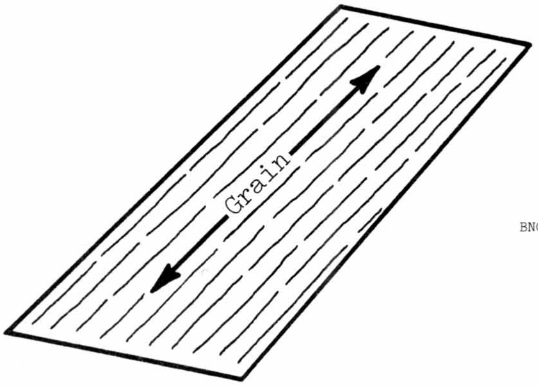
PROJECT II: A STUDY OF VERTICAL AIR CURRENTS

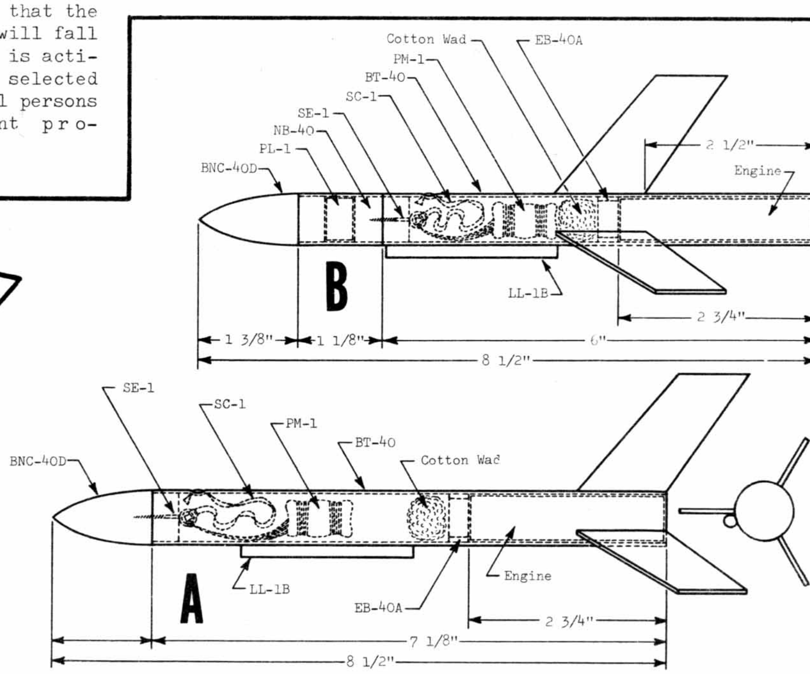
It is possible to apply model rocketry to meteorology. One of the primary examples of this can be in the use of models which incorporate large parachutes and lightweight bodies. This project is especially suitable for rocketeers who have access to fairly large open areas for their flying.

In the atmosphere air currents travel not only in a horizontal direction, which we normally feel as wind, but also in a vertical manner. Rising air currents will be present in areas where air temperature is warmest and descending air currents where the air is coolest. These temperature variations and the resulting air currents are called thermals and are not normally noticeable to the average individual standing in an open area, but must be measured by sensitive electronic thermometers.

The vertical air currents caused by heat variations are readily perceptible through observing a descending model rocket. While the normal time for the descent of a model with an extra large parachute from an altitude of 1000 feet would be from 1 to 3 minutes, times as long as 20 to 30 minutes may be observed if the rocket is launched into an area of ascending air currents.

NOTE: Extra care must be exercised when launching an unstable rocket. The experimenter must bear in mind that the rocket will take an erratic path during flight and will fall to the ground before the parachute ejection charge is activated. Considering this, a launching site must be selected which is free of highly flammable materials and all persons in the vicinity of the launching must have sufficient protective cover.





A suitable rocket will have at least 20 square inches of parachute area for every gram of rocket weight.

In the parachute duration event of a model rocket contest at Denver, Colorado, in December, 1962, one rocket descended to within 25 feet of the ground before the parachute was fully deployed. But when the parachute finally opened, the rocket began to rise, reaching an altitude of about 800 feet, and remaining in the air for over 10 minutes. The only explanation for this phenomenon would be that the rocket was caught in a rising current of air.

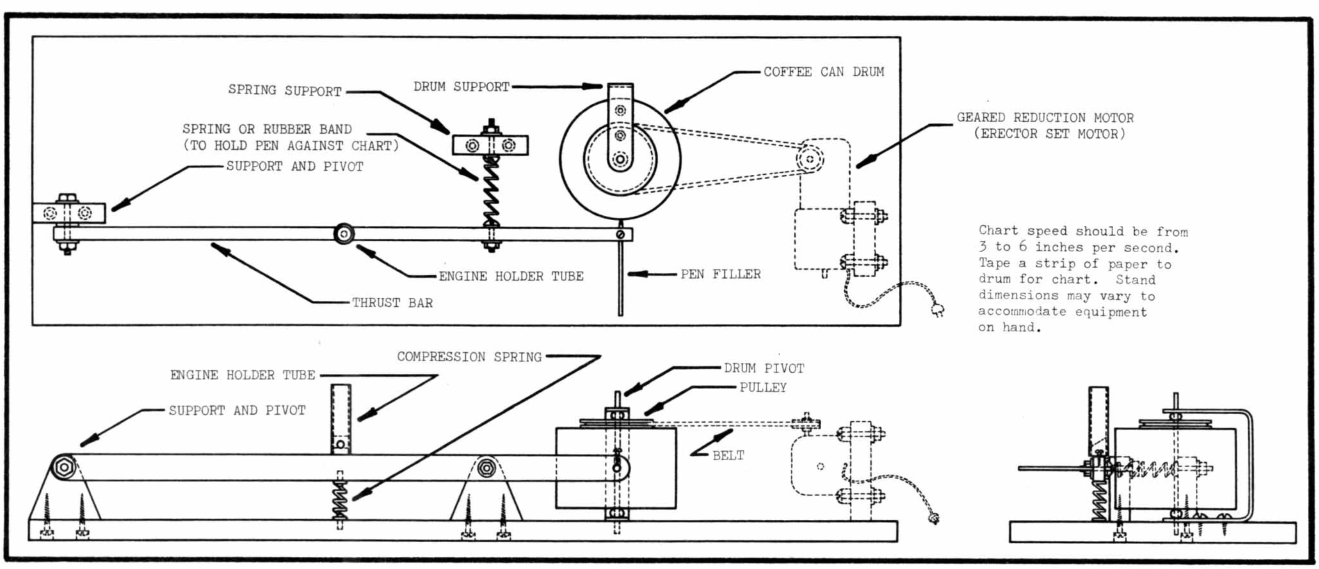
Studies of this type must be made when the wind is not blowing. Simple arithmetic will show that if the wind is blowing at ten miles per hour, and the rocket remains in the air twenty minutes, it will drift more than three miles from the launch area before it touches ground.

In studying vertical air currents, a contour map of the area will be quite valuable. Suitable maps of most regions are available from the Department of the Interior, U.S. Geological Survey. The section of the map which deals with your particular area should be enlarged, and additional details, such as the type of surface (pavement, plowed field, dry pasture, rock outcropping, and green pasture and crop land) should be filled in.

Plot the behavior of the descending rockets against the map, and see if you can determine any relation between the type of surface and the air currents, between the time of day and the currents, and between the amount of cloud cover and the air currents. For each flight note down any periods during which the rocket was in the shade of a cloud, and see if you can determine any relation between the amount of sunshine (insolation) and the air currents.

A well designed, properly adjusted boost-glider, such as the Space Plane, can also be used in the study of air currents. For additional information and ideas on the action of air currents, consult books from your local library on meteorology and weather. Once you have learned to use the various types of library facilities, you will find them to be very valuable in your future scientific experiments.

In your exhibit, display the rocket vehicles used in the tests, your map, charts of descent rates over dif-



ferent areas and under different conditions, charts showing the relation of over-all temperature to time of descent, and diagrams showing the flow of air currents under different conditions such as morning sun, late afternoon sun, dense high clouds, etc. Any other pertinent data you can locate should also be included.

PROJECT III: EFFECTS OF ROCKET FLIGHT ON TRAINING

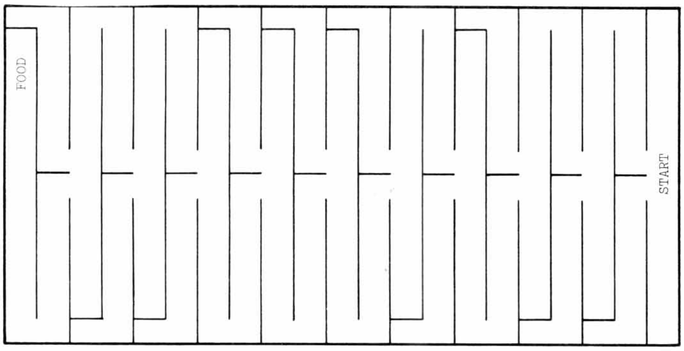
The purpose of this project is to determine the effect of rocket flight, acceleration and weightlessness on the ability of a trained animal to perform in the manner to which he has been previously conditioned. This project involves studies in biology, psychology, and rocketry, and should be quite interesting as well as rewarding.

Design and construct a reasonably difficult maze through which a mouse can be trained to run in a given length of time. Design and pre-test a payload capsule suitable for launching the mouse to a specified altitude. The rocket should be of the Ranger type, cluster powered. Thoroughly train the mouse so that he will run the maze immediately upon release from the capsule. For information on the construction of the maze, the training of the mouse, and the incentives necessary for the mouse to perform, visit the local library and study the subject in the encyclopedias and psychology books.

Among the books which should prove quite helpful in the project are: A Behavior System by Clark L. Hull, published 1952 by Yale University Press, The Animal Mind by Margaret F. Washburn, published 1936 by Macmillan Company, and An Introduction to Animal Psychology by Norman L. Munn, published 1933 by Houghton Mifflin Co. If these books are not available in either your school or public library, your librarian should be able to obtain them from the state library. In any search for material on the subject, be sure to check both the animal and psychology sections of the library.

After the mouse has been trained to what appears to be his maximum ability he is ready for the first flight test. Be very careful to record all data, including type of maze, vital statistics on the mouse, training period length, average time for negotiation of the maze at end of training period, etc. Also record data on the rocket which is to power him into inner space--the power of the engines, the weight of the rocket, general and special design features, etc. Record all data gained on the pre-test flights (made with a weight equal to the mouse in the capsule) and if possible take both still and motion pictures of the whole proceedings to have on display in your exhibit.

To get the best results from your tests it will be advisable to subject the mouse to more than one rocket flight and repeat the tests using several mice. Note if the mouse is confused after his first flight. If so, does he, after additional tests, become accustomed to rocket flights and perform as before? If not, does his ability to negotiate the maze improve or decline with additional tests, and by how much? As a control, have one trained mouse which is not launched and take regular tests on his performance.



Additional advantages can be gained on your project if you have an Altiscope and can present altitude data on the rocket flights along with the trigonometry involved. At the fair, display such things as the rocket itself, its padded capsule and the maze. Also display pictures of the flights, launchings, and a mouse immediately before and after flight. Have the mice on display with pictures showing one entering the capsule, leaving it, and running the maze. Exhibit the electrical firing equipment used in launching the rocket. Make graphs and charts illustrating the rocket flight characteristics, achieved altitude, etc. Show charts recording the performance of the mice before and after each successive flight.

PROJECT IV: INVESTIGATION OF THE KRUSHNIK EFFECT

A young model rocketeer by the name of Krushnik discovered several years ago that when a model rocket engine is recessed more than a certain amount into a body tube, it fails to develop any effective thrust. However, little more research has been carried out on this effect. As a science fair project, a study of this effect should be quite rewarding, as it offers the advanced rocketeer an opportunity to do some original research. Because of the potential complexity of the project, however, it is not recommended for students who do not have at least the equivalent of 1 year of high school science or who are not prepared to invent, design, and build, by themselves, the equipment needed.

Among the materials needed for any project on the various factors of thrust is a static test stand. For this project, the rocketeer will have to design a suitable recording stand, bearing in mind the requirements of the experiments which will be performed. Basically the stand will consist of a drum, a motor drive for the drum, and an engine holder, spring mounted, which moves a pen or pencil against the drum in a direction at right angles to the movement of the drum. The surface of the drum should have a sheet of paper taped to it for the pen to record on, with this paper replaced after each test firing. B.8-0(P) engines are recommended for use in test stands. In conducting tests with any equipment of this sort, it is necessary to observe all reasonable safety precautions, and it is especially important to stand well out of the line of the engine exhaust.

For this project it will be necessary to obtain thrust curves for the same type engine when its nozzle is recessed various distances. Other observations such as sound produced by the engine when firing (amount and type) and flow characteristics of the exhaust gases should also be noted. It will be necessary to determine whether the loss of thrust is related to the distance the engine is recessed only, regardless of body diameter, or whether the loss of thrust is related to the percentage of the tube diameter the engine is recessed, and whether the loss of thrust is due to a "pipe organ effect" in the tube, to the extra length of tube allowing the decelleration of the exhaust, or to some entirely different cause.

The rocketeer will have to take extensive notes on his experiments, reduce the data he collects, form a hypothesis, test his hypothesis, and draw conclusions. A thorough acquaintence with the scientific method will be necessary for this. The results of the tests should then be written into a report, covering all aspects of the experiments, including the nature of the controls on the experiments, repeatability of thrust characteristics on the engines used, repeatability of the results of the experiments, and effect of atmospheric and other conditions on the tests.

At the fair, engines, tubes, the test stand and other equipment used should be displayed, along with diagrams showing the internal characteristics of the engines, information on the safety factor of the engines and typical thrust curves for the engines under normal conditions. There should be diagrams showing the flow characteristics of the engine exhaust under different conditions, graphs showing the relation of thrust to the distance the engine is recessed, and a copy of the complete report on the experiments. Also, the rocketeer might include some explanations of potential applications of the effect, such as controlling thrust in solid fuel guided missles.