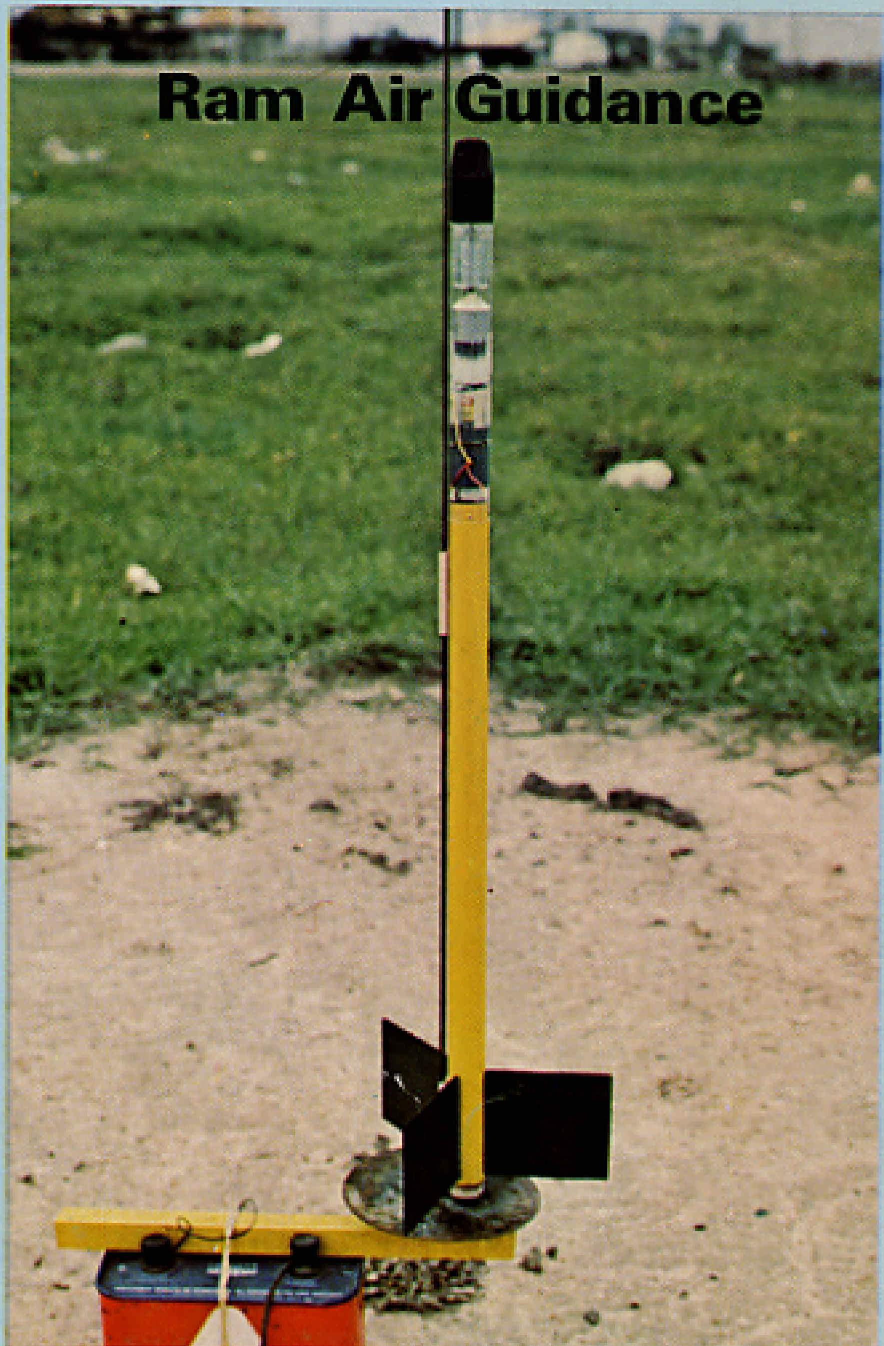
MODEL ROCKETRY

February 1970
50 ¢

The Journal of Miniature Astronautics
Incorporating THE MODEL ROCKETEER

Yugoslavian PD Design



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Model Rocketry

Volume II, No. 5
February 1970

This month's cover shows one of the experimental rockets employed during Forrest Mims' testing of the Ram Air Control system described in this issue. The project, which took first place in Senior R&D at NARAM-11, resulted in a prototype system for model rocket guidance. The Ram Air Control article begins on page 28. (Cover photo by Forrest M. Mims.)

From the Editor

The recent proposal by Model Products Corporation for the establishment of a "Professional Division" of competition by the National Association of Rocketry raises several important questions. Over the years this problem of professional competition within the hobby has been largely ignored. However, with the increasing number of manufacturers, the advantage in product sales from winning regional or national model rocket competitions would be tremendous. The modeler would also benefit, since the manufacturer flying his rockets in open competition against other manufacturers will be encouraged to improve his product. Thus, from the point of view of both the manufacturer and the rocketeer, such competition should be encouraged. Competition by the manufacturers must, however, be achieved within a contest framework which does not disadvantage either the rocketeer or the manufacturer.

There are two ways a manufacturer or his employee may compete--either as an individual in competition with other modelers, or as a representative of the manufacturer in competition with either other modelers or only with other manufacturers.

It is clear that an individual employed by a major model rocket manufacturer enjoys an advantage because of the resources available to him over the "average" rocketeer. This advantage is readily apparent in such areas as Scale and Research and Development. However, there are other

(Continued on page 5)

Regular Features

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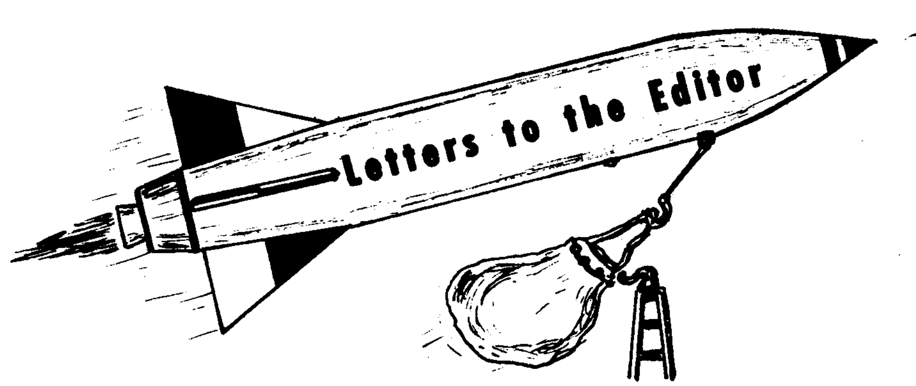
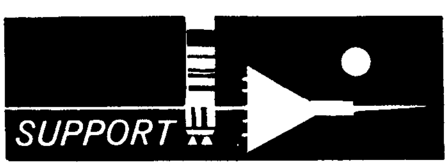




Infra-Red Tracking

I have read a great deal in your magazine concerning tracking problems and since you encourage people to send in their ideas (good or bad) in hopes that someone's wild speculations or carefully-thought-out plans will solve the ills of our hobby, I've decided to give you this idea of mine on tracking (for what it's worth).

From everything I read in your magazine, tracking models at night with tracking lights in their payload sections is rather easy. Of course, this is impractical during the day because background light would drown it out, but a model rocket in flight generates a good deal of infrared radiation from its engine, and, if it were painted black, would absorb additional heat from the sun. Might not this look like a beacon against a dark sky through an infra-red sniperscope?

Admittedly, I don't know a great deal about them, and the price might be prohibitive for anything other than national meets or record trials, but at least these could be assured of a closed track.

Mark A. Lytle
NAR 13206
New Kensington, Pa.

Technical Reports

Having been involved in model rocketry for nearly ten years I have had a chance to see the hobby develop. My first model was a Model Missile Aerobee-Hi and my first catalogue came from Estes Industries. At this time, the catalogue was mimeographed and consisted of about ten pages. The most technical article available was an article by G. Harry Stine about the "New Look in Model Rocketry". I've seen the companies, their newsletters, the NAR, and hobby coverage grow. Now your magazine has come on the scene and, in one fell swoop, it has at least doubled the amount of information available in vital areas – technical reports and papers.

As an engineering student and serious model rocketeer, I am disturbed by the cries against technical papers. Up until this time, the preponderance of literature available was either non-technical or watered down to the level of younger enthusiasts. This literature has done, and is doing, a great service – however, there is a need for the higher-leveled papers, too. The rocketeers who are in the hobby for the sheer joy of it already have several sources of information available. Furthermore, in the first seven issues of **Model Rocketry**, there were 44 articles of a non-technical or semi-technical nature, while there were only 11 technical articles. So for all of you who don't dig calculus or using graphs, fine – you are the backbone of the hobby. However, don't ask those of us who do enjoy these articles to give up the few that we have available. If the hobby's publications become mired in either extreme, a very valuable part of many persons' lives is going to degenerate. As long as we have our diversity, our hobby has a chance to grow steadily.

Robert E. Cramer
Ohio Northern University
Ada, Ohio

Automatic Computation

I read the article in the October issue of **Model Rocketry**, *Automatic Computation for Rocketeers* by Charles Andres, on finding the center of pressure of a rocket, and I found the article very interesting. I live next to the University of Rhode Island, and fortunately I have a friend whose father works in the Business Math Department; the department has a 1050 terminal which ties in with the University's IBM 360 computer. We set up the program and found a couple of mistakes in it: 1.) There was an extra parenthesis (the last one) in line 93 [which we omitted]. 2.) The first number of each set of data was supposed to be spaced seven spaces from the first number of the preceeding except for the first, which was indented one space.

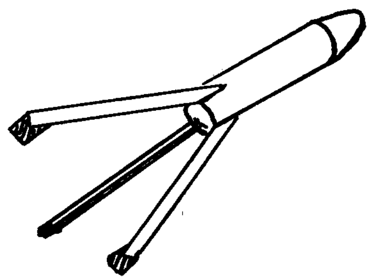
Thomas Fette
Kingston, R. I.

The Escape Tower

HELP! Save model rocketry from that insidious madman (I refer to Tom Milkie) before he destroys original thinking everywhere with his telepathic abilities to steal original designs!

Take, for instance, the Mercury-like rocket at the top of his page; I built and launched a similar design back in 1967. (Unfortunately, its remains now lie in my junk box; I forgot to include a recovery system.)

For instance, the "sham-roc". I have designed four similar rockets and tested one – the Selenite, the Mercurite, the Gravastable III, and the KLM (a sketch of which is shown below).



For instance, his plans to build a flying scale LEM. I had a plastic LEM almost finished being flight converted (before it fell off my dresser and was demolished).

For instance, the Zeta . . . Enough examples. I'm going to fight back! My wastebasket is filled with ridiculous ideas. He can't steal ALL of them. Prepare yourself for a flood of nutty ideas – the Itoopla, the Glidex, the Mirage, the JATJ I, the JATJ II, the . . .

Geoff Landis
Winnetka, Illinois

We're looking forward to seeing some of your designs. From the letters we have received, some of Tom's way-out ideas aren't so way-out after all. An LM has been test-flown, Doug Malewicki has test-flown an Apollo capsule, etc. . . .

Multiplexed Foxmitter

I am very interested in model rocket transmitters and am now building the modified version of the Foxmitter. After reading the *Technical Notes* section of your October issue I have become particularly interested in multiplexing the Foxmitter. I have done some research into the matter and I think I have come up with the answer. I am sorry that I can't give you a schematic and parts list because I don't know quite enough electronics, but I am able to give the specifications for such a system.

In order to multiplex the Foxmitter for resistance type sensors (e.g., photocells, thermisistors, etc.), the audio oscillator circuit of the transmitter should be repeated for each of the sensors. Each of the circuits should be modified so that it has a center frequency between 20 and 20,000 Hertz (normal human hearing range), so that the signal can be easily deciphered. The center frequencies should be determined by dividing the 20 to 20,000 Hz scale into equal parts according to the number of sensors. These sensor circuits should be connected in parallel and their total resistance should not be more than that of the standard single sensor circuit of the transmitter. This group of oscillators would be connected to the current amplifier of the transmitter, just as the standard one is connected.

Seperation of the signals can be accomplished by playing a recording of the transmission through filter circuits centered around each of the oscillator center frequencies and recording the output for each sensor. Deciphering the output may be done by Fox's method by by connecting a VOM across the output to record the magnitude of the signal.

Because I do not know enough electronics to build this system myself, I hope some other rocketeer who is an expert in electronics will build it and publish the results in this magazine.

Peter O'Neill
Wilmington, Delaware

"Professional" Competition

SAI Issues Reply

In reply to the MPC proposal on "professional" competition in the NAR, the following position statement has been released by Tag Powell, President of Space Age Industries:

For the past four years Mini-Wheels has sponsored a professional model car racing team. This pro team has traveled throughout the United States, Mexico, and England. In model car racing there are amateur, semi-pro, and pro classes. The pro teams are sponsored by the five or six major model car products manufacturers. These factory-sponsored teams were the great hope to spur new contestants in competition.

The manufacturer's sponsored teams did not live up to all that was expected. The manufacturer's "pro" drivers used equipment from any source, including expensive custom-made products not available to the average model car driver. The amateur could not keep up with changes, the novice did not have the building skill and could not afford to buy this expensive equipment. For example, a model car chassis – from $3 to $8 in local hobby shops as compared to the "pro's" $55 custom built chassis. Consequently, the amateur, the novice or beginner, lost interest. This was one of the many problems which arose from pro competition.

Space Age Industries Division of Mini Wheels, Inc., believes that a proposal for professional model rocket competition was long overdue. Space Age Industries congratulates MPC for that giant step forward. The following suggested changes in the MPC position paper are made by SAI from previous experience in pro or factory-sponsored competition.

MPC states that, though exempt from a Professional Division, a designer receiving royalties from a model rocket design produced as a kit by a manufacturer "provided said model rocket designs are not flown by the designer in sporting competition against non-professionals." SAI feels that the designer should be allowed to fly his model in non-professional competition.

1.) We feel that the rocketeer with a new design would be reluctant to allow a kit to be made of his model as he would then never fly this model again in non-professional competition.

2.) We see no reason why the kit designer is any different from anyone who has bought a kit and flies it in non-professional competition.

MPC also states that "a manufacturer is not restricted to using only those designs of his current kits, but may enter any free design fabricated from his parts available on the market." SAI disagrees. In professional competition between manufacturers, existing kits should be flown against other existing kits. This would prove the efficiency of the kits on the market. A seperate contest for future or prototype kits could be set up for models made from manufacturer's accessories.

On all other basic matters we agree with MPC and look forward to the discussions at the HIAA show in Chicago. We accept the challenge of MPC's gauntlet and choose as weapons our kits against theirs, or any other manufacturers'.

LAC Comments

At the request of NAR President Ellsworth Beetch, the Leader Administrative Council discussed the issue of professional competition at their November meeting. The LAC recommended that, to insure product improvement would dominate pure publicity, the proposal formulated by the LAC stipulates that manufacturers compete not only among themselves, but against top non-corporate modelers in a "Professional Class" open to anyone (except Juniors) who wanted to declare himself in such a class for the contest year. All manufacturers and their representatives who wished to compete would automatically be placed in this class. As a safeguard against non-standard engine thrusts, the NAR Standards and Testing Committee would be permitted to select several engines for testing from among those used for competition by those in the Professional Class.

Open Letter

An Open Letter to the Board of Trustees, National Association of Rocketry

December, 1969

Gentlemen:

Recently a major manufacturer in the model rocket field circulated a draft proposal to create a "Professional" category of competition within the framework of the N.A.R. Model Rocket Sporting Code. The draft presents a thoughtful and thought-provoking approach to a complex and controversial issue. The author(s) and sponsor deserve congratulations for their forthright effort to provied a solution.

The issue involved can be expressed, I believe, in a statement such as, "It's neither fair nor reasonable to expect an average, hobbiest modeler to compete effectively against a professional". This issue is common to all sports/hobbies that sponsor and encourage competition. It has been dealt with, more or less effectively, by many. The model rocket fraternity must consider the issue in the context of it's own problems and needs without being unduly influenced by the solutions evolved by others.

The issue becomes a problem only if the "Professional" enjoys some intrinsic advantage over the non-professional. The principal ingrediants of success in competitive model rocketry are skill and patience. These qualities most assuredly are not a monopoly of the "Professional". However, he usually but not necessarily enjoys some secondary advantages over the average, particularly the younger modeler. Most important of these are access to a greater variety of tools and he enjoys the happy circumstance of being paid to develop and polish his skills. The tools are certainly a convenience and save much time but they are not essential to quality workmanship. The skills can be developed during evenings and on week-ends as well as during the work-day.

One other factor that I think influences the thinking of many modelers on this issue is the suspicion that the "Professional" may not build his own models. While this suspicion may or may not be justified, it is equally applicable to the non-professional and is, therefore not germone to the "Professional" issue.

The "Pink Book" already recognizes that different levels of resources and capabilities exist by specifying age classifications for membership in the N.A.R. as well as for competition. The concept of a "Professional Division" is really only an extension of that principal to a small, albeit important, segment of the total membership.

Assuming that a problem truly exists, there appear to be three basic, possible solutions.

FOR TEXT OF MPC PROPOSAL SEE JANUARY MODEL ROCKETRY

Proposal Brings Comments

1. Bar all "Professionals from sanctioned competition.

2. Ignore the issue, or deny that a problem exists, and continue as in the past.

3. Create a "Professional Division" of competition as suggested by the proposal. Variations of these basic alternatives are also possible.

The first alternative is, I believe, untenable. I can't see that it would provide any significant benefit nor would it solve any problem. It could, however, seriously jeopardize relations between the N.A.R. and the model rocket industry. Relations which, for the ultimate good of all, must be fostered not hindered.

The second alternative is the easy way out and by no means unreasonable. Several of our kindred hobbies have conducted highly successful competition programs for many years without differentiating between "Professionals" and non-professionals.

The third alternative, as proposed by the recently circulated draft, I believe has some rather serious flaws. Granted that, at least from the point of view of the manufacturers, it is an excellent approach. I think that it requires significant revision if it is to conform to the stated aims and purposes of the N.A.R. The proposal as submitted, would create a contest-within-a-contest situation in which the competition would be keen, possibly even bitter, since the results would have a direct bearing on product sales. The pressures thus generated, with all their ramifications, would place an unwarrented and undesirable burden on the already overworked volunteer contest officials. Furthermore, there would be no significant benefit accrueing to the N.A.R. or to the hobby in general which could not be achieved by less painful means. The system proposed would assure that the "Professional Division" would be financially self-supporting, insofar as prizes are concerned. Nevertheless it would make use of N.A.R. facilities and organization for what would be essentially commercial purposes.

A possibly viable variation of the third alternative would be to establish an "Expert" category rather than a "Professional Division". Since it is unlikely that a manufacturer would underwrite a novice to demonstrate his products, it would be equitable to automatically classify all "Professionals", as defined in the proposal, as "Experts". Additionally, individuals who have demonstrated competitive competance would be designated as "Experts". Finally, other individuals who met certain minimum requirements could be classified as "Experts" at their own request. The present point system could be utilized n specifying standards. I would expect that there would be no age limits, either maximum or minimum on the "Expert" class.

I believe that such an "Expert" classification would provide equable competition within the N.A.R. Code and would remove some of the previously mentioned objections to a "Professional" class while significantly weakening most of the others. I would expect that the model rocket industry would welcome such an "Expert" category, since they could then say, when they did win, that they not only bested their market place competition but also, by golly, some of the best model rocketeers in the country.

Respectfully yours;
H. J. Honecker
N.A.R. 12689

Age Revision Urged

I have received a letter form Model Products Corporation pertaining to their position in model rocketry, and I feel that there is another solution to this problem.

As Senior Advisor for the MASA Section in Mansfield, Ohio, I have had the opportunity to discuss this question at length with others in this area. We have come to a conclusion which might be of help to everybody interested in model rocketry.

I therefore recommend that the National Association of Rocketry change the membership grades as follows:

Junior – under 14 years of age
Leader – at least 14 and less than 18 years of age
Senior – 18 years of age and older
Expert – any person or persons that wish to compete with professional model rocketeers as long as over 21 years of age.
Professional model rocketeers shall be defined as any person who has received pay for at least 6 months in that contset year for designing, engineering or manufacturing of model rockets or any part thereof. (Membership would expire August 31 of each year.)

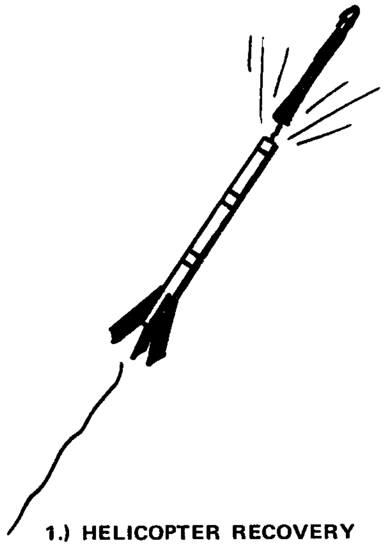
Robert Hagedorn
Mansfield, Ohio

(From the Editor, cont.)

rocketeers who also, by virtue of their positions as professionals in the aerospace industry, persons with access to sophisticated aeronautical testing equipment and data, writers and aerospace employees with access to scale data and/or actual rockets, etc., have an unfair advantage in competition with the "average" rocketeer. The creation of a voluntary "Expert" category, open to all NAR members, would aleviate this problem. Manufacturers' employees and all others who, by their association with the aerospace field, have an unfair advantage in competition could voluntarily declare themselves "Experts" and compete in regioal and national meets among themselves. In smaller meets the Expert Division could be flown jointly with the Senior Division if there were not sufficient "Expert" entries for them to compete alone. In the Expert Division each contestant would compete as an individual, not directly representing a manufacturer or organization. He would be permitted to use all manufacturers' parts and supplies, and any research facilities and data available to him. These "Experts" by their superior knowledge of the field would be expected to contribute the major technological advances to the hobby, and as they employed these advances in their competition rockets their knowledge would become available to all rocketeers.

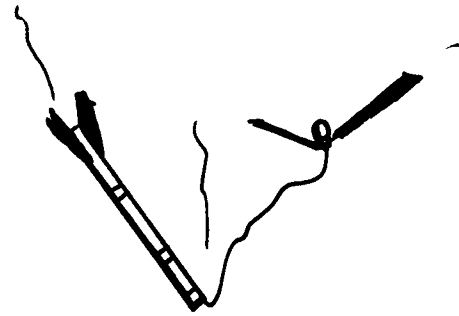
The proposed "Expert" Division, however, will not take care of the manufacturers' need for direct, public competition with their own products. To allow for this, a "Manufacturers" Division, consisting only of teams from the manufacturers could be created. These teams, flying only manufacturers' unmodified kits, would compete directly against each other. Such an event would encourage the construction of superior kits by each manufacturer. Here the emphasis would be on the manufacturer and his products, not skills and abilities of the individual team members. The rockets flown should be the product of the manufacturers' employees, and the requirement that the contestant build his own model could be suspended to allow any full-time employee to construct and/or fly the models. Since this event would be of great benefit to the manufacturers as a method of increasing public awareness of their products, the full cost of all "Manufacturers" Division competitions should be borne by their contributions to the NAR.

Unfortunately, the problem of manufacturers and "professional" competition is too complicated to be solved by the establishment of only a single new competition division. Individual employees of the model rocket manufacturers as well as other aerospace professionals cannot be totally excluded from competition, but they cannot compete fairly in any of the established divisions, thus an Expert category is required. However, to permit the manufacturers the public exposure they desire, a separate Manufacturers competition would also be required. If the manufacturers are willing to assume the operating costs of their own event, there is no reason for the NAR to deny them this public exposure.

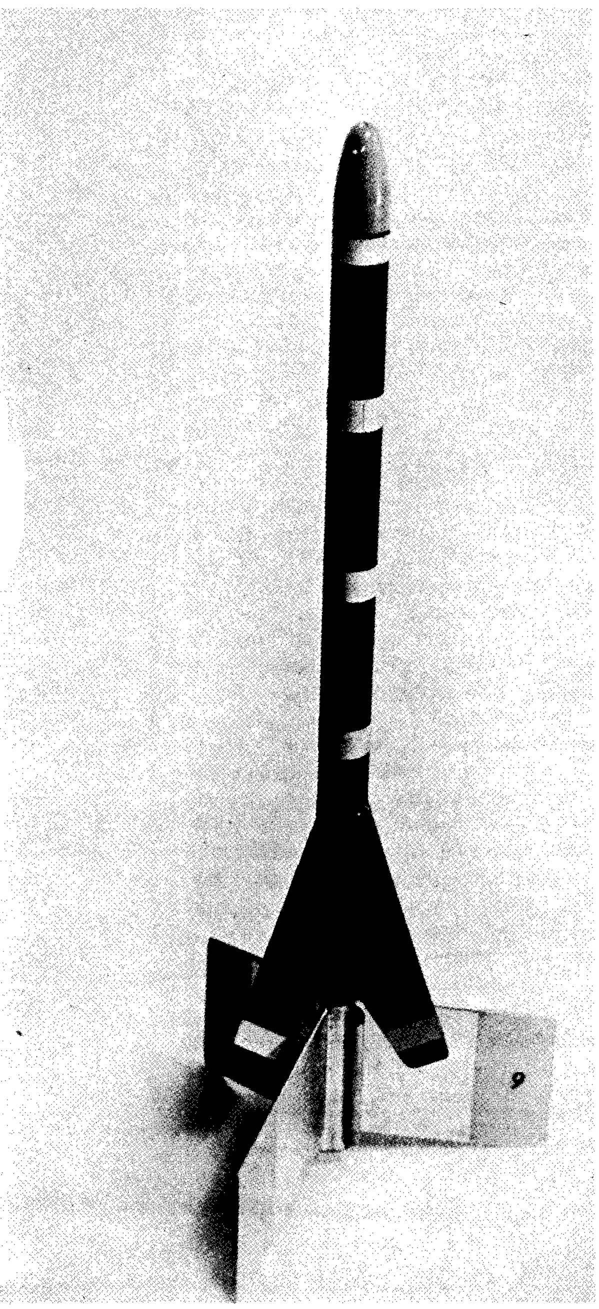


1.) HELICOPTER RECOVERY DEVICE IS EJECTED

2.) DEVICE UNFOLDS



3.) ROCKET BEGINS TO DROP



HELICOPTER

The GYROC model rocket kit, manufactured by Estes Industries, is an interesting design which relies on a "helicopter recovery" device to slow the rocket's return to earth. The rocket incorporates two large hinged flaps on its main fins which are spring loaded by elastic bands. At the apogee of its flight the spent engine casing is ejected and the two hinged flaps spring about in opposite directions. The resulting aerodynamic forces spin the rocket as it falls and the rocket slowly spirals back to ground without the drift normally associated with parachute recovery methods.

The altitude capability of the GYROC is, however, limited by the drag caused by its broad fin surfaces and large fin frontal areas.

This article presents the results of a design and flight test effort to develop a helicopter recovery system which can be used with a rocket capable of maximum altitudes.

The solution to the drag problem involves a rocket of small diameter but rather long length with a unique folding helicopter device contained within the rocket tube. A low frontal area and favorable weight distribution permitted by the compact internally stored recovery device result in low drag and exceptional stability. High altitudes with both single and two stage flights are the rule for this design.

Before going into the actual design, it may be interesting to consider some of the inherent advantages in a helicopter recovery system over the more conventional parachute and streamer methods. The following lists some of the more apparent advantages.

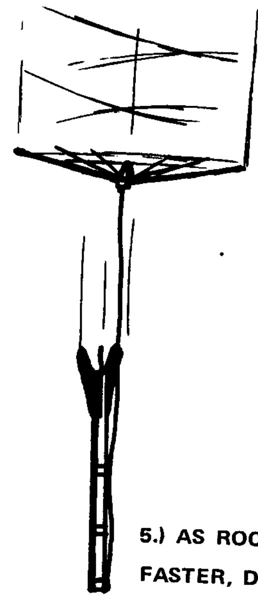
1. The recovery system can be designed to withstand the heat of the ejection charge for many flights.
2. A properly designed helicopter device can be deployed while the rocket is traveling at high speed without damage.
3. During descent, a helicopter recovery system is relatively insensitive to side winds which produce high drift rates with parachutes.
4. The helicopter recovery device can be designed to take some time to come to peak efficiency thus allowing a rapid initial descent followed by a slower rate of descent near the ground. This will insure recovery nearby, even on windy days.
5. The device generates more lift than a streamer, but with similar drift rates, and can be used with a heavier rocket.

To be sure, there are some real disadvantages in a helicopter recovery system, but these will be discussed later.

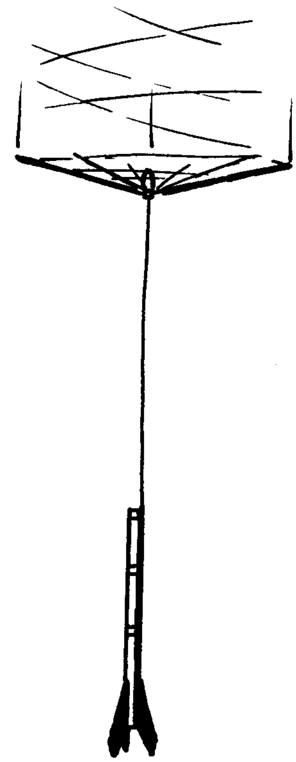
Launch Vehicle

The prototype launch vehicle designed to perform the flight tests of this

4.) SPEED INCREASES



5.) AS ROCKET DROPS FASTER, DEVICE BEGINS TO SPIN



6.) LOW VELOCITY HELICOPTER DESCENT

RECOVERY

by Norman Smith

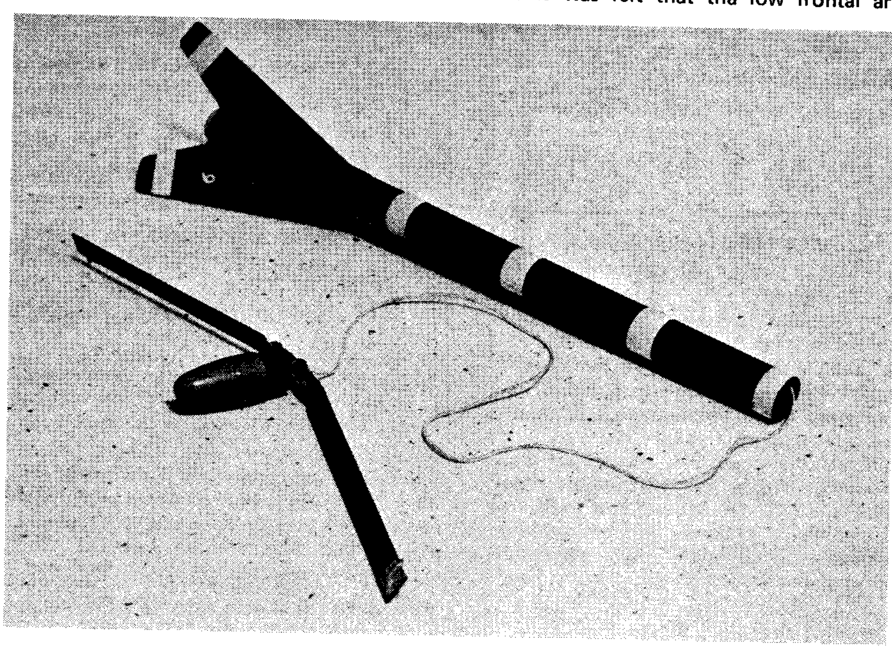
ecovery system was constructed of rather unusual materials relative to the materials commonly in use today for model rockets. It was desirable to fabricate an almost *indestructible* rocket in the event that early helicopter devices failed to operate as planned. At the same time it was necessary, of course, to build the rocket entirely in keeping with the safety codes of model rodketry.

The prototype was therefore constructed from a paper base 1/32" wall black phenolic tube of about 0.7" I.D. The fins were cut from linen base phenolic sheet 1/32" thick. A standard two-part resin-hardner epoxy adhesive was used to fasten the fins to the tube. The booster was also constructed of a phenolic tube, but more conventional balsa fins were used. The booster fins were 1/8" thick.

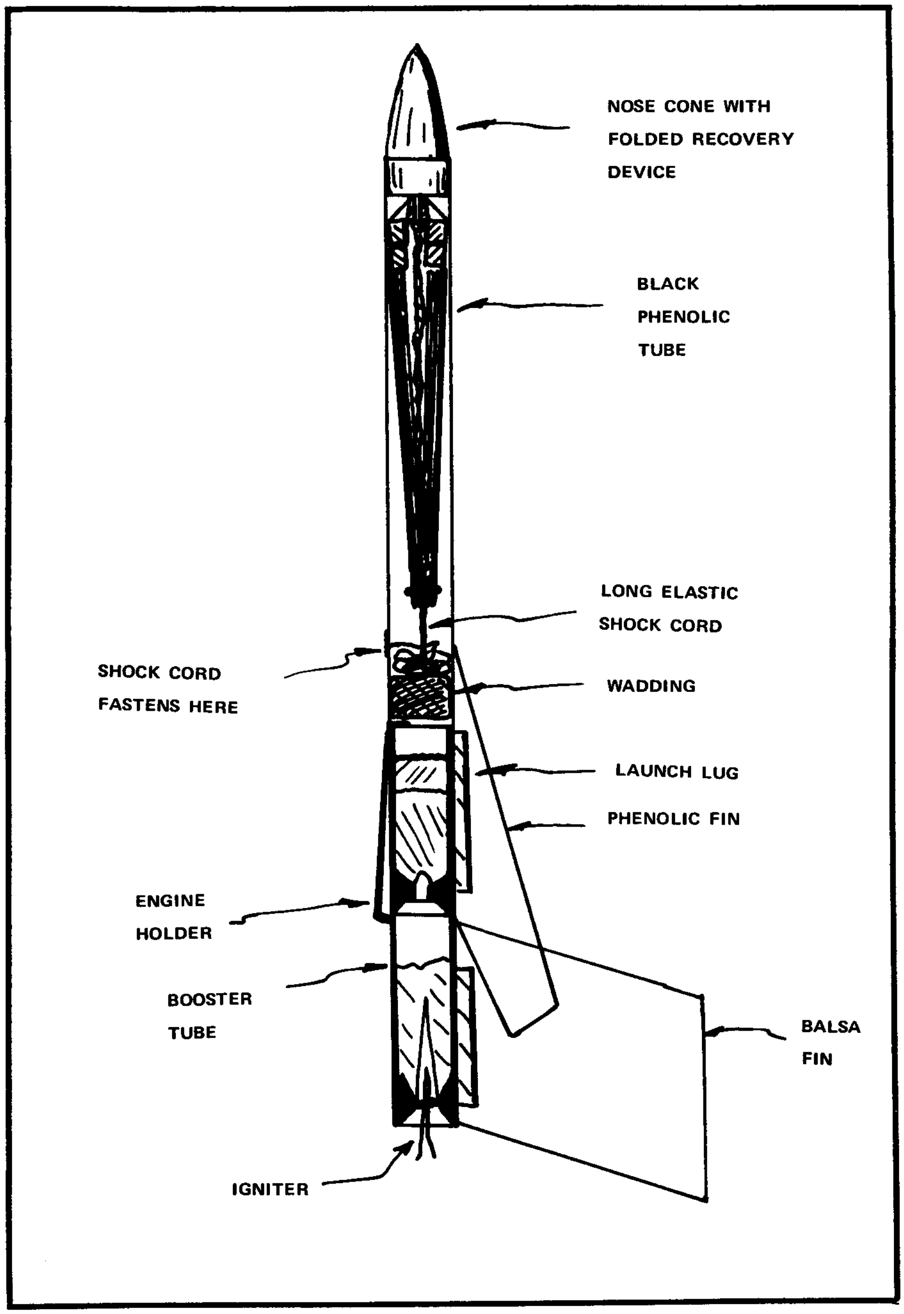
Since fairly high ejection charge pressures would be built up before the long and heavy helicopter device would be ejected, it was necessary to provide an engine holder to prevent engine casing ejection. A paper clip was bent to shape and inserted through the rocket tube. A small piece of gauze soaked in epoxy held the engine holder in place. This engine holder was even used successfully with two stage flights.

A launch lug was provided by epoxy-
g a plastic soda straw to the side of the cket. Of interest is the fact that soon after initial flight tests, the straw slipped out of the epoxy, and the epoxy alone served as a fine launch lug thereafter.

After the fins were securely mounted, their leading and trailing edges were carefully rounded by sanding. It was not possible to put a sharp knife edge on the trailing edge of the fins due to the fibrous nature of the linen base epoxy, but it was felt that tha low frontal area



Shown above is the helicopter recovery device employed in the rocket described in the text. Note that the helicopter blades are fastened directly to the rear of the nose cone.



of the 1/32" fins would insure very low aerodyanmic drag even with a rounded trailing edge.

The final step was to paint the rocket. The main stage tube was left black, and the fins were painted red with white stripes. White stripes were added to the main stage tube. The booster was painted silver with red fin tips.

When completed, the rocket was both extremely strong and surprisingly light. Flight testing later proved the design to be capable of extreme altitudes with no noticeable wind-cocking or other deviations from vertical flight.

Recovery Device

The folding helicopter recovery device may look like a formidible construction task to those of you considering building a similar unit, but it's really not as bad as it may appear. Consider instead the job of getting one to work, when the only way to test it is to launch it. There seems to be no way to stabilize the device without allowing for at least a 300 foot drop.

The device that was first built and tested used single span blades. Initial flight tests indicated that more blade surface area was required to generate the required lift, and blades that fold axially along their lengths were installed. The final design uses up almost all the available space in the rocket tube and it is very lucky indeed that this later proved adequate. Of course, if a maximum altitude design was not being strived for, it would be a simple task to design a wide blade single span device that would fit in a somewhat larger body tube. (Estes BT-50 for instance).

It is recommended that a nose cone with a fairly small fineness ratio (length/diameter) be used or centrifugal forces generated by a misaligned and spinning nose cone may destabilize the device.

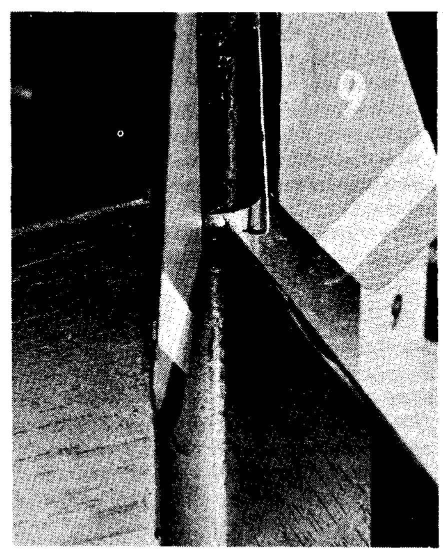
The shock cord should be carefully placed between the two folding blades when packing the helicopter device into the rocket tube as a guard against possible entanglement when the device is ejected.

Construction of the helicopter recovery device should proceed as follows. Cut a ¼" square balsa spar into three small pieces as shown in the illustrations. These pieces will comprise the hinges joining the two blades. Sand the center piece until a slight dihedral is formed when the two outside pieces are held on each side. The diameter of the rocket tube should determine the length of this center piece. A small strip of either nylon hinge material (available at your hobby shop) or gauze can be cemented or pinned to the balsa forming a hinge.

The completed unit should now be inserted through a ¼" diameter eyelet with a short piece of rubber band along the top surface. Refer to the photographs for details. Tie the end of a long (two foot) shock cord to the bottom of the eyelet. Cement the entire unit to the eyelet taking care not to get any cement between the center piece and the two balsa blocks on each side.

The completed unit should fit easily into the rocket tube when folded.

Prepare two pieces of wire as shown. The wire end with the square loop should be a snug fit about the balsa blocks of the hinge assembly. After sliding the wire over the balsa blocks, the rubber band should be pulled taut, and the whole assembly wrapped in thread and soaked with cement. When dry, the unit should



Note the unusual procedure used for the engine clip. When the booster stage detaches, the clip springs back holding the upper stage engine in place.

spring open when folded and released.

Cut two blades as shown. A fillet of white glue will bond the wire frame to the top of the blade temporarily. When dry, short strips of gauze soaked in glue can be placed over the wire frame forming a strong bond. The second half of the blade (not shown in the photographs) should be held alongside the completed blade unit while gauze or paper hinges are placed along the bottom surface. Attach a short piece of elastic cord to the top surface of the completed blade assemblies such that the two spar blade springs open when released.

Completely fold the entire helicopter recovery device as follows. First fold back the axially hinged blade. Bring the two blade tips together and carefully try to slide the complete assembly into the rocket tube. It probably will not fit smoothly the first attempt, so don't worry. Sand any areas that seem to be interfering with a smooth fit. If the rubber band at the hinge assembly is rubbing against the tube, cut two small notches into the corners of the balsa blocks, and the rubbing should cease to be a problem.

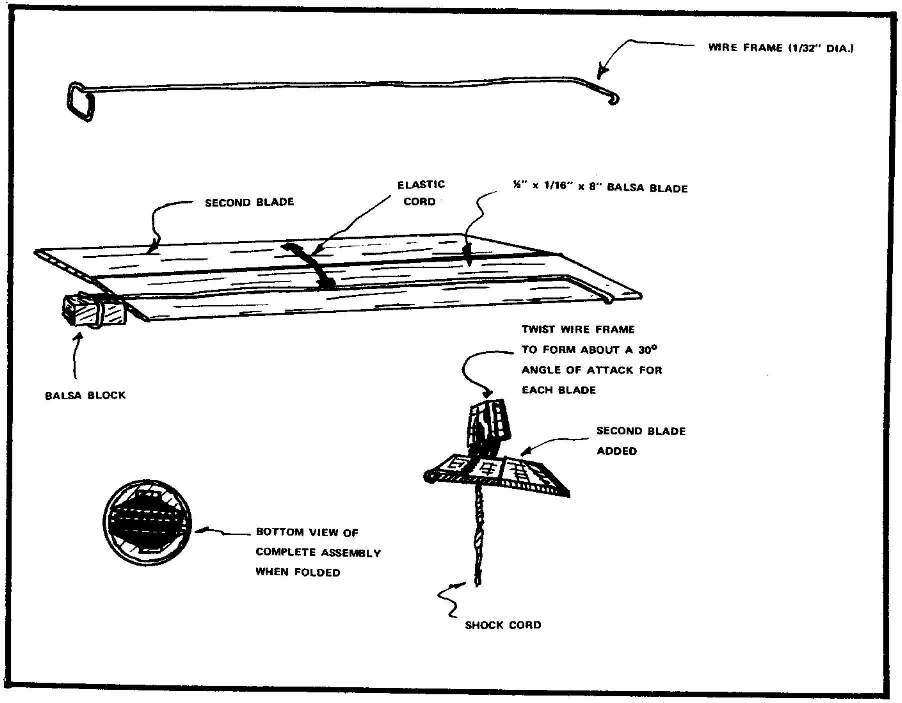
Paint the helicopter device with only the thinnest of coats of paint, as a unit too heavy will not work. Install the free end of the shock cord to the inside of the rocket tube as close to the engine as you can get it. With the prototype phenolic vehicle, a small hole was drilled into the side of the tube and the shock cord passed through with a small piece of wire glued along the tube fastening the shock cord securely. Do not attempt to do this with a cardbaord rocket tube as the wire will most certainly rip through the side of the tube if it is pulled too hard.

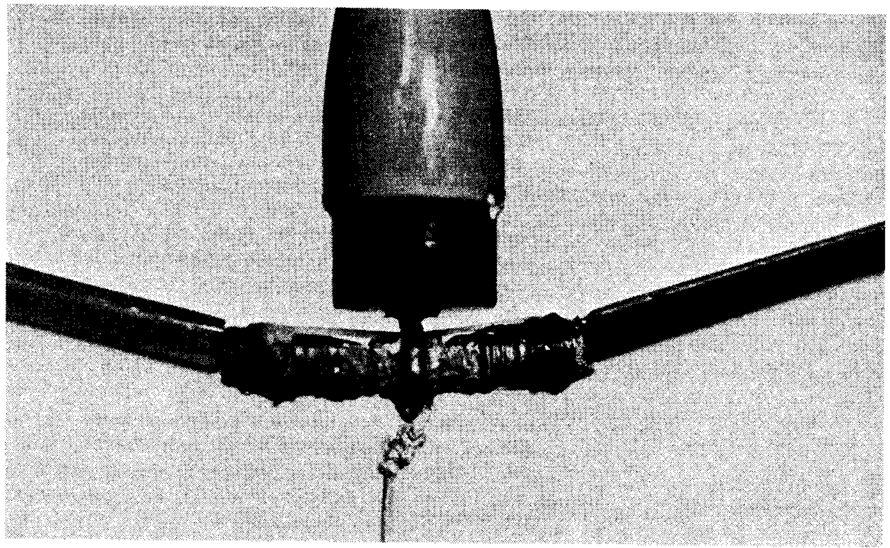
A small but dense wad of flameproof recovery packing should be used to minimize gas leakage. When packing the helicopter recovery device, take special care to insure that the shock cord is not snarled with the helicopter blades. The cord should be placed right down the center of the assembly.

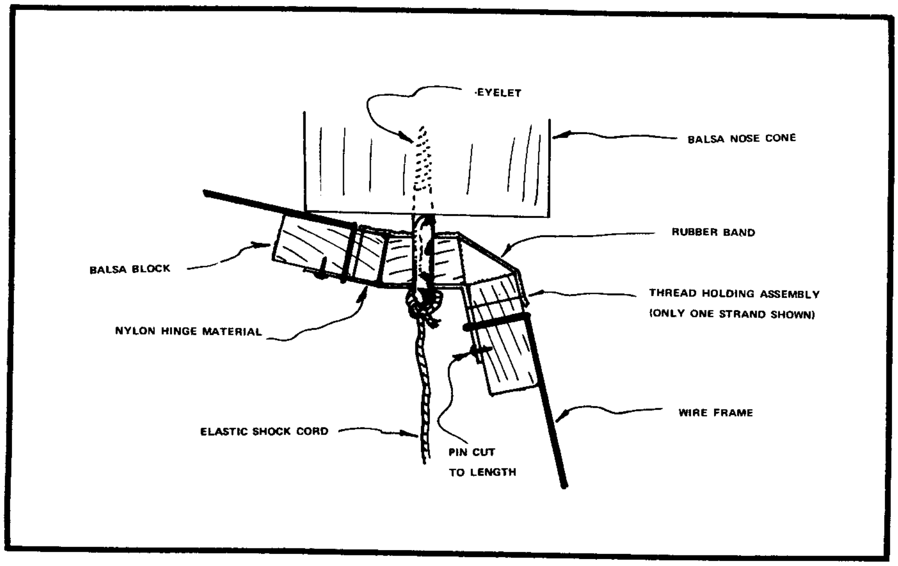
When not flying the rocket, store the helicopter recovery device outside the tube in the unfolded position. This will insure that the rubber bands do not lose their strength prematurely.

Summary

One of the most important things that was learned early in the test program was that it is very difficult to track a model rocket at high altitudes which does not have a big colorful parachute or streamer billowing along behind it during the descent. This fact is probably the biggest (and unanticipated) disadvantage inherent with helicopter recovery. This fact was not noticed before the test program simply because the GYROC with which we were familiar, never went high enough for tracking to be a problem. It was inevitable that the rocket would be lost, and it is only luck that allowed the rocket to be found enough times for the recovery device to be finally made successful.

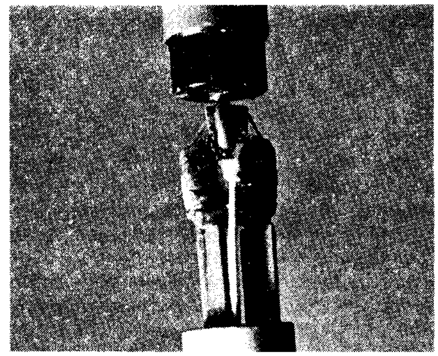






Flight History

1.	B14-5	Launch vehicle flown with parachute, single stage; flight successful.
2.	B14-5	Single stage flight with payload section simulating weight of helicopter device; parachute recovery; flight successful.
3.	C6-5	Same as above; parachute deployed during ascent, breaking shock cord; rocket streamlined in from over 1000 feet and sank 9" into ground; no damage.
4.	C6-7	Same; extra two seconds of time delay to allow rocket to reach peak altitude; almost out of sight, successful recovery.
5.	B14-5	First test with helicopter device; blades fouled on shock cord, rocket tumbled down; no damage.
6.	B14-5	Same; helicopter device failed to stabilize, tumbled down beside rocket; no damage.
7.	B14-5	New axially-folding, wider blades installed. Recovery device fouled on shock cord; minor damage to helicopter blades.
8.	B14-5	Elastic bands added to unfold blades; rocket climbed to about 1000 feet and dropped to about 700 before recovery device spin rate was adequate to slow descent; flight successful.
9.	C6-7	Same; rocket climbed to about 1500 feet; descended with device operating perfectly from about 1000 feet; flight successful
10.	B14-0, C6-7	First two stage flight; rocket climbed almost out of sight; descended perfectly; flight successful.
11.	C6-0, C6-7	First attempt at maximum altitude; rocket climbed out of sight; returned with snarled shock cord; no damage.
12.	C6-0, C6-7	Same; helicopter device worked perfectly.
13.	C6-0, C6-7	Same as above.
14.	C6-0, C6-7	Same; recovery crew lost sight of rocket and rocket could not be found.



The helicopter recovery device is folded back on itself to fit neatly in the body tube.

Reliability of the helicopter recovery device was not as high as the simpler streamer of parachute systems in use with most model rockets. If a parachute fails to open, it at least helps to slow the descent somewhat. The helicopter recovery device, when not spinning along perfectly, had about the same terminal velocity as the rocket itself, and as such, did little to soften tie impact of landing. If reasonable care is exercised, however, there is no reason why helicopter recovery systems cannot be used. Paint your rocket a very bright color, and you have an advantage on windy days.

As interesting as the recovery system, was the rocket itself. Phenolic tubing and phenolic fins are extremely strong and long lived materials for model rocket applications. After thirteen recoverable flights, five of which involved landings which were somewhat less than soft, the rocket looked as if it had never been flown at all. The booster is on its second set of balsa fins and the booster tube looks like it is new. It has been performing as a workhorse booster ever since the original rocket was lost.

Experience with phenolic materials has prompted the construction of a two-stage F engine rocket with minimum diameter and 1/32" fiberglass fins. The rocket has been flown successfully and a report will soon be published describing the flight tests and construction. You may be interested to know that the vehicle survived a recovery system failure from over 4000 feet and survived without a mark!

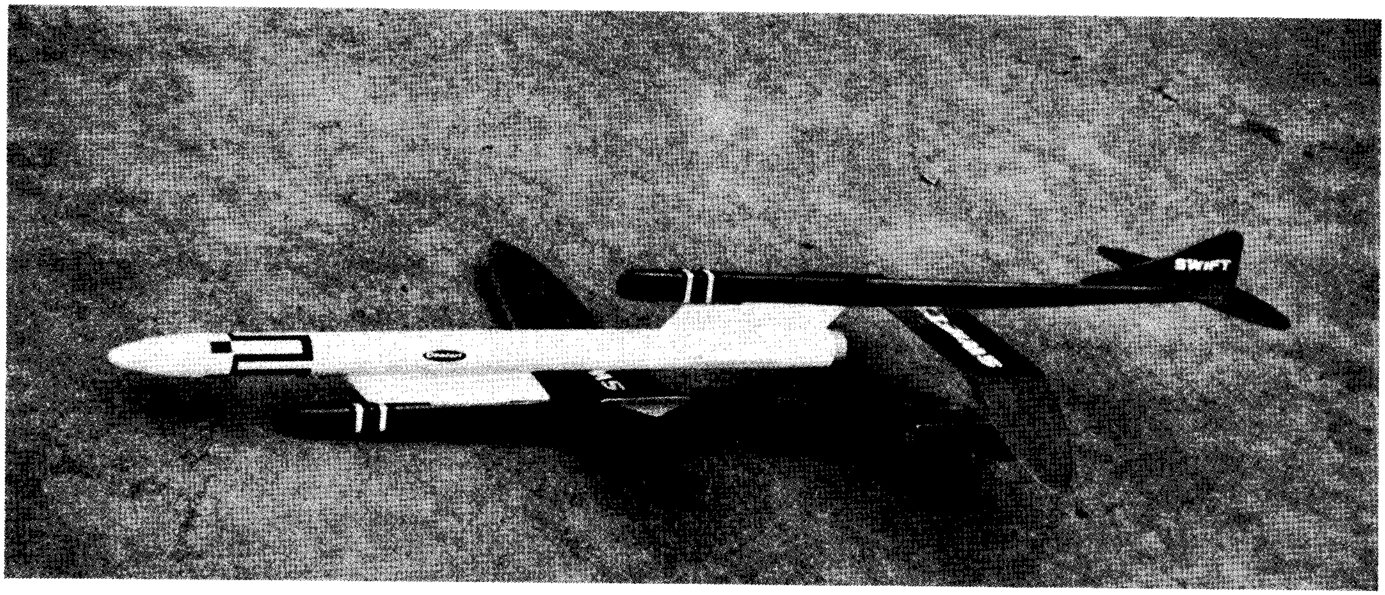
Q&A

I am very interested in soft-landing model rockets using retrograde engines. I would like to know where I can buy Jetex engines, as they are not available in Butte.

Jerry Absher
Butte, Montana

As I mentioned in my article, I strongly recommend that you do not attempt to use a Jetex 50B engine as a retrograde thruster for rocket thruster for rocket recovery. Half the time they don't ignite, and they also have a nasty habit of allowing all their exhaust to escape out the side when the wick jams in the nozzle. They have also been known to explode.

Actually, as I subsequently found out by speaking to Lindsay Audin about it, he used a Jetex HT-50 rather than a 50B. This engine has a thrust of about four ounces for two seconds and a larger nozzle than the 50B, so there is no wick jamming problem. Still, though, half of the time it won't ignite because the wick burns so badly. If you still want one, though, you can buy one by mail order from America's Hobby Center, 146T West 22nd Street, New York, New York 10011. I believe the HT-50 is $1.49 and the fuel pellets and wick are 20 for 98 cents, but it has been many years since I checked and you should request price information before actually placing the order.



MELVILLE BOYD describes how to get double the fun out of your boost/glide flights. Build the Super-Swift, two Centuri Swift B/G's mounted on a single pod. The Super-Swift can be constructed entirely from the parts contained in two Swift kits. The Super-Swift is ideal for testing your B/G modifications, mount one unmodified glider and your test bird on the pod at the same time and compare their performance.

The SUPER SWIFT is a simple and elegant modification of two standard Centuri SWIFT kits. Each kit is constructed in the normal manner, with the following exceptions:

1. The lower pod has a thrust ring glued where the nose cone would be.

2. The upper pod has no engine mounting, but is glued onto the lower pod.

3. The pods are positioned such that the glider mounts are at 180° to each other.

4. The rear end of each glider mount tab is rounded to facilitate smooth release of the gliders upon ejection charge.

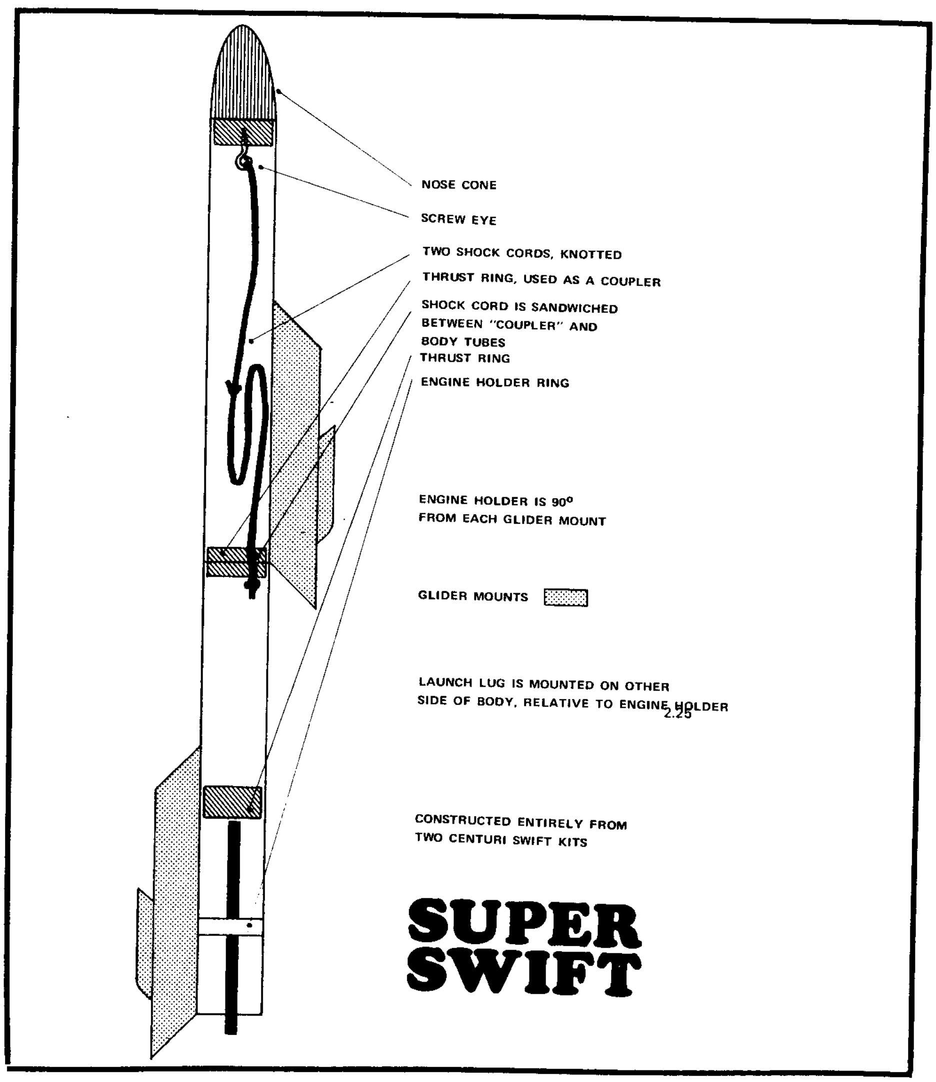
5. The two shock cords are tied together and slipped around the "coupler" before it is glued in place.

The following parts will be excess: (one each) screw eye, nose cone, parachute kit, engine holder and retainer ring. These are handy extras to keep for future designs.

The SUPER SWIFT probably would not be allowed to compete, in NAR sanctioned boost-glide competition, but it is great fun. Launching two similar gliders with the same boost vehicle provides an excellent opportunity for comparing each glider's performance.

Super-Swift

Length, with pod	**23"**
Wingspan	**11"**
Glider weight	**0.402 oz.**
Total weight	**1.502 oz.**



How to Make Your Own Body Tubes

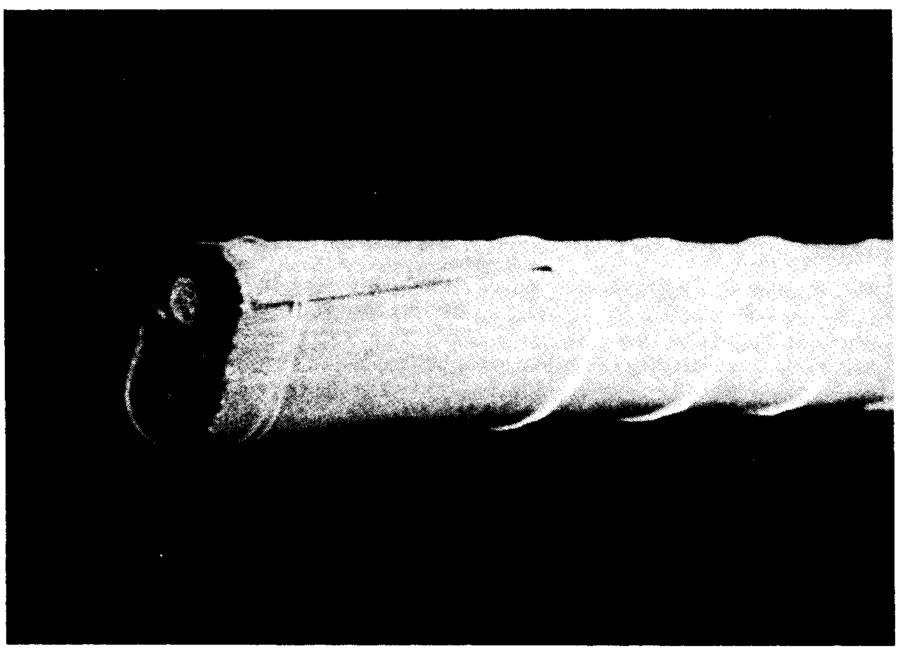
by Carl Kratzer, NAR 5568

The "classic" methods for construction of body tubes from paper, sheet balsa, block balsa, and plastic are described. Especially helpful to the scale modeler about to tackle his first non-kit scale bird..............................

Most model rockets use a cylindrical body tube as the primary structural member. The greatest majority of rocketeers use commercially manufactured thin-wall paper tubes for their models. These tubes are available in a wide range of diameters and lengths. There are certain instances, however, when it is desirable or even necessary to fabricate your own tubes. Typically, a scale model which requires two or more body diameters is unlikely to be adaptable to commercial tubes, making it necessary to roll at least one tube by hand.

Paper Tubes

Paper tubes are wound by two methods: parallel and spiral. Parallel wound tubes, such as those used as engine mailing tubes, are quite strong but also rather heavy and are not commonly used in commercial kits or plans. On the other hand, spiral wound tubes are much lighter and still have adequate strength for most normal applications. A description of the method of rolling a spiral tube by hand was given by John Pollock in his Nike-Apache scale article (MRm November, 1969), therefore we will restrict the following discussion to the fabracation of parallel wound tubes. Very little experimentation has been done with different papers and adhesives for rolling body tubes though a few types have been recommended by various sources. Many types of paper can be found at art supply and stationary stores. Paper density is normally specified by its weight per ream of basic stock. A ream is simply 500 sheets and basic stock size is 24 by 36 inches; of course, the paper is available in smaller quantity and dimensions. The old NAR technique reports recommended 100 pound tagboard stock or 125 pound (two-ply) bristol stock. These papers are stiffer than ordinary writing papers and thus well-suited for this application. If available, a lighter stock would be more manageable though more windings will be required to achieve an equivalent strength. Some papers are available with glossy coatings and with flourescent colors; these may be experimented with by the energetic modeler.



Balsa body tubes can be constructed in a variety of shapes. This one allows the body tube to taper to the shape of two 18 x 70 mm engines to reduce the model's drag.

Probably the most suitable adhesive for rolling body tubes is bookbinding cement although any paper glue *which does not shrink* can be used. White glue and mucilage are not recommended as they will cause the paper to wrinkle and curl.

The body tube must be wound around a sturdy form which has an outside diameter equal to the desired inside diameter of the tube. Either a hardwood dowel or piece of metal tubing will work nicely. Other paper tubes can be used as forms provided they are not too easy to deform. The amount of paper needed will depend upon the desired thickness and strength of the tube. The winding process should be started by first attaching one end of the paper along the length of the form with small pieces of "magic" tape. The tape will adhere firmly enough to prevent slippage during rolling yet allow the finished tube to be removed from the form. Next spread a thin layer of glue along the paper about 3/8 inch from the attached end. Continue spreading glue along the paper at regular intervals and roll the paper tightly around the form. Finally, secure the loose end of the paper to the tube and wrap several rubber bands around the tube to keep it from slipping. Extra care must be taken to avoid gluing the tube to the form.

Balsa Tubes

Paper body tubes are certainly the most simple to purchase or produce by hand but they do have some shortcomings. All paper tubes have a seam which is unsightly and not easy to hide. Also some types of paper do not accept as brilliant a finish as others. In the case of high-performance birds, perhaps the body contributes more weight than desired. These drawbacks can be minimized by using hand-rolled balsa bodies. Considerably more skill and patience is required to make a successful balsa tube but the results usually warrant the effort.

To roll such a tube you must use a form like that discussed previously. Recall that the diameter of the form must be selected to match the inside diameter of the final tube. A piece of thin sheet balsa is selected such that the width (across the grain) is cut to the circumference of the tube and the length (along the grain) is cut to the length of the tube. The thickness will depend upon the diameter of the tube and the quality of the stock; in general 1/32 inch wood should be used for diameters up to about 1 inch and 1/16 for tubes between 1 and 2½ inches in diameter. Immerse the balsa into a bath of lukewarm water and allow it to soak until the sheet becomes soft and pliable. Remove the wood and line the grain up along the length of the form and carefully wrap the balsa around it. The edges of the balsa will form a butt joint which is sealed later. Several tight rubber bands should be wrapped around the tube while it dries out. After the tube has dried completely it will retain its present contour. Apply balsa cement or body putty into the joint and cover the entire tube with a single layer of Japanese tissue or silkspan (in general, available at most hobby shops and model aircraft suppliers) using clear dope as an adhesive. The resulting tube should be a bit lighter and easier to finish than a standard paper tube.

Some scale models, such as the V-2 and Regulus, require tapered airframes. Though it is possible in certain cases to construct the body with a series of paper tubes, adapters, and tail cones it is often desirable to use a single homogeneous member. Balsa bodies of this type can be turned on a lathe or power workshop with relative ease and good results. Unfortunately few modelers have access to such equipment and must settle for less. Twenty dollars or less can be spent on a "toy" workshop such as the Mattell product. I have used this tool with varying degrees of success. It is only good for pieces up to six inches in length but dies include a guide template to incure accurate reproduction of the prototype. If you use this workshop, I recommend a minor modification to the dead center. In place of the plastic center provided with the tool, substitute a short length of hardwood dowel glued into the end of the balsa block. The diameter of the dowel should be slightly less than that of the depression in the tailstock. This change will eliminate excessive vibration of the block while spinning. After the body had been turned it should be sliced in half lengthwise and hollowed out with a modeling knife or router. The halves should be cemented together with an engine holder tube through the center. The seam can be sealed with body putty.

Plastic Tubes

Some of the rocket manufacturers sell plastic body tubes in the same sizes as their line of paper tubes. Generally these tubes are used as transparent payload sections or for dummy models; the tubes cannot withstand the heat caused by a rocket engine exhaust flame or ejection charge. Plastic tubes are not normally used in competition birds since they are heavier than their paper counterparts. Scale models of finless prototypes are usually fitted with clear plastic fins to stabilize the model without detracting from its scale qualities. In the past rocketeers rolled collars from clear sheet plastic onto which the clear fins were appended. An easier and more attractive method is available by simply replacing this homemade collar with a length of clear plastic tubing. In several cases plastic tubes are available in sizes just larger than other commercial paper tubes; most notably an Estes PST-40 fits over an Estes BT-20 and a Centuri No. 10 plastic tube fits over an Estes BT-50. Plastic coin tubes (available from coin dealers) also fit over some standard tube sizes. Duco or styrene cements can be used as adhesives.

On occasion it may be necessary to have a stronger body of payload section than can be acquired with paper or balsa tubes. Any modeler launching delicate photographic or electronic payloads would like to decrease the effect of damage due to a recovery failure. Fiberglas is among the strongest plastics known and is also quite easy to pripare. Sig, AHC, and other hobby distributers have the materials available in kit form and individually. The body form must be coated liberally with release agent to prevent to prevent bonding of the resin to the form. The resin and catalyst are mixed accurately according to the instructions provided with the kit; resin will not harden alone. The working time with the catalyzed resin is about 15 minutes. Brush the mixture evenly on the form and apply three or four layers of glass cloth around it. Brush additional coats of resin until the cloth is thoroughly impregnated and allow to cure. If necessary, tie the cloth nin place with pieces of thread.

The resulting tube, when removed from the form, will be highly resistant to sheer forces coused by stable recovery and can also protect its contents in case of rain. Epoxy should be used to attach other components to the fiberglas. Catalyzed resin can also be used alone as a fireproofing or hardening compound for paper or balsa body tubes.

Other Materials

Rocketeers have experimented with other types of body tubes and some of their results can be summarized in this section. Paper tubes obtained from rolls of wrapping paper, tiolet paper, aluminum foil, and the like are generally unsuitable for use in model rockets. They are thicker, heavier, and weaker than commercial body tubes and often have a very pronounced seam which is highly susceptable to structural failure in addition to their unsightliness. Rolling tubes from aluminum has been tried unsuccessfully, and one infamous modeler once wound a body tube from masking tape. For large F-engine birds plastic golf club tubing has been used despite its relatively high weight and tendancy to warp. Other ideas are often tried and experimentation with new materials or methods is certainly encouraged.

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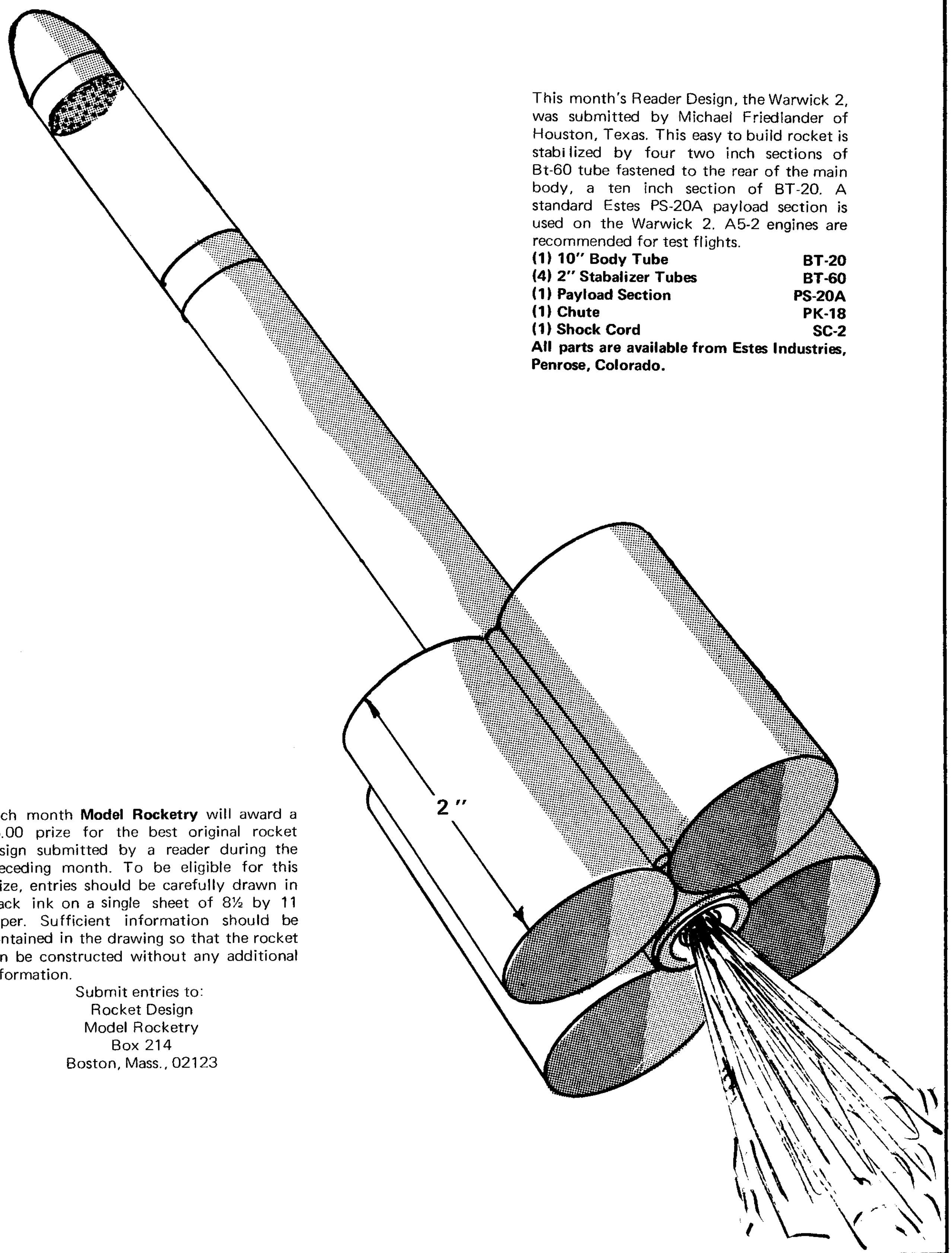
Reader Design Page



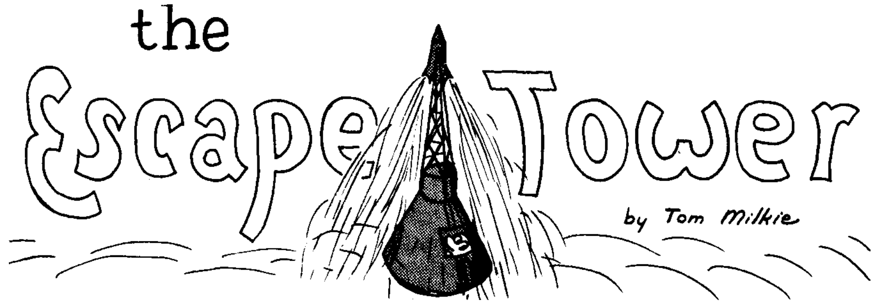
This month's Reader Design, the Warwick 2, was submitted by Michael Friedlander of Houston, Texas. This easy to build rocket is stabilized by four two inch sections of Bt-60 tube fastened to the rear of the main body, a ten inch section of BT-20. A standard Estes PS-20A payload section is used on the Warwick 2. A5-2 engines are recommended for test flights.

(1) 10" Body Tube	**BT-20**
(4) 2" Stabalizer Tubes	**BT-60**
(1) Payload Section	**PS-20A**
(1) Chute	**PK-18**
(1) Shock Cord	**SC-2**

All parts are available from Estes Industries, Penrose, Colorado.

Each month **Model Rocketry** will award a $5.00 prize for the best original rocket design submitted by a reader during the preceding month. To be eligible for this prize, entries should be carefully drawn in black ink on a single sheet of 8½ by 11 paper. Sufficient information should be contained in the drawing so that the rocket can be constructed without any additional information.

Submit entries to:
Rocket Design
Model Rocketry
Box 214
Boston, Mass., 02123



THROW YOUR ROCKETS OUT THE WINDOW!

If you ever want to find the effect of drag on your rockets in order to calculate altitude, optimize design factors, design lowest drag systems, etc., you would have to have access to a fairly expensive wind tunnel and balance system. After many hours of work you would probably arrive at a drag coefficient that is inaccurate due to wind tunnel turbulences, balance inaccuracies, and gauge errors. Soon you would probably become so disgusted that you'd throw your rockets out the window. Now you're getting somewhere!

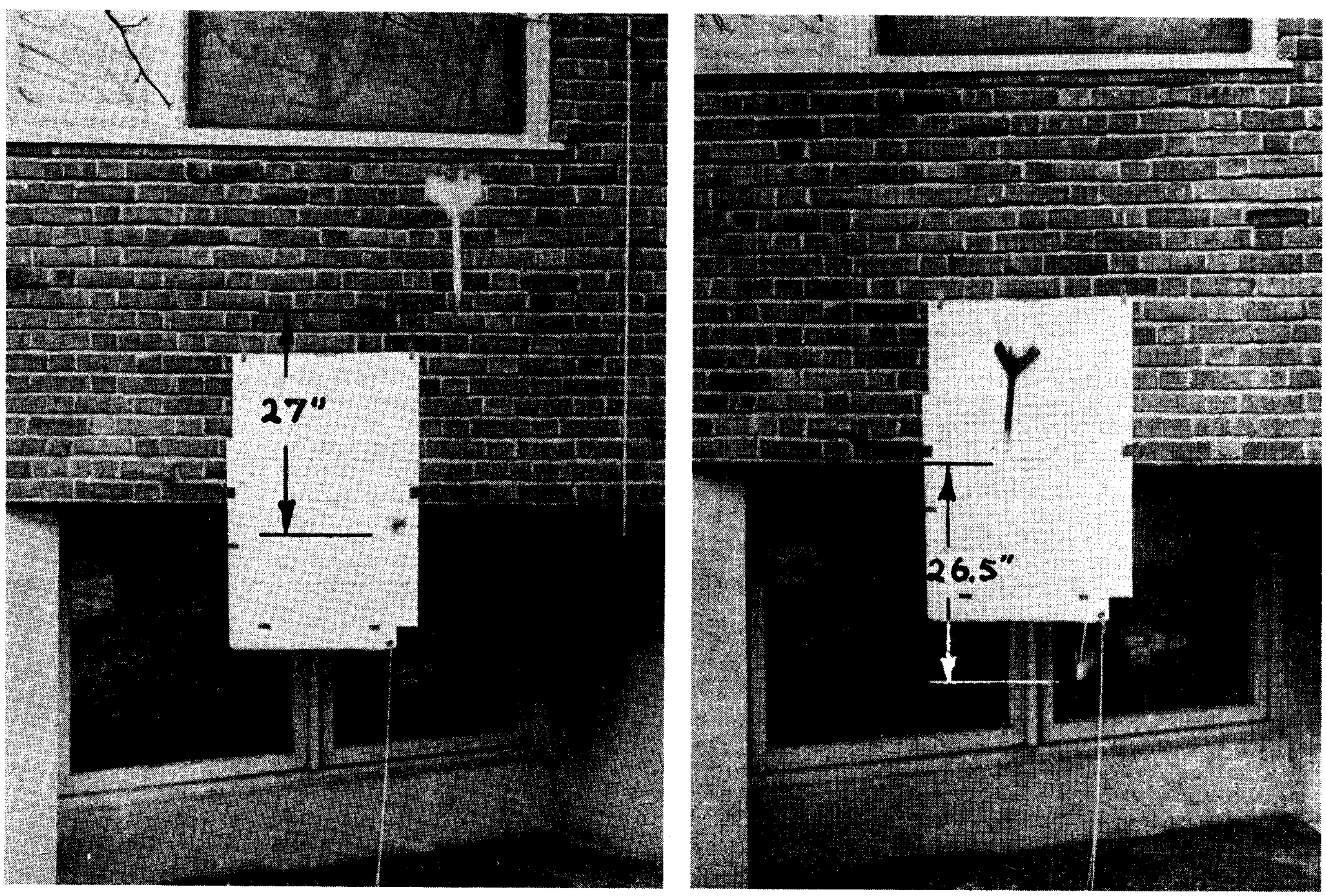
After all, what's a better way to find out the drag coefficient than to let the rocket fall smoothly through the air and see how much drag slows it down! Basically, the system explained herein is this: You drop your test rocket and a heavy mass at the same time from a known height. Since the mass falls without much affect of drag, and the rocket is slowed down by drag, a photograph of the rocket and the weight will show a separation. This measure, along with other factors, can lead to a calculation of the drag coefficient.

This method can be used to test any stable rocket design, except for some boost/gliders and odd designs. To increase the effect of the drag, the rocket is dropped without an engine. (This also makes the rocket stabler, which can be of some advantage.) Some designs, though may have to have an engine in place to make them stable.

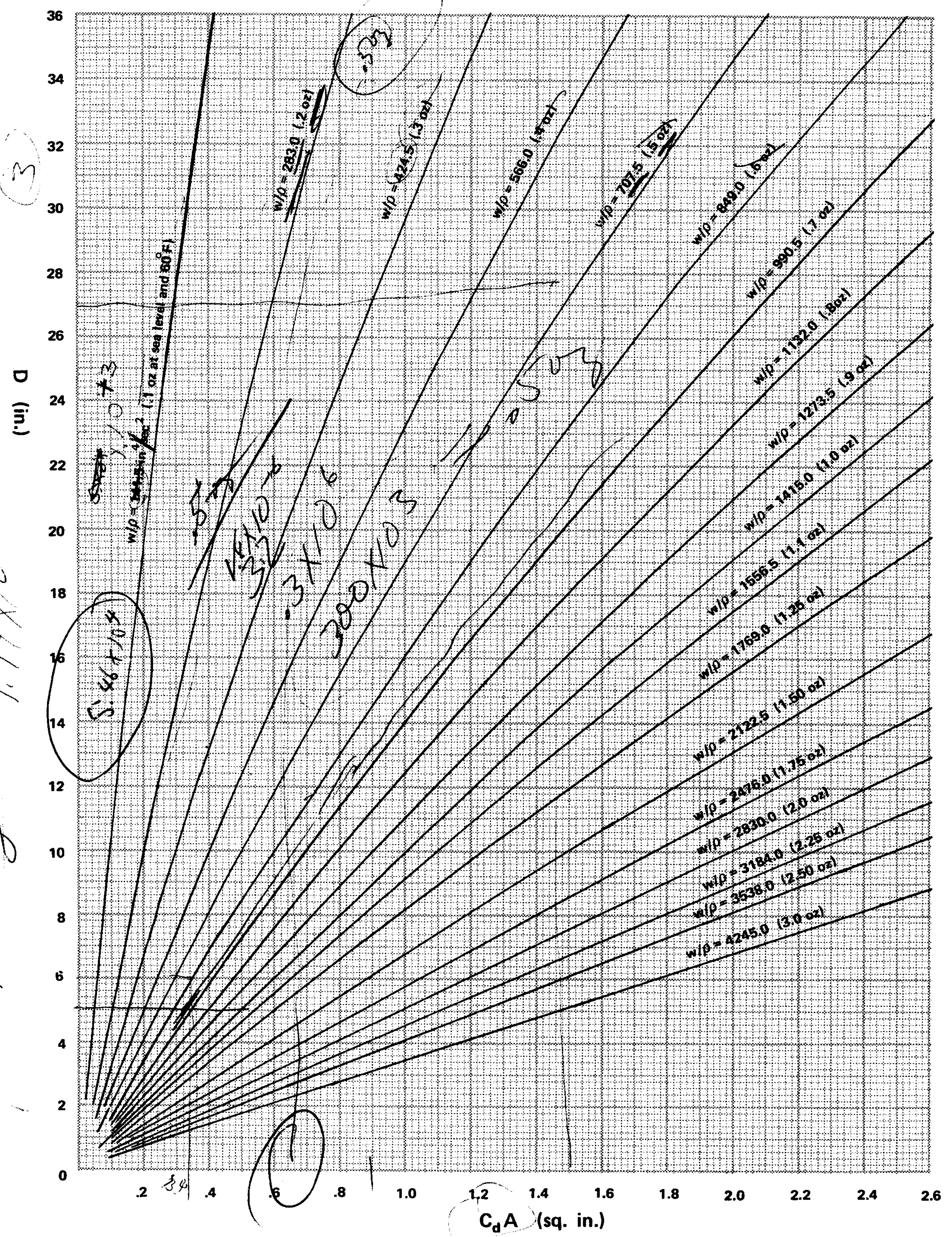
The weight need not be very streamlined, just heavy and visible. A padlock was used in some of the tests, as was a ball peen hammer. A heavy lead sinker would probably do quite well. The only important consideration is that the weight should not damage the rocket when it bounces around after landing. You may question why a "heavy weight would have less drag than a light rocket". The fact is, the weight may have **more** drag force acting against it, but it will also have **more** force pulling it towards the earth. (After all, F = MA, said Isaac Newton.)

The height that the rockets were dropped from was 25 feet (300 inches). The graphs are based on this height since it is always possible to find a place that high (the roof of a two-story building), and because adequate differences between the rocket and the weight are observed (around 6 inches). Higher altitudes are better (more accurate) but you will have to work with the equations shown to get data.

The nagging question in your mind is now probably: "What do I care about the drag coefficient of a rocket that I just pranged by throwing off the roof!" However, with the engine removed, the rocket does not acquire much momentum in the fall and cannot really damage itself. A loosely folded blanket is sufficient to



Here are some results: The weight used here is a padlock. Careful measurement of the photo can determine D, regardless of any blurr. Note that the chart is marked in inches and the 25 foot mark is designated.


D (in.)
$C_d A$ (sq. in.)
0
2
4
6
8
10
12
14
16
18
20
22
24
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30
32
34
36
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
(.1 oz at sea level and 60°F)
w/ρ = 283.0 (.2 oz)
w/ρ = 424.5 (.3 oz)
w/ρ = 566.0 (.4 oz)
w/ρ = 707.5 (.5 oz)
w/ρ = 849.0 (.6 oz)
w/ρ = 990.5 (.7 oz)
w/ρ = 1132.0 (.8oz)
w/ρ = 1273.5 (.9 oz)
w/ρ = 1415.0 (1.0 oz)
w/ρ = 1556.5 (1.1 oz)
w/ρ = 1769.0 (1.25 oz)
w/ρ = 2122.5 (1.50 oz)
w/ρ = 2476.0 (1.75 oz)
w/ρ = 2830.0 (2.0 oz)
w/ρ = 3184.0 (2.25 oz)
w/ρ = 3538.0 (2.50 oz)
w/ρ = 4245.0 (3.0 oz)

completely cushion the impact.

To determine the difference in height between the rocket and the dropped weight when they reach 25 feet will require photography. The camera should be tripod mounted (or mounted firmly on some kind of stand) and the shutter released by a cable. With your expert camera eye trained by taking pictures of rockets accelerating off the pad, you should be able to catch the rockets in the picture after a friend releases them from above. A shutter speed of 1/200th of a second or faster is desirable.

If you don't have all this equipment, don't dismay. Your camera can be mounted on a table or chair, set to take a picture of the falling rockets. A cable release is not necessary. Even a camera like an Instamatic (fixed shutter speed of 1/90th of a second) can be set up, capable of measuring differences to the inch.

The picture can be blurred considerably, as long as it is possible to see where the beginning of the blurr is. I have even taken useable pictures from a hand-held camera. To help snap the shutter at the right time, have your friend dropping the rocket and weight give a short countdown, and make some trial tests to estimate timing. You needn't catch the weight as it exactly passes 25 feet, anywhere near that will be fairly accurate. The most important thing is to make sure that the "dropper" releases the rocket and weight at the same time and with the tip of the rocket level with the bottom of the weight. Take a few shots to be certain that you got a good one.

Very important in the use of the photographs is a backdrop marked with horizontal lines at one inch intervals (or smaller). Make this with a marker pen on a 2 ft. by 3 ft. cardboard sheet which will be taped to the wall during the drops. An important thought when making this backdrop is this: If the rocket and weight are dropped so that they pass the backdrop one foot in front of it, a difference of 6 inches between the rocket and the weight may appear greater on the backdrop markings, due to the camera angle difference. Consult the diagram for a clearer explanation of this. For example: If the camera is 10 feet from the backdrop, the lines marked "inches" on the backdrop should really be 1.1 inches apart. This can amount to a difference in ten inches, so the affect cannot be ignored. Consult the simple equation for finding the scale markings on your backdrop. One hint: To keep track of rockets dropped, put a card with a number on it in the view of the camera. Also put the temperature on the card, as they may be helpful during later calculations.

For more experienced photographers, this photographic problem can be solved with a high degree of accuracy. The camera shutter may be tripped by the weight hitting a switch upon landing. Even better, the experiment can be run in a stairwell or other indoor facility (also good because it is more draft-free) or at night, so that the shutter can be opened and the dropping weight can activate a strobe flash. If you're really tricky, you may be able to use photographic paper as the backdrop and have the falling weight operate a flashbulb, casting a shadow

How to Find the Drag Coefficient

First drop your rocket (without an engine) along with a heavy weight from 25 feet and photograph it as described in the article.

From the photograph, determine as accurately as you can, the difference in height between the bottom of the weight and the tip of the rocket. This measure is refered to as D. Let's say that this comes out to be around 5.0 inches for an Estes Alpha.

The density of air is determined by consulting the density graph, knowing the altitude of the test site (above sea level) and the temperature. If you are testing at 75 degrees Fahrenheit, at an altitude of 2000 feet above sea level, then the density equals about 1.74×10^{-6} (oz-sec^2/in^4).

When you have a good value for the density, find the weight of your rocket in ounces. Then compute the value of density/weight.

If your Alpha weighs in at .62 oz., then $W/\rho = 2.81 \times 10^{-6}$ sec^2/in^4.

Find the curve with approximately this value of W/ρ on the second graph, then find your value of 5.0 inches for D. This point of the line had a value of .35 for the CdA. You could then compute estimated altitude, etc. with this value for CdA.

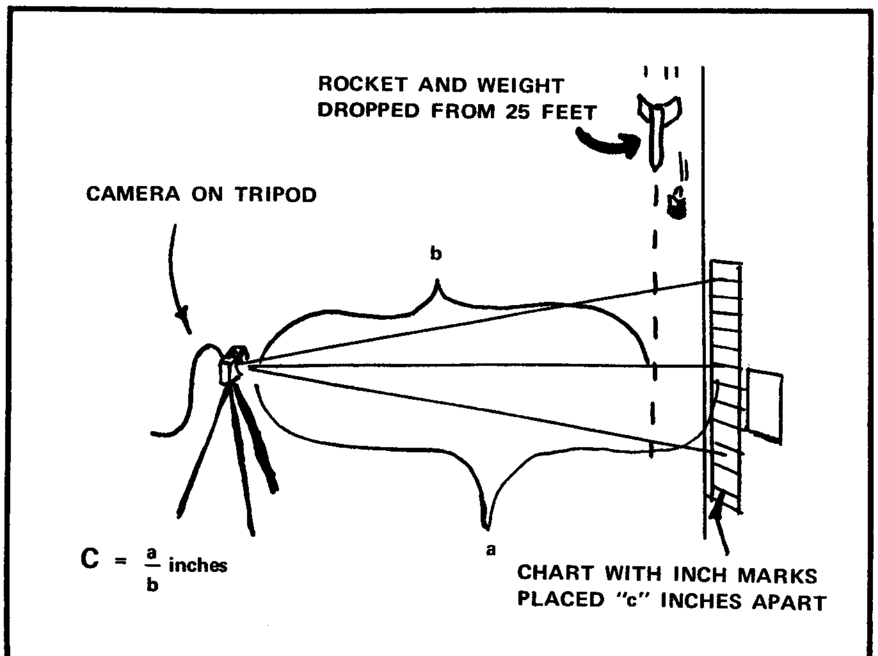
However, you could find just the coefficient of drag (Cd) by dividing CdA by the frontal area of the body tube. A = .785 x (diameter squared). For a BT-50, A = .785 x .976^2 = .750. Cd for the Alpha then equals .467.

If you wish to do your own calculations on models beyond the range of the graph, this is the basic equation used:

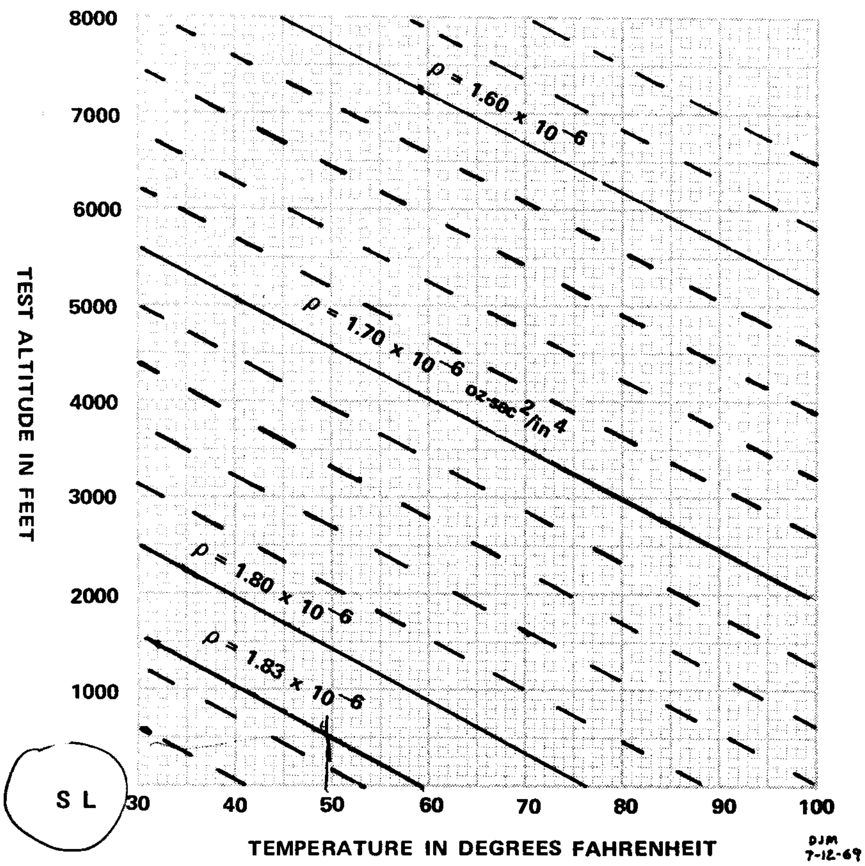
$$D = H_0 - \left[\frac{\ln\left(e^{2\sqrt{\frac{H_0 \rho C_d A}{m}}} + 1\right) 2m}{\rho C_d A} - 2\sqrt{\frac{H_0 m}{\rho C_d A}} - \frac{1.385\, m}{\rho C_d A} \right]$$

D = difference in height between rocket and weight
H_0 = height from which dropped
ρ = density of air
Cd = coefficient of drag
A = frontal area of rocket
m = mass of rocket

Units used in the graphs were all inches, ounces, seconds, etc.



AIR DENSITY COMPENSATION GRAPH



on the paper! To keep the separation small, drop the rockets from a shorter height. Another untried possibility is to use a movie camera.

Besides the difference in height of the weight and the rocket (referred to as "D"), you will have to record the air temperature, as this is needed to compute the air density, which affects the final result. Just as important is an accurate measure of the weight of the rocket (in the configuration when tested). When you know the value of air density/weight of the rocket and D, you can, by consulting the graph, find the factor C_dA. This is the coefficient of drag times frontal area, and need not be further reduced, as the value C_dA is used in predicting altitudes and optimizing designs.

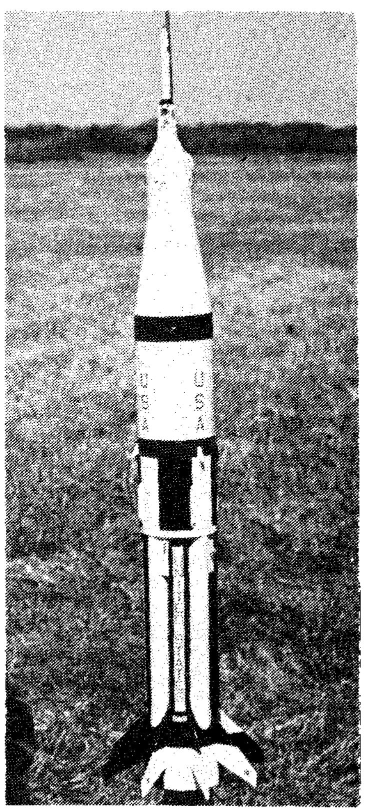
The equation for finding C_dA was derived from the basic drag equation:

$$F = \tfrac{1}{2}\rho C_d A V^2$$

As you can see, the final equation does not show C_dA in terms of other factors. It is quite transcendental (meaning that) as the data in the graphs was determined by computer.

If all measurements are kept accurate, this method can determine C_dA to an accuracy of .001 square inches. To those not familiar with C_dA, lowering this factor will decrease drag, and usually increase your altitude (though not always -- see Doug Malewicki's **Model Rocket Altitude Performance** report, **Centuri Engineering** (TIR-100).)

After explaining this method to a rocketry friend, he suggested another alternative: To find the C_dA of a Camroc rocket why not have it snap a picture just before it hits the ground and. . .



Underground Songs of The NAR

The Underground Songs of the NAR were snitched from an underground song sheet and from hidden tape recorders at NARAM-10. The persons, places and events described are purely fictional (unless you know otherwise). From time to time **Model Rocketry** *will publish selections from the underground song sheet.*

SATURN-B
(Words by Doug Frost)

Refrain: Saturn-B very pretty
And the Saturn's flight is neat,
But the price of the big Saturn
Is impossible to meet!

My heart was sold the day Vern told
Me Saturn scale was true;
A sadder man but wiser now
I sing this song to you.

Refrain.

When I was out at NARAM-9
Lee Piester said to me,
"Don't buy yourself that Saturn bird;
Buy something else from me!"

Refrain.

When out upon the rocket range
G. Harry said to me,
"Go buy yourself my Handbook and
I'll autograph it free!"

Refrain.

At NARAM-10 I came again
To fly my Saturn-One
Lee Piester brought his Saturn-Five
And spoiled all my fun!

Refrain.

Boost/Glider Performance

by Doug Malewicki

Part III

DERIVATION OF DURATION EQUATIONS

Parachute Duration

The parachute duration equation is not of major importance for this article, however following the step-by-step mental processes involved will prove invaluable. Once the basic concepts are understood, then the subsequent glider analysis should flow logically and be correspondingly easier to follow.

First let's try to understand exactly what happens to the parachute-rocket system as it is falling out of the sky. At the instant of engine ejection, the rolled up chute is kicked out and exposed to the airstream. The extra drag due to the chute at this time is very small and is not really doing much in terms of slowing down the rocket. This drag, however, is large enough to start unrolling the chute.

As the chute unrolls and begins to unfold, its drag becomes larger and larger until it snaps fully open. The resulting large aerodynamic drag just about stops (decelerates) the lightweight plastic chute in an instant, whereas the rocket body tends to want to keep going. Thus, a very large tension force occurs between the chute and the rocket body and the appropriately named shock cord stretches and hopefully does not break. This "opening shock", of course, decelerates the rocket body considerably over a short time.

Little by little the parachute-rocket system slows down to some steady downward velocity which produces an amount of aerodynamic drag which *just balances* the gravitational attraction of the earth on the system (the rocket's burnout weight). It is from this point in time–when there are no further unbalanced forces and accelerations on the system–that we proceed with our analysis.

Now that the parachute-supported rocket is coming down at a steady rate called the sink velocity (sometimes referred to as the terminal velocity), we can see that we can draw a free body diagram which shows the aerodynamic reaction force (drag (D) in the case of a parachute) balancing the weight (W).

Thus for a steady sink velocity V_S we can write the balance equation:

$$W = D$$

But we know that the aerodynamic drag force itself depends on the parachute drag coefficient (C_D), its surface area (S), the air density (ρ) and the sink velocity (V_S) according to the familiar relation:

$$D = C_D S \tfrac{1}{2}\rho (V_S)^2$$

Thus, substitution of equation 2 into 1 gives:

$$W = D = C_D S \tfrac{1}{2}\rho (V_S)^2$$

which we can now directly solve for the sink velocity V_S.

$$W/(C_D S \tfrac{1}{2}\rho) = (V_S)^2$$

Or, taking the square root of both sides

$$\boxed{V_S = \sqrt{(W/S)}/(\sqrt{C_D}(\sqrt{(\tfrac{1}{2}\rho)}))}$$

This equation will give the sink velocity in feet per second of any weight-to-surface area (W/S) parachute having any drag coefficient (C_D) under any atmospheric density condition (ρ).

The *duration* is simply the *inverse* of the *sink velocity* and gives the time to come down each foot of altitude.

$$t = \text{Duration time} = 1/V_S = 1/(\text{ft./sec.}) = \text{seconds/one foot}$$

For convenience we deal with the duration times for the parachute falling each 100 feet of altitude (t_{100}) which, of course, will be 100 times as long as the time to fall one foot.

$$t_{100} = \text{duration time per 100 feet of altitude}$$

$$t_{100} = 1/V_S(100 \text{ feet})$$

Now substituting the sink velocity V_S determined by substituting equation 3 into equation 4 we obtain:

$$t_{100} = (1/((\sqrt{(W/S)})/(\sqrt{C_D}(\sqrt{(\tfrac{1}{2}\rho)}))))(100 \text{ feet})$$

$$\boxed{t_{100} = (\sqrt{C_D})(\sqrt{(\tfrac{1}{2}\rho)})/(\sqrt{(W/S)}) \times 100 \text{ feet}}$$

which is a completely general equation for duration for each 100 feet of altitude.

When comparing one parachute duration rocket to another, we normally restrict the performance to standard atmospheric conditions. The standard density for air at a sea level elevation and a temperature of 59°Fahrenheit is .002378 lb-sec^2/ft^4 as denoted by the symbol $\rho_{s.l.}$. Using a constant value for density means only two basic variables C_D and W/S remain, which means the results can now be plotted on graph paper.

If you are interested in actual performance at non-standard elevations and temperatures, you can take the air density of interest into account *after* determining the sea level standard performance through the use of the *density ratio* as defined by the greek letter (σ) *sigma*

$$\boxed{\sigma = \rho/\rho_{s.l.}}$$

where ρ is the variable density which depends on temperature and elevation and $\rho_{s.l.}$ is the fixed sea level standard density for a temperature of 59° F.

Basically

$$\rho_{s.l.}\sigma = \rho_{s.l.}(\rho/\rho_{s.l.}) = \rho$$

and using $(\rho_{s.l.})(\sigma)$ to replace its equivalent ρ (Equation 6) in the duration equation (Equation 5), we obtain:

$$t_{100} = (\sqrt{C_D}(\sqrt{(½\rho_{s.l.}\sigma)})/\sqrt{(W/S)})(100\ \text{feet})$$

In most applications of this equation, the density ratio (ρ) will equal 1.0 and you can see that the results will then be for flights in standard sea level density air.

Next, we want to substitute all the known constants into the equation to obtain a final equation with only one constant. Also note that since we model rocketeers use weight in ounces and surface area in square inches that the proper conversion factors must be included to insure that the duration times still remain in seconds.

$$16\ \text{oz.} = 1\ \text{lb.}$$

$$144\ \text{in.}^2 = 1\ \text{ft.}^2$$

$$\rho_{s.l.} = .002378\ (\text{lb.-sec.}^2)/(\text{ft.}^4)$$

With the above values Equation 7 becomes:

$$t_{100} = \frac{(\sqrt{C_D}(\sqrt{½(.002378\ \text{lb.-sec.}^2/\text{ft.}^4)\sigma}))}{\sqrt{((W\ \text{in oz.}/S\ \text{in in.}^2)(\text{lb.}/16\ \text{oz.})(144\ \text{in.}^2/\text{ft.}^2))}}(100\ \text{ft.})$$

$$t_{100} = ((\sqrt{C_D}\sqrt{\sigma})/\sqrt{(W/S)})(100\ \text{ft.})\sqrt{(.0001321\ \text{sec.}^2/\text{ft.}^2)}$$

$$= ((\sqrt{C_D}\sqrt{\sigma})/\sqrt{(W/S)})(100\ \text{ft.})(.0114939\ \text{sec./ft.})$$

$$t_{100} = 1.14939\ (\sqrt{C_D}\sqrt{\sigma})/\sqrt{(W/S)}\ \text{seconds}$$

which is the final equation for parachute duration for each 100 feet of altitude. Note that the drag coefficient and density ratio must be in terms of ounces per square inch in order to be compatible for use with the final form of the duration equation.

For sea-level standard parachute durations when the density ratio $\sigma = \rho/\rho_{s.l.} = 1.0$ the equation reduces to:

$$t_{100}\ \text{at sea level standard} = 1.14939\sqrt{C_D}/\sqrt{(W/S)}$$

or once the sea level standard duration is computed then the duration is computed then the duration at any elevation and temperature is found by multiplying by the square root of the density ratio $\sqrt{\sigma}$.

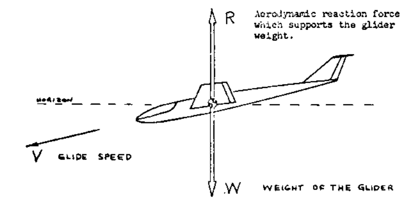
$$t_{100}\ \text{at any elevation and temperature} = (t_{100}\ \text{at sea level standard})(\sqrt{\sigma})$$

Values of the square root of the density ratio $\sqrt{\sigma}$ for various field elevations and air temperatures are presented in figure 4.

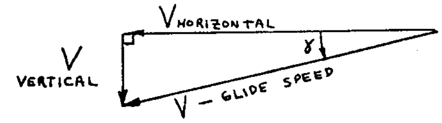
Glider Duration

As in the case of the parachute analysis, the equation we derive for glider duration only describes the *steady* gliding motion. Nothing can be said about the altitude lost and time spent by the glider between the time the pod ejects itself and the glider transitions from vertically upward flight to *steady* horizontal flight.

Once the glider has transitioned and is in a steady glide, we can draw a free body diagram similar to that shown in the derivation of the parachute equation.



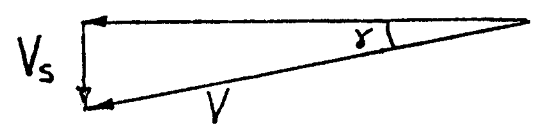
The weight of the glider (W) must be exactly balanced by the aerodynamic reaction force (shown as R). Note that the velocity of the glider is not straight down as in the case of the parachute, but is slightly tilted from the horizon.



where γ - the greek letter gamma is called the flight path angle

If we resolve the glider's velocity into vertical and horizontal components, we see that the vertical velocity shown above is what is called the sink velocity V_S for the parachute and which we will now also call sink velocity for the glider.

We already know that once we establish an equation for the sink velocity we can invert it to solve for glide duration in exactly the same way as done for parachute duration. One of the first things you should notice is that the sink velocity V_S can be related to the glide speed V as follows using trigonometry.

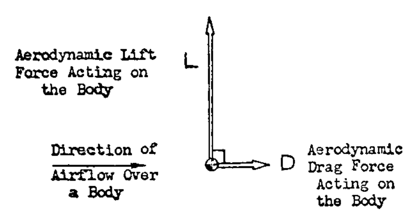


$$V_s = V\sin\gamma$$

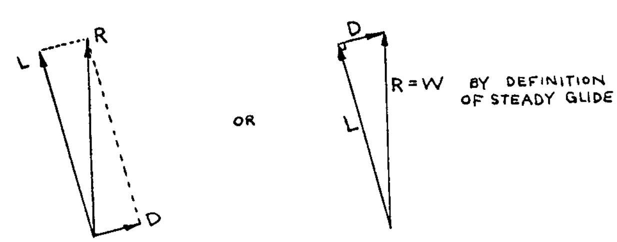
or

$$\sin\gamma = V_s/V = \text{sink velocity/glide speed}$$

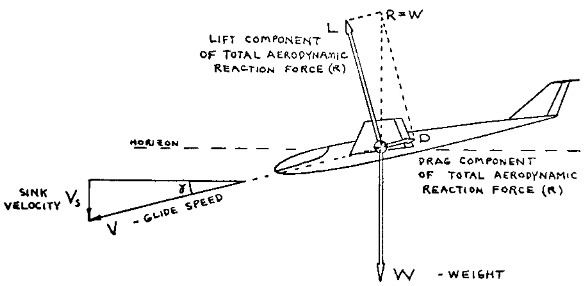
Now we are ready to discuss what makes up the aerodynamic reaction force (R) which supports the glider weight (W). From basic aerodynamics we know that LIFT FORCES (L) are aerodynamic reaction forces which act *perpendicular* to the airflow over a body and that DRAG FORCES (D) are aerodynamic reactions which act *parallel* to the airflow over a body as shown:



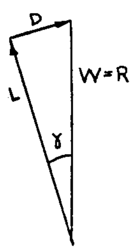
The total aerodynamic reaction rorce (R) is thus made up of two components–Lift and Drag.



Re-drawing a more detailed free body diagram we now have:



Especially note from the diagram that the angle between the lift force (L) and the total aerodynamic reaction force (R) *must equal* the flight path angle (γ) which helps establish several other trigonometric relations:



$$W\sin\gamma = D$$
OR
$$\sin\gamma = D/W = \text{Drag/Weight}$$

$$W\cos\gamma = L$$
OR
$$\cos\gamma = L/W = \text{Lift/Weight}$$

Now we can proceed to determine the sink velocity with the information gathered so far and the basic lift and drag equations.

$$\text{Lift} = L = C_L S \tfrac{1}{2}\rho V^2$$
$$\text{Drag} = D = C_D S \tfrac{1}{2}\rho V^2$$

where

C_L is the non-dimensional lift coefficient
C_D is the non-dimensional drag coefficient
S is the wing surface area used for size reference
ρ is the atmospheric sensity which equals $(\rho_{s.l.})(\sigma)$ as before, and
V is the glide speed

We start with equations 2 and 4 for sin γ

$$\sin\gamma = V_s/V \qquad \sin\gamma = D/W$$

which means, of course, that

$$V_s/V = D/W$$

or solving for the sink velocity

$$V_s = DV/W = (\text{Drag force})(\text{glide speed})/(\text{weight})$$

Substitution of Equation 8 gor drag gives:

$$V_s = (C_D S \tfrac{1}{2}\rho V^2)V/W = (C_D S \tfrac{1}{2}\rho\,[V^3])/W$$

The glide speed V can be determined form Equation 7 for lift and Equation 5 which relates lift and weight.

$$L = W\cos\gamma = C_L S \tfrac{1}{2}\rho V^2$$

or

$$W\cos\gamma/(C_L S \tfrac{1}{2}\rho) = V^2$$

meaning that the glide speed

$$V = \sqrt{(W\cos\gamma/(C_L S \tfrac{1}{2}\rho))}$$

raising to the third power we obtain:

$$V^3 = (W\cos\gamma/(C_L S \tfrac{1}{2}\rho))(\sqrt{(W\cos\gamma/(C_L S \tfrac{1}{2}\rho))})$$

Substitution of this V_3 equation into Equation 10 for the sink velocity then gives:

$$V_s = \frac{C_D}{C_L\sqrt{C_L}}\sqrt{(W/S)}\,\frac{\cos\gamma\sqrt{\cos\gamma}}{\sqrt{\tfrac{1}{2}\rho}}$$

now

$$C_L\sqrt{C_L} = (C_L)^{2/2}(C_L)^{1/2} = C_L^{\,3/2}$$

Thus, the badic equation for the sink velocity in feet per second becomes:

$$V_s = (C_D/C_L^{\,3/2})\sqrt{(W/S)}\,(\cos\gamma\sqrt{\cos\gamma})/\sqrt{(\tfrac{1}{2}\rho)}$$

and *inverting* it exactly as done in the case of parachute sink velocity yields the gliding flight duration in terms of seconds to come down each foot of altitude.

$$t = 1/V_s = (C_L^{\,3/2}/C_D)(\sqrt{(\tfrac{1}{2}\rho)}/\sqrt{(W/S)})(1/(\cos\gamma\sqrt{\cos\gamma}))$$

From this equation we can see that for maximum glider durations we'll want the largest possible aerodynamic glide factor $C_L^{3/2}/C_D$ and the lightest possible wing loadings W/S. You can also see that durations will be longer in cold air at sea level than in hot air at higher elevations because the atmospheric density will be higher for the standard day conditions.

You probably have also noticed that if the term $1/[\cos\gamma\sqrt{\gamma}]$ was not in this final equation that its basic form is the *same* as the parachute duration equation *when* $\sqrt{C_D}$ is substituted for the aerodynamic glide ratio $C_L^{3/2}/C_D$.

At this point we have to digress because we have a problem—namely that there are four variables involved in obtaining a final duration answer. These variables are the aerodynamic glide ratio, the wing loading, the air density, and γ as it appears in the cosine term. On two dimensional graph paper you can only plot two variables!

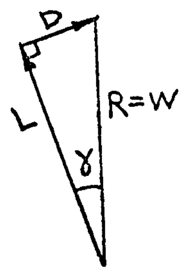
By using the constant sea level density $\rho_{S.L.}$ = .002378 lb-sec²/ft⁴ we eliminate one variable. If we are interested in atmospheric effects on glider durations we can modify the sea level durations using the square root of the density ratio correction $\sqrt{\sigma}$ exactly as described in the parachute equation derivation. It then, of course, requires a simple mathematical computation rather than a direct graphical answer. However in the majority of cases we are only interested in "standard sea level" performance, so the extra work is generally non-existent.

One variable down and one more to go! We are still left with the influence of γ as a third variable affecting our duration answers. The obvious solution to reducing the total number of variables to two so we can plot the data is to call the $1/[\cos\gamma\sqrt{\gamma}]$ a negligible small error term and just throw it out. Engineers and scientists have been doing this sort of thing for centuries using such statements as "it would be obvious to the casual observer" as apparent justification. Great–but the so-called casual observer is in reality usually restricted to the author alone–and the only reason he understands "why" is because he has worked on the problem for at least a year or two.

Justification that the term indeed is negligible proceeds as follows. If you first look in a trig. table you will find that for small angles near zero degrees that the cosine terms remain very close to 1.00. Thus, if we could prove that actral flight path angles (γ) are small for all reasonable glider configurations then we will in essence be multiplying the basic duration equation by 1.0 and can conclude that no real overall effect on duration exists.

Referring back to the figure associated with Equations 3 through 6 we see that the flight path angle (γ) is also related to the aerodynamic lift and drag forces

$$\text{cotangent}\gamma = \cot\gamma = L/D$$



$$= \frac{\text{"adjacent" side of right triangle}}{\text{"opposite" side of right triangle}}$$

L/D is called the LIFT TO DRAG RATIO. L/D is important especially for manned gliders because when the pilot flys at the maximum possible lift to drag ratio (L/D) then the flight path angle (γ) is necessarily a minimum (the flattest possible glide path) as reflected by Equation 14. This in turn means that the glider will geometrically travel the farthest distance forward possible for each foot of altitude lost. Basically, if you know the lift to drag ratio (L/D) of a given airplane you can directly calculate how far it will travel in still calm air from a given altitude.

L/D is a direct measure of range efficiency. A pilot flying a modern-day high-performance glider with an L/D of 40 will be able to reach a landing field that another pilot at the same altitude flying a medium-performance glider with say an L/D of 20 could not possibly make. (This again assumes calm, still air with no thermal activity to help the poorer plane make the landing field).

Note that knowledge of L/D says nothing about sink velocity or duration from a given altitude. One glider may have more range capability from a given altitude than a second, but it may be flying at a glide speed of 3 or 4 times that of the second. In other words, the first glider will be on the ground while the second is still flying. The sink velocity depends on weight, wing area, *and* the aerodynamic coefficients, whereas range capability depends *only* on the aerodynamic coefficients as shown:

$$L/D = (C_L S \tfrac{1}{2}\rho V^2)/(C_D S \tfrac{1}{2}\rho V^2) = C_L/C_D$$

In summary, the following table gives actual numbers for the duration equation error term for flight path angles of 0 to 15 degrees.

Having actual numbers should help you see that this term is indeed small for typical manned gliders. The next question in your mind should be: "Do our own model rocket type gliders have similar lift to drag ratios?" The answer based on crude preliminary data is no! I have found that my best pop-pod gliders are flying with L/D ratios no greater than about 12, which means that something like a rear-engine delta wing B/G will be considerably lower.

Flight Path Angle in Degrees γ	Lift to Drag Ratio L/D = cot γ	Cos γ	Error Term
0°	∞	1.00000	1.00000
1°	57.290	.99985	1.00023
2°	26.636	.99939	1.00091
3°	19.081	.99863	1.00205
4°	14.301	.99756	1.00367
5°	11.430	.99619	1.00574
6°	9.5144	.99452	1.00828
7°	8.1443	.99255	1.01128
8°	7.1154	.99027	1.01477
9°	6.3138	.98769	1.01875
10°	5.6713	.98481	1.02323
11°	5.1446	.98163	1.02820
12°	4.7046	.97815	1.03370
13°	4.3315	.97437	1.03972
14°	4.0108	.97030	1.04627
15°	3.7321	.96593	1.05336

High Performance Top Manned Gliders have L/D = 40

Medium Performance Gliders have L/D = 20

Crudest 2 Place Manned Training Gliders have L/D = 10

NOTF: There is less than 2% error for L/D greater than 6

One further interesting fact that the above table helps to point out is that as L/D gets lower (meaning γ gets higher) that the error term *increases* above 1.00. Thus, any durations computed with a midified version of the equation which neglects this error term will in fact yield slightly shorter duration times than if the error term was left in the equation and its effect considered. In other words, dropping the error term from the basic duration formula(Equation 13) is conservative because it gives duration answers which will be close to, though very slightly less than actuality. With the above justification explained, we now drop the error term and have the modified equation for duration shown:

$$t = (C_L^{3/2}/C_D)(\sqrt{(\tfrac{1}{2}\rho)}/\sqrt{(W/S)})$$

Finally, in a manner identical to that shown in detail for the parachute duration equation we substitute the same known constants and conversion factors in order to obtain a formula for duration for each 100 feet of altitude.

$$t_{100} \text{ at sea level standard} = 1.14939\,(C_L^{3/2}/C_D)/\sqrt{(W/S)}$$

And agian, the duration per 100 feet at other elevations and temperatures is found by multiplying the sea level standard duration by the square root of the density ratio ($\sqrt{\sigma}$) as found in figure 4.

$$t_{100} \text{ at any elevation and temperature} = (t_{100} \text{ at sea level standard})(\sqrt{\sigma})$$

REFERENCES

Angelo Miele,**Theory of Flight Paths**, Volume 1, Addison-Wesley Publishing Co., 1962 (pages 120, 152, 192)

Daniel Dommash, **Airplane Aerodynamics**, Pitman Publishing, 1961 (page 363)

Courtland Perkins and Robert Hage, **Airplane Performing Stability and Control**, John Wiley and Sons, 1960

John R. Taylor, **Janes All the World Aircraft 1963-1964**, McGraw Hill, 1963 (sailplane data from various countries, pages 330 through 361)

Douglas Malewicki, **Model Rocket Altitude Performance**, TIR-100, Centuri Engineering Co., 1968

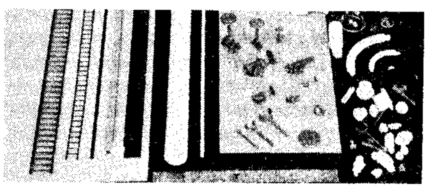
New Product Notes

Series III A engines have just been introduced by Estes Industries, Inc. These short (1.75" length) engines are available in A5-0S, A5-2S, and A5-4S types. Having a thrust duration of 0.5 seconds and a peak thrust of 46 ounces, these engines have a 2.50 newton-second total impulse. Their thrust-time curve is the same as that for the A5 Series I engines. Priced at 35 cents each or 3 for 80 cents, the new short A's are available from your Estes or from your local Estes dealer.

To go with the new engines, Estes has introduced the Astron Beta, a two-stage altitude rocket. Weighing only 0.75 ounces, the 13½" model is available in kit form (kit K-45) for $1.

Plastruct, Inc., makers of quality plastic scale model structural shapes and parts, has released a new catalog featuring 200 new items including a broader range of sizes in previously offered modeling parts.

Scale modelers constructing launchers will find creative applications for the wheels, cylinders, nozzles, valves, supports, pipe caps, reducers, bends, elbows, coupling sleeves and pins -- as they are, or modified for particular uses. Additional sizes of stairs, ladders, ladders with cages, tees, and thinner sheet stock are also part of the new catalog. Stainless steel scale rulers, a new cement ideal for bonding Plastruct, and a cement dispenser bottle are also listed.



The 20-page illustrated Plastruct catalog No. 170 complete with building tips and how-to information is available at hobby and craft shops or may be obtained for $.50 U.S. coin from Plastruct, Inc., 1621 N. Indiana Street, Dept. MR, Los Angeles, California 90063.

If you have not seen the colourful, 16 page, action-packed condensed catalouge of popular, fast-selling Centuri Model Rocketry Products, be sure to get a copy. Double-page spreads in vivid colour display the most popular sport flying models and the complete line of highly detailed Super Scale model rockets which include the Saturn V, Little Joe II, and the famous German V-2. Sold only in kit form, Centuri flying model rocket kits are easy to build and fun to fly. For the active model builder, rocket club member, school teacher, or youth activity leader, high-quality custom part assortments are shown along with the widely-acclaimed altitude tracking and measuring device, the Sky-Trak.

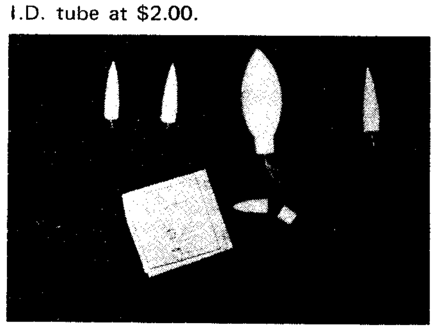
Ask your local hobby dealer for the new catalouge. If not available locally, it may be obtained free of charge by writing to Centuri Engineering Company, P.O. Box 1988, Phoenix, Arizona 85001.

Add decorative stripes to your rockets with black or white Mini-Stripe tape. Available in 1/32, 1/16, 3/32, and 3/16 inch widths in both colors. It can be used to decorate your rockets, add roll patterns to scale birds, or to mask unpainted areas when adding fine detail to your scale rockets. A 150 inch length of Mini-Stripe is priced at 35 cents, from Mini-Wheels Hobby Center.

Apollo 11 emblem decals (illustrated below) in full color are also available for a

limited time from Mini-Wheels Hobby Center, 714 Raritan Ave., Highland Park, New Jersey. Priced at 25 cents each plus a stamped, self-adressed envelope for return.

Competition Model Rockets has introduced several new items to their model rocket line. Light weight plastic nose cone kits consisting of a one piece cone, adapter for body tube, and shock cord attachment are available in the following sizes: NC74 1½" parabola for 0.710" I.D. tube at 2 for $.50, NC74a 3" parabola for 0.710" I.D. tube at 2 for $.90, NC77 3" ogive for 0.710" I.D. tube at 2 for $1.00, NC90 3" ogive for 0.864" I.D. tube at 2 for $1.10, and NC92 3" ogive for 0.894" I.D. tube at 2 for $1.15. A special lightweight plastic "egg-capsule" with a foam rubber lining molded to the shape of an egg is available to fit 0.895" I.D. tube at $2.00.



Lightweight, strong, three-ply, spiral wound paper tubes with an 0.013 inch wall have also been introduced. A white glassine paper covering allwos fine finishing of the tubes. RB74 fits standard 18mm diameter engines. With an 0.710" I. D. and 0.738" O.D., the 12" long tube is priced at $.20 each. RB77, which slip fits over the RB74, has a 0.740" I.D. and 0.766" O.D. and sells for $.25 for a 12" length. RB90, fitting the FSI A through E engines, has a 0.864" I.D. and a 0.890" O.D. and is priced at $.35 for a 14.10" length. RB92, which slip fits the RB90, has a 0.894" I.D. and 0.920" O.D. and sells for $.30 for a 12" length.

SOLICITATION OF MATERIAL

In order to broaden and diversify its coverage of the hobby, MODEL ROCKETRY is soliciting written material from the qualified modeling public. Articles of a technical nature, research reports, articles on constructing and flying sport and competition models, scale projects, and material relating to full-scale spaceflight will be considered for publication under the following terms:

1. Authors will be paid for material accepted for publication at the rate of two dollars ($2.00) per column inch, based on a column of eight-point type thirteen picas wide, for text, six dollars fifty cents ($6.50) for drawings, and two dollars ($2.00) for photographs accompanying text. Payment will be made at the time of publication.

2. Material submitted must be typewritten, double-spaced, on 8½ by 11 inch paper with reasonable margins. Drawings must be done in India ink and must be neat and legible. We cannot assume responsibility for material lost or damaged in processing; however our staff will exercise care in the handling of all submitted material. An author may have his manuscript returned after use by including a stamped, self-addressed envelope with his material.

3. Our staff reserves the right to edit material in order to improve grammar and composition. Payment for material will be based on the edited copy as it appears in print. Authors will be given full credit for published material. MODEL ROCKETRY will hold copyright on all material accepted for publication.

Those wishing to submit material should send it to:

Editor,
Model Rocketry Magazine,
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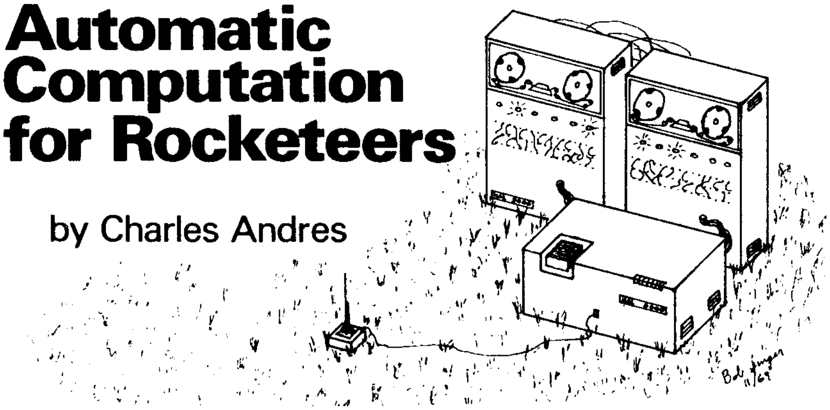
Automatic Computation for Rocketeers



by Charles Andres

In the October, 1969 issue of **Model Rocketry**, I discussed the basics of computer programming in regards to the Fortran IV language. All of the programs were written with intent for use with an IBM 2740 remote terminal hooked to an IBM 360 system. However, as I pointed out before, the programs outlined in this series should be able to be used without change on any computer accepting FORTRAN IV, and should, with slight modification, be acceptable for use with those computers still employing FORTRAN II and other closely related languages.

```
M.0072 BEGIN ACTIVITY

/input
/insert rocket(1234)M.0073 ACTION IN PROGRESS
M.0070 ACTION COMPLETE
/display M.0073 ACTION IN PROGRESS
/JOB GO
/FTC NAME=ROCKET
C             CALCULATION OF THEORETICAL ALTITUDE
              DIMENSION I123(8)
              REAL M,MB,K
38            READ(5,26)(I123(J),J=1,8),WT,BOWT,CD,D,TB,F
26            FORMAT(8A4/6F11.5)
              M=WT/32.2
              MB=BOWT/32.2
              A=3.142*(.5*D)**2
              K=.000154*A*CD
              XB=(-MB+SQRT(MB**2+K*TB**2*(F-M*32.2)))/K
              VB=(TB*(F-(M*32.2)))/SQRT((MB**2)+(K*((TB**2)
             1*(F-(M*32.2)))))
              HC=(MB/(2*K))*ALOG(((K*(VB**2))/(MB*32.2))+1)
              TC=SQRT(MB/(32.2*K))*ATAN(SQRT(K/(MB*32.2))*VB)
              HT=HC+XB
              TT=TC+TB
              WRITE(6,36)(I123(J),J=1,8),XB,VB,HC,TC,TT,HT
 36            FORMAT('NAME: ',8A4/' BURNOUT ALT.= F7.0,' UNITS.
              BURNOUT VEL.
              1= ',F7.0,' UNITS/TIME UNITS. '/' COAST ALT.= ',F7.0,'UNITS.
              2COAST TIME= ',F7.2,' TIME UNITS.'/' TOTAL FLIGHT
              TIME= ',F7.2,'
              3TIME UNITS. TOTAL ALT.= ',F7.0,' UNITS. ')
               GO TO 38
               END
/DATA
VOID I B 4-4
        1.374      1.163      .75      .736      1.20      14.38
V-2 A 8-3
        1.97       1.82       .75      1.325     .82       23.00
M.0070 ACTION COMPLETE
/end runM.0073 ACTION IN PROGRESS
END OF COMPILATION ROCKET
NAME: VOID I B 4-4
BURNOUT ALT.= 293. UNITS.   BURNOUT VEL.= 358. UNITS/TIME UNITS.
COASTING ALT.= 676. UNITS.   COAST TIME= 5.53 UNITS/TIME UNITS.
TOTAL FLIGHT TIME= 6.93 TIME UNITS.    TOTAL ALT.= 969. UNITS.

NAME: V-2 A 8-3
BURNOUT ALT.=  39.  UNITS.   BURNOUT VEL.= 171. UNITS/TIME UNITS.
COASTING ALT.= 186. UNITS.   COAST TIME= 2.97 UNITS/TIME UNITS.
TOTAL FLIGHT TIME= 3.39 TIME UNITS.    TOTAL ALT.= 224. UNITS.
```

Fig. 1 A sample display of the theoretical altitude program as it is displayed from the memory banks of an IBM 360 computer. Orders for the display are typed in small letters; the computer's response is written in large letters.

The first article (**MRm**, October 1969), explains the meaning and arrangement of the lines in a basic program. A second installment, (December 1969) showed a program to calculate the Center of Pressure in a rocket using the Barrowman method. Thus, only the differences between the first two articles and this one will be outlined below. The calculation of predicted altitude for model rockets is a subject which has probably fascinated at least 3/4 of all model rocketeers, and we all have asked or have been asked the question: "How high will it go?" (The question "How high did it go?" is asked almost as frequently, but due to the fact that rocket tracking still leaves something to be desired, I won't bother to provide an answer for that one yet.) The average modeler will usually reply: "Oh, somewhere between 500 and 600 feet." Ah! but it is the refined modeler who can reply: "According to my calculations as compiled by an IBM 360 computer, it should travel exactly 715.6 feet with a B 4-4 engine!" And if it gets up above 300 feet or so, he can always say that the computer is right due to the fact that nobody has calibrated eyeballs. The closer your unsuspecting friend is to the launcher, the higher the rocket will seem to go. Seriously though, every time we design a model rocket, expected altitude is almost certainly going to be a primary consideration, even in drag races.

Before 1964, altitude prediction was reduced to just such a guessing game as mentioned before—usually one had to go on past performance from similar models. But in 1964, an article appeared in **Model Rocket News** the newsletter from Estes Industries, entitled "Rocket Math". Although the method presented was fairly accurate, it involved a set of repeated equations and presented no way to measure the drag characteristics of the rocket. However, it was the first step. Also in 1964, Len Fehskens developed a method for predicting altitude. However it was not published or distributed. Doug Malewicki, who was also working on the problem, developed a set of graphs which were published in 1967 and 1968 by Estes Industries and Centuri Engineering, respectively. These were the now-famous Altitude Prediction Charts. These charts were the best altitude predictors to date and were fairly easy to use. In October of 1968, in the first issue of **Model Rocketry**, George Caporaso published a set of equations to determine the altitude of a model rocket at any point in its flight path. He also published the derivatives of the integrated equations which make up the equations in this computer program. These equations possess several advantages over the Malewicki Charts. First, it takes less time to use them. All you need to do is to type in the lift-off weight, the burnout weight, the calculated drag coefficient, the body diameter, the burn time, and the average thrust. (Once you get to the computer console of course!) Second, the program is variable. One can compute and compare FSI, Estes, Centuri, MPC, etc. rockets and engines on one program. No more need to thumb through graphs hunting for the right ones, looking for conversion factors, etc. This is to say nothing of hypothetical cases. Try designing a monster rocket with six stages all employing a cluster of 25 F-100's! (Better change the units to get answers in miles. Or try to calculate the amount of thrust needed to orbit one empty engine casing one hundred miles up at 17,500 miles per hour! And third, the results are fairly accurate. In a number of tests, I found them to be more accurate than Malewicki's original charts. Caporaso arrived at the same conslusion as stated in his article: "The approximation equations were found to agree with the iterations to within 1.5%; just as good or better than the Fehskens-Malewicki soloutions."

The Program

The program is very simple, but with this simplicity comes reliability which is quite high. The program as it is displayed from the computed memory is illustrated in figure 1. As stated last time, the commands made by the operator are typed in small letters; the computer's reply is in capitals. When typing this program in for the first time, type **/input** before **/job go.** In addition, if you are planning to save the program, type it as far down as **/data** and then ask for a **/run** before saving it. Then, anytime it is to be used, just ask for it to be inserted, (as it was when it was displayed) and then immediately start to type in the data. When you are through, type **/end run** and the answers will be typed exactly as they are at the end of figure 1. I have found that I can compute twenty-five different flights in about fifteen minutes, depending upon the speed of typing in the data and the immediate activity of the computer. (If it is busy, it will take slightly longer to type in and slightly longer to collect the output.) Figure 2 shows a flow chart of the program – again very simple and direct. This program is sufficiently easy to program so as to be a good beginner's try in operating a computer. The structure of the program is as follows : the mass of the rocket (m) is calculated as the liftoff weight (wt) divided by the acceleration due to gravity (g) which equals 32.2 if the program is to find the altitude in feet and 9.8 if the height is to be found in meters. (If you are planning to use the metric system, it is a good idea to list the weight in kilograms and the force in newtons (answers will be in meters) Otherwise, use ounces and feet throughout. (Time is always counted in seconds or some increment of a second.) The mass of the rocket at burnout, (mb) is also found by dividing burnout weight (bowt) by g (32.2 in this program) The frontal cross-sectional area of the body tube is found by pi times the largest radius squared. (Fins are usually too small in frontal cross-sectional area to make a difference) This answer will be in wquare inches (or square centimeters.) The drag constant K is found to be .000154 (air density at sea level at 59°F) times A times Cd, the drag coefficient. This dimensionless coefficient is reported to have a value of about .75 (see the **Handbook of Model Rocketry** for the reason) and is largely determined by the shape and the finish of the model. This constant can vary from rocket to rocket going from about .35 to about .9 for most model rockets. (In a future issue, a program for the automatic computation of Cd will be shown.) The burnout altitude (xb) is computed by the negative rocket mass (-mb) plus the square root of (mb^2) plus drag constant (K) times the burn time (tb) squared all times the average thrust of the rocket (F) minus liftoff mass (m) times (g) with everything being then divided by (K).

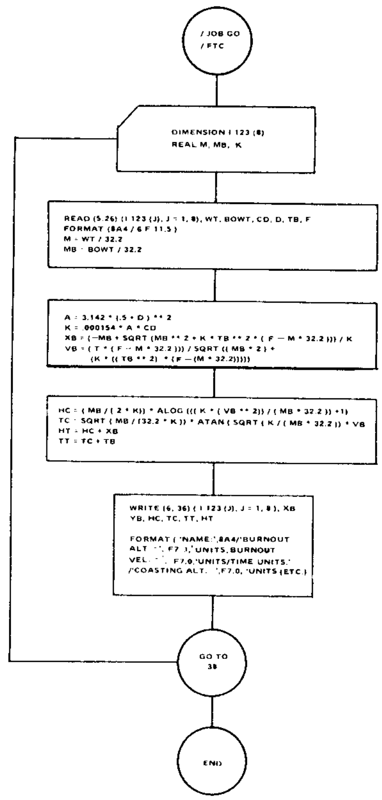


Figure 2.

The velocity at burnout (vb) equals (tb) times the quantity (F-mg) divided by the square root of mb^2 + (K)(tb^2)(F-mg).

The coast time is computed as the square root of (mb) divided by (g)(K) times the arctangent of the square root of K divided by (mb)(g) all times (vb). (The arctangent is the angle in radians whose tangent is the quantity of the above equation.)

Total altitude is then computed as being the burnout altitude plus the coasting altitude, and the time to reach apex is computed as the coast time plus the burntime. (In the program liftoff to apex is considered to be total flight time.) Interestingly enough, this time would also be equal to the length of time needed to reach the ground from apex if there were no type of recovery system deployed. In addition, the speed of the rocket at impact would be roughly equal to or greater than the burnout velocity.

Because of the built-in inaccuracy of the program due to "varying incalculables" such as wind velocity, relative humidity, engine thrust discrepancies, etc. finding the altitude to the nearest foot is sufficient and smaller increments are meaningless. Thus, all altitudes under the format given are only figured to the nearest foot, and time to the hunderdth of a second. This is sufficient accuracy for all practical purposes with this program. As in the last program presented, a space for the rocket name for further identification of data is provided and must precede each bit of data. (See October 1969 article for explanation). The program name, **ROCKET(1234)** is arbitrary, and can be changed to any other name desired. However, each program must possess a different name. This one could be called **HEIGHT(1234)**.

With this program, all altitude figures for model rockets can be considered accurate to at least 10% (probably closer) if but only if the following assumptions hold true:

> The rocket's weight is accurate for liftoff and burnout as well as there being a correct value for the rocket diameter.
>
> The drag coefficient is accurate (Cd can be determined to a large extent by observing altitude during perfect weather conditions and matching it with computer altitude conditions figures found by varying

FIG. 3 TABLE OF COMPARED VALUES FOR COMPUTER PREDICTED ALTITUDE, MALEWICKI PREDICTED ALTITUDE, AND ACTUAL TRACKED ALTITUDE

Rocket and Engine	Tracked Altitude	Computer	Difference	Malewicki	Difference
Payloader B 4-4	887	922	+35	1320	+433
Excalibur ½A6-2	186	213	+27	337	+151
Aerobee 300 C 6-5	1062	1059	- 3	900	-162
Arcon ½A 6-2	249	217	-32	300	+ 51
Arcon A 8-3	337	336	- 1	690	+253
Void I A 8-3	490	513	+23	555	+ 65
Drifter ½A 6-2	104	85	-19	125	+ 21
V-2 A 8-3	225	224	- 1	370	+150

the Cd value.)

The wind during the entire flight is 5 m.p.h. or less.

The rocket is at least statically stable, and had good dynamic stable, and has good dynamic stability.

The temperature at the launching site is between 50° and 70°F.*

The launch pad altitude is between sea level and 1000 ft.*

The computer program is correctly written and that the data is properly spaced according to the format statement. This is extremely important; improperly spaced data will give erratic answers or none at all.

All data is expressed in a common system of measurement. (Preferably either FPS, MKS or CGS.)

The rocket velocity remains subsonic during the entire flight (for all practical purposes,, under 750 ft/sec.) Above this velocity, drag increases more greatly than the equations show until the speed of sound, 1100 ft/sec is reached. (Don't get excited when a Streak with a D seemingly breaks the sound barrier.)

Weight is assumed to be constant during thrusting. (An average value is used.)

Thrust is assumed to be constant during the burn. (An average value is used.)

Overall drag coefficient does not increase during the coast phase.

The rocket is launched straight-up with little or no wind or turbulence; so the flight continues at 0° angle of attack. (A non-vertical trajectory analyses program will be described in a later issue.)

Additional weight losses due to smoke delay burnoff is neglected.

* These two values can be changed according to the graphs in the Malewicki Report (Estes: Altitude and Temperature Correction Factor p. 13; Centuri: Air density compensation graph p. 45) — Colorado rocketeers take notice! I usually have to at least "winterize" the program by changing these lines, and then change them back again when the weather gets warm.

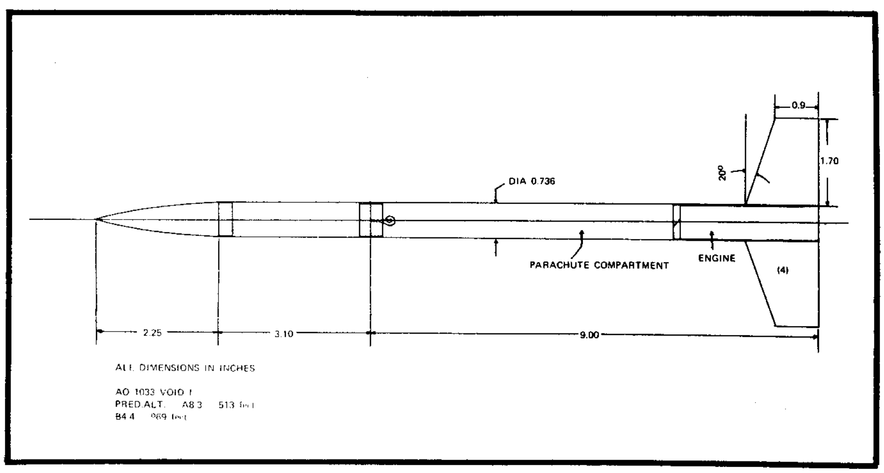
Results

In the applications I have made thus far in testing the validity of the programs, I have found that actual flights as tracked and reduced come relatively close to the prescribed altitude value, as do the time to apex values (at least to the tenth of a second). From this, I surmise that the velocity values are also fairly accurate. Some of these results are included in the table in figure 3. (Tracked altitudes are done with two altitude-azimuth trackers with a baseline of either 500 or 900 feet.)

Figure 4 shows one of the models used termed the Void I which consistently flies to almost exactly 500 feet. A better version could be made to fly higher, but the Cd on the Void is just about .75, it being a rocket with only average finish.

The best proof of the accuracy of this program was shown by leader Predicted Altitude at NARAM-11. Charles Zettek, Jr., who took first place coming within 0.6%, had predicted 160 meters (524.9 feet) with an Excalibur employing forward conventional ejection. The computer had previously predicted an altitude of 525 feet; but he had also flown several test flights with the same model prior to the meet (at sea level, no less!) getting at or near the 525 foot mark. I flew my original Excalibur (with rearward ejection) anticipating a slightly higher altitude (162 meters). However, this model flew better than anticipated — it flew 11 meters higher (567 feet) which was good for third (7.4%) — which just goes to show that one should test fly and track predicted altitude models! (Not to mention the difference between rearward and forward ejection.)

The equations show that one must do everything possible to reduce the Cd, as nearly every other parameter is determined to an extent. An interesting idea though is that of the negative drag induced by a conical boattail. However, this consequently means a larger cross-sectional area than necessary. With this program it might be possible to see if one outweighs the other (at least on paper) or if by making one design compromise it is equally offset by the other. It is easy to see that this program will enable one to know to some extent how high his rocket will fly while it is still on the drawing board. Since maximum altitude is of utmost importance (except maybe in drag races) this program should be of significant interest to nearly everyone. Hopefully, it will cut time usually spent on altitude calculations to a minimum thus creating more design time resulting in better designs!



CORRECTION

In October 1969 article, the equation in FORTRAN on the top of the last column on page 31 should read as follows to match the given equation printed in standard math.

```
CNAF=(12*(s/d)**2)/sqrt(1+((2*L/a+b)**2))
```

Bibliography

Andres, Charles, "Automatic Computation for Rocketeers," **Model Rocketry** (October 1969), pp. 30-32.

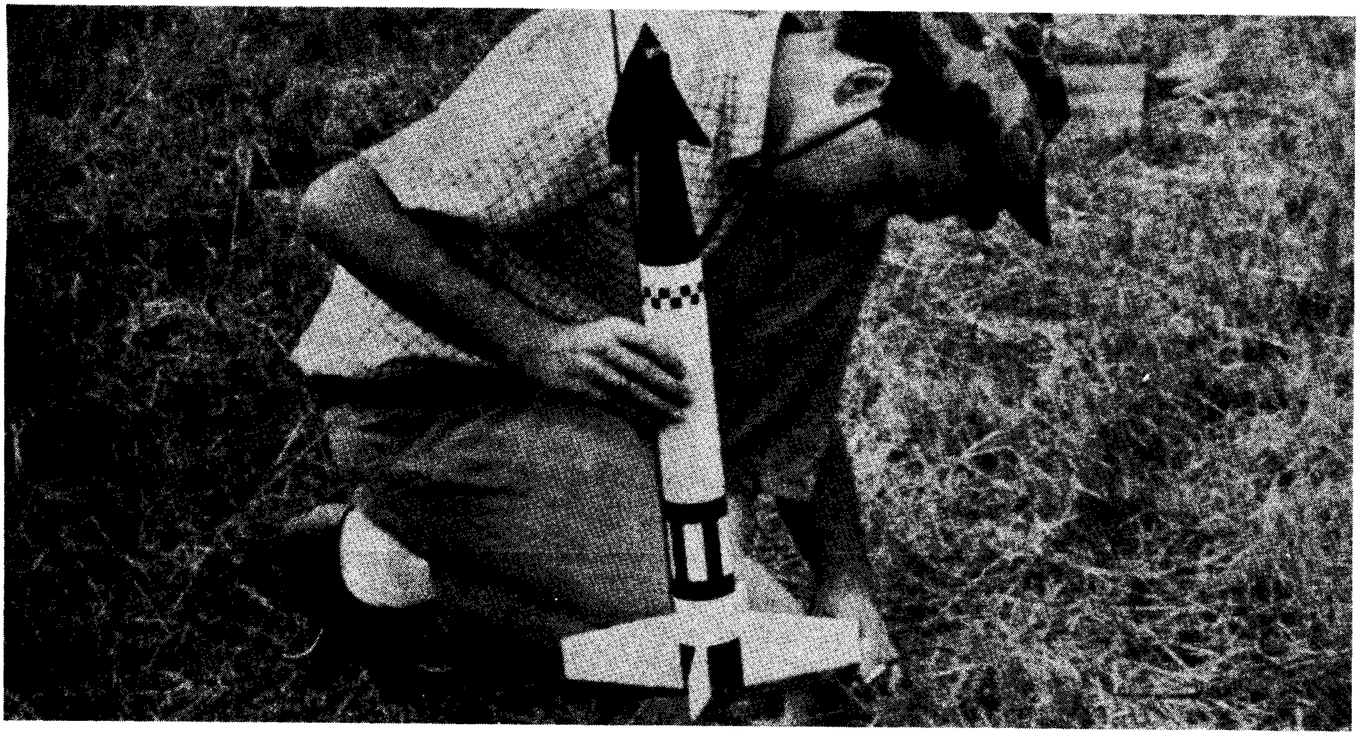
Caporaso, George, "Model Rocket Altitude Calculations," **Model Rocketry** (October 1968), pp. 11-12.

IBM, **(RAX)(360A-CX-17X) User's Manual**, White Plains, Technical Publishing Dept., 1967.

Malewicki Douglas J., **Model Rocket Altitude Prediction Charts**, Penrose: Estes Industries, 1968.

----, **Model Rocket Altitude Performance**, Phoenix: Centuri Engineering Company, 1968.

"Rocket Math," **Model Rocket News** (June 1964), Penrose: Estes Industries.



Is that a Dyna-Soar on top of the semi-scale Titan?

Photo by Mike Dombrowski

PHOTO GALLERY

Readers are invited to submit photographs of their model rockets for publication on this page. Our staff will, select those photographs having superior quality and composition for inclusion in the **Model Rocketry** *Photo Gallery. Send your photos to:*

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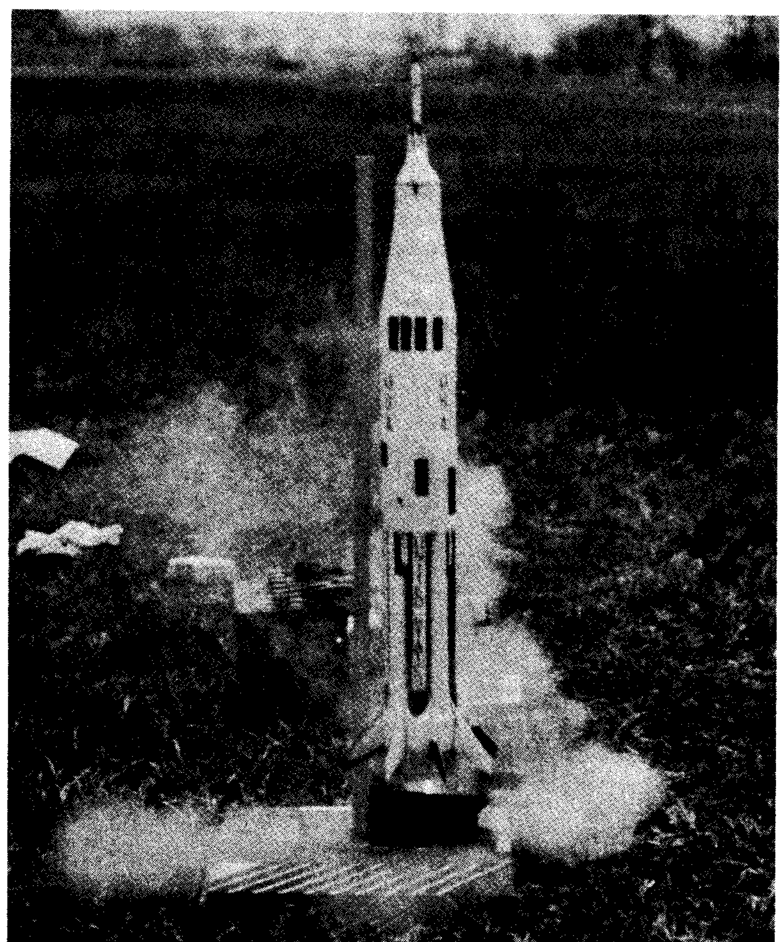


Photo by Gregory Guzik

Ignition of an Estes Uprated Saturn 1B built by Dennis Vogen.

First Place Senior R&D Project at NARAM-11:

Ram-Air as a Method of Rocket Control

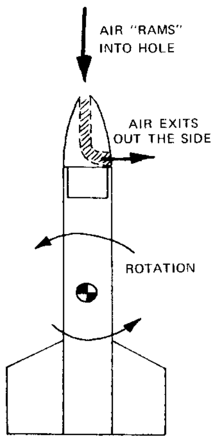


Figure 1

by Forrest M. Mims

The following report, first presented at NARAM II, represents a detailed study into the problems of one type of model rocket guidance. At NARAM II, the report attracted the attention of several Air Force Academy faculty members who requested of its author permission for advanced aeronautical engineering cadets to study the concept in more detail using the Academy's fine wind tunnel and water table facilities. Four cadets participated in the study, which was completed on December 12, 1969. Details on the Air Academy study as well as construction articles on the inexpensive wind tunnel, water table, and other equipment used by Mims will appear in future issues of **Model Rocketry.** Author Mims has agreed to answer reader's questions about his project. Answers to the most frequently received questions will appear in **Model Rocketry.**Address your questions with a stamped, self-addressed envelope to:

Forrest M. Mims
6901 Zuni S.E. A-12
Albuquerque, New Mexico 87108

Mass ejection into the lateral flow has been used as a method of rocket control for some time (ref. 1-2). The concept is not original to man as several classes of aquatic animals employ a similar form of mass ejection for directional control and propulsion. Consider, for example, the squids and sea-squirts (as described in reference 3). Reference 3 also suggests a possibly sophisticated form of mass ejection employed by numerous fish, wherein water taken in through the mouth is passed out through the gills in a manner beneficial to boundary layer control as well as the normal process of oxygen consumption.

The author has proposed a type of rocket control by mass ejection which does not depend on a onboard supply of fuel but which utilizes ram air which has entered a forward facing port. The air is allowed to enter the rocket through a hole in the nose cone, and exits through a hole in the side. This results in a force which causes the rocket to pivot about the center of gravity. (See Figure 1.) The concept is referred to as Ram Air Control. Larson, in reference 4, has proposed a similar method of control which employs a number of vents near the intake of a ramjet which, by means of their opening and closing, a measure of control might be achieved over the amount of air entering the ramjet at an angle of attack. Larson observed that the ports may be utilized to provide some aerodynamic control due to the moment produced by the off-axis forces caused by air jetting from one or more of the vents.

Part I describes an experimental investigation of Ram Air Control. The investigation began with an analytical study of concept feasibility. A series of subsonic experiments, consisting of wind tunnel tests and the launching of small test rockets, was conducted to verify the analytical study. Though experimental data revealed several discrepancies in the analytical study, feasibility of the concept was supported.

Next month, Part II will present experimental methods by which two axis guidance and control of small rockets may be achieved by suitably directed ram air. The paper concludes with suggestions for futher work and the mention of a fluidic method by which a rocket controlled by ram air might acquire and home on a target without the assistance of electronic or mechanical components.

Analytical Study

In Figure 2, air at velocity V is channeled through the nose section of a hypothetical rocket. Assuming the flow of V to be uniform and neglecting channel resistance and ambient velocity, a basic equation in fluid mechanics may be applied. The resulting force, F, is given by:

$$F = \rho Q (V_2 - V_1) \qquad (1)$$

where ρ is the density of air, Q is the volume rate of flow V_1 is the entrance velocity of the air, and V_2 is the exit velocity of the air. The force component causing a moment about the center of mass (C.M.) of the hypothetical rocket is expressed

$$F_y = F \cos\theta \qquad (2)$$

or

$$F_y = [\rho Q (V_2 - V_1)] \cos\theta \qquad (3)$$

In a practical situation two factors would contribute to a substantial reduction in F_y: (1) Channel resistance, and (2) Interaction of the expelled jet with the ambient air. The resistance of the channel to the flow of air is due to boundary layer buildup at the lip of the entrance port, skin resistance of the channel, and boundary layer separation at the region of channel curvature. Losses in the force component F_y due to the interaction of the expelled jet with the ambient air are more complex. The deflection of a jet by a lateral flow produces frontal and lateral resistance, pressure variations, and large amounts of turbulence. The Soviet investigator Shandorov (in Ref. 5) has presented experimental data showing the configuration of a jet in a lateral deflecting flow. Shandorov has shown that the cross section of a jet exiting from a circular aperture gradually flattens, assuming the shape of a horseshoe whose

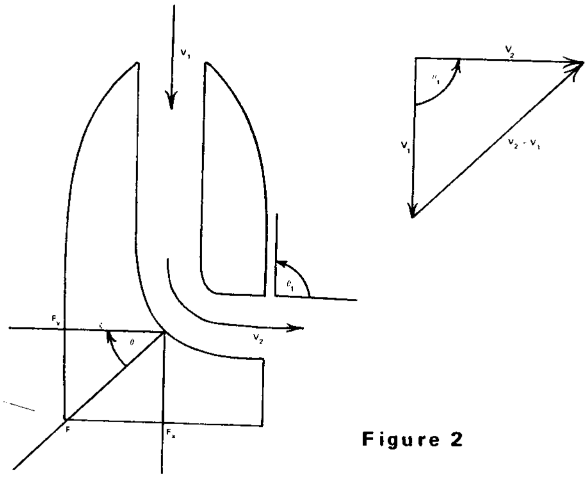


Figure 2

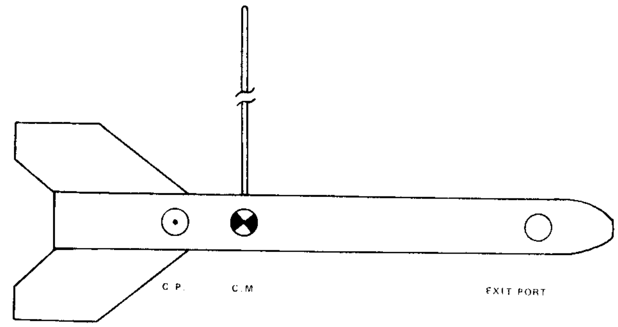


Figure 3

appearance is dependent on the velocity of the jet in relation to the velocity of the ambient. The horseshoe shape is due to the difference in velocity between the central and peripheral regions of the jet. It is obvious that this effect will produce turbulence between the jet and the exterior wall of the rocket immediately posterior to the jet's aperture. This turbulence may be displayed on a Hele-shaw apparatus as in Photograph 1. The apparatus consists of a smooth plane surface over which a sheet of water is caused to flow. Dye injected into the stream makes visible the interactions of the expelled jet with the freely flowing water.

If the sum effect of channel resistance and jet interaction is called F_0, Equation 3 above becomes

$$F_y = [\rho Q(V_2 - V_1)] \cos\theta - F_o \qquad (4)$$

The force F_0 was investigated experimentally.

Experimental Investigation

1.Wind Tunnel Experiments

Wind tunnel test were conducted in an effort to determine the force F_0 for a given situation. A stable model rocket with an air inlet-outlet channel in the nose section was fixed to a 1/8" steel rod perpendicular to the model's center of gravity. The model was placed in the test section of a wind tunnel capable of producing airspeeds up to 200 ft/sec, and was suspended from the affixed rod so as to permit freedom of movement in one plane. As the output port of the air channel was forward and perpendicular to the support rod, maximum angular displacement caused by the channel was indicated by a pointer attached to the portion of the support rod exterior to the test section. The model and rod assembly are shown in Figure 3.

A balance and weights were utilized to measure the force component (F) of the channel. Airspeed in the tunnel was measured with an anemometer which produced a voltage proportional to airspeed. Several runs at different airspeeds were made and the resultant F are shown in Figure 4.

If Equation 3, above, is applied to the parameters of the model, we find that the expected deflection force F_y is substantially reduced by interference term F_0. Figure 5 shows F_y for the real and hypothetical cases, the difference between the real and hypothetical forces being F_0.

As the wind tunnel utilized in obtaining these data was extremely limited due to the small size of the test section, a more detailed experiment was designed for a larger tunnel. The tunnel utilized was capable of producing airspeeds in excess of 450 ft/sec. Velocity in the tunnel was controlled by varying the pitch of the fan blades and was measured with a slant manometer and pitot tube. Two models were constructed of one inch diameter birch. One was capable of receiving each of twelve nose sections, and the other had a fixed nose section and air inlet-outlet channel. The models and nose sections were given a coat of acrylic over several layers of white enamel and were waxed. A 1/4" steel rod was fixed perpendicular to the CG of each model in order to provide a mounting arrangement similar to that used in the previous test.

Unfortunately, previously unrecognized large scale velocity fluctuations in the tunnel prevented usable measurements of F_y. The measurements will be attempted at a later date if the tunnel problem can be corrected.

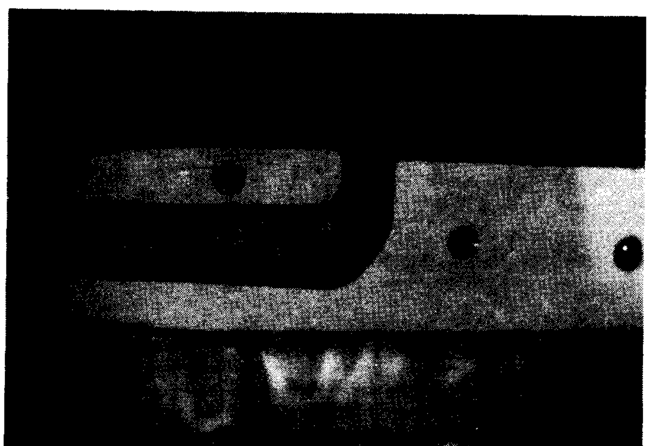


Photo 1. A plexiglass model with movable inserts serves as a simple, yet effective, water table model. The arrows indicate the direction of water flow. Ink injected at one side is deflected by the escaping jet.

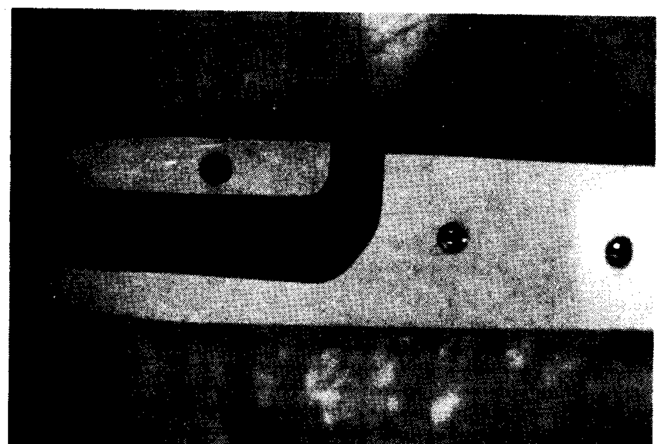
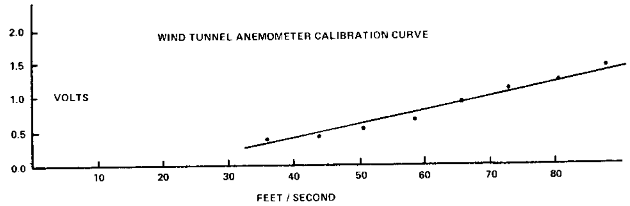


Photo 2. In this photo, ink has been injected directly in the intake of the water table model. Details are lost in reproduction, but the original photographs reveal areas of turbulance.



WIND TUNNEL MEASUREMENT OF F_y

Tunnel Airspeed (ft/sec)	Gram - Centimeters
57.5	4.7556
61.0	5.0728
63.5	5.7069
66.0	6.3408
74.2	8.2433
78.0	9.5115

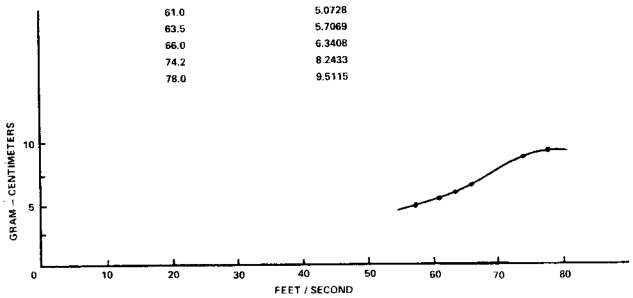


Figure 4

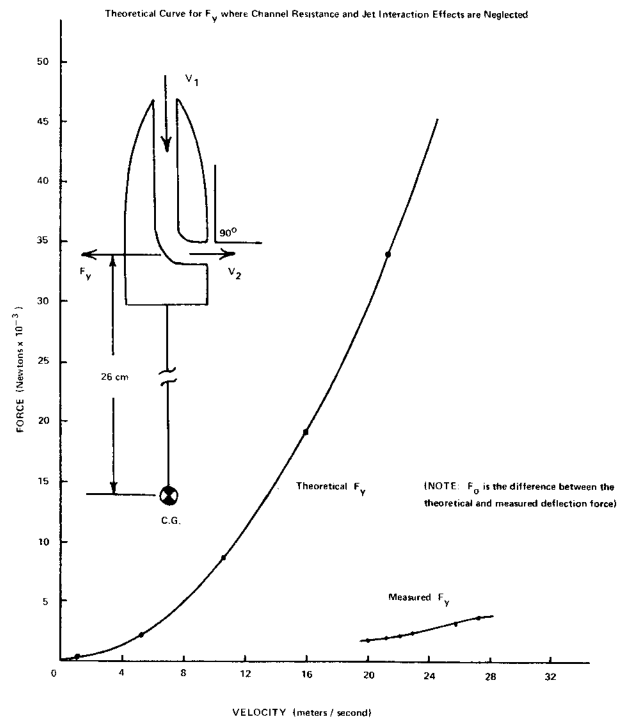


Figure 5

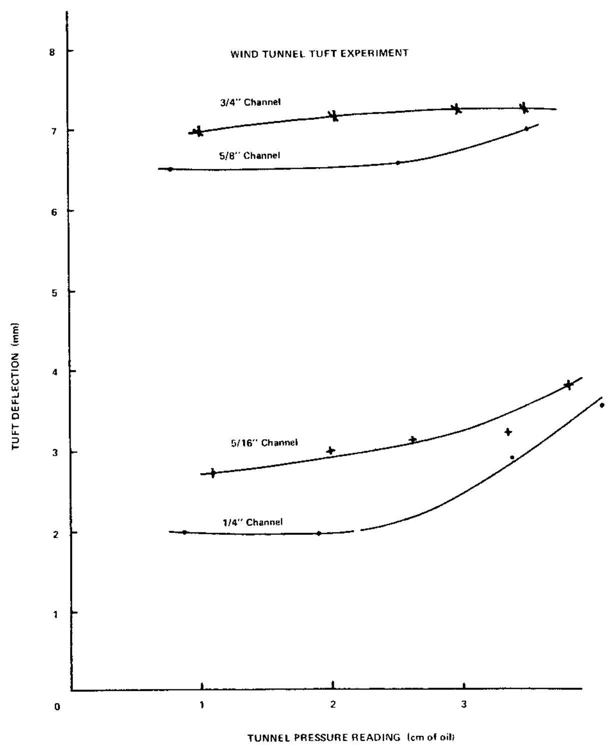


Figure 6

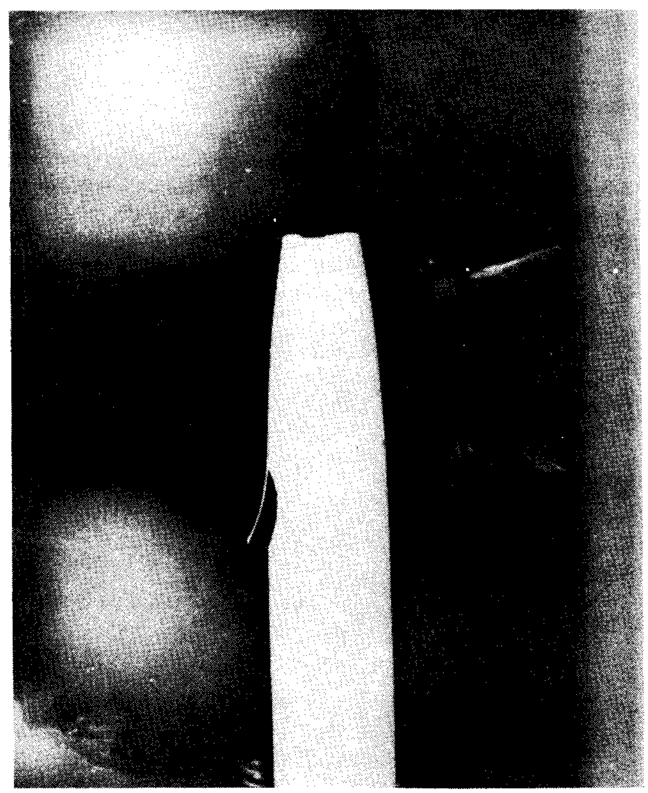
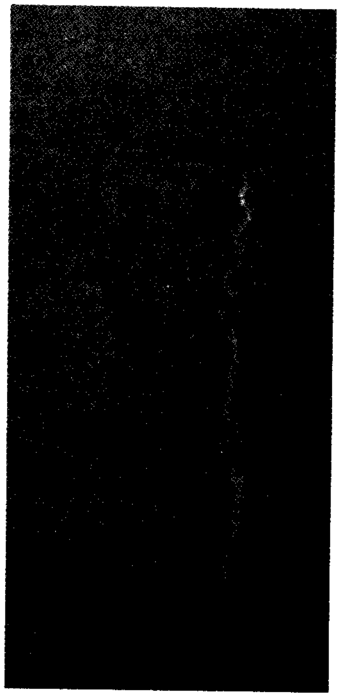
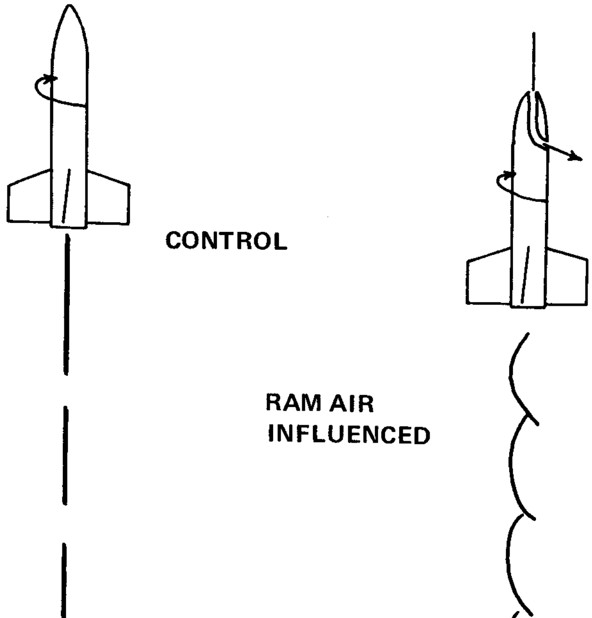


Photo 3. This photograph shows a model in a subsonic wind tunnel at the University of New Mexico. Notice the cotton tuft indicating the deflection angle of the escaping jet of air.





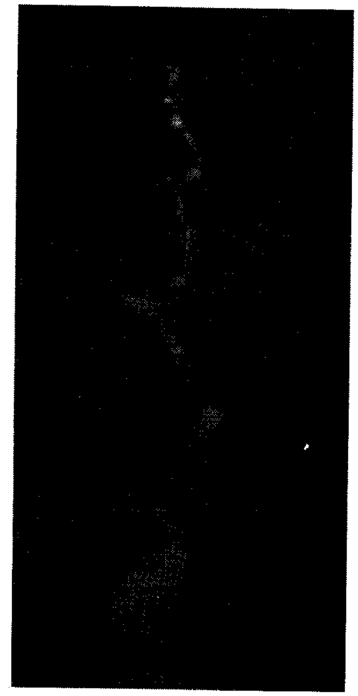


Figure 7

Photo 4. (left) Smoke trail of a typical spin stabilized rocket. Photo 5. (right) Smoke trail of the same rocket shown in Photograph 4. The rocket's nose cone has been replaced by a special ram air intake and outlet. Since the rocket spins during flight, the offset force component of the air exiting from one side of the rocket's nose causes a "coning" motion and a resultant helical flight path. Measurements of such a helix are very important to the understanding of ram air control.

A second experiment was more successful. In order to view the angle at which the jet enters a flow, cotton tufts were attached to the forward lip of the outlet port of each of four nose sections. The nose sections, each with a different channel size, were mounted on a support in the tunnel's test section facing and coaxial to the flow of air and were photographed at various tunnel speeds on Kodak Tri-X Panchromatic and Hi-Speed Ektachrome films. The experiment showed that the jet exits in an arc whose radius is on the outlet port side of the mode. The radius of curvature is inversely related to the ambient velocity and the channel size. These relationships are shown in figure 6. Photograph 3 shows several of the nose sections during runs in the tunnel.

As in the case of Shandorov's horseshoe, the arc of the escaping jets was caused by their internal velocity variations. The location of the center of a circle scribed by each of the arcs indicated that the channel velocity was significantly lower than the ambient velocity. Turbulence caused by the jet, a component of F_0, was demonstrated by tufts fixed to the rear lip of the outlet port of a nose section.

Though the investigation of the reduction force due to these other effects is incomplete, a series of rocket tests was designed to determine if F_y would indeed cause course changes during actual flight conditions.

2.Flight Tests

Flight tests began with the launching of several small rockets, each with a single inlet-outlet port as shown in Figure 7. The fins of each rocket were canted six degrees in order to impart spin to the rockets in flight. If the flights of these rockets resulted in the lateral expulsion from the side port of air which entered throught the nose hole, the moment F_y opposite the direction of the expelled air would be exerted about the C.G. of each rocket. As the rockets were caused to spin in flight, the offset force component forward of the C.G. of each rocket should cause spiral flight paths as in Figure 7.

One night and five day launches were conducted. Photography of smoke trails produced by the rocket exhausts, and in the case of the night launch a flashing tracking light, confirmed the anticipated spiral tracks. Photography of identical fockets without the air inlet-outlet channel revealed normal smoke trails. Several of these launches are shown in photographs 4 and 5.

The results of the initial flights encouraged the development of a more detailed experiment. Five rockets, each 17" x 3/4" and identical in configuration excepting fin angles, were constructed. The three fins of one rocket were mounted parallel to the centerline of the rocket. The fins of the remaining rockets were slightly canted in progressively increased steps for each rocket in order to impart a different roll rate to each of the rockets in flight. Several nose sections were constructed with input to output ratios and areas as shown in Figure 8. As a chamber offers mechanical advantages over a channel in a potential guidance/control situation employing ram air, that configuration was chosen for the nose sections.

As the rockets were to be launched at night and tracked by time exposure photography, each nose section was equipped with a small transistorized multivibrator capable of flashing a tracking light in a variety of repetition rates. As each rocket weighed about 75 grams, rocket motots producing an impulse of about 4 newton-seconds with a burning time of 1.4 seconds were utilized. A series of sixteen launches was conducted with the five recoverable rockets in order to measure flight deflections caused by the various nose sections. A camera mounted one meter from the launching apparatus assembly was focused at infinity and opened to f-16.

A determination of the magnitude of flight deflections by photometrics proved more difficult than anticipated due to

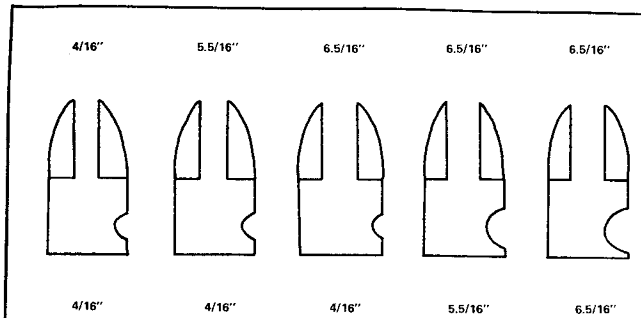


Figure 8

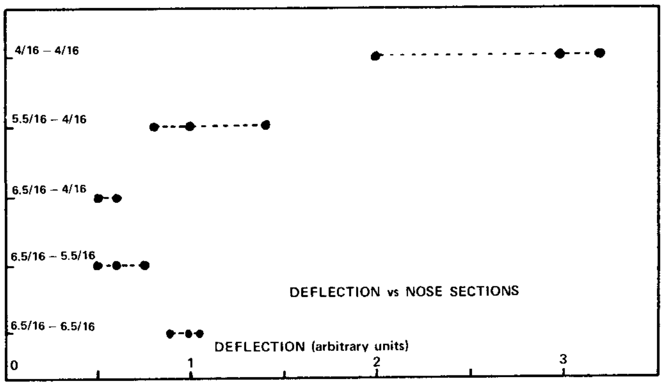


Figure 9

photograph scale distortions caused by the vertical flights, fogging of the photographic film due to lights reflecting from the cloudy sky, and the tendency of the bright rocket exhaust to obscure portions of a flight. Nevertheless measurements could be accomplished on most of the photographs. The resultant data are shown in Figure 9.

The flight deflections showed an interesting pattern. The nose sections with other than 1:1 input-output ratios showed much less deflection than the 1:1 configuration. This is in part due to the failure of air compression to occur as the rockets had airspeeds under 300 ft/sec. Also, absence of a channel probably resulted in considerable chamber turbulence and a resultant efficiency loss. The significant difference between the 1:1 nose sections is difficult to explain. Possibly chamber inefficiency of the large aperture nose section resulted in jet interaction phenomena out of proportion to the interaction effects of the small aperture nose section.

Next month **Model Rocketry** *will describe the rocket employing a two-axis ram-air control/guidance system which evolved from these investigations. The system is designed to steer the rocket towards the sun by automatically directing the incoming air into one of several exit ports rather than out a single port. In the meantime, we suggest that you build a spin fin rocket so that you can demonstrate this interesting control method to yourself. Fly it first with the usual solid nose cone, and then again with a nose cone modified for ram-air control.*

RC Equipment for Your Boost/Glider

by Andrew Elliott

Ever since the boost/glider came of age, attempts have been made to radio-control it. Until recently, most radio equipment was, by model rocketry standards, very heavy and required large, high-powered gliders to be practicable. In the past two years, however, radio equipment has been reduced in both size and weight, and it is now possible to control b/g's as small as Swift class. R/C gear now available and suitable for the rocketeer to use in small b/g's is presented here.

The whole radio-control system consists of transmitter, receiver, battery, and actuator. A summarizing table of the airborne portion of the systems appears at the end of this article.

RECEIVERS

There are three receivers currently usable in boost/gliders: the Bentert, the Albin, and the Commander. The smallest and lightest of these is the Bentert (available from Polks Hobby Shop). This receiver, handmade in Germany by Helmar Bentert, will fit inside ¾" body tubes. There are two disadvantages to the Bentert. First, as it is handmade and imported, it has a high price. Second, the Bentert audio filter requires a 3400 Hz tone for operation, far above the capability of standard transmitters without modification.

The Albin receiver (available from Ace R/C) comes in kit form and when complete weighs only 2.5 grams more than the Bentert. Due also to heavier wiring, the minimum system weight runs around 25 grams as compared to 20 grams for the Bentert. The Albin, however, does accept the 800 Hz tone generated by most transmitters.

The Commander receiver (also by Ace) is super-hetrodyne for use with standard transmitters in areas where interference is a problem. (The high tone of the Bentert effectively filters out most interference.) The Commander is comparatively heavy; it is 21 grams, so mimimum system weight nears 40 grams. The unit might be usable in large gliders, perhaps of Eagle class.

ACTUATORS

The minimum system weight previously mentioned includes the Bentert actuator, also handmade and the lightest on the market. Many other actuators are usable where great leverage is not necessary. 50 ohm relays have been converted into inexpensive actuators merely by extending the contact arm to provide control movement. Also, the large Bentert or the new Adams AR single actuators may be substituted, but airborne package weight may push you into Condor or "Dragon" class range.

BATTERIES

There are really only two types of batteries suitable for r/c b/g's, both of them made by Eveready. The S76e is a 1.5 volt alkaline hearing-aid cell. Two are used in series to power an Albin or Bentert system. The minute 50 ma rechargeable nickel-cadmium battery weighs about the same as the S76e. The Commander needs only two of these 1.2 volt cells to operate, but the other receivers demand three to be reliable.

TRANSMITTERS

The Albin or Commander receiver will accept signals from any of the popular pulse-output transmitters on the market. The list includes transmitters made by most of the r/c manufacturers. For the Bentert, however, the special Bentert transmitter (producing the 3400 Hz tone) or a highly modified standard transmitter is needed.

RADIO CONTROL EQUIPMENT SUITABLE FOR BOOST GLIDERS

Module	Name	Weight	Comments
Receiver	Bentert	5.3 grams	3 to 3.6 volts, Super-regenerative, 3400 Hz tone
Receiver	Albin	7.8 grams	3 to 3.6 volts, Regenerative, Kit form
Receiver	Commander	21.0 grams	2.4 volts, Super-regenerative
Actuator	Bentert, small	7.5 grams	
Actuator	Bentert, large	15.0 grams	
Actuator	Converted Relays	12.0 grams	
Actuator	Adams AR single	17.0 grams	
Battery	Eveready S76e	2.9 grams	Alkaline, 1.5 volts each
Battery	50 ma Nicads	2.7 grams	Rechargable, 1.2 volts each

MASS. TO LEGALIZE MODEL ROCKETS

Legislature Authorizes Fire Prevention Board to Revise Regulations

On December 2nd an act instructing the Massachusetts Board of Fire Prevention Regulations to make regulations permitting model rocket activity within the Commonwealth of Massachusett took effect. The text of House Bill 5094 is as follows:

"The Board shall make rules and regulations for the keeping, storage, manufacture, sale and use of model rocket engines and for the launching, operation, and flying of model rockets in accor ance with nationally recognized standards for model rocketry as promulgated by the National Fire Protection Association. As used in this section, "model rocket engine" shall mean solid propellant rocket engine produced by a commercial manufacturer of whichall chemical ingredients of a combustable nature are pre-loaded and ready for use, and "model rocket" shall mean an aero model that ascends into the air without use of aerodynamic lifting forces against gravity that is propelled by means of an model rocket engine that includes a device for returning it to the ground in a condition to fly again and whose structural parts are made of nonmetallic material."

In anticipation fo this action, the board in October met with Tim Skinner, Chairman of the HIAA Rocketry Division, and George Flynn of **Model Rocketry**, in an effort to more fully understand the distinction between model rockets and amateur rockets. Two weeks later the board, accompanied by approximately 100 Fire Chiefs and their representatives, witnessed a model rocket firing by the MIT Section of the NAR to acquaint them with the behavior of model rockets and the safety procedures followed by the rocketeers. Presently, the board is considering regulations to free model rocketry from the legal regulations presently hampering its growth in Massachusetts. The regulations, when finalized in early Spring, should allow launchings from approved sites in accordance with accepted safety procedures, and the sale of equipment and supplies by hobby shops within the state.

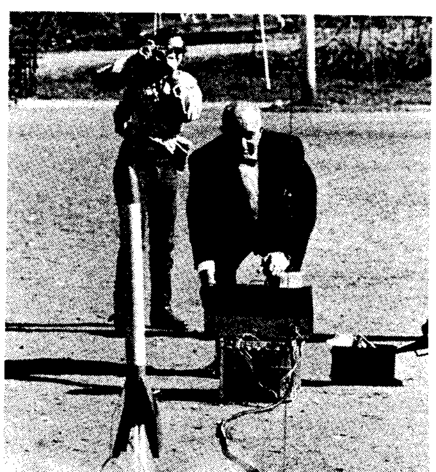


Photo by George Flynn

Massachusetts Fire Marshal Ralph Garrett presses the firing button as an Estes Bertha leaves the pad at a demonstration launching to acquaint the Board of Fire Prevention Regulations with model rocketry.

Rocket Supply Company Purchased

Rocket Supply Company, formerly of Tappan, New York, has been purchased by William Welch, and has moved its facilities to River Edge, New Jersey. Initially the new Rocket Supply inventory will consist of those products formerly marketed by AMROCS. Plans are to expand the current product line soon.

Rocket Supply will again make available "AMROCS Accelerometer". This device, the first commercially available model rocket instrumentation, was initially marketed about five years ago. It is a mechanical, peak reading accelerometer.

Copies of the Rocket Supply catalouge are available for 25 cents from Rocket Supply, Department MR, River Edge, New Jersey.

NEWS NOTES

Washington State Competition Rules Established

The rules for model rocket competition at all contests sanctioned by the Washington State Model Rocket Association (WSMRA) were tentatively established at the November 23 meeting of the WSMRA Board of Directors. These rules will also be employed at the Washington State Championships, scheduled for the Memorial Day weekend.

All events will be divided into age groups for competition scoring and prizes. Junior division will include all rocketeers under 16 years old; all older members will be in Open division.

Eleven basic events were established, all of which will be flown at the State Championships. At regional meets some or all of the events may be flown. The events are as follows:

Class I Altitude – Engine total impulse restricted to not more than 10.00 newton-seconds.

Class II Altitude – Total impulse of 10.01 to 25.00 newton seconds.

Saturn V Superscale Altitude – Any scratch-built or kit Saturn V scale model as large as or larger than 1/100th scale. Kits powered by any number or size of engines are permitted. This is a straight altitude event.

Parachute Duration – 5.00 newton-seconds maximum total impulse.

Boost/Glide Duration – 10.00 newton-seconds maximum total impulse.

WSMRA Payload – Maximum altitude with a B14-5 engine carrying a single NAR standard one ounce payload.

Payload Boost/Glide – Maximum glide duration using any combination of engines, any total impulse, carrying a standard NAR one ounce payload.

Set Altitude – Winning entry is the one coming closest to the target altitude drawn by the judges just before the start of the event. Altitudes from 500 to 1000 feet will be used.

Craftsmanship – Best constructed model wins. All models must fly.

Research and Development – Originality and practicality are the major aims. A written report on each entry must be submitted.

Spot Landing – Rocket landing closest to designated spot wins.

All the points scored by a contestant in each event count towards the championship. Only one official flight will be allowed in each event. Contestants are permitted to use their own launch equipment, including tower launchers. [Closed breech tube launchers are prohibited.]

(From *The Boeing Rocket News*)

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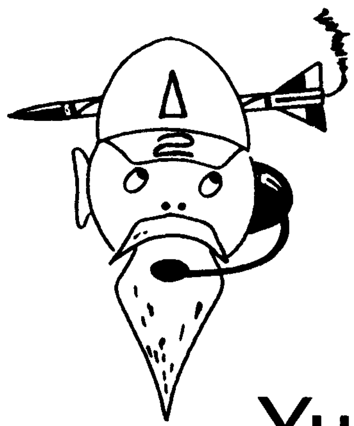


The Old Rocketeer

by G. Harry Stine NAR#2

Yugoslavian Parachute Model

The very long flight duration times achieved during the Fifth Yugoslavian Nationals in Vrsacs, Yugoslavia, last September [and reported in detail herein in an earlier issue] were not the result of any major technical breakthrough, but rather the logical consequence of the fact that the field and the weather at Vrsac on September 28, 1969, happened to be ideal. There was practically no wind, and the field was unobstructed.

However, to give you some idea of the state of the art in Yugoslavian model rocket design, presented here are the drawings for a model rocket used in the Vrsacs competition that was given to me by its designer and builder, Aleksandar Madzarac of Osijek, Yugoslavia. It does have the dubious distinction of being the only Yugoslavian model rocket to have flown across the Atlantic Ocean – in a Sabena 707!

The design is highly reminiscent of several model rockets that have been commercially available in the USA for many years. At first glance, people think it is an Estes Astron Scout or an MRI Lepus. Basically, it is just about the smallest airframe that can be easily put around an 18x70 mm model rocket motor and a parachute. There is nothing low-drag about the design; it is just small and light.

The original Madzarac model uses a commercial Yugoslav paper body tube with handmade balsa nose cone and even handmade launch lugs formed out of sheet brass!

It is possible to make an American version from parts available from at least three manufacturers – Estes, Centuri, and MPC.

The model will perform well with any American Type A or Type B motor. In fact, at Vrsac Madzarac put an Estes B8-6 in it for its last contest flight.

The dimensions on the drawings are all in millimeters. Since the original was built to metric measurements, and since American model rocketry is on the metric system also, I saw no reason to redimension the drawing in the obsolete English units. (Now, let's see . . . that's three inches to a yard, and 5280 yards to a mile . . . and inches divided up into some convenient unit such as 37ths . . . isn't that right, Daddy?)

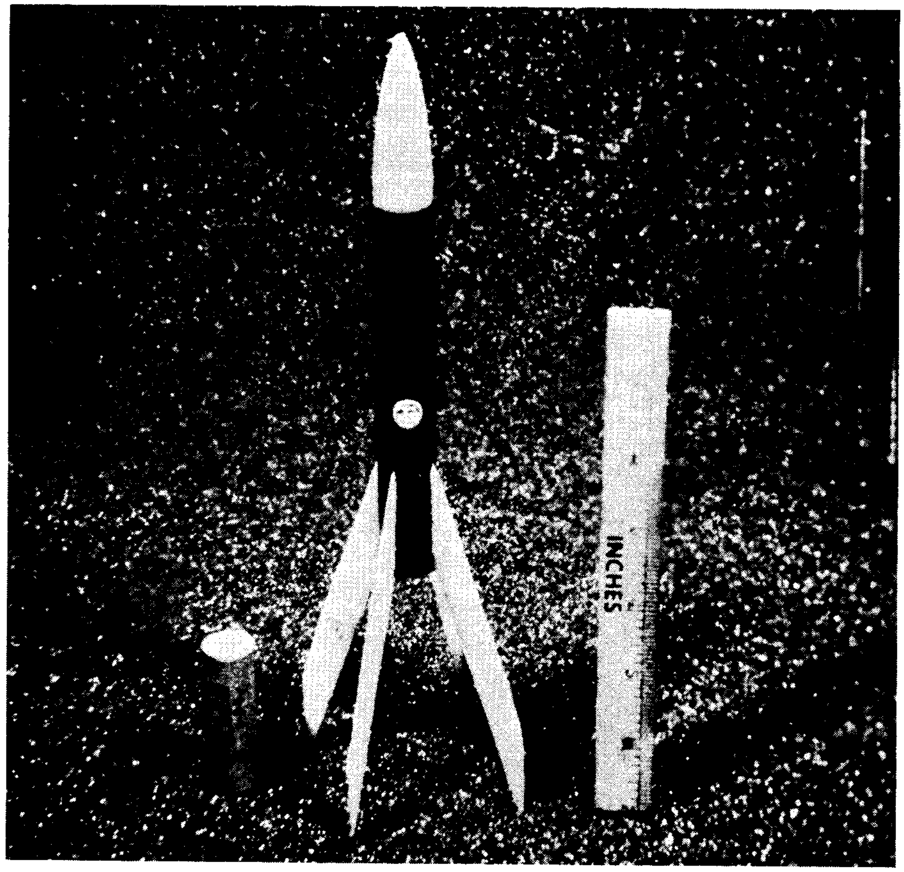
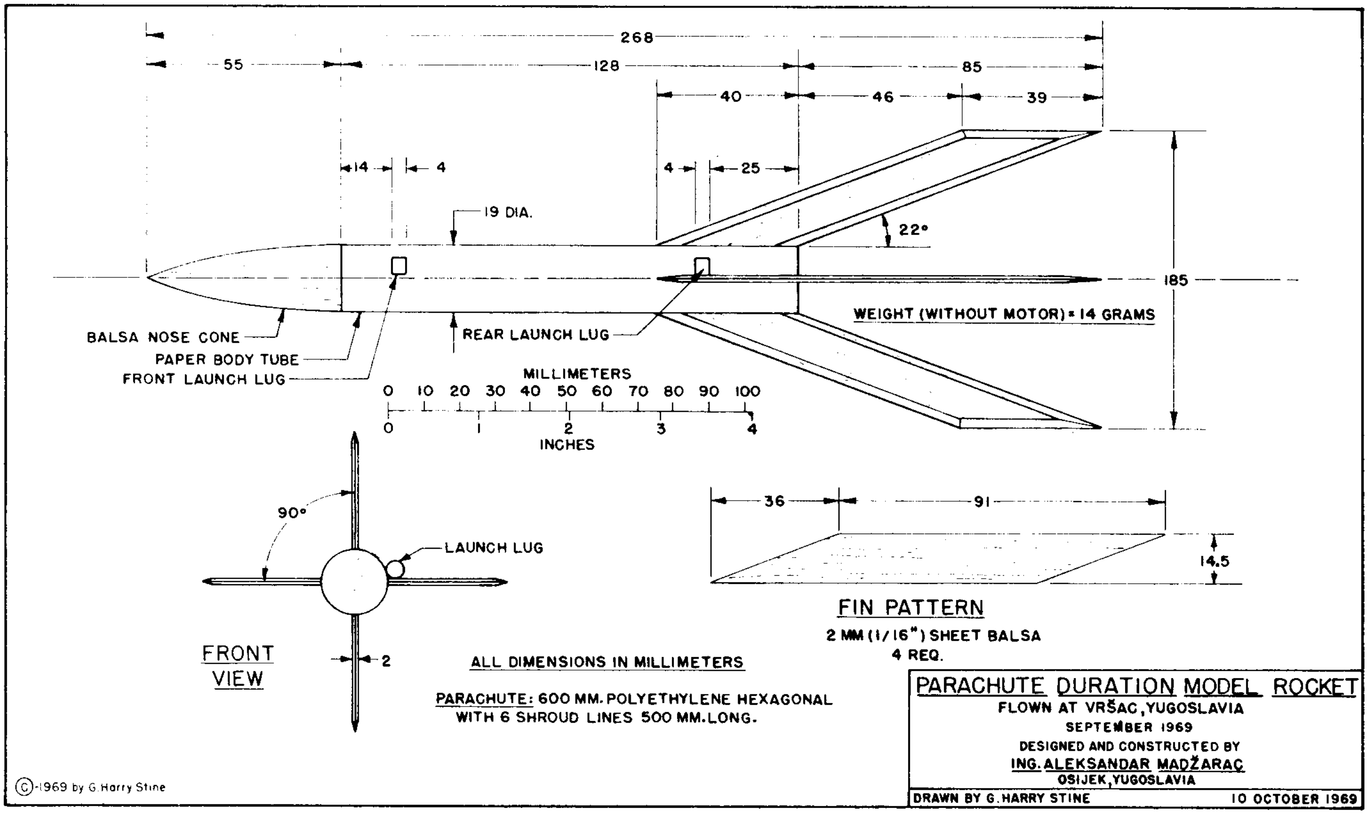


Photo by Stine

The only Yugoslav model rocket to have flown the Atlantic Ocean, the Parachute Duration model of Aleksandar Madzarac, poses with a Yugoslav model rocket motor prior to being preserved for posterity in the Stine model rocket museum

However, if you are an obsolete model rocketeer who still uses the obsolete English system of measurement, the conversion factor is 25.4 millimeters equals one inch.

The amazing thing about the Madzarac PD model is the parachute – a huge hexagonal parasheet 600 millimeters across with six shroud lines each 500 millimeters long. The material was cut from a polyethelene raincoat imported into Yugoslavia from Hong Kong; thus, such parachutes are dubbed by the Yugoslavs "Chaing Kai Shek parachutes", despite the fact that the Nationalist Chinese don't run Hong Kong. It is half-mil polyethelene, and you can get identical stuff from any dry-cleaning establish-



ment in the USA. [Half-mil polyethelene is commonly used in the plastic garment bags that are used by drycleaners to protect the clothes they have just cleaned as they are delivered to you.]

(I can just see the first USA parachute opening in the skies over Vrsacs at the First World Championships next September and proclaiming to the world, "60-minute Martinizing". . . .)

The finish on the model is nothing to tell Aunt Millie about. Just a couple of coats of clear dope. Fins and nose cone are natural balsa color, while the tube is a dull orange paper.

And there isn't too much more that even I can say about a simple model rocket like this. . . .

Photo by Stine

Aleksandar Madzarac of Osijek, Yugoslavia (left) discusses his recovered parachute duration with Otakar Saffek of Czechoslovakia shortly after its official flight at Vrsac in September 1969. Note poly parachute discoloured by carbon black for better visibility.

Book Review:

Shape and Flow

Shape and Flow, ***by Ascher H. Shapiro***, 186 pages, Doubleday paperback, $1.45.

Ascher Shapiro is one of those rare instructors who so effectively confirm their generalizations with pictures and abstractions with experiment. One glides through his little book **Shape and Flow** with the ease of a finely contoured airfoil as Dr. Shapiro demonstrates in pictures and words boundary layer theory, streamlining, drag, and many other concepts necessary to a fundamental understanding of aeronautics and fluid dynamics.

Shapiro's book, which was adapted from the instructional motion picture "The Fluid Dynamics of Drag", begins by informing the reader of those everyday actions so influenced by the dynamics of fluid flow. With emphasis on the parameters of bodies which resist the flow of fluids, Shapiro describes several interesting experiments of a paradoxical nature. The remainder of the book in eloquently simple wording gives knowledge and understanding to the reader so as to enable him to interpret and understand the many apparent paradoxes of fluid flow.

Shape and Flow will be of great interest to the model rocketeer considering experiments in dynamic similitude. Particularly good are sections on the Hele-Shaw technique for determining aerodynamic suitability. More commonly known as the water or fluid analogy, the Hele-Shaw technique passes water or another convenient liquid past a partially or entirely submerged model at a known velocity. Injected dye permits visualization of the fluid flow past the model and at least a qualitative assesment of the model's aerodynamic attributes. Shapiro shows how a knowledge of the fluid's viscosity, density, and speed permits a more quantitative expression of a model's performance in air.

Shape and Flow is probably one of the best books available on basic fluid dynamics. Young and old model rocketeers alike will find it a useful addition to their personal library.

—FMM

THE MODEL ROCKETEER

NATIONAL ASSOCIATION OF ROCKETRY, Box 178, McLean, Virginia 22101

HOUSTON SITE SELECTED FOR NARAM-12

(Washington DC) The 12th National Model Rocket Championship Meet (NARAM-12) will be held at Astroworld in Houston Texas, August 16 through 21 1970. The announcement was made by NAR President Dr. Ellsworth Beetch. National Contest Director Richard Sipes has announced that nine events will be flown. They are:

- **Parachute Duration Class I**
- **Design Efficiency**
- **Sparrow Boost/Glide**
- **Scale**
- **Swift Boost/Glide**
- **Space Systems**
- **Eggloft**
- **Spot Landing (Open)**
- **Research and Development**

According to Sipes, the facilities at Astroworld will enable as many as 250 contestants to participate.

Astroworld offers a unique site for NARAM-12. The launch site is adjacent to the world-famous Astrodome and Astrofair. The host section is Apollo-NASA. Contest Coordinator in Houston is Apollo-NASA Senior Advisor Forrest McDowell. Paul Haney, former "Voice of Apollo" and now public relations director of Astroworld, is assisting in the operation of NARAM-12.

WORLD MEET

G. Harry Stine, Chairman of the NAR Liason Committee, reports that the first FAI World Championships is scheduled for September 22-25, 1970, at Vrsac, Yugoslavia. Under the terms of the Yugoslavian proposal, presented by Kosta Sivcev at the November CIAM meeting, each nation may send a team of three competitors in each event plus a non-flying team manager. Thus, a total of ten official team members may attend the meet from each country. The events to be held are Parachute Duration with a 5 newton-second engine limit, Swift Boost/Glide Duration, and Scale.

Stine recommends that the NAR send a complete team of 10 members, each competing in a single event, except for the team manager. He estimates the cost at $200 per person. Stine has been appointed to the FAI Contest Jury along with Rudolph Cerny of Czechoslovakia and Albert Roussell of Belgium, and will therefore be unable to compete.

Visitors and press are welcome to attend the meet and will be provided with room and board at the Aerospace Center in Vrsac for $40.

An American team is being selected by NAR Vice-President Bryant Thompson and NAR Secretary John Belkewitch. Team members and further details will be announced as they become available.

CIAM MEETS World Championships Discussed

FEDERATION AERONAUTIQUE INTERNATIONALE
MINUTES OF THE TECHNICAL MEETING
C.I.A.M. ROCKETRY SUBCOMMITTEE
6 NOVEMBER 1969
HOTEL FARNESE, PARIS

****

In attendance:

G. Harry STINE Chairman
Albert J. ROUSSELL, Subcommittee Member, BELGIUM
Rudolf CERNY, Subcommittee Member, CZECHOSLOVAKIA
Kosta SEVCEV, Subcommittee Member, YUGOSLAVIA
Bryant A. THOMPSON, Observer, USA

1. The Subcommittee recommends that the maximum model rocket engine total impulse be limited to 5.00 newton-seconds for the Parachute Duration category to be flown at the 1970 World Championships in Vrsac, Yugoslavia, Reason: proximity of the Rumanian border and considerations for safety (security) as requested by the Yugoslavian club.

2. The Subcommittee intends to hold its next meeting on 25 September 1970 in Vrsac, Yugoslavia, immediately following the 1970 World Championships for the reason that all Subcommittee members are expected to be in Vrsac for these Championships and can therefore hold a face to face meeting regarding recommendations and agenda items to be presented before 1970 C.I.A.M. Plenary Session. Permission is requested to allow the Subcommittee to submit late proposals for inclusion in the 1970 C.I.A.M. agenda. The Subcommittee President will see to it that the proposals are duplicated and distributed to all C.I.A.M. delegates within 30 days of the Vrsac Subcommittee meeting, so that no additional work will be required at FAI Headquarters.

3. To relieve expense and work at FAI Headquarters, the Subcommittee will undertake the preparation and mimeographing of the versions of Section 4b in French and English prior to the 1970 World Championships so that all nations and persons participating in the 1970 World Championships will have official copies of the rules well in advance of the competition. Permission is requested to do this.

4. The Subcommittee reviewed the detailed proposal from Yugoslavia regarding the 1970 World Championships. Several minor changes and recommendations were made. The Subcommittee recommends the approval of this detailed proposal by the C.I.A.M. Plenary Session.

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EDITOR'S NOOK

Since the editorial switchover last month things have begun to settle back to normal and wheels have begun to turn. I have received several articles from new contributors and reports from some NAR committees. I was quite pleased to hear from Stephen Fentress of South Hollywood, California, who has offered to do drawings and artwork for the magazine. Hopefully we will begin to see his work next month.

Now that cold weather has set in in the northern states, sections have an excellent opportunity to schedule indoor activities such as guest speakers, symposiums, and field trips.

I have received numerous letters from NAR officers, LAC members, and other NAR members asking that current point standings and NAR/FAI records be published regularly in the magazine. Arrangements are being made with the Contest Board to provide this information as it becomes available. At this time, no records have been officially accepted by the FAI. Your suggestions for new features are always welcome.

Some of you old-timers will undoubtedly recognize some of the material used in the magazine from time to time as reprints from old issues. I hope you will bear with those who are reading these articles for the first time.

Despite any prevailing evidence to the contrary, I do believe there exists at least one NAR member in the vicinity of Ithaca, New York, who is willing to help me with typing and composition of *The Model Rocketeer*. Any volunteers?

In upcoming issues I hope to introduce new flags for regular columns, improved artwork, and more photos. If anyone has some photos that might be appreciated by the membership, please submit them; I will gladly return them after use. All other contributions in the form of prose, poetry, or artwork are also welcome, of course.

. . . .

"The Model Rocketeer", official journal of the National Association of Rocketey, is published monthly as an integral part of Model Rocketry. The National Association of Rocketry, a non-profit educational and charitable organization, is the nationally recognized association for model rocketry in the United States of America. This magazine is sent to all NAR members as part of their membership privileges. Material for publication in "The Model Rocketeer" may be submitted to the editor c/o NAR Headquarters.

Editor: Carl G. Kratzer
Section News: Charles M. Gordon
Washington Scene: James F. Kukowski
Publications Chairman: James S. Barrowman

SECTION NEWS

By Charles M. Gordon

VETERAN CONTEST DIRECTORS TO CONDUCT SYMPOSIUM

Members of the WAMARVA (Washington-Maryland-Virginia) area sections are sponsoring a lecture/demonstration symposium about regional meets on February 22, Washington's Birthday. Section Advisors Richard Sipes (MARS), James Barrowman (NARHAMS), and Howard Galloway (SSB) will lead the discussions, to be held at the Goddard Space Flight Center in Greenbelt, Maryland.

Using their vast amount of previous experience as a backbone, the symposium will cover such topics as coordination in preplanning of the contest, quick and efficient range set-up, modern data-processing techniques, and other items of interest to the potential contest organizer.

The symposium will provide much needed help to unexperienced contest planners and it is hoped that a report will be written afterwards to cover the same material.

Members wishing more information on this upcoming event are urged to contact the symposium coordinator:

Mrs. Judy Barrowman
6809 97th Avenue
Lanham, Maryland 20801

ANNAPOLIS EXPOSITION

The Annapolis Association of Rocketry of Annapolis, Maryland operated two booths at the Science and Technology Exposition of Greater Annapolis October 31 through November 2, 1969. Other booths at the Exposition were manned by representatives of science-oriented organizations in the Annapolis area, with twenty student projects included in the exhibit. Over 4,000 spectators viewed the exhibits during the three-day show.

One of the booths contained literature about the AAR, the NAR, WAMARVA, and Estes Industries, along with many finished models and an electric animated display showing the flight of a typical model rocket. Over 135 young people signed up to receive more information about AAR and other sections in their neighborhoods.

Part of the other AAR booth featured modelers building kits. The other part contained rocketeers operating a 9100A computer, owned by Hewlett-Packard, trying to familiarize themselves with it by solving two-station tracking problems.

AAR, with the help of Star Spangled Banner Section and Glen Burnie Rocketeers, put in over 150 man-hours on this project and are looking forward to Sci-Tech III in 1970.

SHORT REPORT - MOUNTAIN DIVISION

The following item is taken from the October '69 issue of *Misfire*, newsletter of the Metro-Denver Rocket Association.

Mr. Mel Severe, Manager of the NAR's Mountain Division, reports of efforts being made to revive two sections in the Colorado Springs area – the Peak City Section and the Rampart Range Section.

The Severe family (all active rocketeers) along with members of MDRA held a demonstration launch for the Crain, Colorado community as an effort to form a club there.

Interest in forming an NAR section has also come from Boulder, Pueblo, Montrose, Westminster, Berthround, and Kremmling, Colorado, as well as from Roy, Utah [near Salt Lake City]. Necessary literature and information has been sent to each of these areas by Mr. Severe, who is also monitoring responses to maintain interest.

N.B.: Division managers who might wish to have similar reports printed should send them to NAR SECTION NEWS or the Editor of the *Model Rocketeer*.

RANDALLSTOWN SECTION HAS ITS DAY

On November 22,1969, Randallstown Rocket Society Day, the official designation of the day as set aside by Baltimore County (Maryland) Executive Dale Anderson, the Randallstown Rocket Society held its annual Rocket Club Banquet. Awards were given to top section members in the section's ten special areas of achievement for the year.

That evening, the president of the Randallstown Optomists presented the section with a charter as an official Junior Optomist Organization.

In conjunction with all this the November 23 issue of the *Baltimore Sun Magazine* featured a three-page article on one of the section's monthly launches, including extensive commentary and many photographs.

Congratulations to the Randallstown Rocket Society. Keep up the good work which has obtained this publicity for your section, showing that your section is working to make model rocketry a well-known and accepted hobby in your area.

ECRM-4

The fourth annual East Coast Regional Meet, sponsored by NARHAMS, will be held April 10, 11, and 12 at the US Army's Camp A. P. Hill, Bowling Green, Virginia. The events scheduled are Scale, Hawk B/G, Swift B/G, Eggloft, Class I PD, and Class O Altitude.

Due to the enormous growth of membership in the WAMARVA area in the past few year, NARHaMS has decided to limit the number of contestants to approximately 70. At this time, however, no method of selection has been chosen. More information on ECRM-4 will appear next month.

Interested persons may contact Andy Elliott, 10203 Leslie Street, Silver Spring, Maryland 20902 for information.

ODDS & ENDS

The Tracker, newsletter of the Southland Association of Rocketry of North Hollywood, California, reports a short demonstration launch given for Cub Scout Pack 961 of Los Angeles, on November 15, 1969. The launch included flying single- and double-stage models, a Camroc, and an eggloftér.

* * * * * *

On November 21, 1969 the UFO section (United Flying Organization) of Rockville, Maryland officially merged with the NARHAMS of Seabrook in order to provide more for, and prevent loss of, the remaining members of UFO. The process of merger involved simply having the UFO members join the NARHAMS section. The name NARHAMS and its present officers remain unchanged.

An ironic twist to this merger is provided by the fact that UFO was originally formed four or five years ago by members of NARHAMS who wanted a new section closer to their homes.

* * * * * *

The October '69 issue of *Misfire*, newsletter of the Metro-Denver Rocketry Association, reports the presentation of several rocket kits and engines to members of the section by George Roos of Flight Systems, Inc., in appreciation of help they gave at the NARAM-11 range store.

* * * * * *

The cover of *Contrail*, newsletter of the Three Rivers Section of Pittsburgh, Pennsylvania, has an interesting difference from other spirit-process newsletters normally seen. Instead of the usual one or (rarely) two colours, this newsletter uses no less than three and sometimes four colours combined in a single drawing.

The artist, who is quite talented [as may be seen in any of the last four issues], is section president Dennis Brandl, who has mentioned that he wished there were more colours available for him to use.

Nice going, Dennis – keep up the good work!

* * * * * *

The Randallstown (Maryland) Rocket Society made plans to visit the Franklin Institute in Philadelphia, Pa., near the first of the year. More information on the trip in a future issue.

* * * * * *

On November 9,1969 the Natural Science Museum Model Rocket Research Society of Cleveland, Ohio held a boost/gliders only contest. First and second places were taken by models using class A engines though maximum for the meet was 5.00 newton-seconds (class B).

Before the contest started Mr. Seard, NSMMRRS senior member, displayed one of the upper stage nozzles used in the Polaris missile and gave a brief talk on its composition and the mechanics of its operation. The nozzle on hand had been rejected because the anti-blistering holes drilled into it had been cut too deeply.

* * * * * *

The NARHAMS section of Seabrook, Maryland presented a NASA film of the Apollo 11 space flight, man's first lunar landing mission, on December 12, 1969. Section members, their parents, and friends were present for this spectacular film.

* * * * * *

The Metro-Denver section of Denver, Colorado will be selling sodas and popcorn to the contestants and spectators at future meets to help build up the section treasury without having to raise members' dues.

* * * * * *

Another note from the NSMMRRS section in Cleveland tells of plans by some of its members to enter the Northeastern Ohio Science Fair and the National Plane and Space Show, both to be held in Cleveland in March.

* * * * * *

Brief mention is made in *Igniter Current* of a tentatively planned trip by members of the Fairchester Section to the Sikorsky plant in Stratford, Connecticut, some time in February. Interested persons should contact the section for more information.

* * * * * *

In October, November, and December the Xaverian High School Model Rocket Society, as a regular section activity, showed NASA films for its members. Films included MARINER 4 [the NASA photomission to Mars]; LEGACY OF GEMINI [the major accomplishments of the Gemini program]; STEPS TO SATURN; THE X-15; and others.

This section activity is an excellent idea, useful in maintaining member interest in the section and in interesting prospective members in the field. Keep it up, XHSMRS.

* * * * * *

NAR SECTION NEWS will appear each month as a regular part of the *Model Rocketeer*. Those sections wishing to have news and/or information of their section printed in this column should prepare all material and send it to:

NAR Section News
c/o Charles M. Gordon
192 Charolette Drive
Laurel, Maryland
20810

Remember my motto: IF I DON'T HAVE IT – I CAN'T PRINT IT!

LAC Newsletter Award

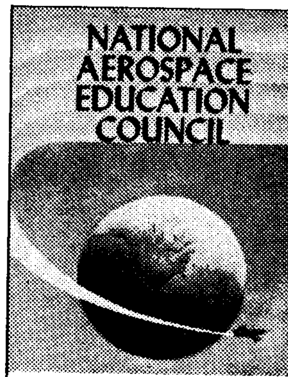
Bruce Blackistone receives the LAC newsletter trophy from Contest Director William Roe at NARAM-11. The trophy, donated to the NAR by North American Rockwell, will again be presented at NARAM-12. The Section producing the best newsletter for the 1969-70 Contest Year will receive the trophy.

Aerospace Education

The National Aerospace Education Council (NAEC) is a non-profit, non-governmental organization of educators who are interested in the inclusion of aviation and space concepts in the curricula of our schools. The membership is composed primarily of teachers, librarians, counsellors, and administrators but also includes representatives of the aerospace industry and of national and state aviation and space agencies.

The objectives of the NAEC are to aid and encourage teachers and students to gain a knowledge of aviation and spaceflight and of their impacts on society and to provide information related to exploration of space, aviation, and career opportunities.

Membership in the NAEC, including two periodicals and various teaching aids, is available to aerospace educators who may request an application from NAEC, Suite 310, 806 15th Street NW, Washington, D.C. 20005.



MINUTES OF THE NOVEMBER LAC MEETING

The following is a summary of the official minutes of the November 29, 1969 meeting of the NAR Leader Administrative Council. The original, full length version of this report may be obtained by sending a stamped, self-addressed envelope to: Jay Apt, 40 Woodland Ave., Pittsburgh, Pa. 15232.

The meeting was called to order at 9:45 am at the George Washington Motor Lodge in Willow Grove, Pa. In attendance were Elaine Sadowski (Chairman), Jay Apt (Secretary), Bob Mullane, Joe Persio, and Greg Scinto. Mike Poss and Gary Spriggs were unable to attend.

Elaine presented a bill from Bruce Blackistone for having the Newsletter Trophy engraved. She will submit the bill to the Association.

The minutes of the August 12, 1969 meeting were read and unanimously approved.

Elaine opened discussion of the motions remaining from the last meeting. Joe suggested that something be done to circulate the NAR section roster. Possibilities of inclusion in *Model Rocketeer* or special mailings were discussed. Elaine said she would contact *MR* editor Carl Kratzer and NAR HQ about the matter.

Discussion continued on the suggestion for lowering the minimum number of NAR members required to charter a section. Jay furnished a list of areas with eight or nine NAR members who may be interested in forming sections, and volunteered to contact these members and determine their interest.

Elaine asked about the status of the LAC elections for NARAM-12. Joe said he planned to implement the procedure described in his open letter and will send notification to Carl Kratzer on November 30.

Elaine announced that she will again handle the newsletter award this year and will notify Carl of same. Several possibilities for judges were mentioned.

Elaine began discussion and voting on the motions in Bob's open letter of September 29. The motions after being restructured are as follows:

MOTION 1.) That the LAC, in cooperation with HQ, NARTS, Publications Committee, or whoever it is has the authority in the matter prepare and publish a new NAR flyer to be made available to HQ for distribution.

MOTION 2.) That the LAC distribute (through *The Model Rocketeer*) a list of all NAR committees and the addresses of their chairmen and see that this list is published once a year.

MOTION 3.) Based on a request by Mr. Atwood dated August 9, 1969. Bob rephrased the motion to read: That each LAC member "wet nurse" a new section for 12 months.

Elaine called for votes on the motions. Motion 1 was passed unanimously and Bob was appointed to implement it. Motion 2 was also passed unanimously and Elaine offered to contact Carl about it. Motion 3 was tabled pending Tina Feldman's technical report on the subject.

Discussion of the ideas in Joe's letter followed. His first was that a computer be programmed to tabulate NAR contest records and point standings. Mike Poss volunteered in an open letter to work on the project. Elaine will talk with Mike and Mr. Sipes (Contest Board Chairman).

Joe suggested that a chapter be added to the Section Manual on how to take and help the press to take good photographs of model rocket scenes. Greg was appointed to contact people for their contributions and select an editor for the piece.

The meeting was recessed for lunch at 11:30 am and reconvened at 12:45 pm.

Joe suggested that a flow chart of NAR organization be made and included in the Section Manual or *The Model Rocketeer*. Gary Spriggs was appointed to the job.

Joe also suggested that a poll of NAR sections be taken to find out what skills and educational background they possess. Greg recommended that Charlie Duelffer of Fairchester Section be asked to write the poll.

LAC members (left to right) Jay Apt (secretary), Bob Mullane, Greg Scinto, Elaine Sadowski (chairlady), Joe Persio at the November 1969 meeting.

Elaine read Mike Poss's two motions from his November 4 open letter. The first was to publish all NAR and FAI records in the magazine before NARAM-12. Jay volunteered to contact Carl Kratzer and Mr. Sipes.

Mike also suggested that the name of the Southland Division be changed since it is also the name of a previously chartered NAR section in California. Elaine recommended that the Southland Section first contact Mr. Atwood before referring to the LAC.

Elaine read a letter from Carl Kratzer dated November 11, 1969. He requested copies of all LAC open letters and minutes. Elaine appointed Jay to handle it. Carl also said he wanted news of local events and for LAC members to encourage local sections to contribute material for the magazine.

Elaine then opened discussion on a request from Dr. Beetch (President) and Capt. Thompson (Vice-President) that various proposals for a "professional" competition class be considered. Lengthy comments ensued which were submitted to Capt. Thompson for appraisal.

Elaine said that Capt. Thompson needs NARTS materials, especially plans, and that he does not have the facilities to redraw the plans. Greg volunteered to collect scale data, find draftsmen, and be responsible for plan production.

Elaine said that she had received a suggestion from a trustee that *The Model Rocketeer* be more chatty. She will forward this suggestion to Carl Kratzer. *(Ed. Note: Will comply when I receive more "chat". Thanks for the suggestion.)* She also asked that the membership be encouraged to write to LAC.

Elaine said that Capt. Thompson needs advertising for NARTS in *The Model Rocketeer*. Jay agreed to find out NARTS requirements and help write the ads.

Elaine reported that Dr. Gregorek (Trustee) requested that a study be made of the age classification scheme as he feared that 16-year-olds were too much competition for the younger modelers. Jay suggested the following division: 1.) through 13; 2.) 14-16; 3.) 17-20; 4.) 21 and up. The others concurred and Elaine asked Jay to notify Mr. Sipes, Dr. Gregorek, and Dr. Beetch of the recommendation.

Jim Barrowman (LAC Advisor and Trustee) had requested that LAC look into the availability of technical reports to be published in *The Model Rocketeer*. Bob volunteered to coordinate a long-range program to produce basic technical reports and find authors for them.

Elaine summarized the assignments given at the meeting.

Greg moved that the meeting be adjourned. The motion passed unanimously and Elaine adjourned the meeting at 4:18 pm.

Respectfully submitted,
Jay Apt, LAC Secretary

PROJECT PLEIADES

Project Pleiades was presented as a Research and Development entry at NARAM-8 in Wilmington, Ohio. The project was a team effort produced by Veron Estes, Gleda Estes, Betty Estes, and Norman Avery of Penrose, Colorado and was concerned with the development of a single-stage payload vehicle for use with the Estes Camroc aerial camera. Although the entry did not achieve a place in the competition, it was acclaimed for its thoroughness and practicality.

INTRODUCTION

An early problem encountered in experimentation with various rocket camera designs was that of insuring the correct nose-down attitude for the best verticle photographs. At the same time it was realized that a single engine, single stage vehicle did not give adequate altitude, particularly with sufficient delay to give a vertical photograph. It was felt that a single stage booster vehicle of adequate power would be preferable to a multi-stage vehicle in that it is not always practical to chase several rocket sections which may land several hundred feet apart. Finally, it was recognized that the vehicle muct provide a relatively stable, slow moving platform for optimum picture quality. It was decided that the following vehicle characteristics were essential

1) Altitude in excess of 500 feet at shutter release.
2) Positive means of insuring a nose-down attitude at shutter release.
3) Low velocity at shutter release.
4) One piece to recover.

VEHICLE DEVELOPMENT:

1 Working under the premise that a preliminary recovery deployment to slow, aim and stabilize the vehicle and a prime deployment to activate the shutter and provide proper retardation of descent would be ideal, it was decided that the vehicle should have at least two engines with distinct delay times. To satisfy requirements 2 and 3 above, the rear-ward ejection of either a parachute or a streamer was selected as the most promising technique.

A preliminary test model was built to these requirements from parts on hand. In place of a camera, the rocket was fitted with a payload section on the main bodey to accomodate various payload weights. The two engines were mounted in pods on the side. One pod was ducted into the main body behind its noseblock, permitting rearward ejection of the parachute or streamer. The other pod was adapted to eject its nose closure and a parachute in normal manner. The fins were mounted on the main body.

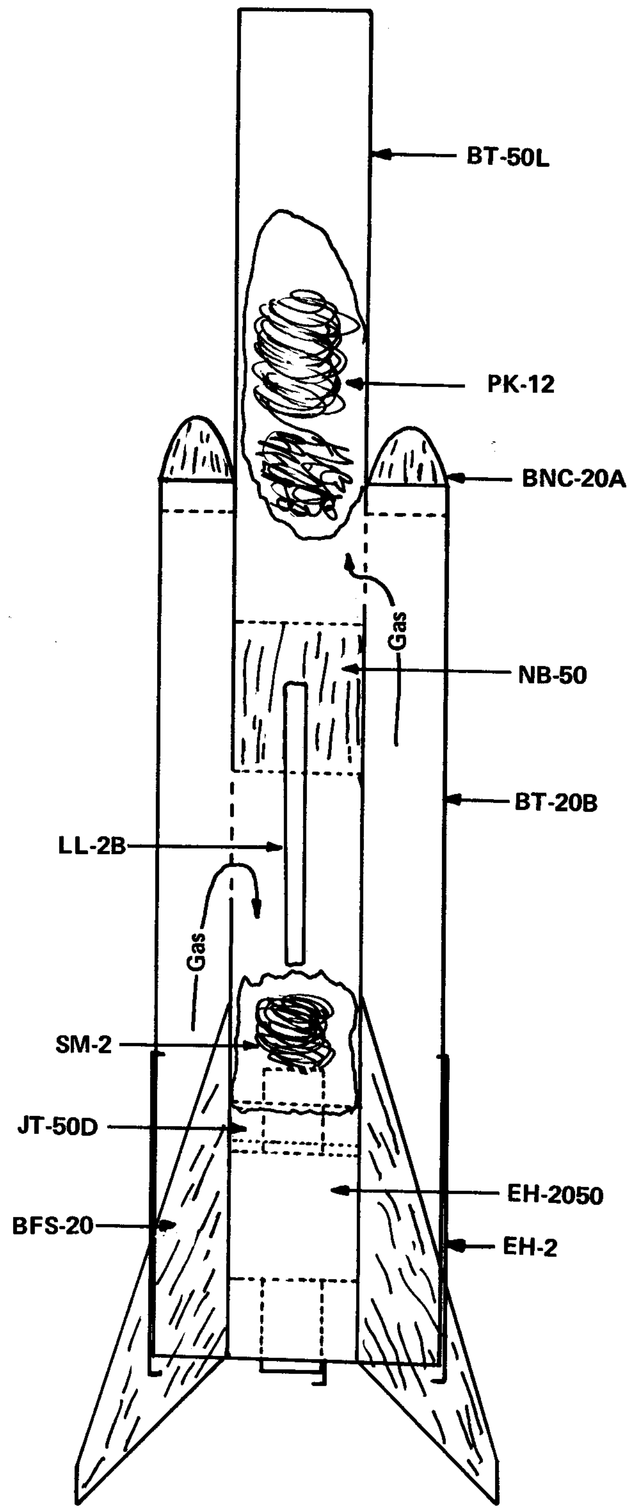
Flying with various payloads provided the following information:

1) A streamer would provide adequate slowing, aiming, and stabilizing when ejected rearward—a parachute would make the assembly sway.

2) The off-center mounting of the engines caused the vehicle to veer away from a verticle flight—this was more pronounced with lighter payloads.

3) For payload weights in a range equivalent to the various cameras being considered, an engine pair of B.8-2 for the preliminary system and a B.8-4 for the prime system gave best results.

II The second vehicle was a direct outgrowth of the first. To correct



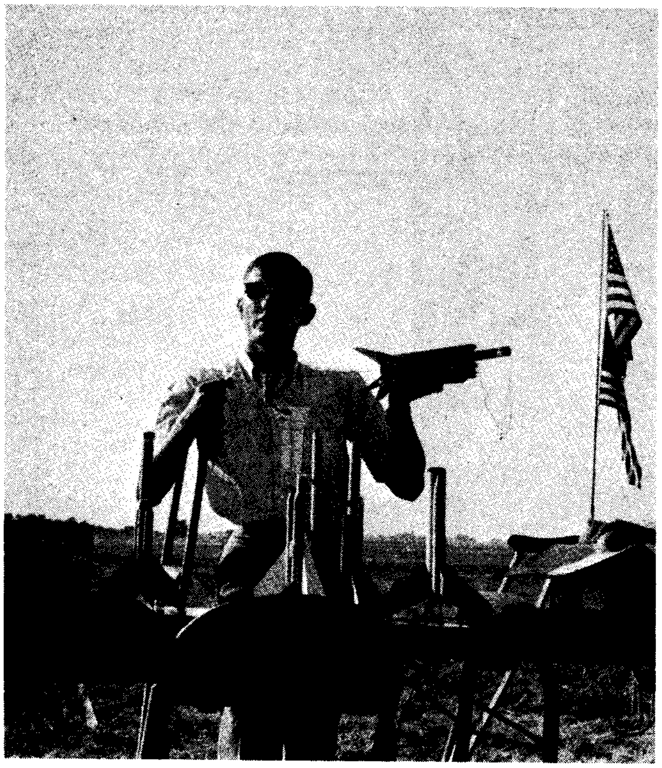


Photo by Vern Estes

Norman Avery of the Estes-Estes-Estes-Avery team delivers an oral presentation of Project Pleiades to the judges and contestants at NARAM-8.

the off-center thrust of the side-mounted engines, two of the fins were mounted at an angle. To make the prime recovery mechanism compatible with a standard Estes Camroc, the prime pod was ducted into the main body (a BT-50) ahead of a bulkhead (nose block); the preliminary pod was ducted to the main body behind the bulkhead.

III To reduce the torque moment from off-center thrust and to increase the performance of the carrier, Pleiades III was built with a cluster of three engines mounted in the main body (an Estes BT-60). A side pod was provided for the preliminary recovery system (a rearward ejecting streamer). One engine holder tube was ducted to this pod, the other two engines were allowed to discharge their ejection charges forward into the main body which contained the prime recovery parachute with a modified Camroc on the front.

While a more vertical flight was achieved and good prelimir.ary and prime recovery were obtained, it was felt that the vehicle was excessively bulky and slightly overweight.

IV Working towards a more sophisticated vehicle, No. 4 was built with its two engines in side pods. However, in this model, the ods were mounted on opposite sides of the main body. Once again, a bulkhead was provided in the main body with the preliminary pod ducted behind the block. The prime pod contained the main recovery parachute and the shutter release mechanism of the Camroc was extended back to the nose closure of the prime pod. The reasoning behind this arrangement was that if the vehicle were suspended at about its center of gravity by its main parachute, it would be less susceptible to damage on landing.

Launchings of this model bore out the value of mounting the pods on opposite sides. The performance of the rocket was quite adequate, with flights over 800 feet obtained. However, the extended shutter release proved to be a nuisance when prepping the rocket. Finally, no actual advantage in lowering the rocket sideways was found.

V The next version was quite similar to No. 4. However, the prime pod was ducted into the main body ahead of the bulkhead. Thus the Camroc itself was activarated in a normal manner, with the main parachute packed immediately behind the Camroc.

In flight, vehicle No. 5 perfor quite well, yielding sharp photographs from altitudes in the vicinity of 600 feet. The only criticism raised was that a bit more altitude would be nice.

VI Pleiades VI was built as a dual-use model. It can be flown in either a two engine configuration using a B.8-2 and a B.8-4, or in a 3 engine configuration with a B.8-4 engine in the preliminary pod, a B.8-6 in the prime pod, and a plugged C.8-0 or a B.8-0(P) in the center. In the three engine configuration, the B.8-4 in the preliminary pod exhausts its ejection charge through a part into the main body aft of the bulkhead. This forces the center engine and its holder out, followed by a streamer which is connected to the main body.

The action of the streamer against the air stream creates drag, thus reducing the speed of the vehicle. The model turns over and points toward the ground before the ejection charge in the prime engine (B.8-6) is activated. Since the ejecting gases from this engine are ducted into the main body ahead of the bulkhead, the Camroc is activated in the normal manner and the main parachute is deployed (in a normal manner).

Altitudes in excesss of 800 feet at shutter release have been achieved using this model in its three engine configuration. Electrical ignition with a buss bar system as described in Volume 6, Number 1 of the Model Rocket News has proven quite satisfactory.

The Wayward Wind

by Gordon K. Mandell

In last month's column we learned how to compute the characteristics of a rocket nozzle designed for optimum expansion and saw about how much thrust we could expect to get from a nozzle of a given size operating at a given combustion *champer pressure* p_o. This month I'm going to discuss the considerations influencing the design of the propellant *charge*, or *grain* which (in solid propellant rockets) supplies the hot, high-pressure gas required for the nozzle's operation.

To illustrate our discussion let's draw a diagram (Figure 1) of the simplest solid porpellant grain confuguration imaginable, the so-called "end-burning" or "cigarette-burning" grain, contained within a model rocket engine casing. The engine has been ignited and the propellant is being consumed such that the aft surface of the grain is burned away at a rate of x inches per second. The area of the grain surface on which burning is occurring (which I will call A_b) is then just equal to the internal cross-sectional area of the casing. The model rocket engine in which the grain is contained has a nozzle whose throat area is A_t square inches. We want to know what chamber pressure is produced by this burning process, for (as we saw last month) the value of p_o has a strong influence on the thrust the engine will produce. We would like to find the value of the burning rate x, since this will enable to compute how long the engine will burn before it exhausts its propellant. In the course of these calcualtions we shall also compile enough information to be able to compute the specific impulse of the propellant when burned in any given motor-casing/nozzle assembly.

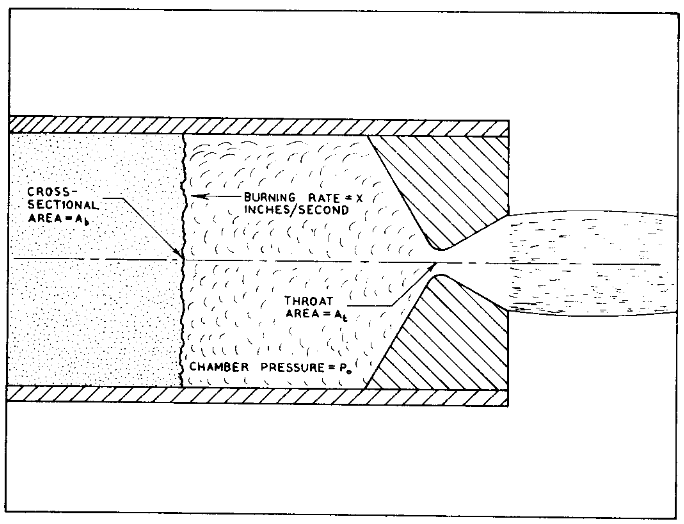


Figure 1. An end-burning grain being consumed in a model rocket engine.

First of all, it has been observed experimentally that the burning rates of most rocket propellants depend on the pressure under which combustion takes place (i.e., the chamber pressure). This pressure depencence is often of a form called Vieille's Law:

(1) $$x = a\,p_o^{\,n}$$

where a and n are characteristics of the propellant. Values of a and n for many propellants have been determined and may be found in the literature of rocket technology. In the case of JPN Ballistite (a double-base propellant composed mainly of Nitroglycerin and Nitrocellulose), for instance, n is equal to 0.73 and a is 0.00392 for p_o expressed in pounds per square inch, absolute (PSIA) in the region of p_o = 2000 PSIA. The exponent n is always less than 1.0 for practical rocket propellants, and it is almost always greater than zero. It is better from the standpoint of combustion stability if n is small, say about 0.25 or less; however the propulsion engineer must often accept a larger n in order to get a propellant with a high specific impulse. I will assume that everyone who has read this far knows what specific impulse means and why a high one is desirable.

A knowledge of the constants a and n for a propellant which obeys a burning rate law of the form of equation (1) enables the designer to calculate the chamber pressure resulting from the burning of that propellant as

(2) $$p_o = \left[\frac{A_b\,C^*\,a\,\rho_p}{A_t}\right]^{1/(1-n)}$$

where ρ_p is the density of the propellant in pounds (mass) per cubic inch, and

(3) $$C^* = \frac{\sqrt{49{,}800\,T_o/M}}{\Gamma}$$

where T_o, called the *adiabatic flame temperature*, must be known in degrees Rankine. A temperature given in degrees Rankine is equal to that temperature given in degrees Fahrenheit plus 459.6. Thus for instance, 70°F equals 529.6°R. M is the average *molecular weight* of the gases resulting from the burning of the propellant; its numerical value is identical in all systems of units. Γ, as we saw last month, is given by

$$\Gamma = \sqrt{\gamma}\,(2/\gamma+1)^{(\gamma+1)/2(\gamma-1)}$$

where γ is the ratio of specific heats of the combustion products. The quantity C* is called the *characteristic velocity* because its units come out as feet per second when it is calculated as I have described above. With a and n having the same numerical values used in calculating x in inches per second, p_o will be obtained from equation (2) in PSIA. It is then a simple matter to compute x from equation (1), and if we know the length w of the end-burning grain we can find the duration of thrust from the formula

(4) $$t_b = w/x$$

Finally, the specific impulse I_{sp} of rocket motor can be determined from

(5) $$I_{sp} = C^*\,C_F/g$$

where g is the sea-level acceleration of the earth's gravitational field, 32.174 feet/second². Instructions for calculating C_F were given in last month's *Wayward Wind*. Notice that C* depends only on the properties of the propellant, whereas C_F depends not only on the propellant property γ but *also* on the chamber pressure and the nozzle area ratio. The specific impulse obtainable from a given rocket propellant thus depends on the design of the motor in which it is used as well as on the propellant itself. The properties of the propellant which are

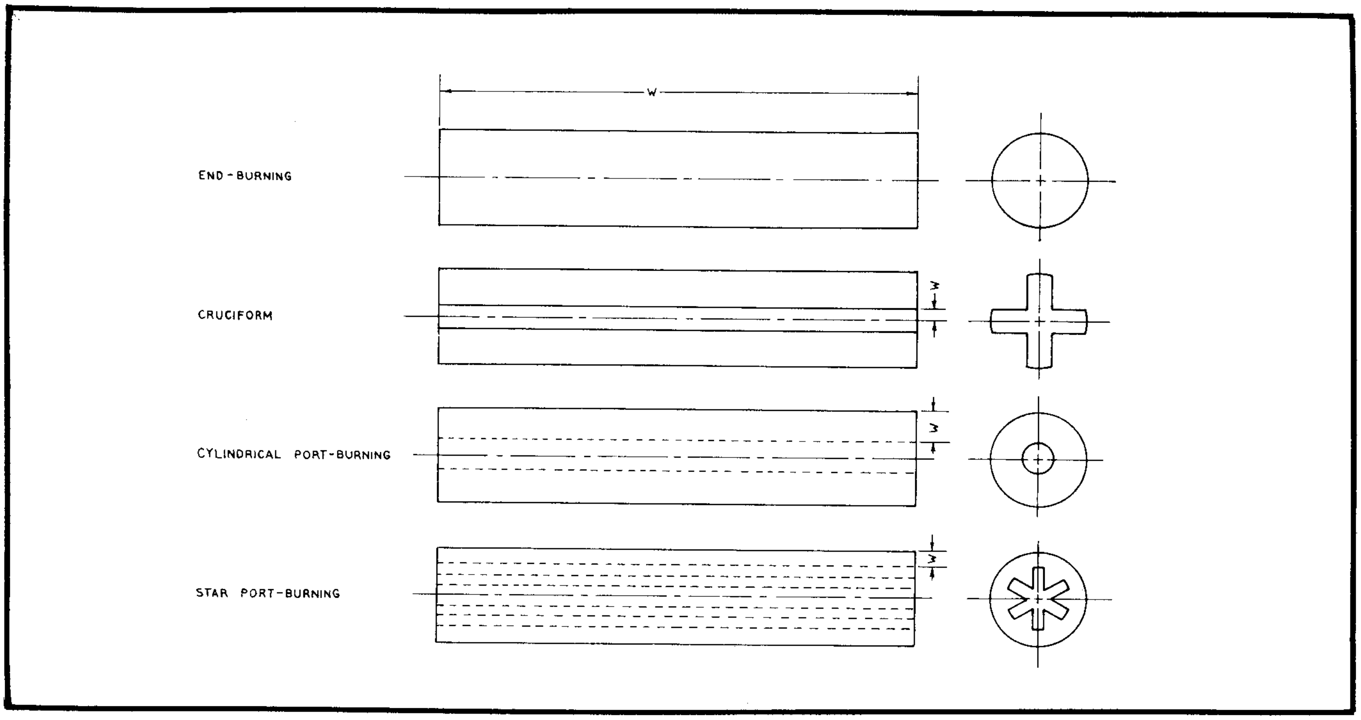


Figure 2. Definition of web for some common grain designs.

desirable in order to attain a high I_{sp} are a *high* adiabatic flame temperature, a *low* molecular weight of combustion products, and a *low* value of γ (as close to 1.0 as possible). Motor characteristics conducive to high I_{sp} are a *high* chamber pressure and an optimally-expanded nozzle.

I have used the symbol "w" instead of "l" to represent the length of the grain in equation (4) because the extent of the propellant in the direction perpendicular to the surface on which burning occurs is in general refered to as the *web*. The web equals the length only in the case of an end-burning grain. In the case of a grain which is *not* end-burning, but which burns on internal or external lateral surfaces, the web is the depth of propellant perpendicular to the burning surface whcih must be consumed before all the propellant is spent. Webs for some non end-burning grains are shown in Figure 2.

Note that, in a grain which is not end-burning, the burning surface area is not generally constant; it changes as the propellant is consumed. Thus the chamber pressure, and therefore the thrust, also vary during the burning of an engine using such a grain. The cruciform grain has a thrust which *decreases* with time, and is so called a *regressive-burning* grain, while the tubular port-burning grain has a thrust which *increases* with time and is therefore called a *progressive-burning* grain. The star port-burning grain can be so designed that its thrust is almost constant over the burn time, since the increase in port size is counteracted by the consumption of the "points" of the grain. Such a grain is said to be *neutral-burning*. Thrust-time curves for these grain types are shown in Fugure 3. Laterally-burning grains are used for high-thrust, short-time applications, while end-burning grains provide lower thrusts for

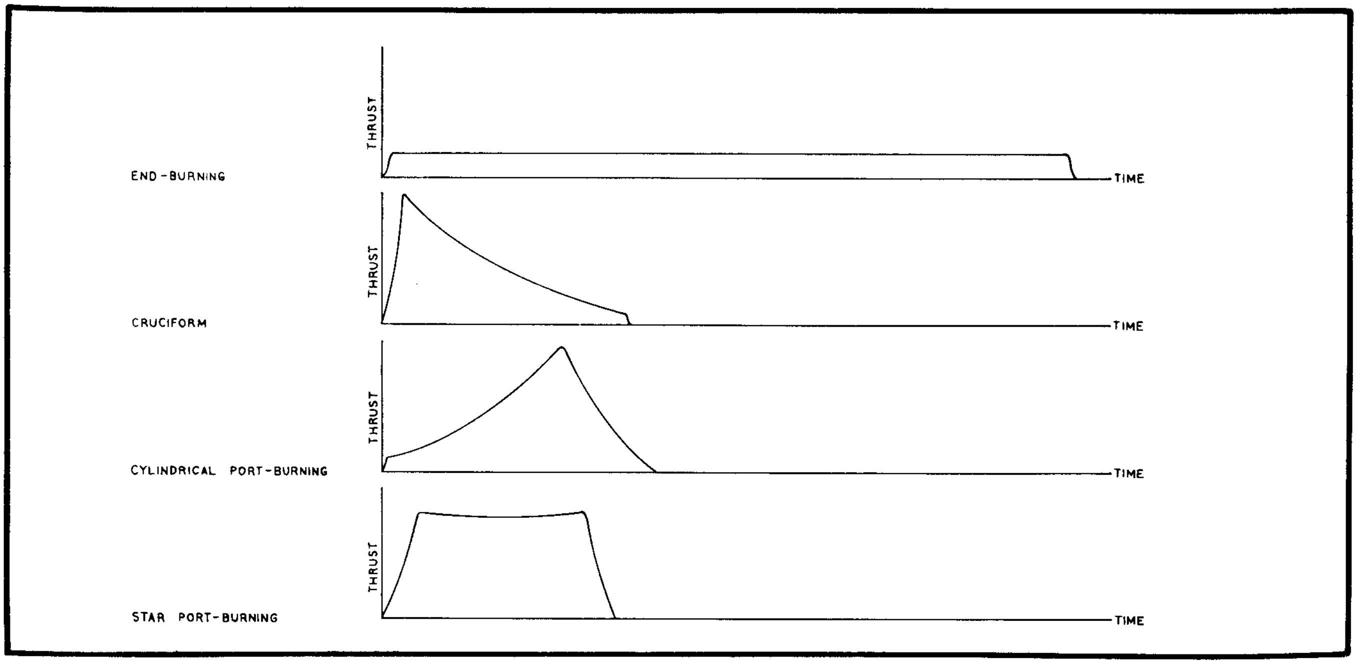


Figure 3. Thrust time curves for some common grain designs.

longer times. The tubular port-burning grain is presently the only non end-burning type used in model rocktery.

In order to accurately determine the pressure-time and thrust-time curves of grains which are not neutral-burning it is necessary to divide the problem up into small increments of time, say thousandths of a second, and to treat the pressure, thrust, and burn rate as constant within each increment but changing as the propellant is consumed from one increment to the next. The designer (or more likely an electronic computer) just continues the incrementation process until the whole web is consumed. The total burn time is then the sum of all the increments; equation (4) cannot be used. The engineer will have to design his nozzle to be optimally expanded at the *average* chamber pressure during the firing. C_F, and consequently I_{sp}, will change slightly during the burn due to variations in the chamber pressure, and average values must be used in computing performance. I anticipate that only the most advanced modelers will ever undertake such time-varying calculations, and therefore I will not describe them in any more detail.

I would, however, like to close with a simple extension of my example from last month to illustrate the use of the formulae presented here in designing an end-burning grain. Suppose the motor of last month's example (p_o = 147 PSIA, throat diameter = 0.1 inch) uses a propellant whose characteristics, in addition to a γ of 1.35, are:

$a = 0.02$
$n = 0.22$
$T_o = 2500^oR$
$M = 50$
$\rho_p = 0.072$ pounds/cubic inch

The motor is designed for use in competition as an NAR Class C engine. What is the required internal diameter of the casing, what is the duration of thrust, what is the web and what is the specific impulse?

First we compute C* according to equation (3), obtaining

$$\sqrt{49{,}800\, T_o / M} = 1580$$

and with Γ = 0.673, we obtain C* = 2340 feet per second. Then, rearranging equation (2) to read

$$\frac{A_b}{A_t} = \frac{p_o^{(1-n)}}{C^* a \rho_p}$$

we have

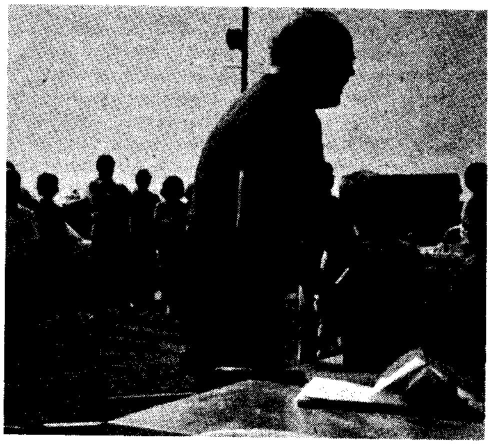
$$p_o^{(1-n)} = 50.1$$

$$C^* a \rho_p = 3.38$$

So A_b/A_t is 14.83. Now since the burning surface is a disc the diameter of the inside of the casing, the required casing internal diameter will be 0.1 times the square root of 14.83, or 0.386 inch. From last month's results we know that the motor's thrust is 1.445 pounds. To be in NAR Class C the motor must have a total impulse of no greater than 2.24 pound-seconds. In fact, most model rocket manufacturers design their engines to somewhat less than the maximum impulse permitted in a given class so that slight variations occuring in the manufacturing process don't put them over the limit. Suppose we choose to design to 90% of the maximum allowable impulse, or 2.02 pound-seconds. Then the burning duration must be (2.02/1.445) or 1.4 seconds. From equation (1) we find

$$a\, p_o^n = (0.02)(30)$$

so x = 0.6 inches per second and the web must be (0.6)(1.4) or 0.84 inches. Finally, again remembering from last month that C_F is 1.225, we obtain the specific impulse from equation (5) as 91 seconds — moderately good for a model rocket motor of the pressed-powder type. You can see that, with a grain diameter of a bit over 3/8 inch and a grain length of a little under an inch we would expect the external diameter of the motor to be about 11/16 of an inch, while its length would be about 2½ inches once allowances are made for the nozzle, delay train, ejection charge and end cap — so our hypothetical engine conforms very closely to actual types in use.



Houston's Apollo-NASA Section has been active with a number of demonstration launchings recently. The Apollo-NASA demonstration team (right), under the direction of President Gary King, Vice-president Barry Friedrichs, and Senior Advisor Forrest McDowell, staged the first indoor model rocket competition on December 11th in the famous Houston Astrodome. Paul Haney (left), former Public Affairs Chief of NASA's Manned Spacecraft Center and now Public Relations Director for the Astrodome, has become interested in model rocketry. He has arranged for the club to present model rocket demonstrations in connection with other events at the astrodome.

(Club Notes continued)

The YMCA Space Pioneers of New Caanan, Connecticut flew their section section meet of the contest year, SP-17, in November, 1969. In the scale event, Arnold Jacobsen took first in senior/leader with an Arcas, while Peter Joseph placed first in junior, also with an Arcas. Bruce Dunbar took S/L Plastic Scale with a Revell X-15, and his son Bob Dunbar captured junior first place, also with an X-15. Harry Stine's 81 second flight took first in S/L Parachute Duration, while Greg Jacobsen placed first in junior with 73 seconds. Arnold Jacobsen captured open class Spot Landing with 11.4 meters.

Robert Finch (NAR 12965) is in the process of organizing an NAR section in the North Shore area of Chicago, Illinois. The club, named NASA-II Rocketry Club, is looking for interested rocketeers and/or NAR members, especially senior and leader members, from the area. The club now has 16 active members, and a wind tunnel with electric motor. Interested rocketeers should call 432-8986.

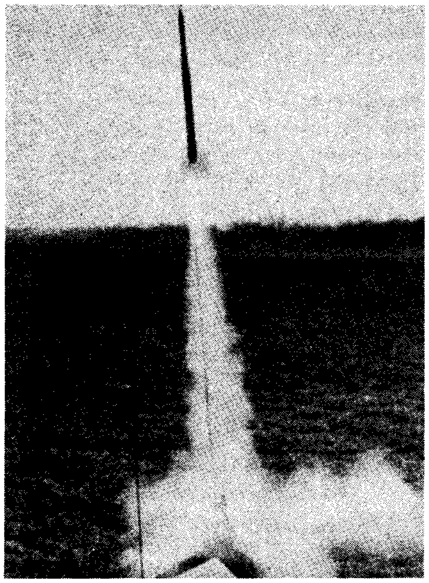


Photo by Jim Visser

An Estes Aerobee 300 model lifts off at one of the weekly launches of the North Penn Valley Model Rocket Club of Hatfield, Pennsylvania.

Fifth grade students at the Pen Argyl elementary school near Bethlehem, Pennsylvania have been constructing and launching model rockets as a science project.

The ABM Club has been organized at Sam Barlow High School in Gresham, Oregon. Under the direction of club president Don Newman and treasurer Dennis Woods, the club has been active in designing and flying model rockets as well as model airplanes.

The Niles West High School near Des Plaines, Illinois, has formed an Astronomics and Asronautics club to test their model airplanes and model rockets. Under the direction of faculty sponsor Wayne Rogoski, the club recently participated in an aeromodeling meet with Elgin High School. The meet was held at Bong Air Force Base in Wisconsin.

Rocketeers in the Middletown-Odessa area of Delaware are invited to contact the Townsend Association of Rocketry, organized last October. The club meets on the first Saturday of each month. Interested rocketeers should contact Charles Ogle at 834-4279 or John Huff at 368-0951.

The Beach High School Model Rocketry Club in Miami Beach, Florida has a current membership of ten. Through the efforts of club president Arthur Diamond, vice president Tad Cypen, and treasurer Ezra Eskandry the club's launching activities have been publicized by an article in the Miami Beach **Reporter**.

An educational rocketry project has been undertaken at the Molalla grade school in Molalla, Oregon. This extracurricular extension of the school's science studies is under the direction of Thomas Smith, a Molalla science instructor. The students, as well as some parents, spectators, and other members of the Molalla faculty participate in the bi-weekly launchings.

Students at the Bayshore Middle School in Bradenton, Florida have undertaken their own model rocket program. Science classes taught by Robert Grove have undertaken the project as an extension of their science curriculum Recent activities have been reported by the Sarasota **Herald Tribune**.

Science teacher Alan Bean has introduced a model rocket program at the

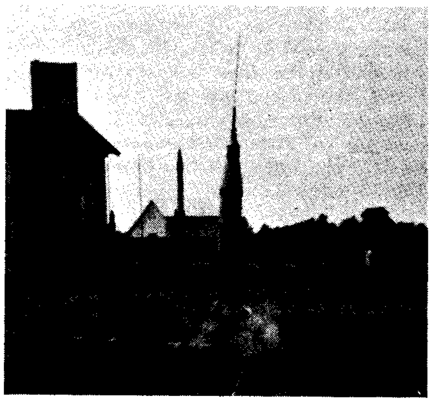


Photo by Richard Boczek

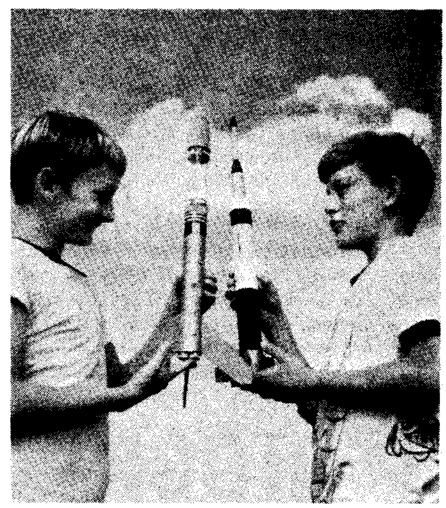
The DuBois Rocket Club has been active in the DuBois, Illinois, area. The photo above shows the club launcher and launch area.

DEALER DIRECTORY

Dunbar Elementary School in Mooresville, North Carolina. 50 to 60 boys and girls have joined the club and participate in regular launches. "I think school should be fun," Bean told the Charlotte Observer. "I use textbooks very little – abstract concepts really have to be demonstrated to mean much."

A new rocket club is being formed in the Glendale, New York area called "TILOB Rocketry Club". While it is not very big at present, the members hope to expand in the near future. Interested rocketeers in the Glendale area should contact John Larberg, 74-35 65th Street, Glendale, 456-8484; or Gerald Theilen, 59-04 Cooper Ave., Glendale, 497-7294.

The latest issue of **Nozzle News**, newsletter of the El Paso, Texas, Saturn Model Rocketry Society, reports the results of SMRS-2, a section meet held on November 1st. Flown form the club's new Eastwood Heights Elementary School launch site, the meet attracted 6 contestants who collected a total of 102 points. Larry Griswold took first place in Drag Race, with David Shin in second and Scott Norris and Kenneth Longenecker tieing for third. Kenneth Longenecker placed first in Parachute Duration with a 127 second flight, while Scott Norris and Larry Griswold took second and third respectively. Only two gliders were flown in the Sparrow B/G event, but Scott Norris turned in a 47 second flight for first place, with Kenneth Longenecker second. In Open Spot Landing, with only three entries, Scott Norris took first, Kenneth Longenecker second and Larry Griswold third. El Paso area rocketeers interested in further information about the Saturn Model Rocketry Section of the NAR can contact Kenneth Longenecker at Rt. 1, Box 467-D, El Paso, Texas 79927.



Photos courtesy Palatka Daily News

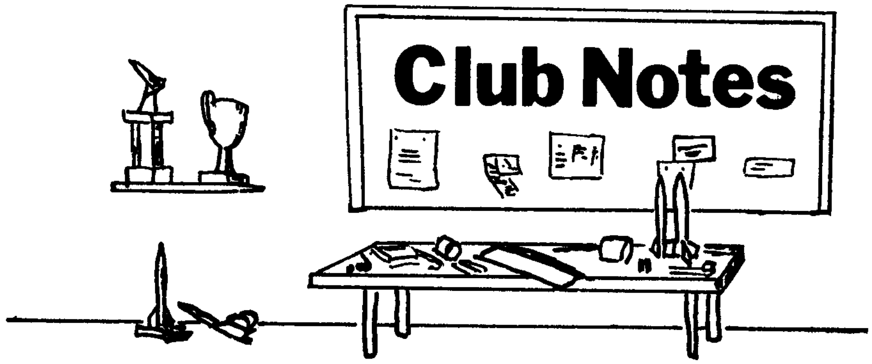
"The Good, The Bad, and The Ugly" RocketC Club has been organized at the Palatka, Florida Middle School. Club members shown above (kneeling, left to right): David Adkins, John Bellamy, and David Pons, (standing, left to right) Gene Pringle, and David Pons. Consisting of 37 members, the club held its first contest in October. Tommy Annis won Drag Race, David Adkins tied Annis in Spot Landing, and David Pons won Egg Lofting. The club also participated in a contest with the Rowlab Rocket Club of Jacksonville in November. Randy Bright (president) took first in Drag Race with a Centuri Iris. "The Good, The BAd, and The Ugly" Rocket Club is eager to compete with other rocket clubs in their area. They can be contacted c/o Wiley Styles, 1100 Husson Ave, The Palatka Middle School, Palatka, Florida.

Tom Sullivan of Bexley, Ohio is interested in organizing an NAR Section in that area. Interested rocketeers should contact him at 258-3037 or write to 354 North Ardmore Rd., Bexley, Ohio 43209.

Send your club or section newslatters, contest announcements and results, and other news for this column to:

Club News Editor
Model Rocketry Magazine
P.O. Box 214
Astor St. Station
Boston, Mass. 02123

Club Notes



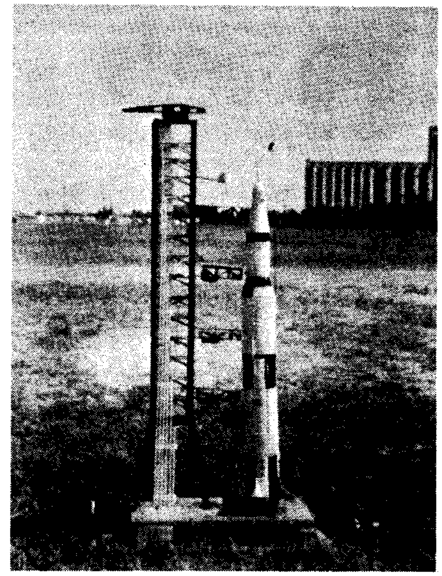


Photo by Art Colgrove

A Centuri Saturn V kit sits on the semi-scale gantry. The rocket and gantry were constructed by Ron Shipley of the Hutchinson (Kansas) High School Rocket Club.

The latest issue of the Southland **Tracker** reports on a November 15 demonstration launch for a Los Angeles Cub Scout Pack. Three Southland members, including senior advisor Vince Jahn, launched many single- and multi-staged models, a "semi-successful" Camroc, and an egglofter. Cub Scouts from Pack 961 acted as recovery crew; not a single rocket was lost during the demonstration.

Bill Green and Dana Martin of Athens, Georgia would like to start an NAR section in the northeast Georgia area. Interested rocketeers should write to Bill Green, Tallahassee Road, Athens, Georgia 30601.

The Bloomfield, New Jersey Model Rocketeers are looking for new members from the New Jersey area. Interested rocketeers should contact Kevin Flanagan, 8 Appleton Road, Bloomfield, New Jersey, 07003.

The South DeKalb Model Rocket Society, formed in August, 1969, is still eager for new members. They recently made contact with the MASER section of the NAR on the north side of Atlanta, and would like to increase their membership and challenge MASER to a contest. The South DeKalb club has very good launch facilities and tracking equipment and would like to apply for NAR charter soon. Anyone interested in joining should contact: Mike Dombrowski, 2638 Tolliver Drive, Ellenwood, Georgia 30049.

A new rocket club (hopefully an NAR section) is being formed in Levittown and the surrounding Lower Bucks County area of Pennsylvania. All interested rocketeers should contact: David Zuchero, 2313 Palmer Avenue, Edgely, Pa. 19007; 945-5844.

Students of the Port Chester, New York Junior High School scheduled a Saturn-V model rocket liftoff two days before the Apollo 12 launch. The event, which was reported in the local **Daily Item**, was organized by club president Michael Kaminsky, vice president Joe Feiner, treasurer Scott Chasen, and secretary Paul Scatenato, all ninth graders at the school. The club's activities are directed by Robert Nigro, chairman of the science department.

The Claremont Rocket Society has held its second demonstration launch, aimed at gaining new members in the Claremont, California area. The club, sponsored by the Claremont Parks and Recreation Department, is open to all youths of the community 10 and older. The club meets every Thursday from 3:30 to 5 pm in the conference room of the Youth Activity Center. Launches are held twice a month in cooperation with the Claremont Fire Department. Further information may be obtained from: Scott Newton, 626-5677; or the Recreation Department, 624-4531.

(Continued on page 46)

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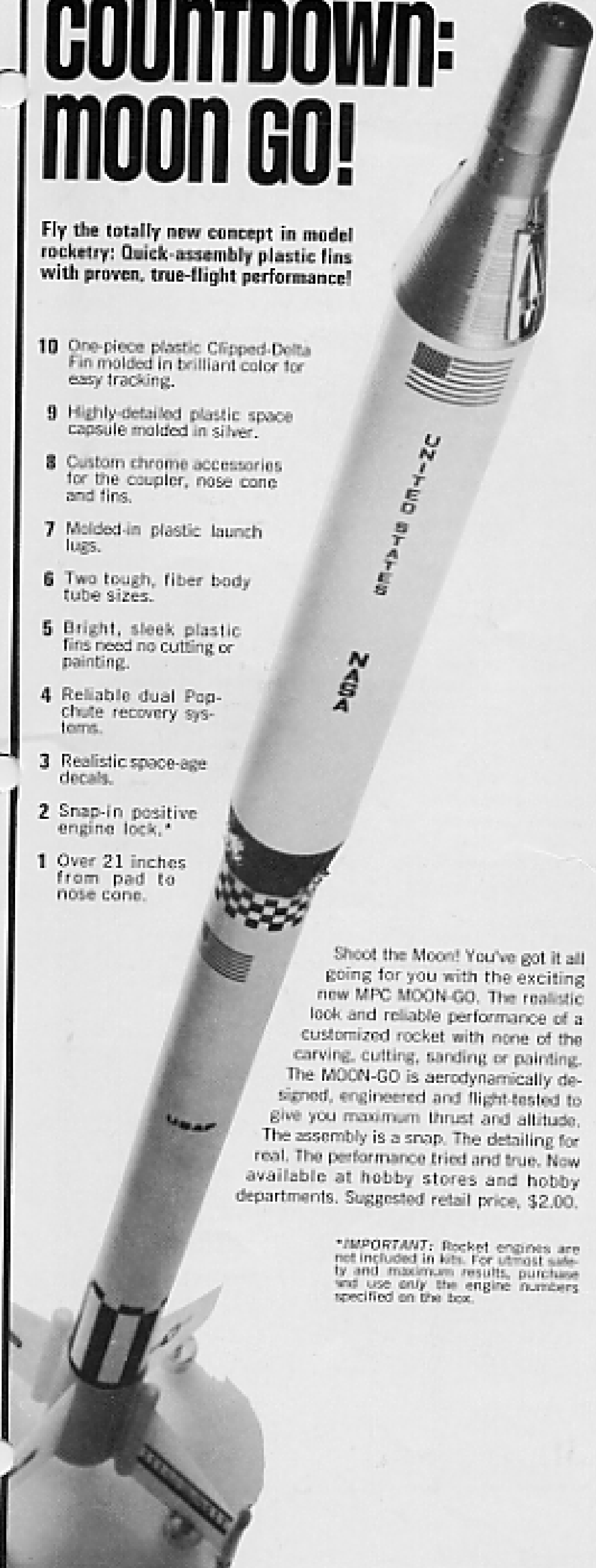

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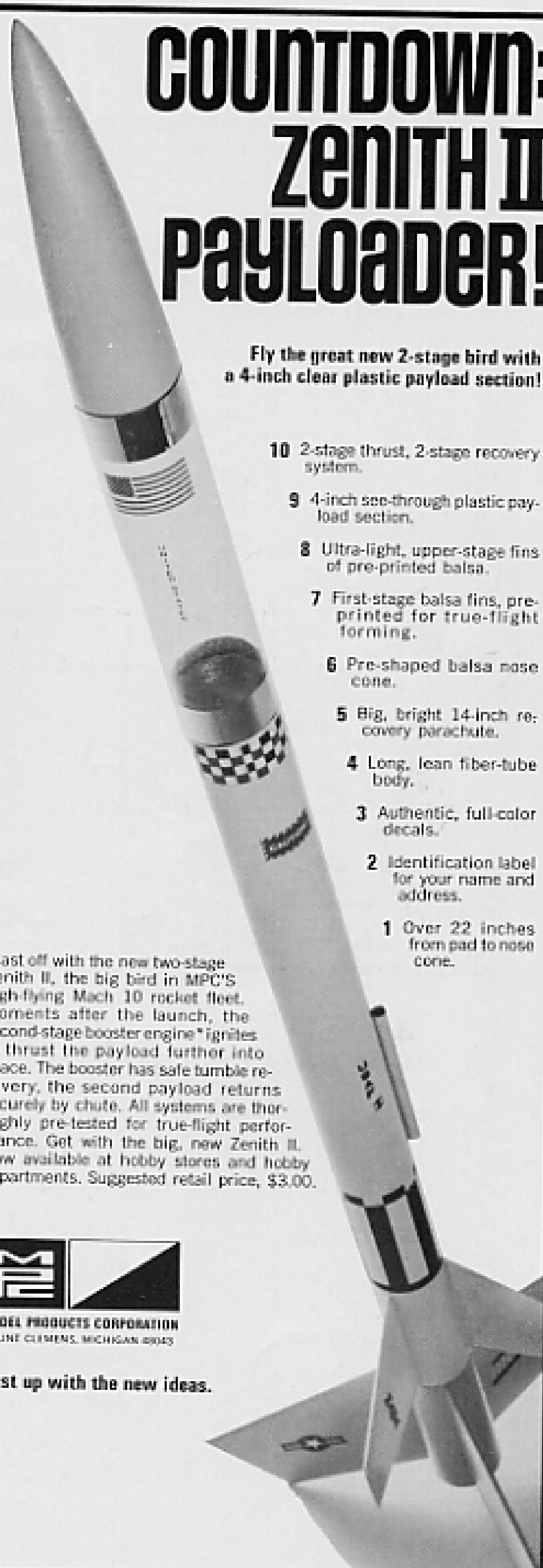

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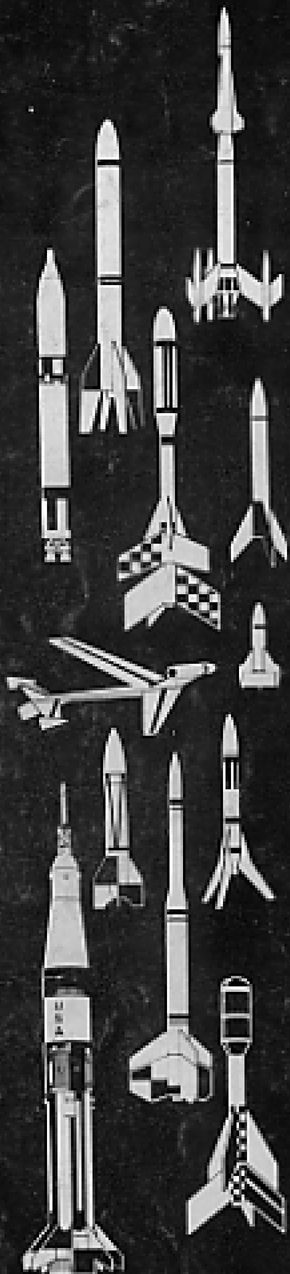

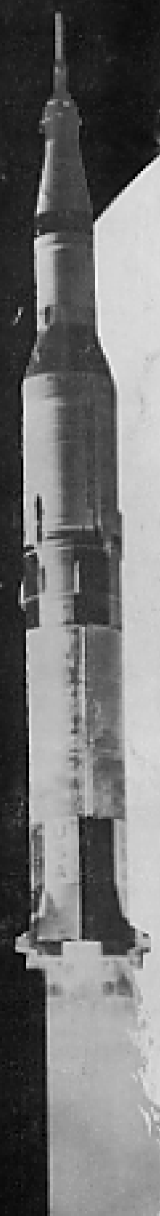

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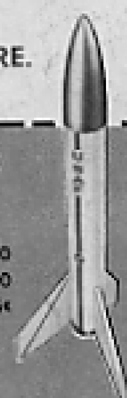

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