Modroc History
The First Model Rockets

THUNDER-BIRD Eagle B/G

Model Rocketry

Volume II, No. 8

May 1970

Cover Photo

This month's cover photo shows the *Thunder-Bird,* a Hawk and Eagle class B/G designed and constructed by NAR Trustee John Belkewitch. A design article on this B/G begins on page 23. (Photo by John Belkewitch.)

From the Editor

For years hobbyists and manufacturers concerned with the model rocket hobby have recognized the need for certain rules of operation to assure the safety of participants and spectators. From its inception in 1958, the National Association of Rocketry has presented a model rocket safety code to its members. Following the lead established by Model Missiles, Inc., the first model rocket manufacturer, and Estes Industries, each major manufacturer has also worked out a safety code and distributed it to its customers.

For all practical purposes *these codes were identical.* The specific wording differed, but the intent was the same. A comparison of the old codes, for example on the question of model rocket ignition, will indicate no significant difference in intent. The Centuri code required: "My model rockets will be ignited by remotely operated electrical means only, and with the proper igniters as recommended by the manufacturer." The Estes code stated: "My model rockets will be electrically ignited, using a launch system with either a switch protector or a safety interlock to prevent accidental ignition of the rocket engine ... [and] I will use only igniters of the type recommended by the engine manufacturer." On the same question, the NAR safety code reads: "I will use a remotely-operated electrical firing system to ignite and launch my model rockets." The intent of all of these codes was identical—to *prevent the use of a hand-lit fuse of the type used in model rocketry before the electrical ignition method was developed.*

A new rocketeer, being confronted with several seemingly different safety codes in

Letters to the Editor

Built-Up Wings

Recently I have been experimenting with two types of wing construction which are applicable to boost/gliders. Both types of wings are lightweight and provide high lift.

The first method of construction uses a thin skin supported by ribs. The skin can be as thin as 1/32" balsa, while the ribs should be cut from 1/8" or 1/16" balsa. In construction, the lower surface of the wing is cut from the sheet balsa, and serves as the basis for construction. Ribs of an airfoil shape are then made and glued to the lower surface, with 1½" to 2" between ribs. The upper surface is then cut from balsa (it will be slightly larger than the lower surface) and is glued and pinned to the rib assembly.

My first RC B/G (which I call the Orange Eagle) had the above wing construction, with a wingspan of 20" and a chord of 3¾". On the first two flights, it did two inside loops on a B.8-2. This was caused by a goof in the design. After undercorrecting for this mistake, the glider did a single inside loop which resulted in a 4" diagonal break in the spruce fuselage. The wing, made of only 1/32" balsa, stood up under all of these flights.

The second method of wing construction involves rib construction, but only the upper surface of balsa wood is used. Thinner wood than usual is sanded to an airfoil, and then is split apart at the high point of the airfoil. These edges are then rejoined, so that an undercamber in the wing results. Ribs are glued in place for strength. The bottom surface is then covered with thin balsa or tissue.

I originally used this construction method on a Sparrow B/G of 40 square inches, using a 1/16" wing and 1/8" braces for an airfoil thickness of 3/16". I have found that this construction, too, is strong

but light weight, resulting in good durations.

Replacing the solid wings of your glider with built-up, airfoiled wings should result in higher altitudes and longer durations because of the lower weight of the glider.

Richard Hyman
Fairport, New York

Many rocketeers have, in the past, dismissed the use of built-up wings, long popular in the model airplane hobby, as too weak to withstand the forces caused by high acceleration model rocket engines. Recent experience of a number of modelers, however, seems to disprove this opinion. The Yugoslavs had success with built-up wings on small B/G's at the Vrsac Championships. See this month's **From The Launching Pad,** *for another built-up wing B/G.*

SCR Controlled Launch System

Your *Wayward Wind* column on Relay Ignition Systems (**MRm**, December 1969) motivated me to finish an old design I had been thinking about for a solid-state launch system using 100 amp SCR's available on the surplus market. SCR's are considerably cheaper than relays, so they are prime candidates for multi-pad club launch systems. Not being an engineer, I'll have to determine a few of the circuit parameters by experiment. I'll let you know how the project turns out.

Stephen M. Byan, Jr.
Randallstown Rocket Society
Baltimore, Maryland

CORRECTION TO AUTOMATIC COMPUTATION

The computer program illustrated in the February issue concerning rocket altitude is correct as far as the program itself goes. However, the data and the results are not correct in their present form. Since this is test data, the program will obviously seem to be in error since computer results will vary from those printed in the magazine. Any rocketeer who wishes to check his program should use the following data which is correct for this program.

INPUT DATA:

Wt.	Bowt.	Cd	D	Tb	F
Payloader 1/2A	6-2				
1.015	.925	.75	.736	.20	21.57
V-2 B4-4					
2.14	1.846	.75	1.325	1.20	14.38
Drifter 1/2A	6-2				
1.53	1.475	.75	.976	.20	21.57
Nike-Smoke F	1.3-6				
6.35	4.28	.75	1.64	9.00	24.05
Aerobee 300 C	6-5				
1.76	1.32	.75	.950	1.70	21.57
V-2 A 8-3					
1.97	1.82	.75	1.325	.42	28.76

CORRESPONDING RESULTS:

	Burnout Altitude	Burnout Vel.	Coasting Altitude	Coasting Time	Total Time	Total Altitude
Payloader 1/2A	6-2					
	14.	140.	206.	3.37	3.57	220.
V-2 B 4-4						
	122.	169.	185.	2.98	4.18	308.
Drifter 1/2A	6-2					
	9.	86.	96.	2.36	2.56	105.
Nike-Smoke F	1.3-6					
	1844.	247.	384.	4.26	13.26	2228.
Aerobee 300 C	6-5					
	468.	514.	594.	4.92	6.62	1062.
V-2 A 8-3						
	39.	171.	186.	2.97	3.39	224.

— Charles Andres

Maryland Area Meet — May 9, 1970, Area Meet sponsored by the Annapolis Association of Rocketry. No further details announced.

NARCAS Annual Record Trials - 1 — May 15-17, 1970. A record trials open to NAR members from NAR-HAMS, SSB, SCS, and New Castle Sections interested in attempting to exceed current NAR and FAI model rocket records. Events: Eggloft, Pee-Wee Payload, Design Efficiency, Parachute Duration, Condor B/G, and Hornet B/G. Site: unannounced. Contact: Carl Guernsey, NARCAS, 2915 Maple Rd., Camp Hill, PA.

ROCHESTER, NY REGIONAL — May 16-17, 1970, a regional meet for NAR members from New York, Massachusetts, Ohio, and Pennsylvania, sponsored by the Monroe Astronautical Society. Events: Quadrathon, ½A Boost/Glide, B Boost/Glide and Design Efficiency. Site: unannounced. Contact: Lee Howick, 2424 Turk Hill Road, Victor, New York, 14564.

New Jersey Area Meet — May 23-24, 1970, an area meet for New Jersey area NAR members. Events: unannounced. Site: unannounced. Contact: Central Model Rocket Club, c/o Rick Jones, 29 International Ave., Piscataway, New Jersey.

HMRARM-1 — May 23, 1970, a competition open to rocketeers from Summers, Mercer, Greenbrier, Monroe, and Fayett counties West Virginia. Events: Open Spot Landing, Class 2 Altitude, Drag Race, Class 2 PD, Class 3 PD, and possibly Hornet B/G. Contact: HMRA, Route 1, Box 141, Hinton, West Virginia 15951.

SPQR-5 — June 21, 1970, Space Pioneers Quality Regional open to NAR members in the Northeast. Events: Scale, Super Scale, Swift B/G, Sparrow B/G, Class 1 PD, and Open Spot Landing. Site: Lapham Field, New Canaan, Conn. Contact YMCA Space Pioneers, 564 South Avenue, New Canaan, Conn. 06840.

MMRR-2 — June 27-28, 1970. Regional Meet sponsored by CSAR, open to NAR members in the Midwest. Events: Super Scale, Eggloft, Sparrow B/G, Swift B/G, Design Efficiency, Parachute Duration, Open Spot Landing, R & D. Site: unannounced. Contact: Miss Vikki Lundberg, 1972 Beal Road, Mansfield, Ohio 44903.

TEXAREA-II — June 27-28, 1970, an area meet for Texas NAR members. No events or site yet announced. Contact: Apollo-NASA Section, c/o Mark Evans, 10203 Overcup, Houston, Texas 77024.

Canadian Convention — July 4-5, 1970. Conference open to all rocketeers. Discussion groups, and launch sponsored by Montreal's Atmospheric Rocket Research Society. Contact: Steven Kushneryk, 7800 Des-Erables Ave., Montreal 329, Quebec, Canada.

NARAM-12 — August 16-21, 1970, the 12th National Model Rocket Championships, open to all NAR members. Events: Class 1 Parachute Duration, Design Efficiency, Sparrow B/G, Scale, Swift B/G, Space Systems, Egg Lofting, Open Spot Landing, R&D. Site: Astroworld, Houston, Texas. Contact: by July 6, 1970, Contest Director, Richard Sipes, 5012 60th Avenue, Bladensburg, MD 20710.
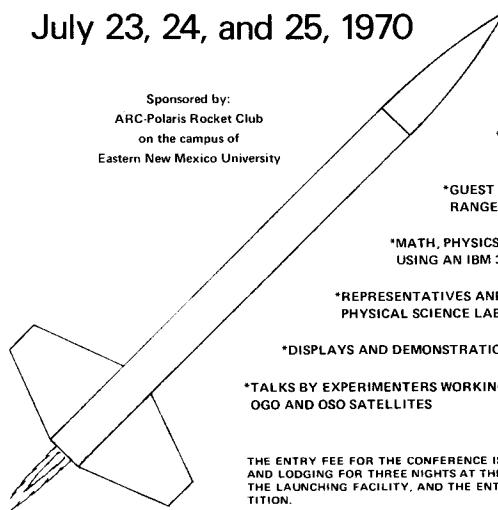
**ATTENTION
CONTEST DIRECTORS**
Mail notices of your contests at least 90 days in advance for listing in Model Rocketry's "Modroc Calendar":
Modroc Calendar
Box 214
Astor Station
Boston, Mass. 02123

Southwestern Model Rocket Conference

July 23, 24, and 25, 1970

Sponsored by:
ARC-Polaris Rocket Club
on the campus of
Eastern New Mexico University

*SPEAKERS FROM NASA PLUS FILMS AND DISPLAYS

*REPRESENTATIVES FROM ESTES INDUSTRIES AND MITS

*TWELVE AREAS OF COMPETITION WITH COMPUTERIZED SCORING

*GUEST SPEAKERS FROM WHITE SANDS MISSILE RANGE

*MATH, PHYSICS, AND COMPUTER SEMINAR USING AN IBM 360 MODEL 40K COMPUTER

*REPRESENTATIVES AND DISPLAYS FROM THE PHYSICAL SCIENCE LABORATORY

*DISPLAYS AND DEMONSTRATIONS OF NEW PRODUCTS
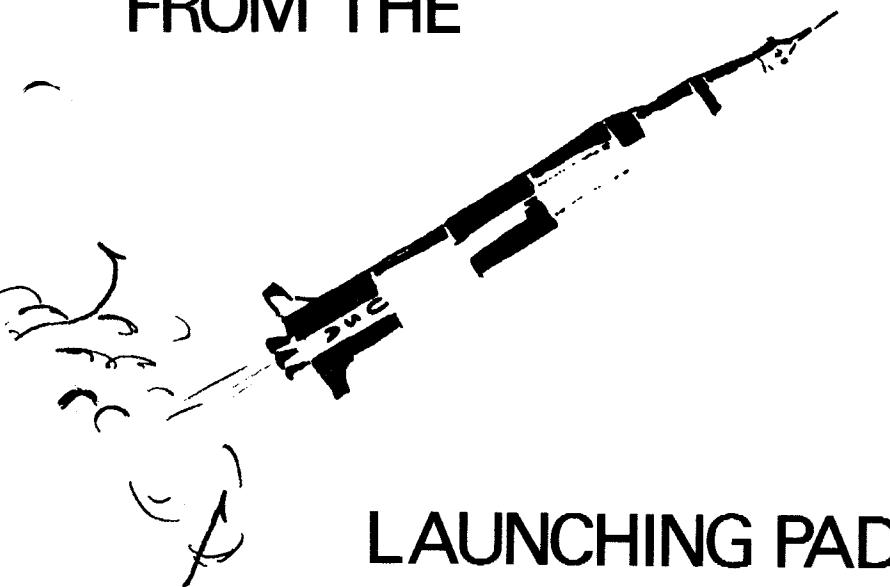
*TALKS BY EXPERIMENTERS WORKING ON THE RECENT OGO AND OSO SATELLITES

THE ENTRY FEE FOR THE CONFERENCE IS $23.00 WHICH INCLUDES ALL MEALS AND LODGING FOR THREE NIGHTS AT THE UNIVERSITY, BUSING TO AND FROM THE LAUNCHING FACILITY, AND THE ENTRY OF FIVE ROCKETS IN THE COMPETITION.

COMPLETE THE FOLLOWING FORM (OR A COPY) AND SEND IT WITH A CHECK OR MONEY ORDER TO: ARC-POLARIS ROCKET CLUB, SWMRC MRM, DRAWER 89, PORTALES, N.M. 88130

Name:_____

Mailing Address:_____

City, State, Zip Code:_____

Age:_____Number of Years as Rocketeer:_____

Name of Your Organization:_____

FROM THE

LAUNCHING PAD
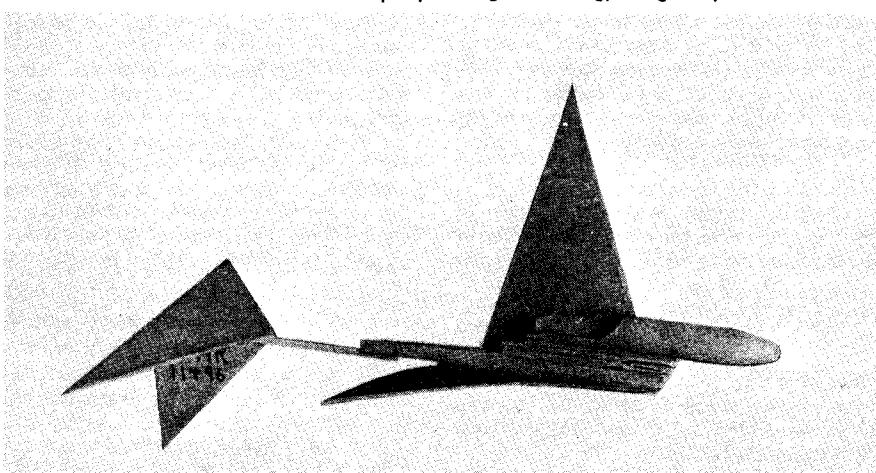
If you're interested in getting started in built-up wing boost/gliders, try modifying an AMA Racer, available at most hobby shops across the country. The B/G shown in the accompanying photograph started out because several Boston area rocketeers said that built-up wings would not have sufficient strength to withstand the liftoff acceleration. After putting the AMA Racer together, I placed it on the launch pad and, half believing the dire predictions, expected to see balsa wood and tissue scattered all over the sky. To almost everyone's surprise, it worked! Since we didn't have a stopwatch at the launch, no time is available. But we'll have it flying again next week, and report on a time next month.

To convert the AMA racer to B/G configuration, first prepare the wing frames adding two additional, equally spaced ribs to each wing (there is sufficient balsa in the kit to do this). Cover both sides of the wing with tissue. You will need additional tissue available at your hobby shop. Cover both sides of the stab and tail, and mount the tail "upside down" on the boom. The wing is also mounted below the boom. A fixed pod, constructed from a piece of BT-20 tube and a nose cone, should be mounted at least 3/4 inch to one inch above the boom. If you mount it any lower the engine exhaust will burn the tissue.
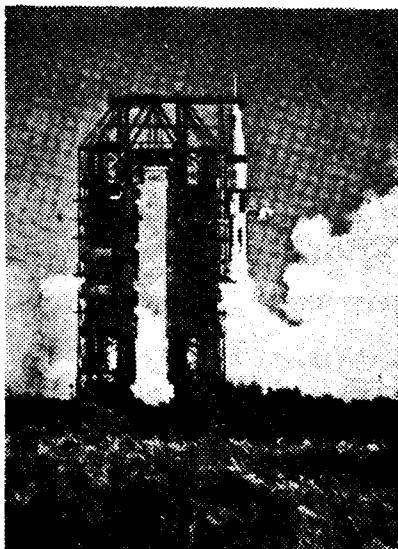
While you're at it, you might put one together according to the instructions. As a rubber powered airplane, it's fun to fly while you're waiting in line to get your rocket on the pad.

Last month I mentioned the new European 12mm X 40mm ½A engines. These engines are being made in the USSR rather than Yugoslavia as reported last month. Powered by one of these DB-3-CM-0.125 motors, the JUG-1 can be used as either an altitude or parachute duration rocket. Liftoff weight of the entire rocket was only 15 grams (about ½ ounce). the Yugoslavian design up to the available 18mm X 70mm U.S. engines, the JUG-1 design is reprinted below. Several interesting design features are readily apparent. The use of two *small* launch lugs, rather than one long launch lug, will greatly reduce the over-

all drag on the rocket. Swept back fins move the CP to the rear while adding much less surface area (and hence much less friction drag) than the non-swept variety. The use of a straight conical nose cone probably indicates that the cone was hand made, and the easiest shape to form was selected, since other shapes are known to give better performance.

Get out your Malewicki report (Centuri TIR-100), and we'll see how much better a 13mm diameter rocket can perform than the standard 19mm to 20mm tube forced on US rocketeers by the minimum engine diameter. If we assume a C_d = 0.5, the 13mm tube has a C_dA = 0.1 while the 19mm tube has a C_dA = 0.2. To calculate the altitude, we'll assume both rockets have a takeoff weight of 20 grams, even though the 12mm engine casings are lighter than our 18mm casings. The 13mm rocket will reach 470 feet, while the 19mm diameter rocket will barely reach 390 feet (almost a
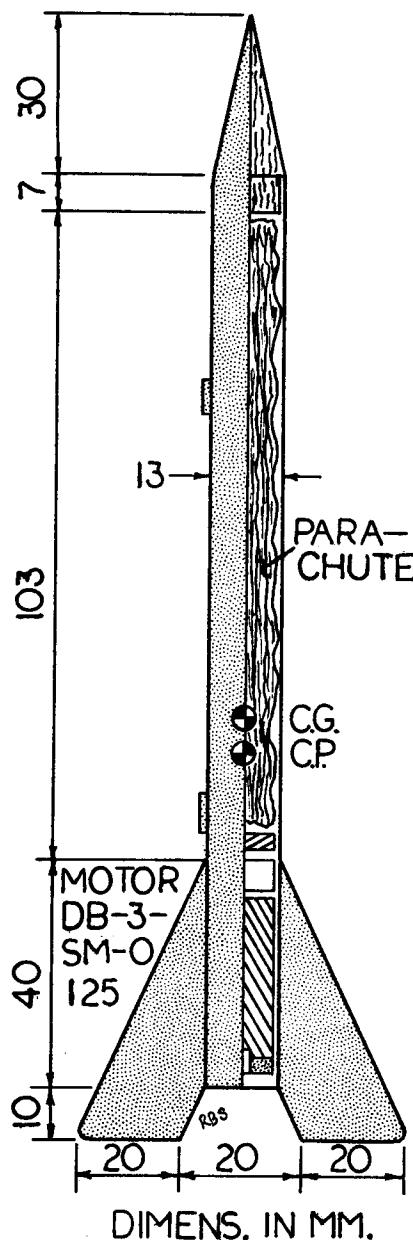
25% altitude increase due only to the engine's smaller diameter).

Don't protest too much, however, since several US manufacturers have recognized the possibilities of 12mm diameter engines, and development work is proceeding.

Model Rocketry has added a new, bi-monthly column beginning with this issue. Forrest Mims, who will write the column, will discuss experimental topics. His column will report on experiments in progress, and suggest topics for future experimentation by ambitious rocketeers. This month he discusses "Infrared Telemetry" from Light Emitting Diodes. Other topics already scheduled for future issues include a wind tunnel which is attached to the side of a moving automobile, and a water table in which flow past various model rocket shapes can be investigated.

After four years and five attempts the Japanese have become the fourth member of the "Space Club" with the successful launching of their own satellite on February 11th. The launching, by the Lambda 4S sounding rocket, placed a small earth satellite in orbit. At the same time, the Japanese Space Development Committee announced an ambitious national program for space exploration over the next six years. Eight satellites, six carrying scientific experiments as well as a series of communications satellites, have already been scheduled. This year, for the first time, the Japanese Antarctic Expedition will launch two geophysical sounding rockets from their base. Next year, 12 rockets are scheduled for launching from the same site. These launches will all be the new S160 sounding rockets developed by the Institute of Space and Aeronautical Science of Tokyo University.

The Japanese Meterological Agency has also taken up rocketry for its advanced, high-altitude observations. A new rocket range near the coastal town of Sanriku has been constructed. The first experimental series, comprising the launching of 40 4-meter long MT-135 meterological rockets (see **MRm** November 1968 for scale data), is due in July. As the Japanese interest in both space exploration and model rocketry expands, we can expect to see a great deal more scale data on these vehicles available. Since most of the Japanese rockets, including the Lambda 4S, are unguided (or have unguided upper stages) they have large fins suitable for scale modeling.

William Bengan prepared a study of model rocket drag for publication in *Topics in Advanced Model Rocketry,* a book to be released this fall by MIT Press. In the book he derives the theoretical drag on a model rocket as a function of angle of attack. One of the most interesting results of Bengan's analysis is the calculation that the lowest attainable C_d is approximately 0.3 at a zero angle of attack for a well designed and finished model rocket.

How close are your rockets to the theoretical minimum? The best way to find

out is to test your models in a wind tunnel and read out the drag force (and indirectly the C_d). However, you can determine the C_d of your model quite accurately, even if you only have a pair of altitude trackers. If the rocket is flown several times with the same engine type, the average altitude can be determined. Working backwards with the Malewicki TIR-100 charts, you can use the actual altitude to determine the approximate C_d. Doug's recent measurements on a typical model rocket gave an average C_d of approximately 0.5.

Rocketeers who attended NARAM-11 will recall Richard Sternbach's flying "scale" outhouse (see photo below). This rocket powered "odd-ball" design attracted quite a bit of attention from even the most outlandish designers. The outhouse stands about 10 inches high, and is powered by a C6-3 engine. We have just received a copy of the plans for this unusual model, and they will be printed in a future issue of **Model Rocketry.**

Last month in the HIAA Show Report I mentioned the new "Countdown" plastic Saturn V with Mobile Launcher kit. Though not intended as a flying model, it looked fairly easy to convert. Bob Parks took up the challenge and spent a few hours working out the details. Plastic fins are, of course, needed for stability. At a recent MIT Section launch the converted Saturn flew to about 500 feet powered by a single C engine. Beautifully stable! Bob is now working out the details of launching from the scale tower.

DIMENS. IN MM.

For Stability or Fin Shape Evaluation

Build the TROJAN

by Robert E. Cramer, NAR 12663

The October 1969 issue of **Model Rocketry** magazine presented plans for the Achilles-X, a fin test vehicle. The Achilles-X may be thought of as a first-generation research vehicle. Although it appears that only the fin shape is changed from flight to flight, this is not strictly true. First of all, there will probably be slight changes in weight, but this may well be neglected. A more important change might occur in the center of pressure location. If the C.P. location changes, so will the static stability margin. How will the researcher know whether any performance changes are due fin shape or changes in static stability margin? A clever designer may be able to design all of the fins so that the CP is in same place, but this would severely limit the vehicle's flexibility.

The Trojan is a second-generation vehicle which attempts to avoid the forementioned difficulty while extending the usefulness of the rocket. The following missile parameters were taken as variables:
1. Fin shape.
2. Weight
3. Static stability margin.
4. Engine impulse.
The design objective was to produce a vehicle with which a researcher could change one variable while holding the others constant. The result is the Trojan.

The heart of the system is the special payload section. By varying the position of nose cone weights using a series of balsa spacers, it is possible to vary the static stability margin without changing the missile weight. Similarly, it is possible to change the missile weight while keeping a constant static stability margin.

The fin shape is changed by using the technique of sectional construction. It is recommended that the fins be designed to have the same area. This will eliminate the extraneous effect of skin drag. The engine impulse is changed by using different motor types.

The following groups of experiments may be performed with the Trojan:

Variable Changed	Variables Held Constant
1. Fin shape	Weight, static stability margin, engine impulse
2. Weight	Fin shape, static stability margin, engine impulse
3. Static Stability Margin	Weight, fin shape, engine impulse
4. Engine impulse	Fin shape, static stability margin, weight
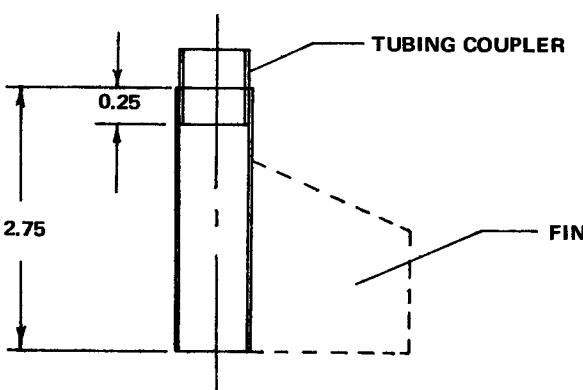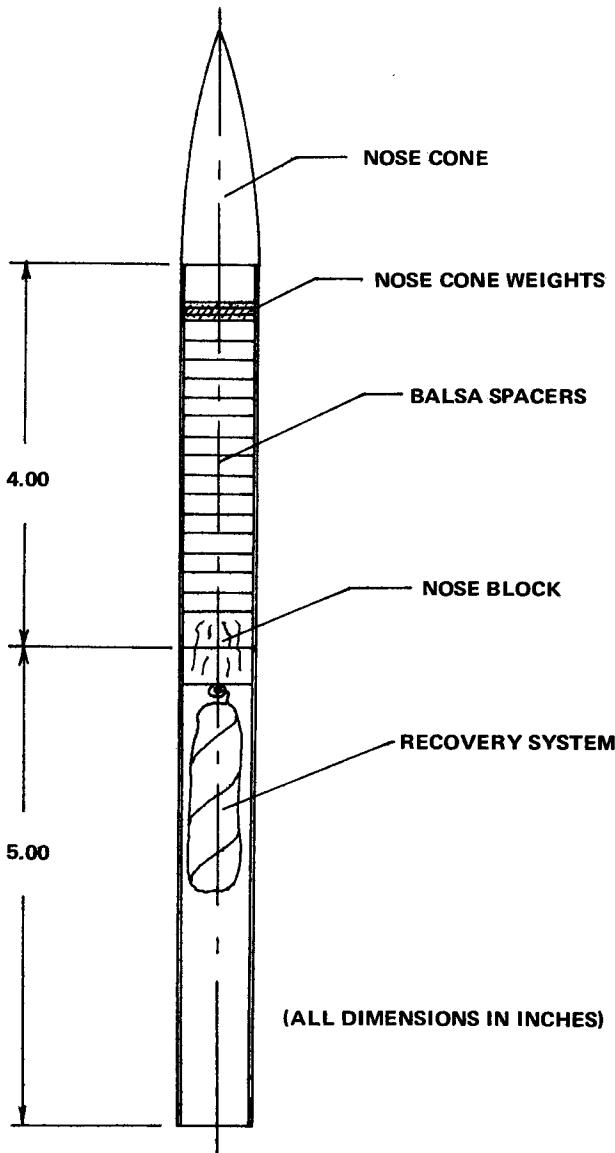
Construction is straightforward. Care should be taken to make the finish on all of the fin units as nearly the same as possible. Also, you may want to put a few slivers of lead in the base of the nose cone. These may be added or removed to make fine weight adjustments. Be sure to wrap a layer of tape around the recovery unit/fin unit joint before launching.

One drawback of this design is the lack of control over the dynamic stability parameters, particularly moments of inertia and damping ratio. This may be overcome in a future design. Until then, it is advisable to fly in calm weather to reduce dynamic oscillations.

Parts List

1	nose cone	BNC-20N
1	body tube	BT-20
3	nose cone weights	NCW-1
24	balsa spacers	11/16" dia.
1	nose block	NB-20
1	screw eye	SE-2
1	parachute	PK-12
1	tube coupler	JT-20C

NOSE CONE

NOSE CONE WEIGHTS

BALSA SPACERS

NOSE BLOCK

RECOVERY SYSTEM

4.00

5.00

(ALL DIMENSIONS IN INCHES)

TUBING COUPLER

0.25

2.75

FIN
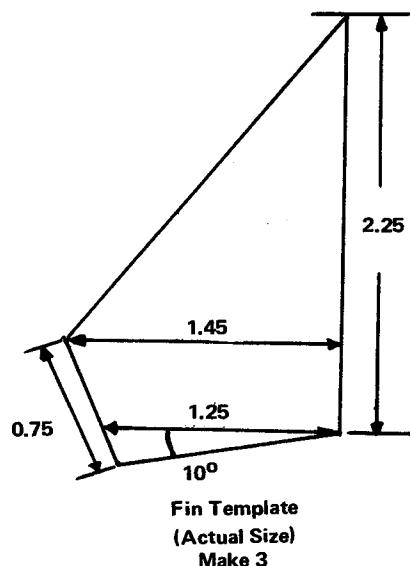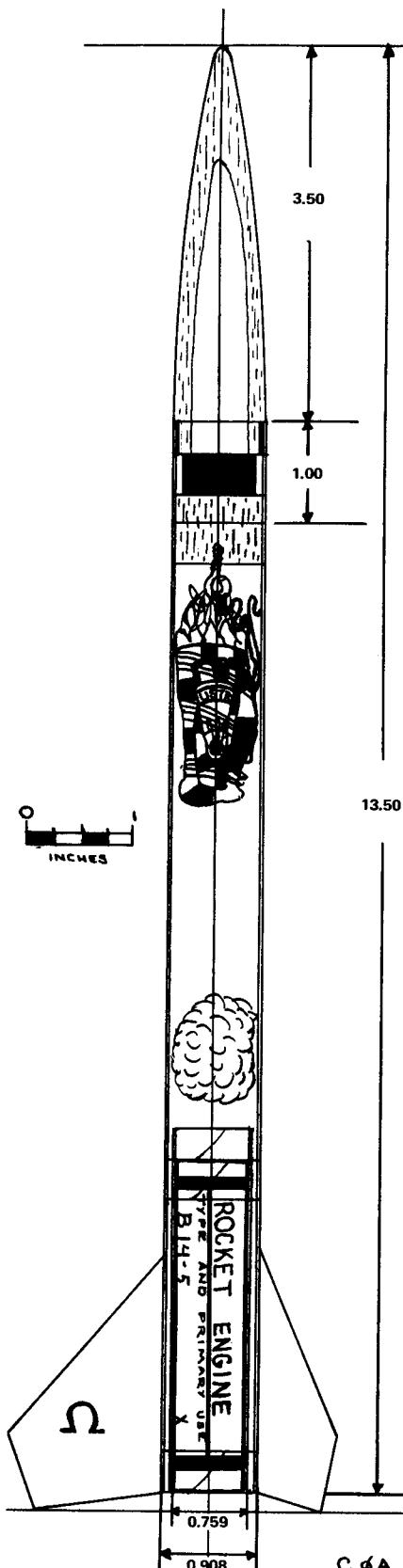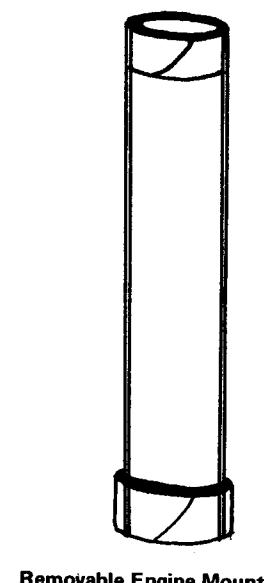
High Performance

OMEGA I

by Charles Andres

3.50

1.00

13.50

INCHES

ROCKET ENGINE
TYPE AND PRIMARY USE
B14-5

Ω

0.759

0.908

C ⌀ A

2.25

1.45

1.25

0.75

10°

Fin Template
(Actual Size)
Make 3

(ALL DIMENSIONS IN INCHES)

Removable Engine Mount

One NAR event which is rapidly gaining popularity is the *Quadrathon.* This event is one of the most severe tests of a model rocket, since the rocket must be flown at least four times in four different events. As stated in the rules, the four events which comprise the Quadrathon include: Class I Parachute Duration, Spot Landing, Class I Altitude, and Pee Wee Payload. For a rocket to perform well at all these tasks, several design factors come into play which must be weighed and considered in designing the optimal Quadrathon bird.

For the rocket to be capable of the highest performance it must be as light as possible, possess good static and dynamic stability, have a low drag coefficient, and be as streamlined as possible. A Quadrathon model also must have strength, a foolproof recovery system, an easily trackable finish, and the versatility to perform well in all four events. The Omega Series was specifically designed for Quadrathon competition.

Since altitude is of primary concern in Pee Wee Payload, and Class I Altitude, it is most important to maximize these Quadrathon point values. As NARAM-11 showed, the parachute duration models which win *are those that are launched as high as practicable even at the price of using a small parachute.* The larger models which were capable of employing 36" and 48" chutes did not get high enough to turn in good times. Thus, a small high performance model is not a hindrance in parachute duration. The only event which regulates model size is Pee Wee Payload. The body tube must encompass the 3/4" diameter standard NAR payload, which rules out .756" diameter tubes. The next smallest size tube available is the T-20 tube put out by MPC and SAI. I used the #8 Centuri tube since MPC tubes are available only through

ΩI Parts List

CEN	Noseblock	BTC-8
CEN	Nosecone	BC-83
CEN	Body Tube	ST-810
CEN	#8 Rings	CR-8
CEN	#7 Rings	TR-7
CEN	Engine Tube	ST-73
CEN	Screw Eyes	SE-10
CEN	Parachute	CP-12
CEN	Shock Cord	SC-18
FSI	Plywood Fin	FM-1

Rear Ejection

OMEGA II
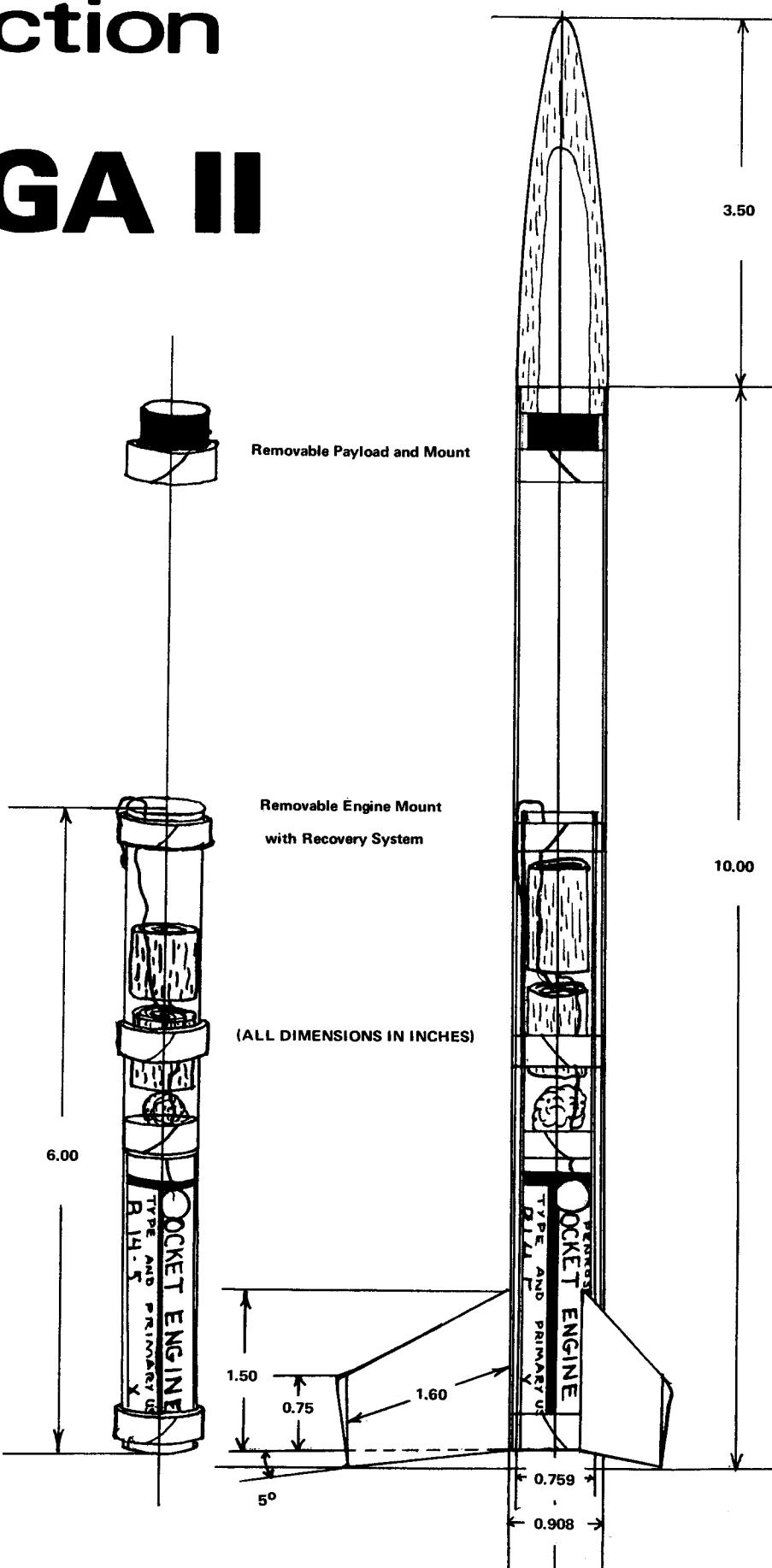
certain hobby stores and then only in a kit with other parts. The #8 Centuri tube has the added advantage of being able to hold FSI engines up through E's, with all models being able to use their engines up through D's. (The largest engine allowed in the Quadrathon is a C.)

The nosecone selected is a Centuri BC-83 which is of parabolic shape with a length to diameter ratio of 1:4.5. This is one of the most efficient nosecones available in model rocketry, the nosecone having a drag coefficient value near .05 according to the **Handbook of Model Rocketry**. The nose should be hollowed to reduce weight even further. The fins are large enough to retain static stability while being small enough to prevent abnormal weathercocking when the payload is inserted. The fin shape is tapered swept, which is one of the more efficient designs for fast moving models.

As in all altitude models, *rearward ejection is desirable* to allow the nosecone to be hollowed, and to *eliminate the forward nosecone-body tube joint*. The rearward ejection method is employed on the Omega II, and is unique in the fact that all of the interior construction of the rocket can be removed. The rocket was designed in this manner to facilitate the insertion and removal of the NAR payload, which must be done in accordance with the rules. Also, since staging is a popular way to increase altitude, a booster stage is shown. The only problem with this is that the Quadrathon is not open to staged models, due to the Parachute Duration and Spot Landing rules. If a second stage is to be used for contests other than Quadrathon, the engine mount on the upper stage has to be changed slightly. This will be discussed later. The only changes that are allowed in Quadrathon from flight to flight are a change in the recovery system from parachute to streamer and of course, the removal of the payload for all events other than Pee Wee Payload.

No launch lug should be used if at all possible. Even a simple tower will increase your altitude. Tower launching is now within range of anyone's pocketbook, with the Econo-Tower featured in **Model Rocketry,** December 1969.

The Omega I is a typical model employing conventional assembly except for the fins and the engine mount. The fins should be made of plywood or basswood to reduce breakage. Since this model must be flown

Removable Payload and Mount

Removable Engine Mount

with Recovery System

(ALL DIMENSIONS IN INCHES)

3.50

10.00

6.00

1.50

0.75

1.60

5°

0.759

0.908

Move This Block Down 1/2 Inch

2.80

3.25

1.90

0.70

1.75

3

(ALL DIMENSIONS IN INCHES)

four times regardless of damage, it is advantageous to use hard wood. It does weigh 3.9 times more than balsa, but the surface on it can be smoothed to a better finish than can be achieved by balsa.

The nose should be hollowed and the transition shoulder cut to a minimum before gluing. The engine mount should not be glued in if FSI engines are ever to be used with the model. The forward #8 centering ring should be glued in at 2.75" so that FSI engines can be employed if desired. This ring will then act as an engine block. With the engine mount in place, smaller engines may be used. However, one must make sure that the engine mount has a very tight friction fit within the tube and that the engine has a tight friction fit within it. Care should be taken to test the force required to move the block when B 14-5 engines are used. It should not move when subjected to nine pounds of thrust. *If it does move, the mount should be made more secure.* If the booster stage is to be used on the Omega I at any time, the engine mount should be replaced by one which will allow the engine of the upper stage to extend beyond the body by 1/2" so that it may couple with the booster. Since this engine mount is not stationary, but can be secured in any position, a single engine mount will suffice, it being necessary to secure the engine block within the mount designed for use with the booster at the point 1/2" lower in the tube. This will mean that the engine will not stick out of the model, but that the engine mount tube will accordingly not remain flush with the outside tube. If it is desired to leave the engine projecting out 1/2" even during single stage operation, a boattail could be fastened on around the extending engine to reduce tail drag as expounded by the CSAR. Hopefully, this design will not only serve as a model but as an inspiration to other Quadrathon builders. Needless to say, the

PARTS LIST FOR THE OMEGA II

CEN = Centuri Engineering
EST = Estes Industries
FSI = Flight Systems, Inc.

5	CEN	#8 Centering Rings	CR-8
1	CEN	Nosecone	BC-83
1	CEN	Body Tube (10")	ST-810
1	CEN	Body Tube (6")	ST-76
1	CEN	#7 Engine Stop	TR-7
1	CEN	Shroud Lines	SL-70
1	CEN	Streamer Set	RS-20
1	CEN	Parachute 16"	CP-16
1	EST	Payload	PL-1
1	FSI	1/16" Plywood 6 x 6	FM-1

ADDITIONAL PARTS FOR TWO-STAGE OMEGA II

1	CEN	Engine Tube	ST-73
1	CEN	#8 Rings	CR-8
1	CEN	#7 Rings	TR-7
1	FSI	Plywood 1/16"	FM-1

model will perform well in other contests also.

The Omega II is significantly different from the Omega I in the fact that it employs rearward ejection while the latter employed the conventional ejection system. In order to do this, I had to make it possible to remove the payload from the model without adding a front nose-body joint, but to allow it to remain in the front end of the model. This required that all of the engine and recovery assemblage be completely removable to allow judges access to the payload. The payload itself must be placed in front of or within a #8 centering ring which is then slid forward to the nose. Next, a #8 centering ring with a #7 engine block glued inside is slid forward to hold the payload in place. This has to have a fairly tight friction fit. When it is secure, the engine mount and recovery assembly is inserted with a friction fit. Needless to say, if the workmanship on the friction fitted engine mounts is lacking, the rocket can undergo a catastrophic structural failure; but if care is taken, this will not happen. The other disadvantage is that once the payload is in, it has to be removable. This can be done with a piece of stiff wire, or by vigorously shaking the payload back and forth until it knocks the retainer out. It is likely to settle in flight somewhat, but not to an appreciable amount. The engine mount-recovery system works much the same as that in the Excalibur (August 1969 **Model Rocketry**) except that now the rocket's streamer or parachute is attached to a shock cord which is attached to the outside of the removable engine assembly. This helps to form the friction fit of the assembly, and prevents the engine from taking the assembly with it when it ejects. If it is desired, the two recovery devices can be replaced with one streamer or parachute, as required by the Parachute Duration and Spot Landing rules. The engine and rocket are then attached to one device which is simpler as long as the cord connecting the assembly is long enough to allow the engine to completely pull out and deploy the recovery device. When the flight is over, the assembly can be removed to allow access to the payload or ease in repacking the recovery system. Many of the problems encountered in loading an Excalibur are eliminated in this way. As with the Omega I, plywood fins are used to eliminate the possibility of breakage. The fin type is one used for the lowest possible drag for slower moving models. The builder has the option of using either fin design since, as I said before, the plans are merely an inspiration to Quadrathon builders.

Flight Preparation

In the Quadrathon, the rocket has to be prepped four times to meet the requirements of the four events. One should have plenty of equipment on hand in order to make the number of changes allowed, and to repair any damage. Unfortunately, bringing a spare rocket is to no avail since everyone is allowed only one entry. This one model should be finished in fluorescent colors such as the new Palmer Rocket Glare Modroc paint since tracking is of the utmost importance.

For Parachute Duration, remove the payload, and insert the largest parachute desirable. An 18" or 24" chute is plenty, since you will want to get the model back. An 'A' engine should be used for this contest. In the Omega II the engine must be attached to the same parachute as the rocket, since, if the engine falls free, time will stop when it hits the ground.

In Spot Landing, the object is to get the rocket to land as close as possible to a predetermined spot. Unless this spot is located several hundred yards from the launch site, a small engine should be used so that the model will not drift much once it is in the air. The Omega II can use its standard engine ejecting method, letting the engine fall under its own separate streamer. This is allowed since it is the distance from the model's nose cone to the pole that is measured. However, since model drift is again undesirable in this event, most competitors will elect to have rocket and engine descend on a common streamer. All engines up to a C can be used in this event.

For Class I altitude, any engine up to a B can be used, and both Omegas should be reduced in weight as much as allowed. The payload should be removed, and the smallest legal recovery device should be employed. (Sometimes if tracking conditions are poor payload weights are left on board to insure a closed track. If tracking loss is recorded, then one receives 0 points for his efforts.) In light of this, B 14-x engines should almost never be used, especially with inexperienced trackers.

Pee Wee Payload is an event which allows all engines up to and including type B engines. The payload must be weighed and installed in the model in the presence of the judges. This can be a little tricky in the case of the Omega II, and a little practice beforehand will reduce embarrassment when the time comes. One should have the recovery system installed and the engine loaded. The unit can then be easily inserted after the payload is in. As with all engines employing rearward ejection, a friction fit is *not* required for the engine. It must be hooked up to the recovery system though. One should also make sure that the parachute or streamer is large enough to compensate for the extra ounce of lead. Again, FSI engines may be used in the OMEGA I.
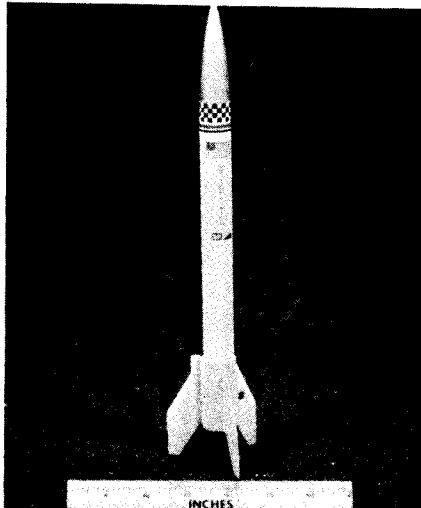
New Product Notes

Model Products Corporation has just released its latest addition to the Astroline flying model rocket series, a high-performance beginner's model called Pioneer-I. With a carefully-engineered combination of plastic and fiber parts, Pioneer-I costs one dollar (without engines), goes together so rapidly that it might be tagged an "instant model rocket," and actually will perform better than some balsa-and-fiber models of the same shape.

All-up weight without engine is a mere 23 grams. Design features an aerodynamically clean 3-caliber parabolic nose cone. The fin and tail assembly is integrally molded of high-impact polystyrene plastic with the fins precisely aligned for the most repeatable flight characteristics possible. To further reduce air drag, the launching lug is incorporated into one of the fin roots. A streamer recovery system is included in the kit, but the Pioneer-I can also be flown with the 10-inch and 14-inch MPC polyethylene pop-chutes or the new MPC ultra-thin 20-inch mylar (R) chute; these chutes are available as accessory items.

Pioneer-I belies the myth that plastic is too heavy to fly properly. Predicted altitude for the Pioneer-I (accurate tracking against summer skies will provide exact data later) is in the 500-foot range with the MPC Type A3-2 engine, up around 1000 feet with the Type B3-3, and an out-of-sight 1700-1800 feet with the powerful MPC Type C6-4 engine. In anybody's book, this is excellent altitude performance from a dollar rocket that can be quickly assembled in about 30 minutes.
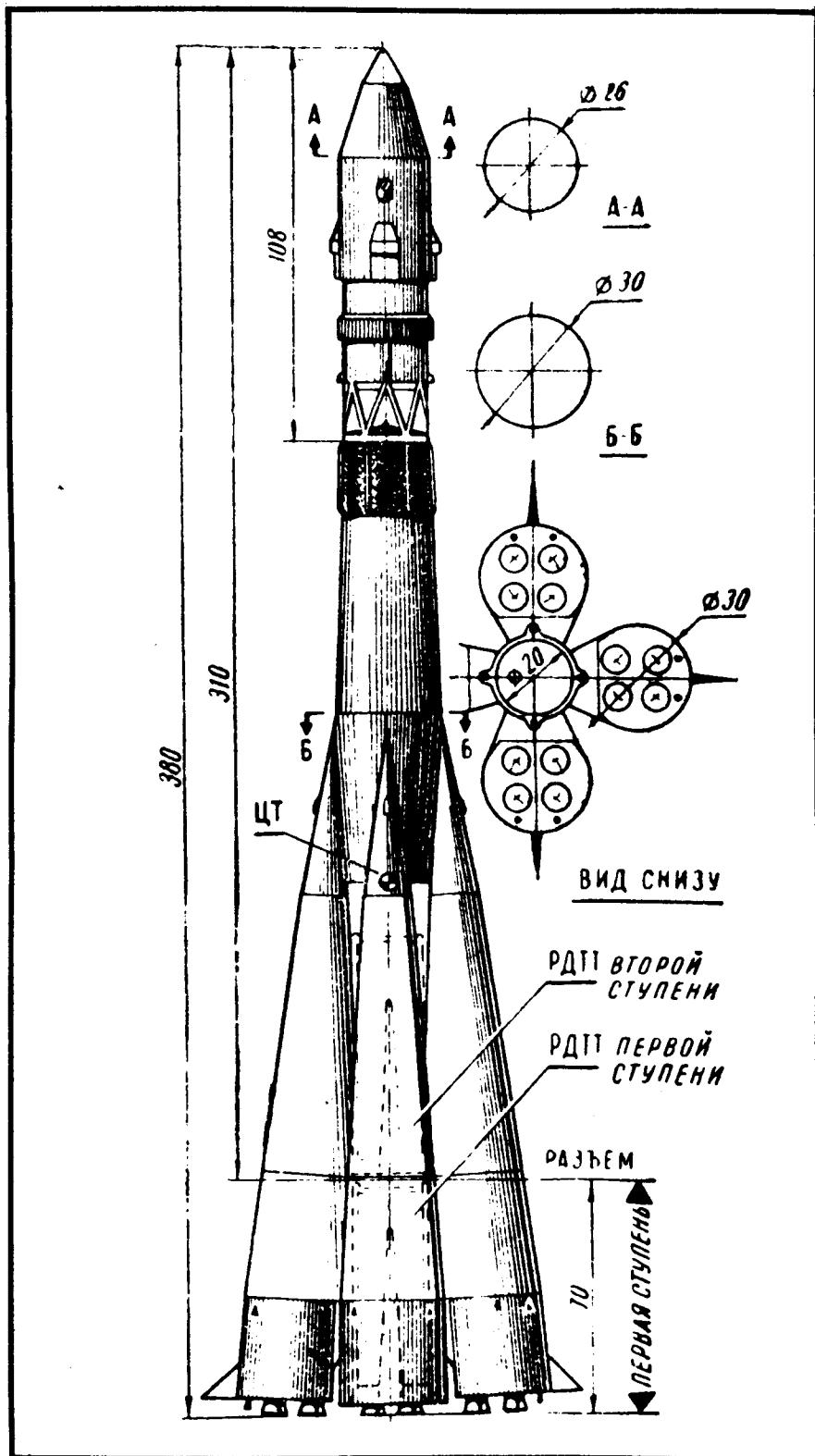
Advanced model rocketeers will immediately see the possibilities of the Pioneer-I in

NAR Altitude, Parachute Duration, Spot Landing, and Predicted Altitude events. Because the MPC T-20 tube which is the main body of the Pioneer-I will also enclose the standard FAI-NAR Payload, only the addition of a payload compartment will convert Pioneer-I into a contender in the Pee Wee Payload and Single Payload events. Immediate field repair of fins by simply slipping an entirely new tail section into place will make the Pioneer-I a powerful entry in the difficult NAR Quadrathon event.

With the combination of low price, high performance, and easy assembly, MPC's Pioneer-I is likely to start whole new trends in model rocketry. Like all MPC products, its available at your hobby store.

VOSTOK SCALE DATA FROM THE USSR

"VOSTOK" drawing, showing prototype dimensions in decimeters (ten decimeters equals one meter). This Russian drawing was supplied by Novosti Press Agency. The Russian inscriptions read (from top to bottom): Bottom View; Rocket Engine of the Second Stage; Rocket Engine of the First Stage; Connector; First Stage.

The following text and drawings were supplied by Novosti Press Agency to help modelers in construction of scale "VOSTOK" models. **Model Rocketry** is presenting it in response to the many letters received after our December 1969 cover photo showing a scale model "Vostok". In addition a series of photos of the "Vostok" launch vehicle have just been received and are presently being prepared for publication. A series of blue prints drawn from the photos, measurements taken from the full size model displayed at the 1967 Paris Air Show, and other sources will soon be ready for publication. The accompanying drawings are the ones used by USSR modelers for construction of their scale "Vostok" models.

The Vostok replica described is an exact model of the life-size rocket. Therefore when building it one should precisely keep to all the parameters, and copy parts as accurately as possible.

Yet, it is impossible to copy the sequence of the ship's flight—so far models cannot go with space velocities. Rocket models have other aims. They should go as high as possible and descend as long as possible: altitude and length of flight are the basic indicators of the model's performance.

The main difficulty in building replicas is that the outer form should be completely determined by the original and flight indices can be improved only by rational designing of the model and optimal division of its stages. It is precisely in this area that designers of rocket models should work. A model is not a blind imitation, but a conscious repetition of the original with a view to the capacities of "minor" rocketry.

Rocket models should be made mainly of non-metallic materials. Apart from ensuring safety in chance explosions of engines and falling of rockets, this also helps to make the model lighter. And the lighter the model, the better its performance.

The weight of a fully equipped model during blast-off should not be more than 500 grams. The model's size makes it quite possible to cope with this weight restriction.

The total weight of the fuel in the engines should not be more than 125 grams.

A Soviet-made standard type rocket engine (for models) contains 20 grams of fuel. Consequently there can be not more than six engines in the model.

Rockets should have devices ensuring their stability in flight—the launching of unstable rockets is forbidden. Therefore in designing a rocket one must by all means achieve its aerodynamic stability. One should remember that this requirement can be fulfilled if in flight the rocket's center of pressure—point of effect of resultant of all aerodynamic forces—is behind the center of gravity. Usually aerodynamic stability is achieved by properly selecting the shape and size of stabilizers. Yet, this method is no good for scale rocket models: their shapes and sizes cannot be changed arbitrarily—they are defined universally with set shapes and sizes of rocket models. Without being able to change the shape of a model it is impossible to alter the position of the center of pressure. To ensure aerodynamic stability only one way remains—proper selection of the place of the center of gravity.

Stability of flight can be improved by eliminating "harmful" features interfering with the motion of the rocket. These features can be created, with regard to the center of gravity, by the engines in the side units of the rocket.

The rocket can have a maximum of three stages. A stage means a part separable in flight and containing engines. A model can be produced in one, two and three-stage variants. The most difficult to build is the three-stage model. Therefore the best thing to begin with the one-stage variant, then changing over to two stages and finally to three stages.

Division into stages is arbitrary. One should not imitate the stages of the original rocket. One can say for sure that the second stage, if built as in Vostok, will be unstable in flight. Besides, the engine of the second stage cannot work twice as long as the engines of the first stage as in the real Vostok, because these are standard type engines.

The model and its stages should return to the ground with parachuting devices, and these can be cupola and ribbon parachutes, rotochutes, etc. If models are used in competitions in duration of descent, the size of the parachute for the last stage may be restricted.

It is particularly important to ensure the safety of the starting of the engine during launching. This ought to be by all means done with the use of an electric ignition system. The distance from the blast-off panel to the launcher should be at least 10 m, and the panel itself should have safety devices preventing accidental ignition of the fuel in the engines. The length of the guiding vertical guiding bars should be longer than the model by at least one meter.

The first stage can have several engines (brace of engines). In this connection one should pay special attention to the design of the ignition system: it should ensure simultaneous and reliable starting of the engines.

—(Novosti Press Agency)

SIZES OF MODEL AND VOSTOK ROCKET

No.	Items	rocket (m)	model (mm)
		Sizes	
1.	Total length	38.0	950
2.	Maximum diameter	10.3	256
3.	Length of main body	28.0	700
4.	Maximum diameter of main body	2.95	75
5.	Length of accelerators (strap-ons)	19.0	475
6.	Maximum diameter of accelerators	3.0	75
7.	Length of third stage	10.0	250
8.	Maximum diameter of third stage	2.58	64

ВОЗМОЖНОЕ ДЕЛЕНИЕ МОДЕЛИ НА СТУПЕНИ

ВИД А

МОДЕЛЬ МОЖНО ИЗГОТОВИТЬ В ОДНО-,ДВУХ - И ТРЕХСТУПЕНЧАТОМ ВАРИАНТАХ. ДЕЛЕНИЕ НА СТУПЕНИ ПРОИЗВОЛЬНОЕ. НА МОДЕЛИ ИСПОЛЬЗУЕТСЯ НЕ БОЛЕЕ ШЕСТИ СТАНДАРТНЫХ ДВИГАТЕЛЕЙ.

"VOSTOK" model drawing from Novosti. Model dimensions in millimeters are shown. Suggested divisions into stages (for a multistage model) are shown.
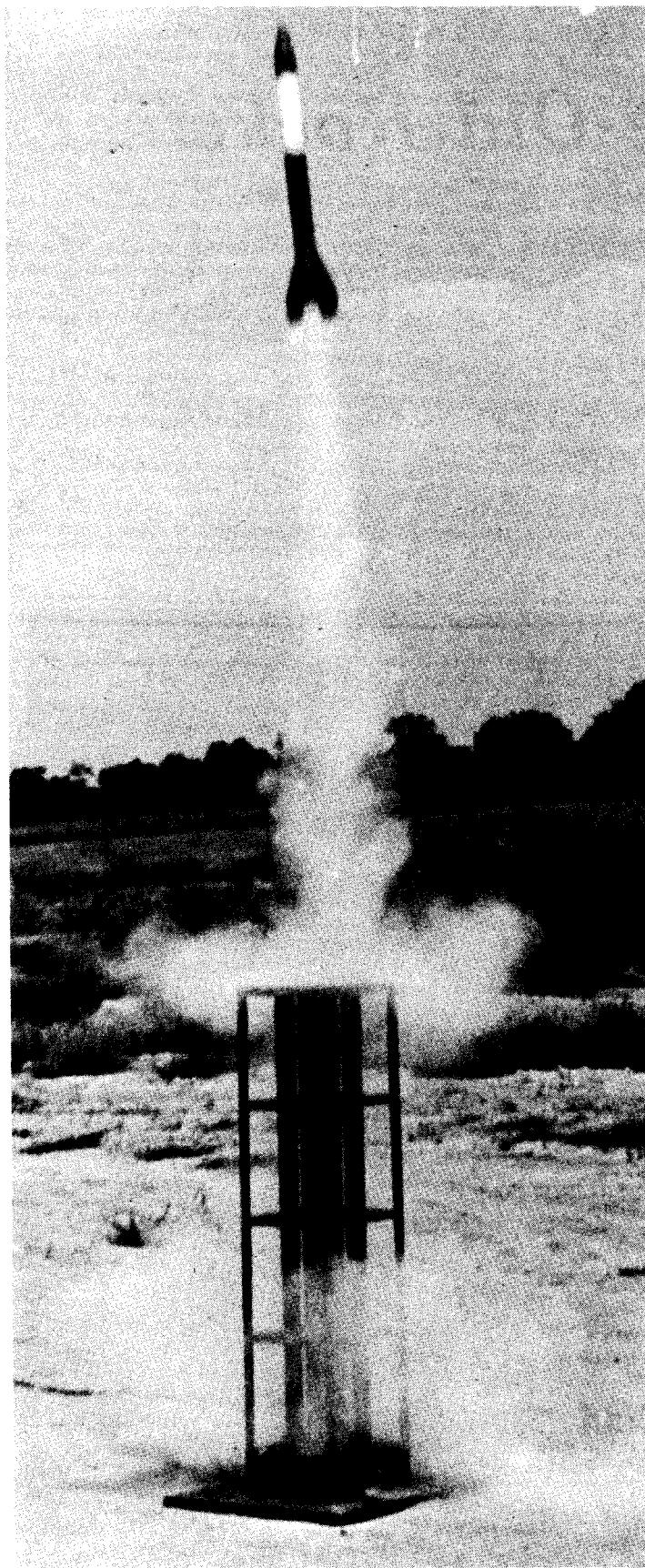
PHOTO GALLERY

Photo by Mike Dombrowski

A payload rocket powered by 3 E5-6 engines is launched from a tower owned by the South DeKalb Model Rocket Society, Decatur, Georgia.
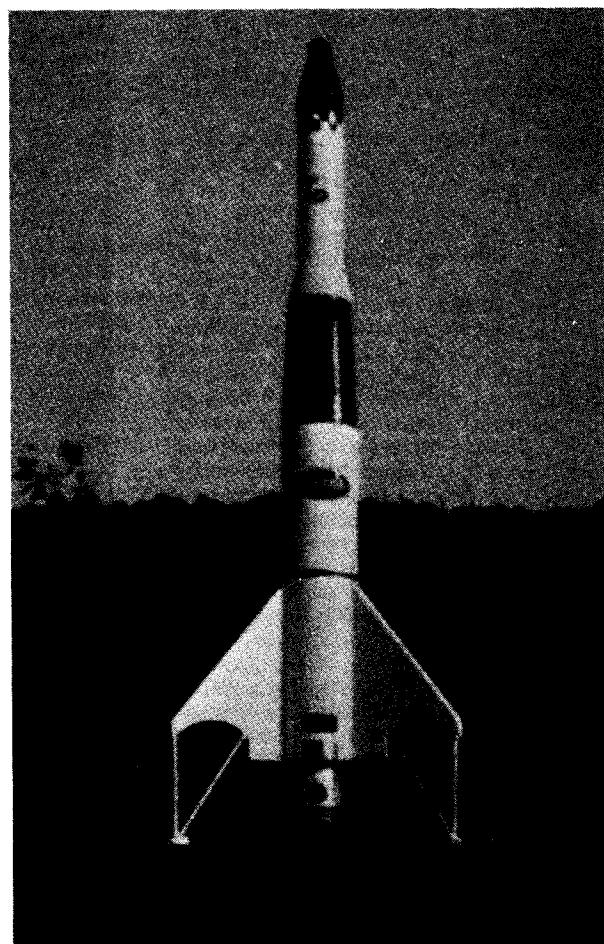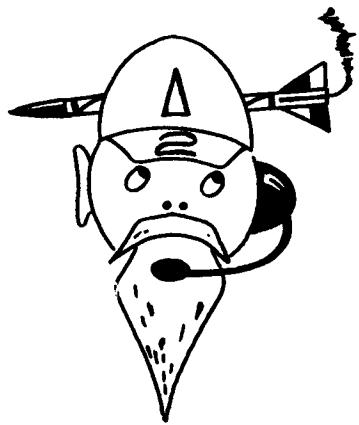
Photo by Robert Lada

A futuristic design poised for liftoff.

The Old Rocketeer

by G. Harry Stine NAR#2

THE FIRST MODEL ROCKETS

All of us suffer from the same delusion: The world really didn't exist before each of us was born. History is a record of "events that never happened written by people who weren't there." This happy little concept, which will drive you right up the wall if you think too much about it, also applies to model rocketeers. Insofar as each of *you* is personally concerned, the hobby of model rocketry simply did not exist at all until the day when *you* discovered it. Right?

Wrong, because it did ... and, wonder of all wonders, it even existed before *I* poked *my* long white beard into the action! Herewith, kiddies, is the True, Complete and Ungarbled Word from the Ancient Astronut Himself—

Before the advent of what we know as model rocketry, there were many rocket vehicles flown made of paper, cardboard, and wood that used a replaceable solid propellant rocket motor. Some of these even had parachute recovery devices. The most extensive flight tests of such rockets were carried out in the early 1930's by the American Interplanetary Society—later the American Rocket Society and today called the American Institute of Aeronautics and Astronautics.

But the model rocket as we know it came about at the request of a builder and flyer of model airplanes.

Robert Carlisle of Norfolk, Nebraska was and still is a builder of scale U-control model airplanes. He has a beautiful collection of flying scale models portraying the history of aviation. In the early 1950's, he gave many flying demonstrations for local schools and civic clubs. But he felt that he needed something to use as a finale in his demonstrations, something that would show vividly the new age of rocket power. So he asked his brother, who was his partner in Carlisle's Correct Shoes store on Main Street in Norfolk.

Orville H. Carlisle (NAR #1) is a hobbyist in pyrotechnics and explosives. He is not a basement bomber because he knows about

as much about the subject as any professional, and he has a library that contains nearly every contemporary book extant about explosives and pyrotechnics. When his brother Bob asked him if he could come up with a little rocket, Orv went to work.

The result saw the first light of day in about 1954 after Orv had developed a reliable rocket engine with delay charge and ejection charge. This little engine, which Carlisle himself taught me how to make in 1957, is 0.5 inches in diameter and 2.25 inches long. Carlisle could make these in total impulse classes of 1/4A to B. These were tremendously powerful little units. One Carlisle engine that I tested on September 13, 1962 showed a total impulse of 4 N-sec, an average thrust of 3.6 newtons, and a duration of 1.31 seconds! Each of

them was hand-made.

Bob Carlisle helped Orv with the CG-CP relationship, and the world's first model rocket, the Carlisle "Rock-A-Chute" Mark I, was born!

It may look crude today, but it works. It flies. It performs.

But Orv felt that he could improve the appearance and the performance. He discovered a plastic crayon sharpener in a local dime store; this would make a good nose cone, he decided. The rest of the Carlisle "Rock-A-Chute" Mark II design evolved around the plastic nose cone!

There were no commercial paper body tubes for model rockets. Carlisle had to learn how to roll his own. He made his parachutes from one-mil polyethylene sheeting. Because of Bob Carlisle, a lot of
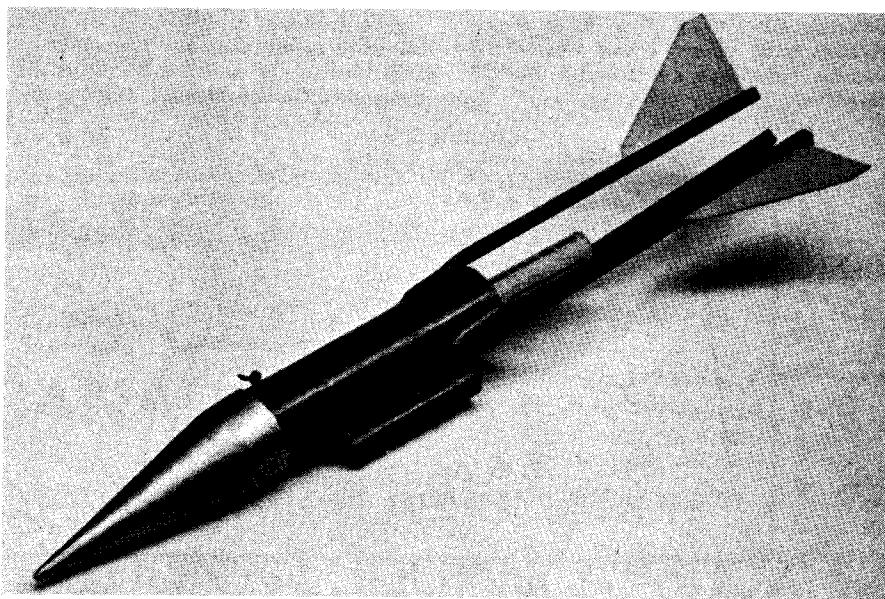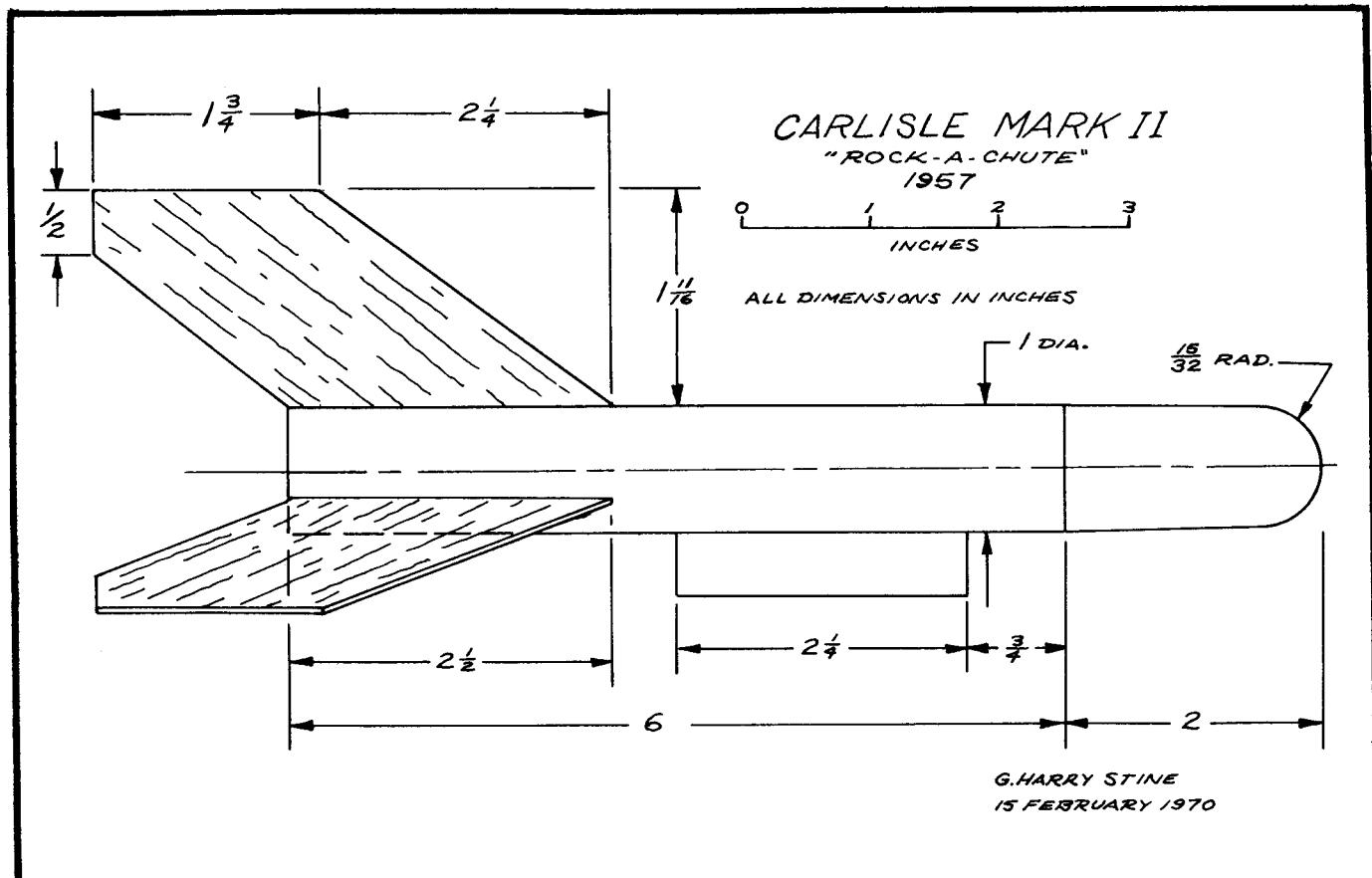

Photo by Stine

An original Carlisle Mark I, the world's first model rocket. Body is one inch diameter, stilts are balsa, fins are tag board. Nose cone is made from paper. The Mark I had parachute recovery. This model is destined for the Smithsonian Institution.

CARLISLE MARK II
"ROCK-A-CHUTE"
1957

ALL DIMENSIONS IN INCHES

G. HARRY STINE
15 FEBRUARY 1970

model airplane technology went into the Mark II.

The Carlisle Mark II is a big, powerful, rugged model rocket. Its body tube is 1.0 inches in diameter and 6.0 inches long. It carries three fins cut from 1/16-inch sheet balsa. The motor mount is a pine ring into which the motor jams with a tight press fit. The launching lug is a motor casing glued to the side of the body tube. Gross weight with a Carlisle 4-4-2 (NAR Type B4-4) engine installed is 50 grams. I have two of the originals, including the first Carlisle Mark II I ever flew.
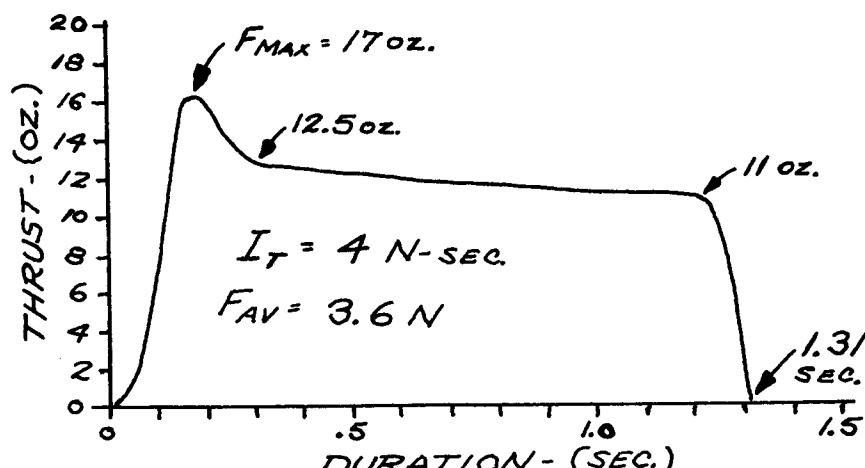
The Mark II is an out-of-sight model. It originally carried an 18-inch parachute; this was enough to set a parachute duration record every time you flew it.

Strange, but you can probably see the Carlisle Mark II influence in many of today's model rocket designs! By today's super-sophisticated standards, the Mark II is a draggy brute. But the basic design is so sound that it has withstood the ham-handed balsa-butchering of a couple of million model rocketeers over a period of nearly 15 years. (Item for later rabid discussion: I agree with Gordon Mandell. Gorillas could

do a better job of building most model rockets than so-called model rocketeers actually do. The level of craftsmanship in our hobby is exceedingly low, *on the average*. Sure, there are some very good model rocketeers, but the sheer number of balsa butchers pulls the average way down.)

Orville H. Carlisle had a fully operational and highly reliable model rocket system in 1957 when he first wrote to me. I was at that time Viking-Aerobee Operations Engineer and Flight Safety Engineer for the U.S. Navy at White Sands Proving Ground in New Mexico. Then, as now, I kept my typewriter busy in the evenings and was writing a monthly department on rockets and space for **Mechanix Illustrated** magazine. The February 1957 issue of **MI** had an article by me about professional rocket safety and a plea for amateur rocketeers to learn something about safety before they unleashed their zinc-sulfur flying pipes. Carlisle's letter said that he'd enjoyed my article, that he agreed with me, and that he had developed a little rocket which might solve the safety problem. He sent me some photographs and asked if I would like to try some out. I said yes.

The huge box arrived at my home via Railway Express with big Class C Fireworks stickers all over it. In those days, model rocketry had not yet won over the NFPA and other organizations. Having been quite thoroughly indoctrinated on rocket propellant safety and all of the other areas of rocket safety by experts from White Sands, Picatinny Arsenal, Aberdeen, and Sandia, I put those little Carlisle model rocket engines inside a steel ammunition can

$F_{MAX} = 17$ oz.

12.5 oz.

11 oz.

$I_T = 4$ N-SEC.

$F_{AV} = 3.6$ N

1.31 SEC.

STATIC TEST DATA: Carlisle Type 4-4-1, hand-loaded by Orville H. Carlisle, April 1958. Tested September 13, 1962 on RDC Model 62A1 static test stand.

Photos by Stine

(Above) Orville H. Carlisle, NAR #1, hooks up one of his Mark II models for a demonstration during NARAM-9. The rocket is being launched from one of his original launchers using a ¼" wooden dowel as a rod.

(Right) The Carlisle Mark II "Rock-A-Chute" was the second design by Orville Carlisle. It is the direct ancestor of today's model rockets. This model from the Stine collection, built by Carlisle in 1957, is still capable of flight.

and ensconced them behind a pile of dirt in the farthest corner of my backyard! On February 10, 1957 after carefully reading the instructions written to me by Carlisle, I prepped my first Mark II and crossed the street, walked over the irrigation canal, and set up the launcher in the middle of a large cotton field. (This historic spot is now covered with houses.) There was no electric ignition; we didn't develop that until a couple of weeks later. I lit the fuse and ran like hell.

When I turned around, I watched what all of you have watched and what I have seen thousands of times since then.

A fluke! It had to be a fluke! Everything had worked. But, hey, that was fun! So I tried it again.
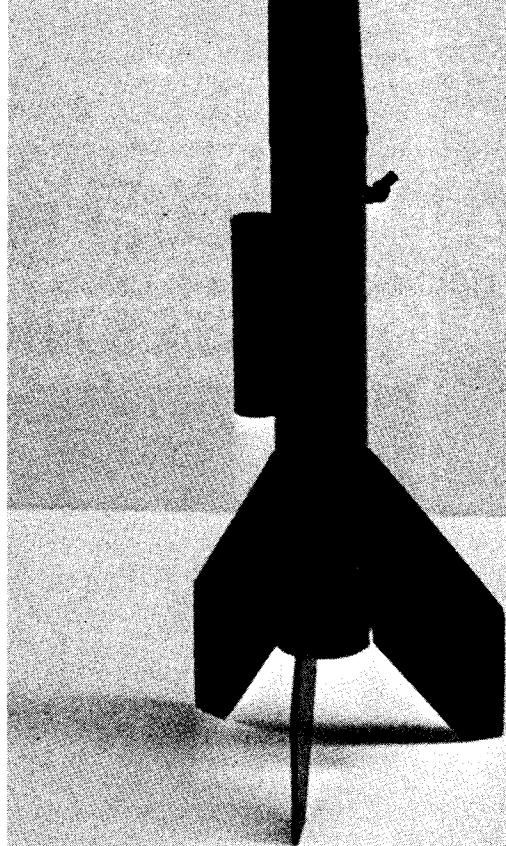
It worked the second time . . . and the third time . . . and the fourth time. Then I got on the telephone to Nat Wagner (chief flight safety man at White Sands), Gilbert Moore of Pogo Project and today's Tomahawk man, and a few other rocket engineer friends. "Look, you won't believe what I've got over here, but . . ."

We used up all the hand-loaded rocket engines that Carlisle had sent.

And we learned something profound and universal right away.

Our launchings took place out on a barren stretch of desert known as the Jornada del Muerto. In a good year with all of 3 inches of rainfall, it is possible to graze one cow per square mile on the Jornada. It is sort of desolate, if you know what I mean. These city-bound idiots who run around saying that we are ruining our environment because we are crowding each other off the face of the earth should spend a day on the Jornada, if they could stand the loneliness. We couldn't see a soul for miles, not even a forlorn cow. Three minutes after the first model rocket was launched into the clear New Mexico skies, forty kids came out of the creosote bush and wanted to launch the next one. No

matter where we went, model rockets drew youngsters like magnets. And it still goes on.

On February 10, 1957 I wrote as follows to Orville H. Carlisle: "Everybody who saw these rockets perform down here was impressed today. The concensus of opinion is that you have done an excellent job of engineering and producing these rockets. With commonsense safety precautions, they are about as safe as any rocket can be . . . Another comment that was passed today: 'We ought to get this shoe salesman down here working for us if he can achieve 100% reliability on a chute ejection like this!' "

At that point in the history of model rocketry, development of the model rocket system embraced a new element. The ancient art of pyrotechnics and the technology of model aeronautics had been combined by Orville and Robert Carlisle to create the basic model rocket. The "grand synthesis" that begat model rocketry as we know it today was the inclusion of the third element, professional astronautic technology. This began at White Sands.

It is still going on today.

The interesting thing, however, is the fact that the first model rockets designed by Carlisle still fly well today and can be built and operated with modern materials, parts, engines, and launching equipment. Furthermore, the Mark I and the Mark II—especially the Mark II—will fly with the best of them today.

Is there any question in anyone's mind at this point regarding why NAR Number One is Orville H. Carlisle of Norfolk, Nebraska?

Wichita State University Low Speed Wind Tunnel
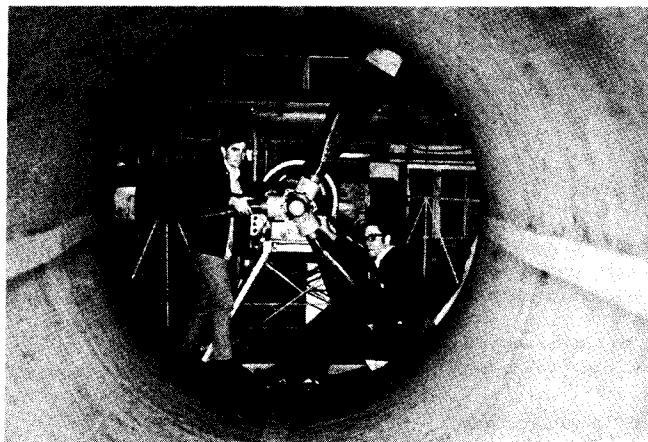
LIFT, DRAG, AND PITCHING MOMENT COEFFICIENT MEASUREMENTS ON THE ESTES NIGHTHAWK BOOST GLIDER

by Douglas Malewicki

LOW SPEED WIND TUNNEL

Otto Jaeger (standing) and Bob Maynard—Senior Honor Students in Aeronautical Engineering are shown in the 9 foot diameter exit section of the wind tunnel. A 60 horsepower electric motor is used to drive the propeller which pulls air through the 4 foot diameter test section. Propeller RPM and blade angle can be varied from a remote control panel to obtain test section air speeds ranging from 40 to 100 miles per hour.

MOUNTING THE NIGHTHAWK TO THE BALANCE
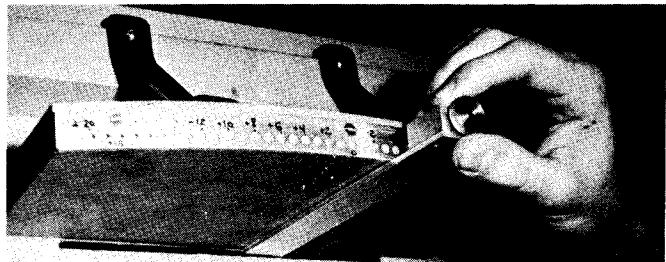
Otto Jaeger (left) attaches the boost glider to an airfoil sting which extends out of the strain gage balance. Prior to obtaining any model data, a separate run was performed on the airfoil sting. This was done so that aerodynamic forces acting on the small sting can later be subtracted from the total aerodynamic data in order to isolate that portion acting on the model alone.

THE NIGHTHAWK B/G READY FOR TESTING
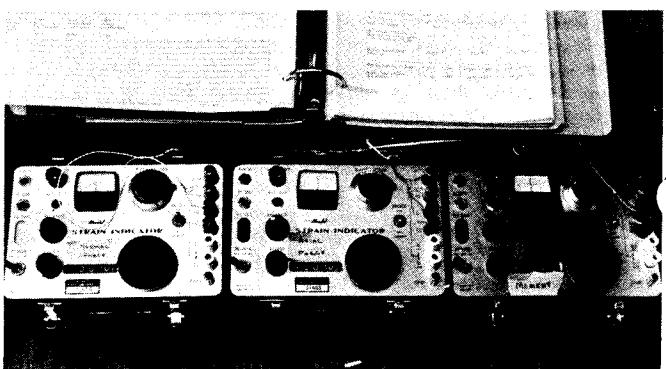
The strain gage balance components are shielded from any aerodynamic forces by the airfoil fairing. *Only* the air forces on the model and its small airfoil sting are transmitted to the strain gages. gages.
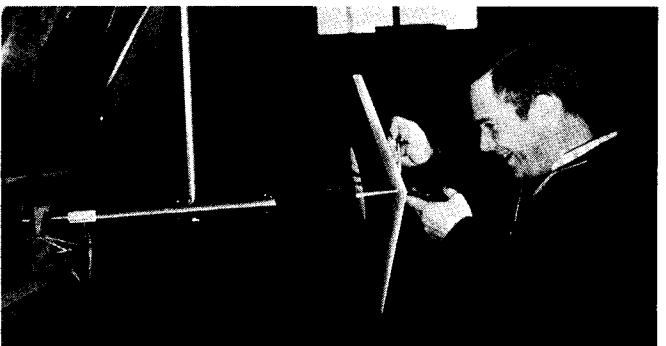
THE ANGLE-OF-ATTACK INDICATOR

The angle-of-attack of the model to the wind tunnel airflow is quickly varied in accurate one degree increments with the aid of a spring loaded tapered pin. The small slit for the aluminum bar was the only hole made through the tunnel wall.

MEASURING THE AERODYNAMIC FORCES

Buried inside the fairing are thin stainless steel beams which deflect in exact proportion to the aerodynamic forces. Bonded to these beams are five pairs of strain gages which change their electrical resistance in proportion to the amount of deflection. These electrical changes are then read out on the three meters shown above. Finally, a computer program converts these electrical readings back into aerodynamic forces and coefficients.

QUICK CHANGE FEATURE

By designing various models for attachment to one sting, time between tests has been reduced to about 10 minutes. A large hatch in the bottom of the test section pivots out of the way for access to the models and the balance.

INTRODUCTION

This article presents aerodynamic coefficient data for the glider portion of the Estes Nighthawk boost glider kit. The meaning of the data is interpreted and then applied to the analysis of a complete boost glide flight. The results are also used to show how to improve the Nighthawk's duration performance. Before you can make any practical use of the wind tunnel test data presented on the following page, you should review the basic glider aerodynamic relations covered in the December 69, January 70, and February 70 issues of **Model Rocketry.** If, on the other hand, you remember what C_L, C_D, a, γ, S, W, L, D, V, V_S, and ρ mean, you are doing great and need not bother.

In addition, we now need to explain the concept of a Pitching Moment.

Glide Stability and the Pitching Moment

We will start out with the definition of a MOMENT. When we discuss a moment in regard to model rocketry performance, we mean a *force* acting at a distance called the *moment arm* rather than an "instant of time." The "size" of a moment is found by *multiplying* this force by the moment arm. Thus, the dimensions of a moment will be pound-feet. For model rocket work, we commonly use ounce-inches. (In the metric system, Newton-centimeters would be the appropriate units to use for a moment.)

What is the net affect of a moment? Basically, any moment acting on a glider during free flight will result in a *rotation* of the glider in the *same* direction as the moment itself. Note that all such rotations occur *about* the vehicle's center-of-gravity (as you may have already learned in your studies on model rocket stability).

The PITCHING MOMENT of a glider refers only to *nose-up* and *nose-down* rotations. There are also Yawing Moments (where the nose goes left or right) and Rolling Moments to consider (where the vehicle "rolls" into a right or left bank). These last two are just concerned with stability rather than with performance. They were not measured in these tests nor will they be discussed. *Only the Pitching Moment affects duration performance.*

The symbol for Pitching Moment is M_{cg}. Here the "cg" subscript is used to denote the moment *about* the vehicle's center-of-gravity. A nose-up Pitching Moment is considered as positive $(+M_{cg})$. A nose-down Pitching Moment is negative $(-M_{cg})$. In other words, a "$+M_{cg}$" tends to rotate the glider's nose upwards from its present position and a "$-M_{cg}$" tends to rotate the nose down from its present position.

When the Pitching Moment equals zero $(M_{cg} = 0)$, there is *no* tendency to rotate either nose-up or nose-down. When $M_{cg} = 0$, the glider will continue flying steadily along as is until it is disturbed by something like a gust. What happens then depends upon whether or not the glider is *stable* in pitch.

A model rocket is stable if its center-of-pressure is behind its center-of-gravity. Any atmospheric disturbance which produces an angle-of-attack produces lift on the fins (a moment about the cg) which tends to rotate the rocket back to zero angle-of-attack, where the fins again produce *no* lift.

A glider is a much more delicate situation. As the glider descends, it has to fly at some combination of speed (V) and angle-of-attack to the wind (a) such that the total aerodynamic reaction force (R) and the weight of the glider (W) are in equilibrium as shown below.

The angle-of-attack (a) at which the Pitching Moment is zero is called the TRIM angle-of-attack. For the glider to be stable as it descends, it *must* exhibit a tendency to return to its TRIM angle-of-attack $(M_{cg} = 0)$ after an atmospheric disturbance. If the vehicle's angle-of-attack is suddenly reduced *below* the trim angle-of-attack, a natural tendency to rotate the nose back *up* to trim must exist. Similarly, any sudden increase in angle-of-attack *above* trim must be accompanied by a moment which tends to rotate the nose *down* and back to trim.

In the wind tunnel, Pitching Moment about the glider's center-of-gravity is measured at numerous angles-of-attack. The resulting M_{cg} is then plotted as a function of angle-of-attack. This graph is very valuable because it immediately shows you the natural trim angle-of-attack for the glider *and* also tells you whether or not the glider will be *stable* in pitch as desired. As can be seen in the following illustrations: 1) the trim angle-of-attack coincides with zero Pitching Moment, and 2) the glider is stable if the Moment versus angle-of-attack line slopes *downward* and to the *right.*

Once the trim angle-of-attack is established using such a graph, the steady flight aerodynamic Lift and Drag Coefficients of the glider can be found *and* something can then be said about the glider's expected duration performance.
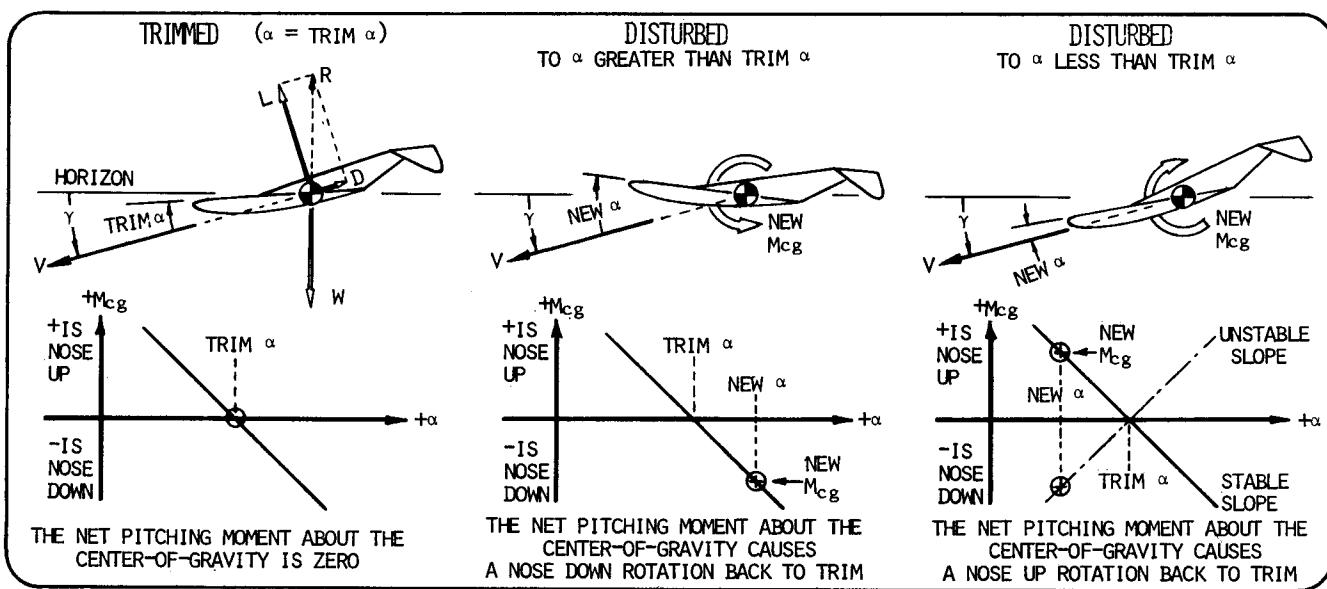
The Pitching Moment Coefficient

For the same reasons that we convert Lift (L) and Drag (D) forces to dimensionless Lift Coefficients (C_L) and Drag Coefficients (C_D), we now convert the actual Pitching Moment (M_{cg}) to a dimensionless Pitching Moment Coefficient about the model's center-of-gravity $(C_{M_{cg}})$ as follows:
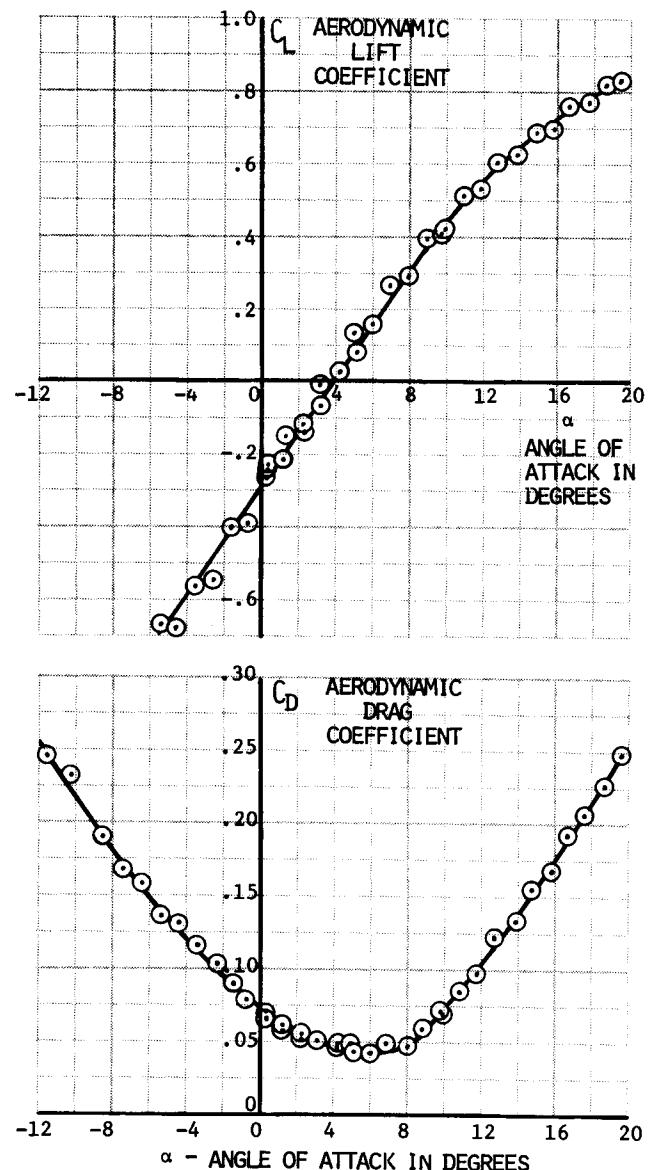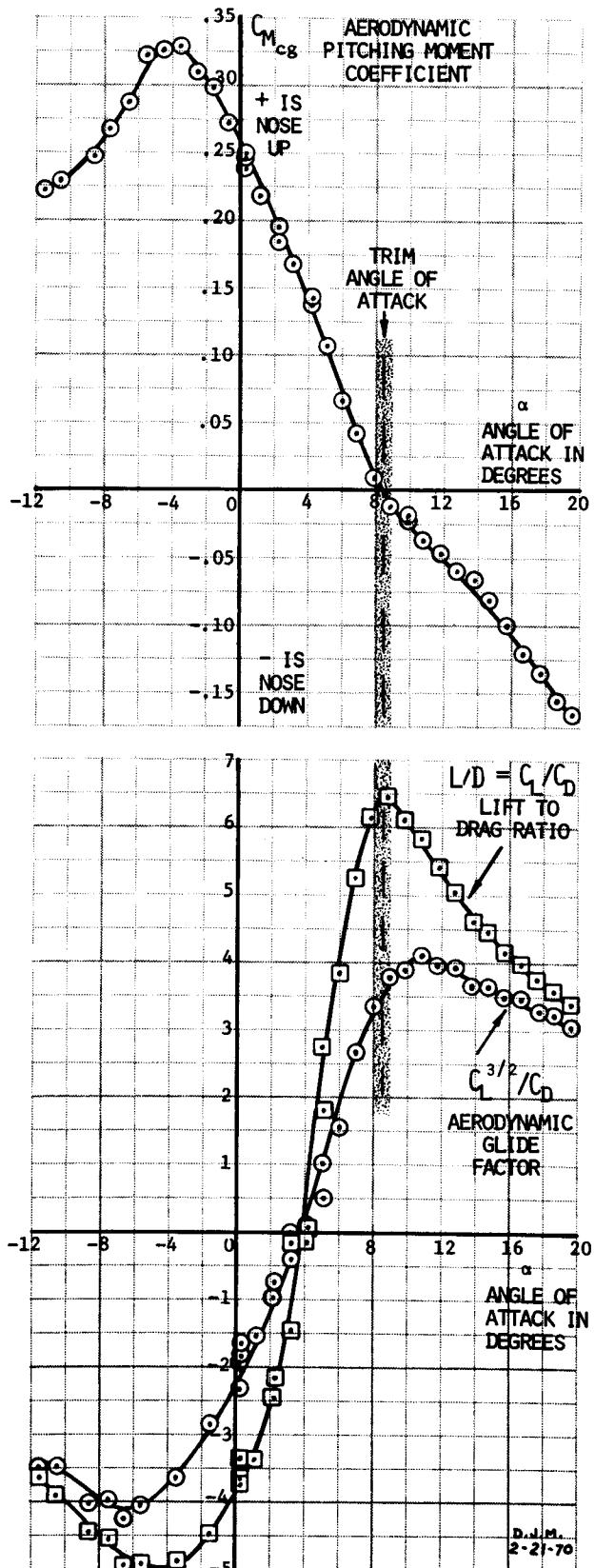
$$C_{M_{cg}} = \frac{M_{cg}}{\bar{c}\, S\, \frac{1}{2}\, \rho\, V^2}$$

Note that a new term $\bar{c}$ has been introduced. $\bar{c}$ is called the *mean aerodynamic chord.* The use of the word "mean" in this sense means "average" rather than "nasty". An approximate value for the length of the mean aerodynamic chord $(\bar{c})$ is found by simply dividing the wing surface area (S) by the wing span (b).

$$\bar{c} = \frac{S}{b}$$

TRIMMED (α = TRIM α)

THE NET PITCHING MOMENT ABOUT THE CENTER-OF-GRAVITY IS ZERO

DISTURBED TO α GREATER THAN TRIM α

THE NET PITCHING MOMENT ABOUT THE CENTER-OF-GRAVITY CAUSES A NOSE DOWN ROTATION BACK TO TRIM

DISTURBED TO α LESS THAN TRIM α

THE NET PITCHING MOMENT ABOUT THE CENTER-OF-GRAVITY CAUSES A NOSE UP ROTATION BACK TO TRIM

The Nighthawk's Lift, Drag, and Pitching Moment variations with angle-of-attack (α) have been plotted in coefficient forms (C_L, C_D, and $C_{M_{cg}}$). In addition, the Lift-to-Drag Ratio (C_L/C_D) and Aerodynamic Glide Factor ($C_L^{3/2}/C_D$) graphs have been lined up with the Pitching Moment graph so that glide performance at the trim position can be more easily illustrated.

MODEL DATA

Weight	W =	1.2 ounces
Wing Span	b =	16.5 inches
Wing Surface Area	S =	42.5 square inches
Mean Aerodynamic Chord	$\bar{c} = \frac{S}{b} =$	2.57 inch
Wing Loading	$\frac{W}{S} =$	.0282 ounces/square inch
Trimmed Center-of-Gravity Location	=	.90 inches from the rear of the body

CONCLUSIONS

Our first observation should be that the Pitching Moment about the Nighthawk's center-of-gravity ($C_{M_{cg}}$) becomes zero at an angle-of-attack (a) of 8.5 degrees. *This* is the trim angle at which the glider will want to fly. By establishing the trim point, we can now proceed to find all the other aerodynamic coefficients during trimmed steady state glide.

For: TRIM a = 8.5° & C_D = .053

we have: C_M = 0 C_L/C_D = 6.4

          C_L = .35 $C_L^{3/2}/C_D$ = 3.5

The most surprising fact to me was that the glider turned out to be trimmed to fly *right at* the maximum possible Lift-to-Drag Ratio (C_L/C_D). The reasons why only became clear to me after thinking about it for a couple of days. Since then, I've also convinced myself that it is not just an unusual coincidence.

Consider *how* the Nighthawk and many other boost gliders are trimmed *and* then things begin to fall in place mentally. You gently throw the glider in a straight ahead glide from shoulder height. If it stalls, you add weight to the nose—if it dives, you add weight to the rear (or remove it from the nose). Little by little you remove the undesired stalling or diving tendencies until the ship glides nice and smooth.

The next question is when is one really *satisfied* with the trimming process and ready to proceed to a rocket powered launch? Think about it a bit and you will realize that for shoulder height launches that you are subconsciously striving for *maximum* range. You will also probably note that you inherently try to keep the tossing action identical from glide test to glide test in order to have repeatable comparison data for any changes made.

The February issue of **Model Rocketry** showed that *maximum* range is obtained when the glide path angle (γ) is as small as possible. It was also shown that this angle grew smaller mathematically as the Lift-to-Drag ratio increased. In other words, by trimming the Nighthawk to glide the farthest possible distance from a given height, you automatically obtained maximum C_L/C_D. With shoulder height launches, it is much easier to physically sense range improvements rather than small time of flight improvements—so range rather than duration time is optimized.

Now, let's talk about trimming hand launch gliders. These can be thrown very hard and often reach heights of 30 to 40 feet. You won't inherently be sensing range (they glide in circles)—you'll truly be sensing time *and* trying to improve it. Don't be surprised to see future wind tunnel data taken on hand launch gliders that shows them to be inherently trimmed right at their maximum possible aerodynamic glide factor ($C_L^{3/2}/C_D$) instead of at maximum Lift-to-Drag ratio (C_L/C_D) as in the case of shoulder height glide testing.

It should be noted that when you shift the center-of-gravity of the glider with the use of ballast that you also alter the model's aerodynamic Pitching Moment about its center-of-gravity curve ($C_{M_{cg}}$ VS a). Both its slope and the angle-of-attack at which the moment is zero (the trim point) will shift.

Fortunately, once you have the $C_{M_{cg}}$ VS a data for one center-of-gravity location, you can mathematically define what the altered $C_{M_{cg}}$ VS a graph will be at any other desired center-of-gravity. You do not have to run separate wind tunnel tests for each new balance point! In a future issue of **Model Rocketry**, we will present the equations used for this purpose and also will explain why they work.

FLIGHT ANALYSIS

OK, we have discussed basic pitching stability and the requirements for the trim condition *and* also have lots of fancy impressive looking graphs. Other than being somewhat interesting in themselves, what good are they?

An example flight performance problem will demonstrate the main use of such data. It is all merely a tool so you can answer questions such as, "If I launch my Nighthawk with a "B4" motor, how long can I expect it to stay up?" Before proceeding with

exactly such an analysis using the Nighthawk wind tunnel data, let's be sure everyone is aware of the important limitations that must be kept in mind once we have a final answer. 1) Will the rocket really go straight up; 2) will the pod really separate right at the theoretical peak; 3) will the glider transition to steady trimmed flight without losing altitude; 4) will theoretical gliding duration be affected by any thermal activity; and lastly 5) how close will the actual atmospheric conditions be to a standard 59°F sea level day? Keeping the above in mind, let's throw one more question your way. "How often would you expect the measured duration for a real flight to exactly match the duration prediction we are about to calculate?" The best answer, of course, is never! "So, why are we bothering?" should be your immediate response.

The main reason is that even though the analysis is in reality severely limited by the transition and thermal luck factors, it still gives you a rough idea of what can be expected under idealized conditions. This means that one boost glider can be *compared* to another mathematically on paper which, in turn, means that the better of the two can be selected without extensive building and flight testing time. Wind tunnel data, combined with mathematics, is a powerful tool for optimizing design changes.

BOOST PHASE ALTITUDE

In order to determine the peak altitude and the best "B4" engine delay time to use, you will need TIR-100, which I wrote for Centuri.

In the boost phase you will also have to take into account the additional weight and aerodynamic drag of the pop-pod. The pod weighs .7 ounces and the "B4" engine weighs .7 ounces. Thus:

$$\text{TOTAL LIFTOFF WEIGHT} = \text{Glider Weight} + \text{Pod Weight} + \text{Engine Weight}$$
$$= 1.2 + .7 + .7$$
$$= 2.6 \text{ ounces}$$

The pop-pod is made from a BT-20 body tube which is .736 inches in diameter. Its reference frontal area is:

$$A = \frac{\pi(DIA)^2}{4} = \frac{\pi}{4}(.736")^2 = .425 \text{ in}^2$$

Since it is quite similar to a regular rocket, we use the usual drag coefficient of .5 to obtain the drag form factor for the pod:

$$\text{POP POD DRAG FORM FACTOR} = C_D A$$
$$= (.5)(.425 \text{ in}^2)$$
$$= .212 \text{ in}^2$$

Next, we determine the drag form factor contribution of the glider itself. Note that during boost the glider *will not* trim to fly at an angle-of-attack (a) of 8.5°. The weight of the pod drastically alters the balance point. If any lift exists at all during boost, the rocket will not go straight up—it will translate sideways or fly in an arc. Thus, it is reasonable to expect that the drag during boost will correspond to the glider's zero lift ($C_L = 0$) condition. We find that a must equal 3.9 degrees for $C_L = 0$. At that same angle-of-attack we then find that $C_D = .048$ (an approximate interpolation).

Note that the glider's drag coefficient was found by dividing the measured drag force in the wind tunnel by a reference wing surface area (S) and *not* a frontal area (A).

$$C_D = \frac{D}{(S)(\frac{1}{2}\rho V^2)}$$

Thus, the drag form factor *must* also be calculated using a reference wing surface area (S).

$$\text{GLIDER DRAG FORM FACTOR} = C_D S$$
$$= (.048)(42.5 \text{ in}^2)$$
$$= 2.04 \text{ in}^2$$

Looking at just the C_D of a winged vehicle (which is based on wing surface area) can be deceiving as you can see. The *total* drag form factor is quite large. A $C_D A$ of 2.04 in^2 gives the same amount of drag at any speed as a 2.3 inch diameter rocket (approximately a BT-70) with its typical C_D of .5. Wings mean drag—so do overly large fins on regular rockets!

The total Drag Form Factor during boost is:

$$\begin{aligned} \frac{\text{TOTAL DRAG}}{\text{FORM FACTOR}} &= \frac{\text{Pod Drag}}{\text{Form Factor}} + \frac{\text{Glider Drag}}{\text{Form Factor}} \\ &= C_D A + C_D S \\ &= .212 \text{ in}^2 + 2.04 \text{ in}^2 \\ &= 2.25 \text{ in}^2 \end{aligned}$$

Using this answer in conjunction with the lift-off weight of 2.6 ounces in the TIR-100 "B4" engine graph yields:

MAXIMUM ALTITUDE	= 270 feet
COAST TIME	= 2.9 seconds

Now the "B4" engine comes with delay choices of 2, 4, and 6 seconds. The 2 second delay is the best choice, but it will result in pod separation .9 second before the rocket reaches its maximum peak of 270 feet. For the sake of simplified analysis, we just assume that the glider portion zooms up the rest of the way after separation and transitions to steady glide at the 270 foot level.

GLIDE DURATION

Here we use the Boost/Glider Performance Graphs presented in the December 1969 issue of **Model Rocketry** to find the duration per 100 feet of altitude (t_{100}) on a standard 59°F sea level day.

For a Wing Loading of $\quad$ W/S $\quad$ = .0282 oz/in^2

and an Aerodynamic Glide Factor of $C_L^{3/2}/C_D$ = 3.5,

we obtain: $\quad t_{100} \quad$ = 23.5 seconds

Assuming 1) that transition to steady glide occurred without any loss from the rocket's peak altitude of 270 feet, and 2) that no thermals exist, we find that the total glide time to reach the ground will be:

$$\begin{aligned} \text{Total Glide Time} &= \left(\frac{\text{Peak Height}}{100 \text{ feet}}\right) t_{100} \\ &= \left(\frac{270}{100}\right)(23.5) \\ &= 63.5 \text{ seconds} \end{aligned}$$

Thus, the total flight time will be:

$$\begin{aligned} \frac{\text{Total}}{\text{Flight}} &= \frac{\text{"B4" Engine}}{\text{Thrust}} + \frac{\text{Coast}}{\text{Time}} + \frac{\text{Total}}{\text{Glide}} \\ \text{Time} & \qquad \text{Time} \qquad \text{to Peak} \qquad \text{Time} \\ &= 1.2 + 2.9 + 63.5 \\ &= 67.6 \text{ seconds} \end{aligned}$$

IMPROVING PERFORMANCE
OF THE NIGHTHAWK

There are two primary ways to improve performance.

1. Reduce Weight

The Nighthawk used in the wind tunnel tests was built more for display and nice appearance than for contest work. It has a two color paint job which added lots of weight. Leaving the color coats off and paying more attention to careful airfoil sanding could easily result in a 40% weight reduction (from the present 1.2 ounces— down to the Estes catalog value of about .7 ounce). At the same time, working towards a more perfect airfoil would tend to increase lift and decrease drag at any given angle-of-attack.

2. Re-trim for Maximum Possible Aerodynamic Glide Factor

The wind tunnel graphs show that the aerodynamic glide factor is $C_L^{3/2}/C_D$ = 3.5 at the present trim angle-of-attack of 8.5°. Shifting the center-of-gravity further aft will result in a new pitching moment curve which crosses zero at a higher angle-of-attack. By re-trimming the Nighthawk to fly at an angle-of-attack of 11 degrees, we can obtain the maximum possible aerodynamic glide factor of $C_L^{3/2}/C_D$ = 4.1, which means duration from any altitude will increase 17%!

One very interesting experiment you can perform is to trim your Nighthawk glider in the usual manner for maximum range from gentle shoulder height launches. Then rocket launch it several times and record the total flight times.

Next, *retrim* it with best *time* in mind rather than best range. This will be difficult from shoulder height launches, so it is suggested that the glide tests be made from 25 feet or so above the ground (a second story window will do). A stop watch for measuring the effects of center-of-gravity shifts between tests will be indispensable. When you are satisfied that you have obtained the maximum aerodynamic glide factor condition, rocket launch the Nighthawk several more times with the same engines previously used and compare the duration results.

◆◆◆◆◆

NEWS NOTES

Genty to Edit Estes' Model Rocket News

Francois M. Genty has been appointed Director of Information Services for Estes Industries. The announcement was made by President Vernon Estes that Genty would

assume the new position with the world's largest manufacturer of model rockets and supplies. Prior to joining Estes, Genty was Assistant to the Director of Public Relations

for CF&I Steel Corporation, with headquarters in Pueblo, Colorado. He had been with CF&I for nearly 16 years, serving in various publicity and public relations capacities.

In his new position with Estes, Genty will report to Robert L. Cannon, Executive Director of the Communications Division. He will be primarily concerned with developing external information programs for the news media, trade publications, and the general public. He will also edit *Model Rocket News,* which is published by Estes Industries and distributed free of charge to all active Estes customers.

Genty was born in Paris, France, and received a B.A. degree from the University of Paris. He is director of Pueblo Diversified Industries for the Handicapped and is also serving as second vice president of the Colorado Chapter of Sigma Delta Chi, professional journalistic society.

For Hawk and Eagle Class B/G

The THUNDER—BIRD

by John Belkewitch
NAR 3183

To the present day, I have not yet come across a boost/glider capable of withstanding the pounding dealt out by C, D, or E engines, until the *Thunder Bird.* I owe a great deal of thanks to George Roos of Flight Systems along with his staff in making this venture possible. I discussed this type of glider with George well before NARAM-9 at Mankato. George supplied the engines and the nose cones for the test birds. His C to E engines afford a great selection to put this bird into the Hawk and Eagle class. One bird was ready to go at Mankato, but the size of the flying area made me chicken out, so it stayed in the model box.

The flyable model of the *Thunder Bird* required extensive research before development of the model which was flown at Wallops Island in the Research and Development competition. This bird leveled out in high winds during the delay train burn and hung there in the sky. Once it spit its engine, it began to climb into the wind like a real bird. It kept flying tight circles into the wind, gaining altitude. My son and I lost it over the swamps where it was still climbing and flying in a still larger arc. We stood there and kissed it good-bye. The secret of its performance will be discussed later, but the bird, in flight at this point, ejects its launch lug with the engine. A launch lug is a free-flight boost/glider's worst enemy. It will foul up the best trimmed glider, if you trim it *before* the lug is installed.

What really led to the development of the *Thunder Bird* was research as to why wings would separate from a bird. Believe it or not, the lesser of the foes is drag. In a modified Falcon, the pylon was moved back and the airfoil changed to give the best possible glide. With a B engine, this Falcon would reach an altitude of 100 feet and glide in a 100 foot circle for 60 seconds. Sound weird? It's true! Ten models were built before wing separation was finally prevented.

I found in a run down of these ten models that wing separation was caused by the noise transmitted through the boom into the wing's tips from the engine exhaust. To simplify this action, take a fishing pole designed for a boat, tap the shank with a ruler, very little tip vibration. Take a nine foot surf pole, repeat the operation and you will note an increase in the amount of the tip vibration. Whack it harder and the tip vibration amplifies to a greater extent. After extensive tests on the Falcon, I found I had whipped the speed of balsa, but a new problem arose.

Since I had run all my flight tests with booster engines to pop out at burn out, I could safely move into the C engine class for the real test. With the A and B engines the Falcon flew straight up. With a C engine the Falcon began to lob over, but it leveled out as soon as the engine popped. (I am speaking of the old Estes' C's with a two second burn.) I began to run shadow tests to check the thermals created by engine exhaust and found that the longer the burn the greater the amount of time the low pressure area lingered over the tail section. As the hot gases pass this position of the boom, two forces of pressure are created. The first force is one tending to move the tail section over so that both forces are equal. So as we go into a long burn the low pressure area lingers a little longer and the greater force of high pressure moves the tail section of the boom over and the bird begins to lob over.

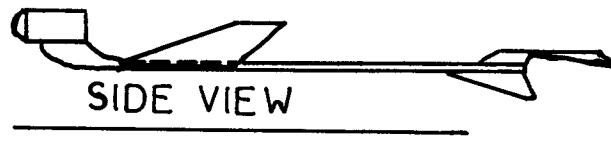The only recourse I had left was to either raise the pod height or

increase the diameter of the body tube. I chose the latter as it would also give a storage area for a chute or streamer. From here I later designed the *Zodiac* which will appear in a future article. The *Zodiac* reverted back to an old hand launch bird we used to build, so I added to it the increase in the body tube size. I left out the buffer strip and waited to see if the wings would hold. The first flight overjoyed me and I proceeded into the design of the *T-Bird.* Since the *T-Bird* would require as much altitude as we could possibly get out of a bird under high impulse, we had a job ahead of us — we means you also. The increase of drag on the *T-Bird* takes place as the bird starts to develop speed on liftoff with the C engine. The drag force squares as the speed increases.

(To satisfy myself after I built the first *T-Bird,* which survived

Photo by George Flynn
NAR Trustee John Belkewitch preps the "Thunder-Bird" for a world record attempt at the Pascack Valley Annual Regional Meet. The B/G went through a cyclone fence, stripping off the wings, but it has now been repaired.

SIDE VIEW

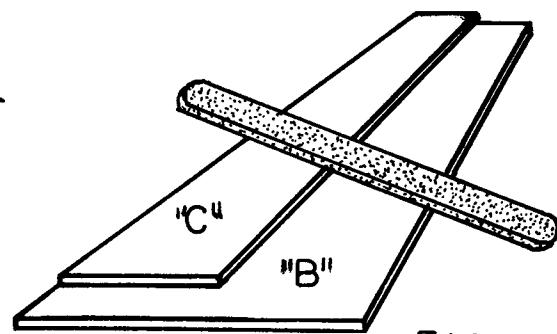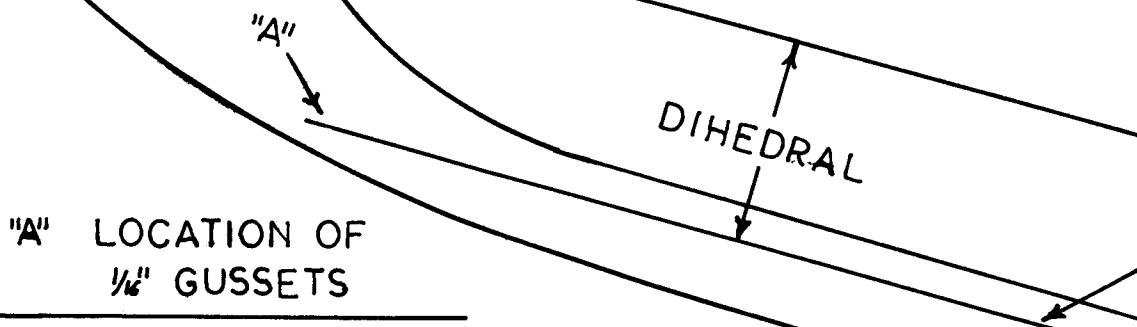WING AIRFOIL SEE TEXT

FRO...

"C"

"B"

FIG #2

"A"

DIHEDRAL

"A"

"A" LOCATION OF
1/16" GUSSETS

MAKE 2
3/32" BALSA
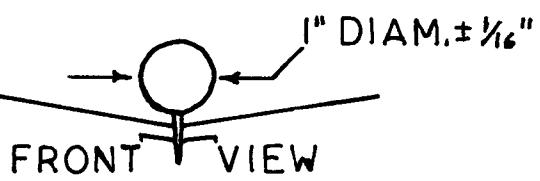
GRAIN

3/32" BALSA

GRAIN

3/32" P...

MAKE 2

ENGINE CLAS...

TYPE   B-C-...

1" DIAM. ± 1/16"

FRONT VIEW

MAKE 2   3/32" BALSA

← GRAIN

"B"
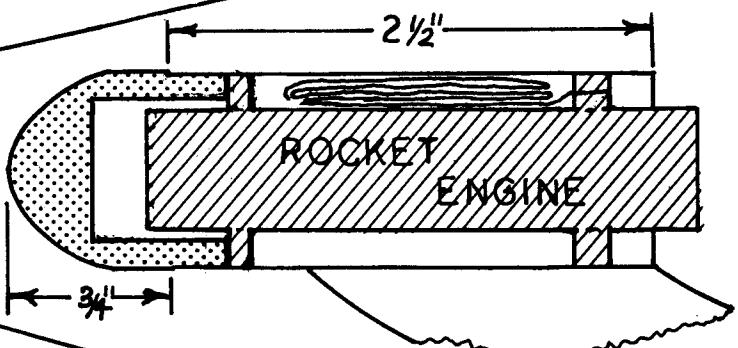
MAKE 2   1/16" BALSA

GRAIN

"C"

2 1/2"

ROCKET ENGINE

3/4"

FIG #1

3/32" PINE OR SPRUCE

MAKE 2 ← GRAIN

CLASS

B-C-D   FULL SCALE

TC 3-18-70

THUNDER BIRD

JOHN BELKEWITCH NAR 3183

FRONT VIEW

1" DIAM. ± 1/16"

MAKE 2   3/32" BALSA

GRAIN

"B"

MAKE 2   1/16" BALSA

GRAIN

"C"

2 1/2"

3/4"

ROCKET ENGINE

FIG #1

3/32" PINE OR SPRUCE

"A"

FIG #2

MAKE 2   GRAIN

ENGINE CLASS

"A"
LOCATION OF 1/16"
GUSSETS

MAKE 2
3/32" BALSA

GRAIN

3/32" BALSA
GRAIN

WING AIRFOIL SEE TEXT

SIDE VIEW

"A"

DIHEDRAL

"A"

"C"

"B"

FIG #2

MODEL ROCKETRY

MAKE 2

ENGINE CLASS
TYPE B-C-D

GRAIN

3/32" PINE OR SPRU

"C"

"B"

MAY

TC 3-18-70

MAY 1970

FULL SCALE

ENGINE CLASS B-C-D

TYPE B-C-D

GRAIN

MAKE 2

3/32" PINE OR SPRUCE

"A"

ROCKET ENGINE

FIG #1

2½"

¾"
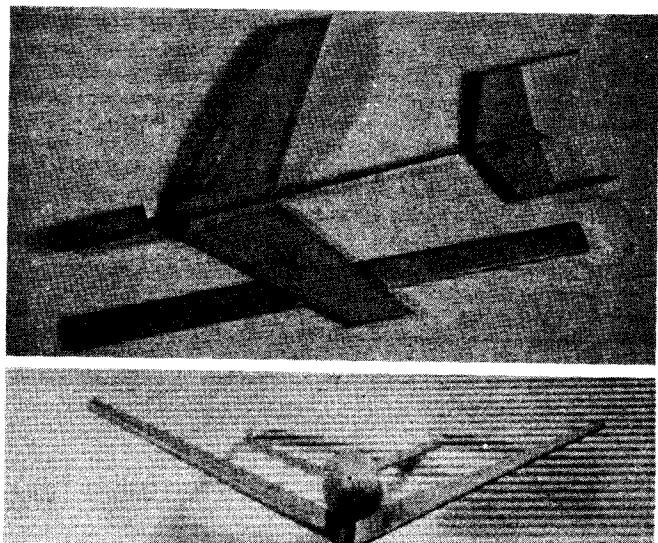
MAKE 2 ⅛" BALSA

GRAIN

"B"

MAKE 2

"C"

FRONT

3/32

MAKE 2

GRAIN

BALSA

two crack-ups, I put a BT-20 back on it. For thrills I flew it in crowds with a B13. It would go up 200 feet, loop over to within 20 feet of the ground, pop its engine, and soar around overhead for 30 seconds. George Flynn now owns this glider.)

To use high-impulse engines, I ruled out pop-pods for safety reasons. I could not see a pop-pod washing overhead with a C or an E engine inside if it fell off the boom on liftoff. This meant that engine popping would be a must. Since the increase in body tube size would provide streamer storage area, this eliminated the Big Red Baron problem. In the research of wing separation, it was found that by adding a buffer strip to the leading edge of the wing, the sound would be suppressed to the wing tip. It was also found that if this buffer strip was kept away from the boom, it caused a confusion of the sound patterns. The buffer strip was used in turn to increase the airfoil of the wing and to provide greater lift. Every advantage had to be utilized in the design of the *T-Bird*. To balance some of the weight at the front, tip plates were added to the tail. The advanced reader can read between the lines as to how these changes increased the performance. I don't care to make my articles of a highly technical nature so we won't lose the young modelers and their dads along the line. The *T-Bird* utilizes all the features of aerodynamics to make it the type of bird for top performance at extreme altitudes. If you don't have the room, don't fly it unless you want to leg it! I lost one of these birds in the indian grass at Hadly Field, New Jersey. At a fly for fun with the Pascack Valley Section it peaked out at about 1100 feet and it went. I still can hear Al Lindgren yelling "What's in that bird!" That's the copper and white bird in the photo. Shirley Lindgren, myself, and a few others gave up searching for it.

At Pascack Valley's first regional at Rutgers Stadium in New Jersey, I tried for a record attempt. I did not have the proper engine on hand so I had to use the only engine that was available. It was a long delay engine, an engine with a delay train longer than any that I had ever used in the *Thunder Bird*. I now believe that I am the only boost/glider builder in the U.S. or all of Europe that can hold the honors of putting a boosted glider through a cyclone fence on its touchdown. The long delay train caused the bird to lose too much altitude before its glide phase. With the falling rate (before ejection) of 32 feet per second, the results were disastrous. This bird leveled out after engine ejection, into a fast glide rate, which would have been good if it had the altitude. On the approach for a landing, it zeroed in on a cyclone fence and came in on the button. The
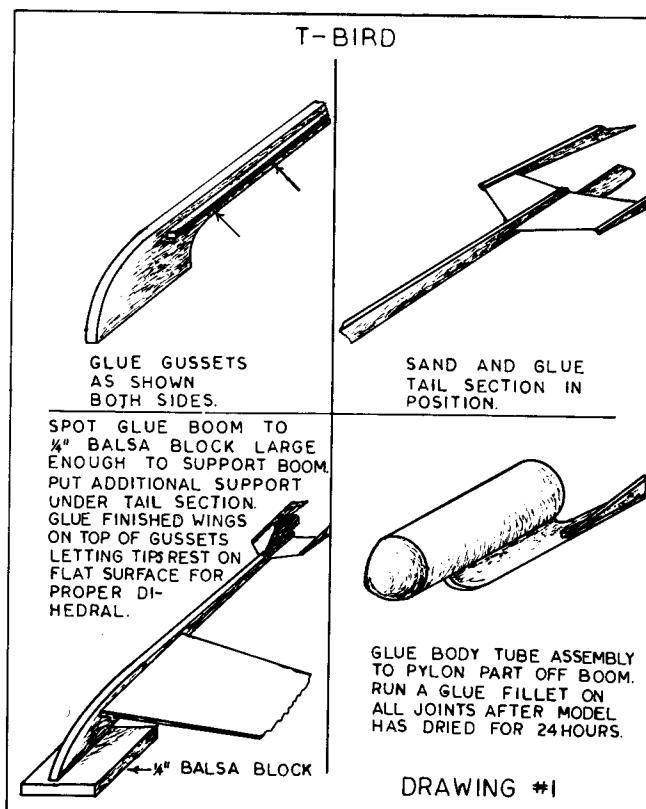

Top and End views of the "Thunder-Bird." Note the dihedral on the elevators.

wings sheared off and the boom and tail section hung up in the fence. This is the very same glider you see in some of the photos in this article. The new boom was constructed of 3/32" pine, planed down to this thickness. This entire bird was salvaged and flown again. My biggest venture here, was to reduce the boom thickness down to 3/64" while increasing the strength of this new boom.

Working with the *Thunder Bird* has opened up a new avenue in the field of boost glide construction. I believe this is the first series of designs to work backwards. We have the *Thunder Bird*, an advanced model, first, next the *Zodiac*, the in-between bird, followed by the *Flea*, a bird that can be flown in the shape of six independent models, derived from the six prototypes of the *Flea*. It was my intent to submit the articles in the reverse order, but I decided to open you advanced boost glide fans into the position of record attempts. This bird can do it hands down. This reliable Hawk and Eagle class boost/glider opens up a new field of experimentation to the modeller.

Although the *Thunder Bird* appears to be difficult to build, it is not. Care must be taken to see that all glue joints are clean and *strong*. Haste building is the modeler's worst enemy.
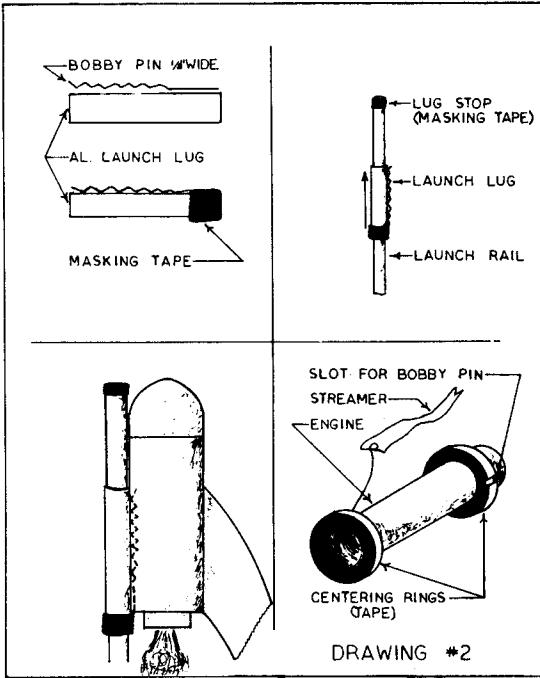
CONSTRUCTION

1. Trace, cut and sand the boom, on a wood of your choice, balsa, pine or spruce. Balsa used should be of a tight heavy grain. A good supply of boom stock can be obtained from store displays. This wood is usually ¼" X 1½" X 36". It can be planed down to any desired thickness.

2. Cut out gussets 1/16" square, the length of the root edge of the wings. Glue below the line scribed on the boom (pod-plane down). Apply glue to gussets and boom, let both dry. Reglue when dry and join parts together.

3. Trace, cut out and sand tail assembly parts. Just round off the leading and trailing edges of these parts. Glue all root edges and let dry. Reglue all root edges when dry and join to the proper place on the tail of the boom. Elevators are glued on the same plane as the rudder. The elevators can be glued horizontally or with a slight dihideral. Position here will give a change in flight pattern in each model. A slight dihideral is beneficial to the model.

4. Trace, and cut, the wings and the buffer strips. Apply glue to both connecting surfaces and let dry. Reglue when dry and join together, letting these parts dry over night. Sand the trailing edge of the buffer strip to meet that of the wing. Don't worry about the step left in the airfoil between the trailing edge of the buffer strip and the wing, it serves a purpose in the flight of this bird. Round off the leading edge of the wings leaving the root edge and leading edge

DRAWING #1

T-BIRD

GLUE GUSSETS AS SHOWN BOTH SIDES.

SAND AND GLUE TAIL SECTION IN POSITION.

SPOT GLUE BOOM TO ¼" BALSA BLOCK LARGE ENOUGH TO SUPPORT BOOM. PUT ADDITIONAL SUPPORT UNDER TAIL SECTION. GLUE FINISHED WINGS ON TOP OF GUSSETS LETTING TIPS REST ON FLAT SURFACE FOR PROPER DIHEDRAL.

GLUE BODY TUBE ASSEMBLY TO PYLON PART OFF BOOM. RUN A GLUE FILLET ON ALL JOINTS AFTER MODEL HAS DRIED FOR 24 HOURS.

¼" BALSA BLOCK

DRAWING #2

between the buffer strip *flat* for gluing.

5. Secure a scrap piece of 1/4" thick wood, large enough to support the boom. Spot glue this scrap to the body tube plane of the boom. This will support the boom while the wings dry in position. Support the tail assembly so all this is on a flat level plane. Apply glue to the root edges of the wings and the gussets, then let dry. Run a fillet of glue along the gussets, lay the root edge of the wing, buffer strip down on top of the gusset. The wing tip should rest on a flat surface. Repeat for other wing. Let dry undistrubed over night.

6. Cut the body tube to the specified length. Hollow out and shape the nose cone, glue and join together. Glue the body tube assembly to the boom. When the model has dried, run a fillet of glue along all the joints. Let dry thoroughly.

7. Trimming of this bird is no different than any other boost glider. Forget the launch for now. This bird in most cases will be tail heavy. The proper trim can only be found through hand launching. Small brads may or may not be required to trim this bird. These are inserted into the nose cone. Its fall and glide rate at ground level is fast because this bird needs altitude to fly. It utilizes its fall rate to activate its lifting forces. All that is required in a hand launch is a level glide.

8. Now come the engine rings. I have been using cut down register tape spools for engine rings. The front ring is fitted tightly. The rear ring the same, but to the rear ring I glue the launch lug. In this way the launch lug ejects with the spent casing. Removing the lug in this manner after liftoff gives a better free flight pattern. The streamer is tied to the front ring and stored in between both rings inside the body tube. (There is another method of getting rid of the launch lug; that is the bobby pin method illustrated in the drawing.) This type of streamer storage eliminates the Red Barons.

9. Final sanding should be done with as fine a grit as possible to remove all balsa fuzz. Painting should be limited to thin coats of dope. Two very thin coats of dope should suffice.

In flying the *Thunder Bird* I recommend a B engine with a short delay train for its first flight. After this bird has been fully flight tested, you can move up to a C, D, or E engine. To really fly well you must first fully understand just what an engine will deliver. This bird will offer much enjoyment and competition. The chance is here to go after some real American and International records. There are many ways in which this bird can be modified and I know you advanced buffs will do it.

PAINT COMPATABILITY

by Connie Stine
NAR 1300

As a model rocketeer I learned very early that many types of paints are not compatible. When my sister, then a new rocketeer, ruined a rocket by using the wrong paint combination, I decided to investigate the compatibility of commonly used paints for model rockets.

This was strictly a development project intended to (1) find which paints would go together and were compatible, (2) discover which paints would give a nice finish and which would not, (3) check the information in Stine's **Handbook of Model Rocketry**, and (4) add to the list the new types of paint that had come on the market.

Test chips of 1/16-inch balsa wood and test pieces of paper body tube material were chosen because of (a) the large number of tests

to be run, and (b) it was not known if various paint reactions on balsa wood would be the same as on paper due to the difference in texture and material. The various types of paint to be tested were listed, and a matrix was drawn up listing every possible combination of the paints with one type as undercoat and another type as a top coat. The paints used were Testor's Dope, Pactra Aero Gloss Dope, Testor's Enamel, Pactra 'Namel, Pactra Scale Flat, Krylon Spray Paint, AMT Spray Lacquer, and Polly S.

All balsa chips, for example, that were to receive the same base coat were painted at one time and allowed to dry. This was carried out until all chips had received their base coats. Then, all chips that were to receive the same top coat of the same material were lined up and given the coat at the same time. This was done until all chips

RESULTS ON BODY TUBES
Top Coat

	TESTOR'S ENAMEL	PACTRA ENAMEL	SCALE FLAT ENAMEL	KRYLON SPRAY PAINT	PACTRA DOPE	TESTOR'S DOPE	AMT LACQUER	POLLY S
TESTOR'S ENAMEL		Smooth Dull	Smooth Dull	Smooth Shiny	Separated	Smooth Fine	Smooth Shiny	Smooth Dull
PACTRA ENAMEL	Dull Finish		Lumpy Dull	Smooth Finish	Separated	Separated	Smooth Shiny	Smooth Dull
SCALE FLAT ENAMEL	Dull Finish	Lumpy Finish		Smooth Shiny	Separated	Lumpy Finish	Lumpy Shiny	Smooth Dull
KRYLON SPRAY	Smooth Dull	Smooth Shiny	Smooth Dull		Separated	Separated	Very Smooth Shiny	Smooth Dull
PACTRA DOPE	Smooth Dull	Lumpy Shiny	Lumpy Dull	Smooth Shiny		Shiny Finish	Lumpy Shiny	Smooth Dull
TESTOR'S DOPE	Dull Finish	Smooth Shiny	Dull Finish	Smooth Shiny	Shiny Smooth		Grainy Shiny	Smooth Dull
AMT LACQUER	Smooth Dull	Smooth Shiny	Smooth Dull	Smooth Shiny	Separated	Separated		Smooth Dull
POLLY S	Very Smooth Shiny	Smooth Dull	Smooth Dull	Smooth Dull	Smooth Shiny	Smooth Dull	Smooth Shiny	

were coated. The results of the applications of one type of paint on top of another type of paint were noted with an artistic eye.

Almost all of the paints in this report were compatible with at least one other paint. A few generalizations were evident. Most dopes will not go over enamels, Krylon or lacquer. Some enamels over Krylon give a nice, smooth shiny finish. If a dull-smooth finish is wanted, one might use Pactra 'Namel over Pactra Scale Flat. Many white paints may turn different colors—i.e.: Pactra 'Namel (flat white) often turns ivory, or a very light yellow, and Testor's Enamels give a greenish tint. Poly S seems to be compatible with all other paints, always giving a dull finish when used as a top coat. The charts below summarize the data obtained.

REFERENCES

Stine, G. Harry, "Handbook of Model Rocketry," Follett Publishing Company, Chicago, 1967, page 40.
Thompson, Capt. Bryant A., "Tech Topics," THE MODEL ROCKETEER, Volume IV, Number 11, December 1962, page 2.

Connie Stine prepares the wood chips during the paint evaluation project.

RESULTS ON BALSA WOOD
Top Coat

TESTOR'S ENAMEL	PACTRA ENAMEL	SCALE FLAT ENAMEL	KRYLON SPRAY PAINT	PACTRA DOPE	TESTOR'S DOPE	AMT LACQUER	POLLY S	
	Nice Finish	Nice Finish	Shiny Finish	Separated	Smooth Dull	Nice Finish	Smooth Dull	TESTOR'S ENAMEL
Nice Finish		Rough Finish	Shiny Finish	Rough Dull	Grainy Dull	Dull Finish	Smooth Dull	PACTRA ENAMEL
Grainy Dull	Rough Dull		Shiny Finish	Separated	Separated	Dull Finish	Smooth Dull	SCALE FLAT ENAMEL
Dull Finish	Nice Finish	Nice Dull		Separated	Separated	Rough Finish	Smooth Dull	KRYLON SPRAY PAINT
Smooth Dull	Dull Finish	Smooth Finish	Smooth Shiny		Shiny Rough	Dull Smooth	Smooth Dull	PACTRA DOPE
Rough Shiny	Rough Shiny	Rough Dull	Shiny Finish	Shiny Lumpy		Shiny Lumpy	Smooth Dull	TESTOR'S DOPE
Smooth Finish	Shiny Smooth	Shiny Smooth	Shiny Smooth	Separated	Separated		Smooth Shiny	AMT LACQUER
Smooth Shiny	Smooth Dull	Smooth Dull	Smooth Shiny	Smooth Shiny	Smooth Shiny	Smooth Shiny		POLLY S

the Escape Tower

by Tom Milkie

GIVE THE TRACKER A BREAK

The weak link in model rocket competition these days is not the launch system or the fool who forgets to put enough wadding in his rocket—it's the poor tracking. Just look at the NARAM this year—less than 50% of the tracks closed. Except for cases of super-high altitude, the problem with most trackers is trying to follow the rocket up to peak.

This idea for a tracker was to avoid that problem. The tracker need only follow the rocket with his naked eye to get an accurate fix. Accuracy is also gained because of the large size of the measuring device (30" X 36") as opposed to other tracking systems (a six inch protractor?). Measurements can easily be made to ± 1/4 degree, resulting in an altitude accuracy of 1% at 45 degrees elevation.

Any tracker who wants to use this "tracking plate" should have his head examined (quite literally) as the measurements shown in the drawing will have to be made on the tracker's head. Then, whenever the tracker wants to use the plate, he merely has to use a head rest high enough to move his head up to the proper height. On the tracking plate shown, this height was 17.5 inches (eyeball to plate). Measured headrests can be made from blocks of wood, carpet scrap, etc.

The launch rod on the plate is not for launching rockets (what a great take-off shot you could make!). The rod is used to align your head to the proper location. Enough measurements are made on one person to get him aligned right under the plate. He then marks the plate with a felt-tipped marking pen for the location of the end and a piece of tape on the rod, keeping one eye closed. These two points need not be at 0 degrees horizontal deviation (azimuth). Any other trackers who want to use the plate can then get into position such that the two spots line up with the rod tip and mark, when the tracker closes one eye. It will be possible to get both spots over these marks only when the tracker's head is at the proper height and lateral position. Then, when tracking, the tracker need only make sure his head is lined up during the countdown, to be certain that his measurement is accurate. A type of "head vise" was used earlier, but it was found not to be necessary. The tracker can roll his head slightly in any direction without significantly changing his measurements.

Construction

Most of the tracking plate is constructed from 1" X 2" lumber. The following supplies will be needed:

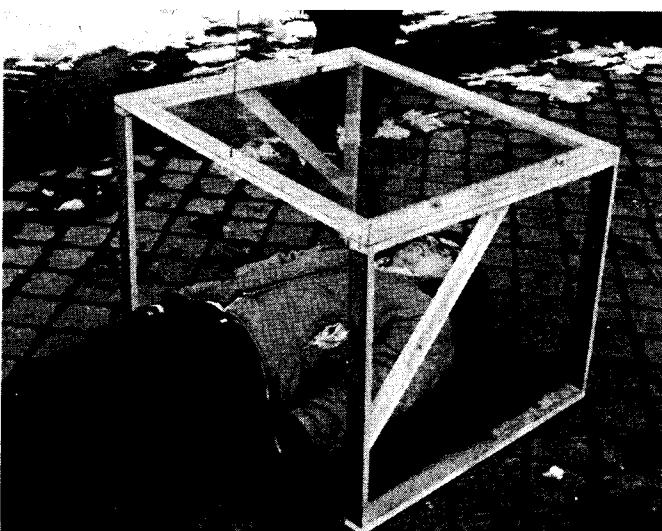|		
2	30 X 1 X 2	Used for plate frame; cut ends in at 45 degrees
2	36 X 1 X 2	
2	24 X 1 X 2	diagonal braces; cut ends in at 45 degrees
1	40 X 1 X 2	long brace; will be bolted to both leg sets
4	24 X 1 X 2	legs
4	30 X 1 X 2	horizontal supports
1	36 X 12 X ½	plywood headboard
1	36 X 30 X 3/16	sheet plexiglass; exact size of all boards can be determined by size of plastic available.

screws to attach plexiglass to its frame
frame nails to keep frame pieces together
nails and glue for legs
8 3" carriage bolts with washers and wing nuts
scrap 1 X 2 for mounting launch rod
3/16" diameter 36" launch rod (3/16" to prevent bending)
carpet scrap or blanket for pad
black felt-tipped marker for applying grid markings
Saran wrap, thin clear plastic or spray coating for protecting lines
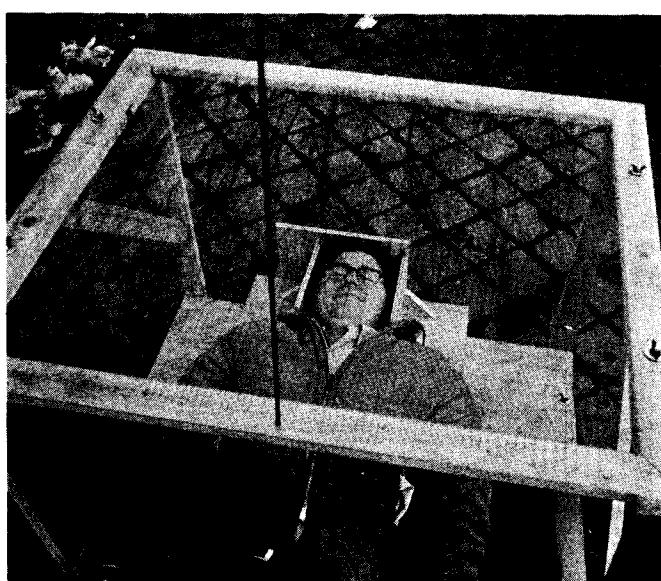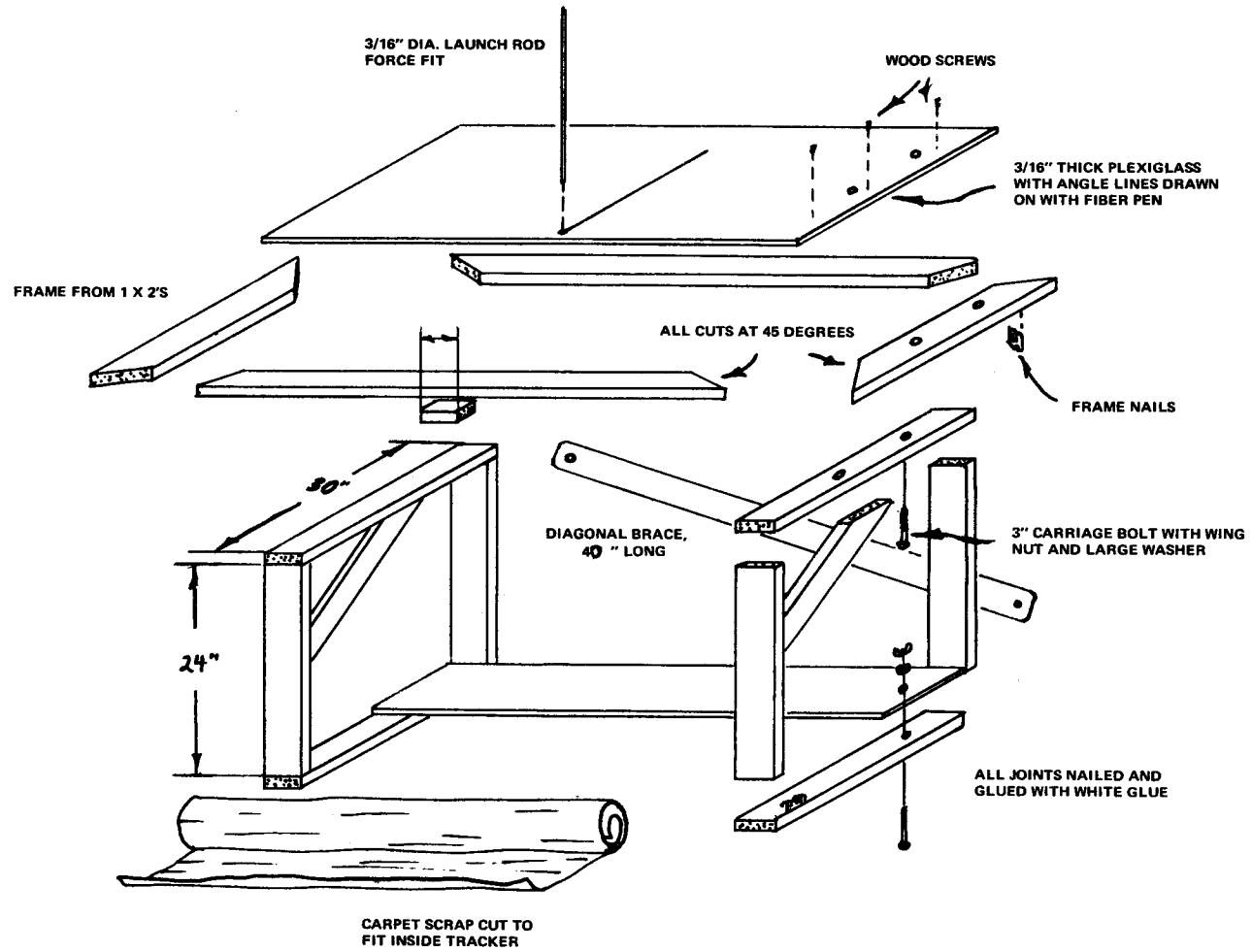
Construct the legs as shown in the diagram, being careful to keep the corners square. Cut the plywood headrest, drill holes in it, and bolt it to the leg assemblies. Cut and fit the frame for the glass panel, drill holes, countersink, and screw the panel to the frame. Fasten the corners together. Now place the framed panel on top of the leg assemblies and drill holes in the horizontal members for bolts. It is advisable at this time to label the corners of the legs and the frame to make later assembly easier.
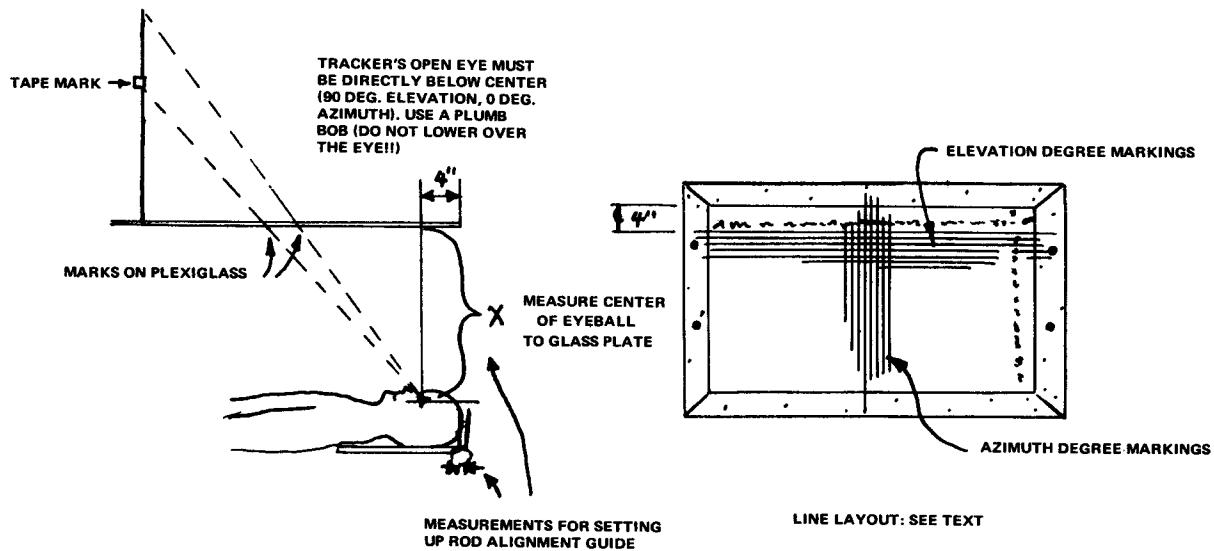
Drill holes to mount the long diagonal brace on the rear. Glue and nail a small block under the frame in the front. Then drill a hole through the panel which will be a tight fit for the 3/16 rod.

Yours truly taking it easy. By following a rocket up with your finger, then marking the bottom side of the plexiglass with a felt marker, it is possible to keep all tracking records right on the tracker.

This crude "head vise" was originally used to keep the tracker's head aligned. It was later discarded.

3/16" DIA. LAUNCH ROD FORCE FIT

WOOD SCREWS

3/16" THICK PLEXIGLASS WITH ANGLE LINES DRAWN ON WITH FIBER PEN

FRAME FROM 1 X 2'S

ALL CUTS AT 45 DEGREES

FRAME NAILS

DIAGONAL BRACE, 40 " LONG

3" CARRIAGE BOLT WITH WING NUT AND LARGE WASHER

24"

ALL JOINTS NAILED AND GLUED WITH WHITE GLUE

CARPET SCRAP CUT TO FIT INSIDE TRACKER

ROD ALIGNMENT GUIDE

TAPE MARK

TRACKER'S OPEN EYE MUST BE DIRECTLY BELOW CENTER (90 DEG. ELEVATION, 0 DEG. AZIMUTH). USE A PLUMB BOB (DO NOT LOWER OVER THE EYE!!)

ELEVATION DEGREE MARKINGS

MARKS ON PLEXIGLASS

4"

4"

MEASURE CENTER OF EYEBALL TO GLASS PLATE

X

AZIMUTH DEGREE MARKINGS

MEASUREMENTS FOR SETTING UP ROD ALIGNMENT GUIDE

LINE LAYOUT: SEE TEXT

Marking the grid on the panel will require a lot of time, but accuracy is necessary. Begin the elevation lines about 4 inches down from the top (rear) side of the plate (side away from the launch rod). Now, using a felt-tipped pen marker, draw a perfectly straight, parallel line across the top surface of the plate for the 90 degree elevation line. All other elevation lines will be a distance L cos B inches away from this line, where L is the distance from eyeball to plate and B is the angle of elevation. Accurately measure out the lengths in one degree increments down the top surface of the plate and. mark them on the sides of the plate (on the frame). Then draw on the elevation lines, using these marks. Azimuth lines, running parallel to the sides of the panel, can be marked and drawn with the same calculations. Measure out the center of the panel and draw a line there; this is 0 degrees azimuth. Each succeeding azimuth line should be drawn as far away from the 0 degree line as the elevation grid lines are from the 90 degree elevation line.

After marking all the lines on the surface, rub off a band near the edge (leg side) of the plate at the rear (beyond and parallel to the 90 degree elevation marking). Then, writing backwards, write in the angle labels for the lines. Finally protect your work with a top sheet of plexiglass, thin celluloid, clear spray plastic, or even Saran Wrap. Your work of art is now complete.

No longer will trackers fail to close due to slow response, small field of view, etc. However, there may develop a problem of the tracker falling asleep. . .

—*TTM*

WHAT'S YOUR FAVORITE ARTICLE THIS MONTH?

Vote here for your favorite articles. List them in order - the most-liked first, etc.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
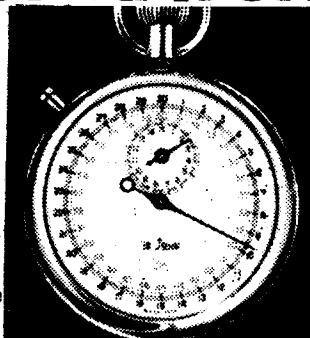7. _____
8. _____
9. _____

Clip this section out or use a facsimile. Paste on a postcard or enclose it in an envelope and send to:

Reader Survey
Model Rocketry Magazine
Box 214
Boston, Mass. 02123

Reader Design Page

This month's reader design, the *Apogee-roc,* was submitted by Scott Rudisill of Des
Moines, Iowa. The *Apogeeroc* is an easy-to-build cluster rocket requiring only readily
available parts. To build this model, first
glue together 3 BT-20D body tubes, and let
dry. Slide a BT-60J tube around the lower
portion of the BT-20D assembly, and glue in
place. Cut and glue the fins, add nose cones,
a launch lug and three engine blocks and let
dry. Your Apogeeroc is now ready for
flight. Use 3 A8-3 engines for the first flight,
and C6-5 or B6-4 engines for later launchings.

Parts List

1	Launching Lug	LL-2C
3	6.5 inch Body Tubes	BT-20D
3	Balsa Nose Cones	BNC-20A
1	2.75 inch Body Tube	BT-60J
1	Sheet Fin Stock	BFS-40
3	Engine Blocks	EB-20A

(All parts available from
Estes Industries)

The Experimenter's Notebook:
Optical Telemetry

by Forrest Mims

Several different sources of optical radiation were studied in detail before considering a system of light beam telemetry capable of being launched in a model rocket. The choice of an optical source for rocket telemetry is affected by inherent limitations of the typical model rocket. (It is important to note that light beam telemetry techniques unsuitable for model rocket work may be in many respects highly suitable for rockets of a larger scale, aircraft, and spacecraft.) These limitations include weight and size of the telemetry package and beam divergence as related to output power of the optical source. Beam divergence, the angular spread of the light beam, is an important parameter due to the rapid velocity of the model rocket and the difficulty of insuring roll control. In short, a rapidly ascending model rocket with an optical beam transmitter of narrow divergence (or spread) will be difficult, if not impossible, to track from the ground. An optical transmitter of large beam divergence will ease the task of tracking but will be hindered by very low optical energies at the optical telemetry receiver. For more information on the relationship between beam divergence and energy, see Appendix I.

It is by now evident that power output of the optical transmitter is an important parameter of a light beam telemetry system. This is particularly true of a source with large beam divergence. Appendix I shows that power density decreases as the square of distance (except for very narrow light beams such as obtained from many types of lasers).

The optical sources investigated for a potential telemetry system are summarized in Table 1. Incandescent lamps, gas discharge tubes, and semiconductor lasers are all capable of relatively high output power. Of these, the semiconductor laser offers the highest modulation capability (that is the ability to carry the largest amount of

TABLE I	
Light Source	Comments
1. Incandescent Lamp	Low cost and fair power output but poor modulation capability
2. Neon Lamp	Low cost and good modulation capability but poor power output
3. Strobe Lamp	Good power output but poor modulation capability and need for high voltage
4. Laser Diode	Good power output and modulation capability, but high cost, and need for high voltage
5. Light Emitting Diode	Good modulation capability and fair power output, but moderately high cost

information). The semiconductor laser is a very difficult device to operate, however, due to its requirement for a high current pulse generator. The pulse generator requires several hundred volts for proper operation and must be capable of supplying pulses less than 200 nanoseconds in duration (a nanosecond is one-billionth of a second). Incandescent lamps are readily available but are limited to very low modulation rates. Gas discharge tubes and strobes, while exceptionally brilliant, are limited in modulation capability due to heating effects, the rate effect, and the requirement of a high voltage pulse generator. Gaseous glow lamps are as readily available as incandescent lamps, and are characterized by a much higher modulation capability. Unfortunately the power output of most glow lamps is very low.

The semiconductor light emitting diode is characterized by a modulation capability as high as the semiconductor laser. However it requires considerably less power for efficient operation (and produces, of course, a less intense beam). The advantages of the light emitting diode to some extent offset its rather low output power and it was decided to employ such a device in a light beam telemetry system to be launched in a model rocket.

Appendix II describes the operation of light emitting diodes in some detail. Suffice it to say here that most light emitting diodes are fabricated from materials similar to those used in transistors and have a light emitting region which is measured in mils (a mil is one thousandth of an inch). Light emitting diodes are generally of two major configurations, planar and hemispherical. The planar diode is characterized by relatively low cost but limited output power. Hemispherical diodes are expensive, but their geometry provides a far more efficient light emitting structure and therefore higher light output than the planar diode. Furthermore, hemispherical diodes emit their energy into a cone with a solid angle of 180 degrees (two pi steradians), therefore providing a wide beam divergence without the need for lenses and other external optics.

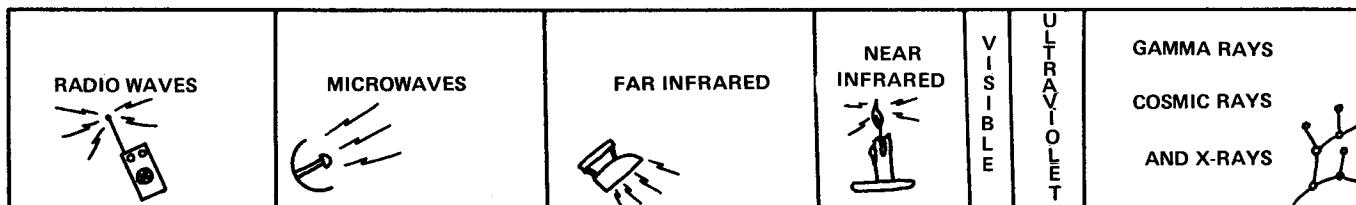| RADIO WAVES	MICROWAVES	FAR INFRARED	NEAR INFRARED	VISIBLE	ULTRAVIOLET	GAMMA RAYS COSMIC RAYS AND X-RAYS

Fig. 1. The electromagnetic spectrum.

A hemispherical light emitting diode was therefore chosen as the telemetry transmitter optical source. Modulation for the diode (that is the signal to send to the ground) was supplied at audio frequencies by a miniature two transistor multivibrator similar to the one described in Reference 3. The pulse repetition rate (the modulation rate) of the multivibrator was varied by a light sensitive photo resistor (a cadmium sulphide cell). The photo resistor and the light emitting diode were mounted in a transparent payload capsule so as to permit a maximum amount of ambient light detection by the sensor and a maximum amount of emission by the emitter. The first telemetry package assembled thusly, Payload I, incorporated a small lens to narrow the 180 degree beam of the light emitting diode to about 30 degrees.

The Optical Receiver

The choice for an optical receiver system is not nearly so limited as the light beam
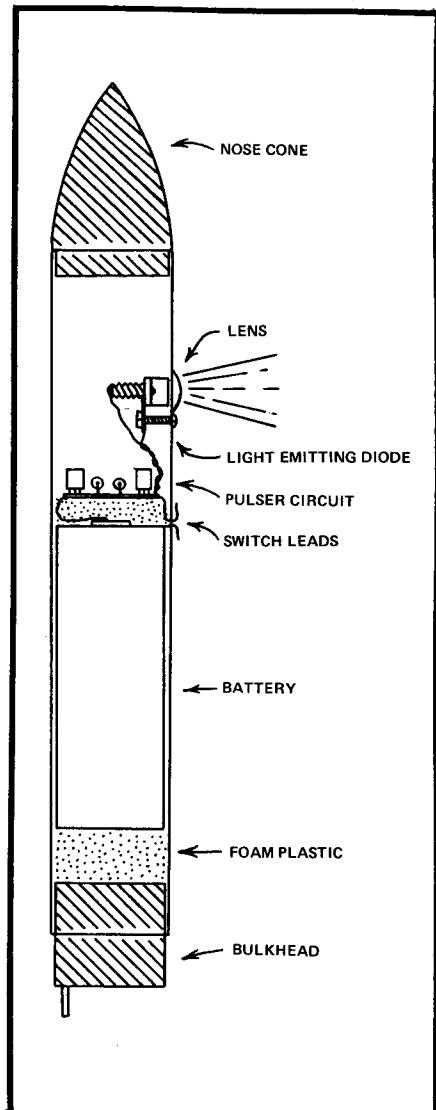

Fig. 2. Payload III showing the light emitting diode pointing from the side. The lens was used only on Payload I and is included here to show its location.

transmitter. Size and weight requirements are of course particularly flexible. As the spectral wavelength of the semiconductor light emitting diode employed as the optical transmitter light source is centered at about 9200 Angstrom Units, a silicon detector with a peak detection response of about 8900 Angstroms was chosen for the optical receiver. The output of the light emitting diode employed in the experiment is invisible to the human eye being just above the region of visible light in the near infrared portion of the electromagnetic spectrum. (See Figure 1 for the relationship of visible and infrared light in the electromagnetic spectrum.) Most photo resistors, while extremely sensitive to visible light, do not respond well to infrared. Exceptions are lead sulphide and cadmium selenide photo resistors. Furthermore, the slow response time of photo resistor detectors discourage their use in high modulation rate optical telemetry systems.

The silicon detector chosen is of the photovoltaic category. That is it produces a small voltage in response to light striking its active area. The tiny voltages produced by the silicon detector were passed on to a five transistor amplifier. The small size of the receiver electronics made possible assembly of the complete receiver into a large lantern type flashlight. The self-contained parabolic reflector made an efficient light collection device for the silicon detector. The convenient hand-held receiver unit was provided with a gain control, miniature loud speaker, and an output jack to which a small battery powered portable tape recorder could be patched. The entire receiver system then consisted of the hand-held light sensitive receiver and a small tape recorder capable of being suspended from the side of the operator of the experiment.

Flight Testing

Following intensive ground tests of the complete optical transmitter was assembled into its payload container and a total of eight test launches were conducted on August 3-4, 1966 from a large field near Denver, Colorado. The first two launches were intended to test the stability and recovery characteristics of the rocket system, and no attempt was made to receive the modulated infrared beam (which was turned on for each of the two launches to test the electronics). Unfortunately, attempted reception of the infrared optical beam on all six subsequent launches was unsuccessful. It was concluded that the bright sunlight overloaded the optical receiver with noise, and arrangements were made to launch subsequent rockets immediately after sunset. The first launch under the new condition was successful in that the tone transmitted by the light emitting diode was received for a distance in excess of ten meters (about thirty feet) after liftoff. Unfortunately, however, the rocket and its light beam telemetry package experienced catastrophic failure due to what might best be described as a near vertical crash into hard earth. Cause of the crash is unknown but shifting of the rather heavy (about 1½

ounce) payload battery due to faulty mounting may have been a contributing factor. If shifting occurred, the resultant change in the center of gravity and center of pressure relationship may have been sufficient to cause an unstable situation.

Analysis of the tape recording revealed a relatively strong telemetry signal superimposed on a large noise level not present prior to launch. It was concluded that the noise level was a result of the rocket motor flame trail. The rather strong signal of the rocket exhaust suggests its possible use as a telemetry or tracking source for rockets. Using recently announced techniques in flame electronics, perhaps the exhaust could even be modulated. It is well established that a stable flame can be readily modulated at audio frequencies by inserting appropriate electrodes and ionizing source in the flame. Telemetry via rocket exhaust flame would be a difficult but extremely interesting project for the model rocketeer with some experience in electronics.

The encouraging results of flight number nine were cause for the reassembly of the light beam transmitter into a second payload configuration. Fortunately, the light emitting diode was not damaged in the otherwise disastrous crash. (In fact the diode was the only electronic component to survive the crash in working condition.)

The new payload assembly incorporated several advantages over Payload I. In Payload I, the battery was attached to the optical telemetry package by a stout nylon cord and a paired flexible cable. While convenient for battery replacement, this arrangement resulted in numerous parachute ejection failures, occasional broken battery leads (as the heavy battery was rapidly ejected from the fuselage and allowed to dangle from telemetry package and parachute), and was a contributing factor to irreparable damage sustained during the crash of Payload I (and possibly contributed to the crash itself). Also, the cadmium sulphide photo resistor was eliminated in favor of a fixed resistor (as being superfluous to an experiment conducted in near darkness). Finally, a small lens attached to the light emitting diode in an attempt to decrease beam divergence and increase range was eliminated in favor of the natural 180 degree beam (solid angle of emission) of the diode alone.

The newly completed Payload II was flight tested during daylight and met an untimely end after but one flight. Cause of the destruction of Payload II was parachute failure. The new battery location and the abundant use of foam plastic padding resulted in no damage whatsoever to the electronics with the only damage being structural.

Payload III, constructed from the salvageable components of Payload II, was launched the first time on August 19, 1966. A drawing of Payload III is shown in Figure 2. The flight was successful in that telemetry signals were received after launch for about seven or eight meters and during parachute descent for about twenty-five meters. Reception of the infrared beam during parachute descent was an unexpected bonus. Payload III was launched a total of

six times between August 19 and August 23 with several telemetry acquisitions similar to the latter.

Discussion and Conclusion

The flight tests demonstrated that the light emitting diode should emit far more than a few milliwatts of infrared light for an effective optical telemetry system. The directional characteristics of the 180 degree angle of light emission make for a nice field of illumination but extremely low power density at the receiver with increasing range. Conversely, a narrow beam, while providing higher power density at the light beam receiver, is severely limited by directionality.

An interesting observation during the flight tests was that the optional signals generated by the rocket motor flame trail made an excellent omnidirectional homing source for the light beam receiver. (It had been thought that the flame trail optical signal, actually noise, would be a significant problem.) The operator of the experiment followed the flame trail signal while periodically receiving bursts of signal from the light emitting diode transmitter as its beam swept across the light beam receiver.

The numerous problems with parachute ejection and the disastrous crash of Payload I showed that much attention should be given to the model rocket payload carrier in an experiment involving instrumentation. A major cause of parachute ejection problems was the rather high weight of the payload assembly. A smoother fitting joint between the payload and the carrier rocket body tube greatly improved the situation. The problems in this area show the need for a fair amount of attention to basic model rocketry while performing experiments with instrumentation. (The author of this report has taken this advice literally and has had many successful launches of fairly complex payloads since 1966.)

The flight tests of a model rocket lofted light emitting diode infrared telemetry device and modulator showed that active optical telemetry is a potentially workable concept but that numerous problems remain to be solved. Active optical telemetry is definitely a specialized technology and is not necessarily applicable to transmitting data from model rockets or small research rockets. Nevertheless, the author feels that there are several special purpose applications where optical telemetry from small research rockets may be very useful. Therefore the topic will be pursued with strong emphasis on the semiconductor laser in place of the light emitting diode. The problems of flight testing a semiconductor laser, modulator, and high voltage power supply are not trivial. Results of the tests will be reported in **Model Rocketry** upon their completion.

Electronic Circuitry

Some readers may be interested in more details about the electronic circuits employed in the light beam receiver and transmitters. The light beam transmitter circuit for Payloads I, II, and III is shown in Figure 6. Resistor "R" was a cadmium sulphide photocell in Payload I. For reasons described previously, resistor "R" was replaced with a fixed resistor of 100,000 ohms in Payloads II and III. Resistor "R" may be varied in order to change the frequency rate of the light beam transmitter.

Any rocketeer wishing to construct a light beam transmitter might consider the circuit shown in Figure 7. This circuit is very simple and is capable of providing very powerful bursts of light from the light emitting diode. The circuit is a simple relaxation oscillator employing a Motorola four-layer diode. The capacitor charges through the resistor until the "threshold" of the M4L3054 is reached (from 12 to 21 volts). At threshold, the M4L3054 diode "breaks down" and allows all the voltage stored in the capacitor to be applied to the light emitting diode in a very narrow, high current pulse. The cycle is repetitious and the frequency rate is dependent on the value of the resistor (the higher its value the slower the oscillator's repetition rate). Try using a small 100,000 ohm potentiometer (variable resistor) for "R" so you can adjust the frequency of oscillation. After you have determined a good potentiometer setting, you can replace this with a fixed resistor.

The capacitor determines the width of each individual pulse. You may wish to try a larger value (for example, .05 or .1 μF).

Of course if you want to build either of the light beam transmitters, you'll need a light emitting diode. They are available from many semiconductor manufacturers, but probably the least expensive consistent with high light output is the SSL-5C marketed by the Miniature Lamp Department, General Electric Company, Post Office Box 2422, Cleveland, Ohio 44112 (Attn: J.D. McMullin). The cost is $7.15 each. By the way, General Electric also sells an excellent booklet on light emitting diodes. Called the "Solid State Lamp Manual," the booklet discusses in great detail theory, characteristics, and applications. Price of the booklet is $2.00.

A block diagram/circuit of the original light beam receiver is shown in Figure 8. The set-up is easy to duplicate since it uses a ready-made amplifier. Such amplifiers are available from several electronic mail order houses, including Lafayette Radio, 111 Jericho Turnpike, Syosset, L.I., New York 11791. Also, nearly all electronics stores handle plastic encapsulated high-gain amplifiers that could be used in the receiver.

The light detector of the original receiver is a pair of silicon solar cells. Solar cells (must be silicon, *not* selenium) are available from most electronic stores. Recall that the detector must be used with a lens or parabolic reflector in order to permit the gathering of sufficient light from the light beam transmitter.

The more advanced experimenter may wish to construct his own amplifier. A suggested circuit is shown in Figure 9. The circuit is not ideal because its gain or amplification factor is rather low. But it will permit the experimenter to learn more about the principles of electronics and light beam communications. Perhaps the circuit could serve as a preamplifier for a high-gain amplifier.

Concluding, infrared telemetry to or from a model rocket is a fascinating but difficult topic. It is an area of research where the model rocketeer can make very real contributions to space science. Countless improvements are necessary in the circuits, ideas, and techniques described in this article. For example, the present tech-
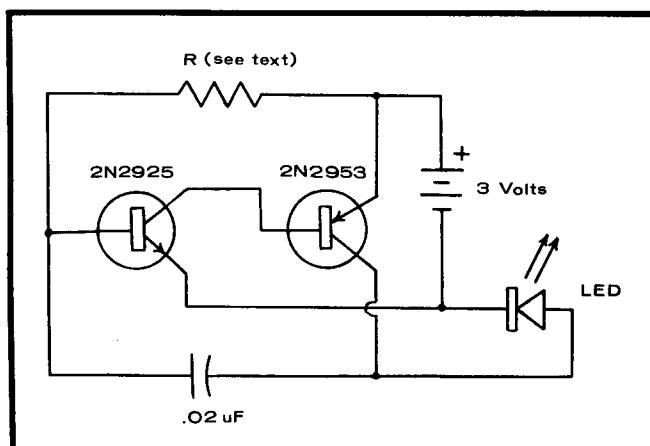

Fig. 6. Schematic of the original circuit used in Payloads I, II, and III. Resistor "R" controls the frequency of the circuit as explained in Appendix 3.
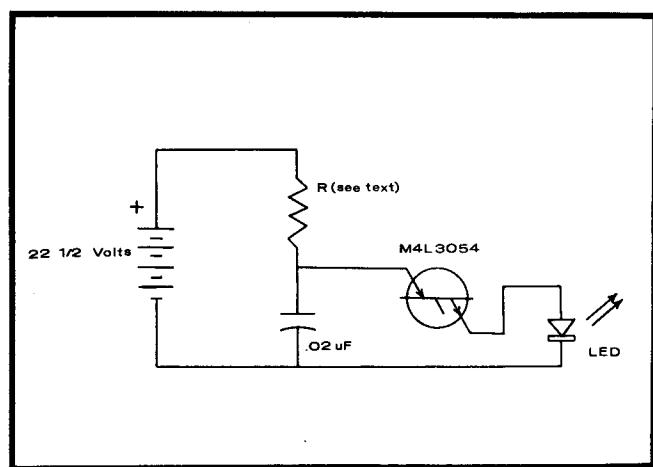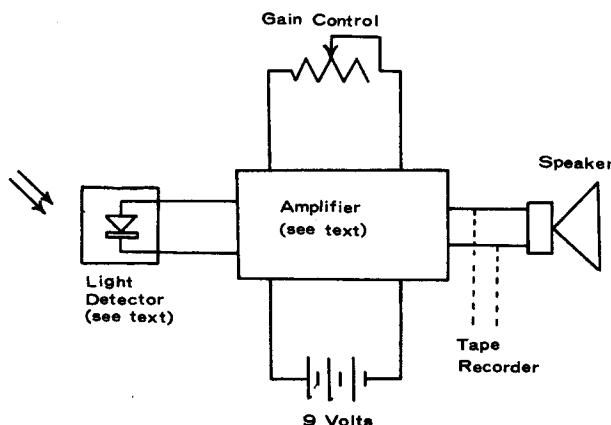

Fig. 7. A suggested circuit for an improved light beam transmitter. The M4L3054 is a four-layer diode.

Fig. 8. As shown by this block diagram/circuit, the original receiver is quite simple. Not shown in the diagram is the lens or parabolic reflector used to collect light from the light beam transmitter.

Fig. 9. The advanced experimenter will want to consider circuits such as this for improving performance of the light beam receiver.

nique will not operate in direct sunlight. The ambitious experimenter will want to add an optical infrared filter to his receiver in order to eliminate some of the sunlight problem. Infrared filters are available from Edmund Scientific, 100 Edscorp Bldg., Barrington, New Jersey 08007.

Also, electronic tuning might be added to the receiver in order to permit the elimination of spurious radiations emanating from the bright rocket exhaust flame trail. The tuning device, actually an electronic filter, would permit only a signal with a frequency of the light beam transmitter to be detected. (Frequency means repetition rate of the transmitter, not wavelength.)

Model rocketeers desiring to begin a light beam telemetry project may send meaningful letters of inquiry to Forrest Mims, 6901 Zuni SE, A-12, Albuquerque, New Mexico 87108.
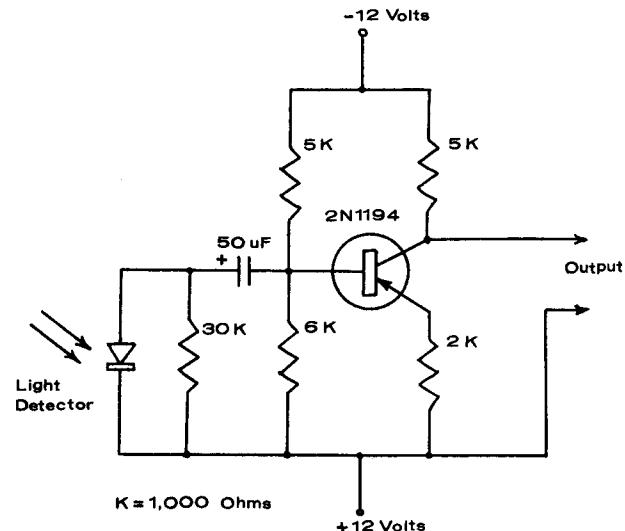
Appendix I

As pointed out in the main text, light intensity decreases as range increases. In fact, the intensity of a flashlight beam shining on a small square of paper is four times brighter two feet away from the flashlight than four feet.

This principle is shown in Figure 3. The principle is called the inverse square law by science books. Formally stated it reads: "Intensity from a light source decreases as the square of distance."

By the way, the inverse square law does not necessarily apply to the very narrow beams produced by most lasers. (Why?)

Appendix II

The light emitting diode is a semiconductor device with the unique property of producing light when stimulated by a small voltage. The most common type of light emitting diode is made from gallium
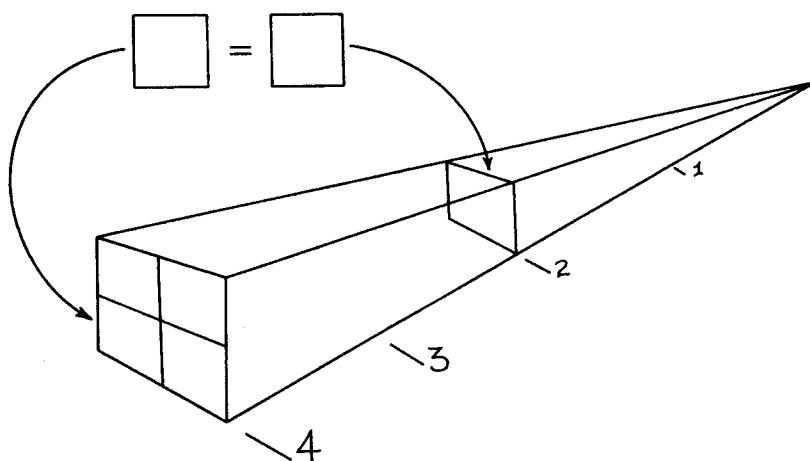
arsenide (GaAs). GaAs diodes emit light in the near infrared portion of the electromagnetic spectrum. As the light is emitted at a peak wavelength of about 8900 Angstrom units, it is invisible to the human eye. Light emitting diodes may be made from materials other than GaAs for production of other wavelengths of light. For example gallium arsenide phosphide (GaAsP) produces red or green light, depending on the concentration of the phosphide. Silicon carbide (SiC) produces yellow light. By the way, SiC was the first application of a semiconductor for the production of light. In 1907 a man tried touching the contacts of a battery to a piece of natural SiC found near Niagara Falls and to his amazement noted flashes of yellow light. His discovery remained unused for over 50 years until scientists at General Electric once again began experimenting with the material. General Electric now offers several of the SiC diodes (each type has a different mounting) through its Miniature Lamp Department. Scientists at IBM and General Electric have recently coated GaAs light

emitting diodes with rare earth phosphors similar to those used in color television picture tubes in order to convert the diode's normally invisible infrared to many other colors (including red, green, yellow, orange, and blue in the visible region). This approach for generating visible light is considerably less costly than making the expensive GaAsP light emitters.

Just like all other electronic devices, light emitting diodes must be mounted or packaged in a special enclosure. The purpose of the mounting enclosure is to protect the delicate diode and to provide electrical contact. Also, a plastic or glass window or lens is included in one end of the enclosure to permit the diode's light to escape. Two types of mounting enclosures are shown in Figure 4. The very complicated looking diode on the left is the type originally made by Texas Instruments in 1962. The diode in Figure 4 is the same type used in the experiments in optical telemetry described in this report. The other diode in the drawing is the most common type sold today. It is about the size of a transistor. The main difference

Fig. 3. The Inverse Square Law: Intensity decreases as the square of distance.

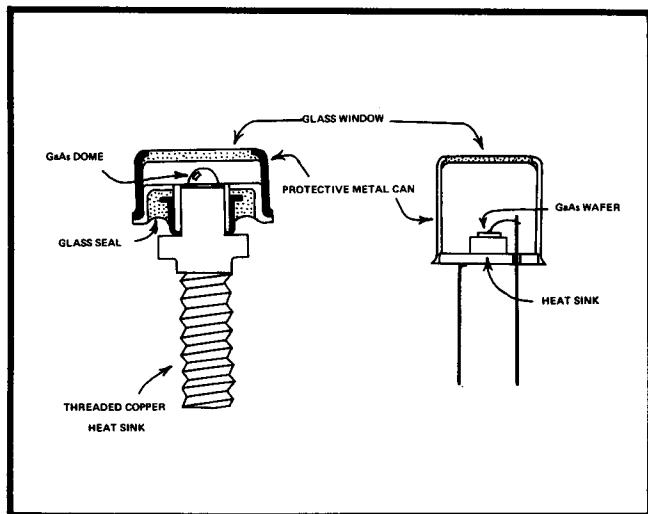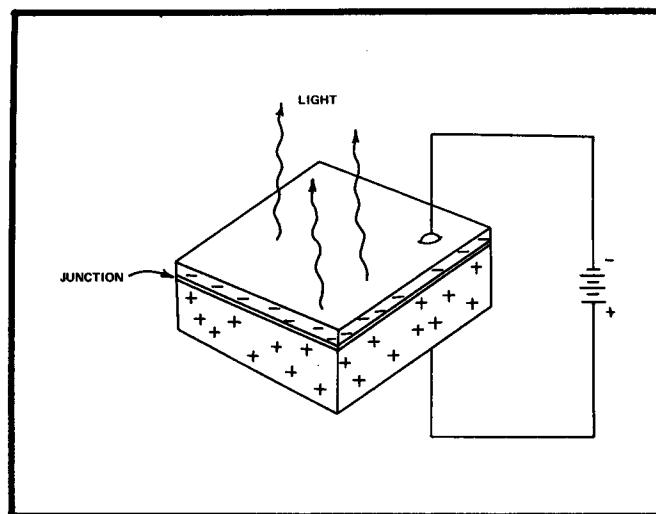Fig. 4. Two common types of light emitting diodes. The one on the left is the type used in the report.

Fig. 5. Principle of light generation by a simple light emitting diode. Light is generated at the junction of positive and negative light emitting material when a small voltage is applied.

between the two enclosures is that the one on the left can absorb much more heat and is therefore used with high power diodes. There are several other types of diode enclosures, one of which is simply a small metal base with two wire leads and a blob of clear epoxy to protect the diode. The epoxy also serves as a lens.

The operating principle of the light emitting diode involves principles of physics called quantum mechanics. A discussion of quantum mechanics is beyond the scope of this report. Suffice it to say that the light emitting diode produces light when electrons which have jumped to higher than normal energy levels because of an applied voltage drop back to their normal position. Most of the light is produced at the junction of two different types of the light emitting material. For example, the GaAs light emitting diode is composed of two flat plates of GaAs, one with a positive charge and the other with a negative charge. As shown in Figure 5, light is produced between the two plates and travels through one plate (which is transparent to infrared but opaque to visible light). Some of the light is emitted from the edges of the junction.

As pointed out in the main report, there are hemispherical and wafer or planar type light emitting diodes. Since the hemispherical type is capable of generating more light than the flat wafer type, it is usually mounted on the type of enclosure shown on the left in Figure 4. The hemispherical diode is more efficient and therefore more powerful than the flat wafer diode because it allows more of its light to be emitted. The flat faces of the wafer type diode unfortunately act like mirrors causing much of the light generated at the junction to be reflected back inside the diode and lost.

The operation of the light emitting diode fulfills some of the requirements for laser action. But the light emitting diode as discussed here is not a laser. Laser action may be produced in a light emitting diode only if two of its surfaces are perfectly flat and parallel. Also, laser action requires that

huge amounts of electrical current be supplied in pulses less than 200 nanoseconds in length. In order to lower the amount of electrical current required for lasing, the semiconductor laser (or laser diode) is made extremely tiny. The active element of a laser diode is much smaller than a single period on this page yet is capable of generating over five watts of light!

The author has done a considerable amount of experimentation with light emitting diodes and lasers and is attempting to miniaturize a laser diode system for launch in a model rocket. A major problem is that laser diodes require a power supply capable of supplying 300 volts. Several devices capable of supplying up to 500 volts from a three volt battery and weighing under an ounce have been designed and constructed but they only permit the laser diode to emit one pulse of light every 20 or 30 seconds. When improvements in the system are completed, a laser diode system will be launched. Recently a new type diode laser which requires considerably less electrical power was announced by RCA and it might be the solution to the problem.

Since laser diodes emit considerably more light than their light emitting diode cousins, infrared telemetry may become a

useful and practical tool for specialized applications.

References

1. **Journal of the American Rocket Society,** "Jet Propulsion of a Remotely Controlled Aerial Torpedo," Vol. 25, No. 1, April 1955, p. 173. (From **"Deutsche Luftfahrer"** Zeitschrift, January 22, 1918.)

2. C.I. Cummings, *Ibid.,* "Radio Telemetry," May-June 1953, p. 141.

3. Mims, F.M., "Transistorized Light Flasher," **Model Rocketry,** Sept. 1969.

For more information on lasers, semiconductors, and telemetry see your public library. More detailed books and references can be found in a college or university library.

Acknowledgements

The author acknowledges Messrs. Bonin and Fischer of the Texas Instruments Company for supplying several light emitting diodes and much helpful advice.

THE MODEL ROCKETEER

U.S. Team Selected for World Championships

Bryant Thompson, NAR Vice-President and U.S. Team Manager, has announced the selection of the following eight NAR members to represent the United States at the First World Championships in Vrsac, Yugoslavia this September:

Paul Conner #5878, District Heights, Md.

Gerald Gregorek #9193, Columbus, Ohio

Al Kirchner, Jr. #1805, Bethpage, N.Y.

James Kukowski #4668, Rockville, Md.

Scott Layne #7901, Kettering, Ohio

George Pantalos #10620, Columbus, Ohio

Michael Poss #5702, Los Angeles, Calif.

Bryant Thompson #1202, Rantoul, Ill.

Gregorek, Kukowski, and Pantalos will compete in Boost/Glide; Kirchner, Layne, and Poss in Scale; and Connor, Gregorek, and Thompson in Parachute Duration.

These contestants were picked by Mr. Thompson from groups of names submitted by NAR trustees, the Leader Administrative Council, and other Senior and Leader members that were contacted. Two criteria were used in the selection:

1. The modelers must be capable of winning.
2. They will be representing the U.S. and must leave favorable impressions (i.e., sportsmanship).

Both criteria were weighted equally. The men selected were chosen for their performance in past National Championships, records held, or outstanding performance during the contest year. The names of three trustees appear among those selected. The NAR Trustees are not only the governing body but are also active modelers who have been elected to this body for their organizational capability or contest experience or both. Therefore any list of outstanding rocketeers would be expected to include the names of some trustees.

Bryant Thompson concludes his announcement as follows, "I realize there are going to be many disappointed rocketeers, just as I was disappointed at not being selected for the Internationals in Czechoslovakia several years ago. But keep competing! Start building your reputation; not only as being a real winner but also a good loser. One who will laugh off a bad decision and go on trying. Every person on the lists submitted for consideration had this type of reputation. Breaking it down to the actual team was a very difficult task. I take full responsibility for team selection. I hope no one feels slighted. Many names were kicked around and I wish they all could be on the team."

Editor's Nook

My apologies for promising to run lists of high point holders last month and not following through. Unfortunately, the NAR Contest Board has been having difficulties with its new data reduction computer program and rather than publish inaccurate results we will wait until useful scores become available. With a cursory glance however, it appears that members of the Apollo-NASA section are high in the running. Presently the Contest Board is undertaking several major projects including revision of the current "pink book", a revamping of the contest paperwork system, and coordination of the National Meet. Members are again reminded to send their rule change suggestions to the CB for consideration.

There are two notable changes in the operation of NARAM-12 which set it apart from previous National Meets. First, participation will be open to *all* NAR members who wish to compete, within practical bounds. Arrangements are being made to accommodate over 300 rocketeers at the meet. If you are planning to compete, don't forget to request an application from the Contest Board before June 1. A NARAM-12 reminder appears elsewhere in this issue. The second change to be effected at NARAM-12 is that the weighting factor for Research and Development competition will be zero. There are two dominant reasons for this rule. Since R&D is not a measure of modelling skill but rather scientific insight, the event should not help determine the NAR National Championships and should be placed in a separate category. Also, the rule will discourage modelers from entering junk projects for the sole purpose of obtaining flight points. Instead of contest points, the R&D winners will be rewarded with *distinctive* trophies. This change only applies to NARAM-12 although it is being considered for inclusion in the next pink book edition. NARAM-12, being the first NARAM ever held in the Southwest, will undoubtedly reflect many other innovations.

Congratulations to the eight rocketeers selected to compete at the World Championships this year. They are all top men and will surely put on a good performance. Apparently funds are tight and some of the contestants may have to fly by proxy. The order of priority is Boost/Glide, Parachute Duration, and Scale.

NAR Headquarters Secretary, Mrs. Ward, reports that total NAR membership reached 3400 in February, 1200 members greater than that of 12 months earlier. New section charters are being issued at unprecedented rates also.

Don't forget to let us know what articles you would like to see in future issues of *The Model Rocketeer;* it's *your* newsletter.

—Carl Kratzer

LAC NEWSLETTER AWARD

The NAR Leader Administrative Council will again sponsor a Newsletter award offered to the most outstanding section newsletter on the basis of quality of content, contribution to section spirit, and effectiveness as a means of communication. The travelling trophy, presently held by NARHAMS for its newsletter *ZOG-43*, will be presented at NARAM-12 to the winning section. Only one copy of the newsletter need be sent to:

Elaine Sadowski
1824 Wharton Street
Pittsburgh, Pa. 15203

STANDARDS & TESTING COMMITTEE REPORT
Vashon Rockets Certified

Since 1957, model rocketry has been based upon commercially manufactured, solid propellant rockets. During this time, the NAR and this Standards and Testing Committee of NAR has worked with manufacturers, local and state governments, and regulatory agencies to maintain reliable, high quality rocket motors, to establish permissive standards and statutes, and to assure safe, practical operating procedures. When a new rocket propulsion system, the cold gas propellant motor, was introduced into the commercial market, this committee was quite properly concerned.

One of the most important regulations governing the operation of model rockets is Federal Aviation Regulation 101 Subpart A, pp. 101.1, a. 3, ii(a) through (d) which furnishes a clear definition of a model rocket and states the conditions under which model rockets may be launched. A model rocket is an unguided rocket that weighs less than 16 ounces at launch, of which no more than 4 ounces is propellant, and is made of balsa, cardboard, similar lightweight materials and of no *substantial metal parts.* Model rockets may be flown without prior clearance from the nearest Federal Aviation Agency unit with the additional stipulation that the model rockets will not be flown in a manner to create a hazard to persons, property, or aircraft. The cold gas propellant rockets require an aluminum tank to hold the pressurized propellant. Because of the aluminum body, the Standards and Testing Committee, as obligated by the By-Laws of the Association, issued a warning to its members in January 1969 that the Vashon Industries Valkyrie Rockets did not conform to FAR 101. The Valkyrie Rockets could not, therefore, be operated with the freedom of model rockets.

In the Fall of 1969, the Standards and Testing Committee conducted an extensive series of tests with the Valkyrie Rocket and found this rocket to possess acceptable flight characteristics and to be of sound engineering design. Once again, however, the Committee judged the Valkyrie, with its appreciable aluminum parts, to fall outside the definition of a model rocket. In January 1970, Vashon Industries submitted to this Committee documented approval from the Federal Aviation Agency to operate single stage, cold propellant rockets, (Valkyrie 1/2, 1, and 2) within the Federal Regulations so long as such operation did not constitute a hazard to persons, property or other aircraft.

Based upon this release by the Federal Aviation Administration, and upon the tests conducted by this Committee, the Vashon Industries, cold propellant rocket motors, Valkyrie 1/2, 1, and 2, have been granted the NAR Safety Certificate.

Because this new classification of rocketry has operational aspects different from the solid propellant rocket motors, a new safety code has been written which applies to the operation of cold gas propellant rockets. This Cold Propellant Model Rocket Safety Code was recommended to the Board of Trustees of NAR at its meeting January 31, 1970. It is to be followed by all NAR members operating these types of rockets.

G. M. Gregorek
Chairman, NAR
Standards & Testing Committee

How to Apply for Records

NOTE: The procedure for filing an FAI international model rocket performance record is identical to that for filing a United States national model rocket performance record. The differences are in the homologation fees and in the number of copies of the data that must be submitted. FAI record categories are limited to Altitude, Payload, Parachute Duration, and Boost-glider duration.

1. The RECORD ASPIRANT or the LOCAL CONTEST DIRECTOR must notify NAR CONTEST BOARD by telephone or telegram within 3 days of the date of the record attempt. The following information must be given: name, NAR number, address, age, record category, contest sanction number, date of record attempt, place of record attempt, value of performance claimed, and whether NAR or FAI record attempt (or both).

2. NAR CONTEST BOARD, upon receipt of notification, replies by letter to the RECORD ASPIRANT (with copy to NAR RECORDS SUBCOMMITTEE along with copy of notification information) acknowledging receipt of notification. If FAI record, NAR CONTEST BOARD immediately notifies John Worth, Academy of Model Aeronautics, 1239 Vermont Avenue N.W., Washington, D.C. 20005 (202-347-2751) who will notify appropriate FAI offices.

3. The RECORD ASPIRANT insures that the LOCAL CONTEST DIRECTOR and judges comply with the requirements of Paragraph 32, U.S. Model Rocket Sporting Code, 1967 Edition. LOCAL CONTEST DIRECTOR must mark all entry blanks and flight cards pertaining to the record attempt with the words "RECORD ATTEMPT". All flight cards involved must be countersigned by the three witnessing judges. A standard NAR Application for Record Homologation may be used. The actual contest paperwork properly signed must be postmarked to the NAR CONTEST BOARD within 7 days as prescribed in the pink book.

4. The RECORD ASPIRANT must forward to the NAR CONTEST BOARD the homologation fee of $25.00 for FAI records and/or $5.00 for USA records at the time the LOCAL CONTEST DIRECTOR submits the competition paperwork to the NAR CONTEST BOARD. The FAI fee is required by FAI to cover costs; NAR fee is necessary to reimburse costs of postage, telegrams, form, telephone, and other material costs of homologating the record.

5. The RECORD ASPIRANT completes all requirements of Paragraph 32.6 and submits 3 copies of the photograph, drawing, and other material (6 copies in the case of FAI records) to:

NAR RECORDS SUBCOMMITTEE
127 Bickford Lane
New Canaan, Conn. 06840

This documentation must be postmarked no later than 60 days after the record attempt and should be transmitted by Certified Mail to insure delivery.

6. The NAR CONTEST BOARD forwards to the NAR RECORDS SUBCOMMITTEE all official contest documents pertaining to the record attempt. This should include the standard NAR Application for Record Homologation (if used), the record aspirant's contest entry blank, and the flight card of the record attempt.

7. Upon receipt of all data, the NAR RECORDS SUBCOMMITTEE reviews the data and documentation. It must be complete, accurate, and beyond question. The NAR RECORDS SUBCOMMITTEE may invoke Paragraph 32.7 for additional information or may require the RECORD ASPIRANT to re-do the drawing or photograph if the RECORDS SUBCOMMITTEE feels that it is necessary. The NAR RECORDS SUBCOMMITTEE then assembles a Record Attempt Dossier (RAD). For FAI records, 3 copies of the RAD are submitted to the AMA for transmittal to the FAI. For USA records, the NAR RECORDS SUBCOMMITTEE issues a letter of acceptance to the RECORD ASPIRANT, files one copy of the RAD, and forwards a copy of the acceptance letter and the RAD to the NAR CONTEST BOARD and to the EDITOR MODEL ROCKETEER.

8. For an FAI record attempt, the NAR RECORDS SUBCOMMITTEE will notify the EDITOR MODEL ROCKETEER upon submittal of the RAD to the AMA. The EDITOR MODEL ROCKETEER will publish, as soon as practical, the name, address, NAR number, age, record category, contest sanction number, date of record attempt, place of record attempt, and value of performance claimed, noting the fact that the record attempt has been filed for FAI homologation.

9. One of the reasons for submittal of complete information about a record attempt is so that the information can be published to notify other model rocketeers of the full details so that they may construct a model of the record attempt vehicle themselves; full publication of information is deemed by NAR to be necessary in the scientific tradition in order to advance the state of the art of model rocketry. A RECORD ASPIRANT therefore tacitly grants publication rights of the photograph and drawing to the NAR for this purpose. Therefore, upon notification by the NAR RECORDS SUBCOMMITTEE that either a USA or FAI record has been homologated and accepted, the EDITOR MODEL ROCKETEER may at that time publish the drawing, photograph, and full particulars of the record-holding model in the earliest possible issue of THE MODEL ROCKETEER, official newsletter of the NAR.

10. For an FAI record attempt, a homologation notice will be received by the AMA from the FAI. The AMA will retain a copy for its files, send the original to the NAR RECORDS SUBCOMMITTEE, and send a copy to the NAR CONTEST BOARD. NAR RECORDS SUBCOMMITTEE will notify the RECORD ASPIRANT and EDITOR MODEL ROCKETEER.

NARAM-12 REMINDER

The 12th National Model Rocket Championship Meet (NARAM-12) will be held at Astroworld in Houston, Texas on August 16 through 21, 1970. The following nine events will be flown:

Class 1 Parachute Duration
Design Efficiency
Sparrow Boost/Glide
Scale
Swift Boost/Glide
Space Systems
Egg Lofting
Open Spot Landing
Research and Development

Facilities for over 300 modelers will be available at NARAM-12.

Anyone interested in attending NARAM-12 should send a postcard requesting an application to the NAR Contest Board, Richard Sipes, 5012 60th Avenue, Bladensburg, Maryland 20710 by June 1, 1970. Please include your name, NAR number, and address with ZIP CODE. A NARAM-12 application package will be sent to you as soon as your card is received. The application must be returned with all fees by July 6, 1970 at the latest. You will be notified shortly thereafter if you are accepted. If for any reason you have not been accepted, all fees will be returned to you with the notification.

SECTION NEWS

By Charles Gordon

The NAR wishes to welcome the following new sections into the organization: Blue Ridge Rocket Association, Mars Area Rocketeers, Los Alamitos-Rossmoor Section, Loyola Rocket Club, and Mariner Rocket Society.

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"The first rocket to fly in the new decade, January 1970 A.D. It flew in peace for all mankind." This quotation was attached to a rocket flown by the Northside Rocket Club (Atlanta, Georgia) on January 1, 1970 at 12:00 a.m. Eastern Standard Time. The model, an Estes Alpha, has been retired by the section—the First Rocket of a Decade.

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Congratulations to the Birch Lane Section (Davis, California) in coming out with Volume 1, Number 1 of the *Tycao Times*, their official section newsletter. Keep it coming, Birch Lane and good luck.

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The Steel City Section (Pittsburgh, Pennsylvania) was treated to a lecture by Richard Fox on his rocket transmitter described in MRm, May 1969, and some of the newer improvements that have been made.

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South San Francisco Post 4103, Veterans of Foreign Wars will sponsor a model rocket club as a community service project. Membership is open to all persons interested in model rocketry. An organizational meeting was held in early March and plans are underway to charter as an NAR section. Anyone interested in the program should write to:

VFW Post 4103
P.O. Box 301
South San Francisco, Calif. 94080

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NARHAMS section holds a monthly launch on the first Saturday of each month at 1 P.M. at the Goddard Space Flight Center Antenna Range, Greenbelt, Maryland. Other WAMARVA area sections or rocketeers wishing to launch at the facility should have their section advisors contact the nearest WAMARVA area section for information or telephone Mr. Howard Galloway at 301-987-4395.

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The Metro-Denver Rocket Association is still working on re-building the old Hogback Rocket Range. The section hopes to have the range in good working order for use this spring. Other modelers in the area wishing to make use of the launch facility should contact the Metro-Denver section for information.

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NARCAS section (Camp Hill, Pennsylvania) is conducting a Record Trial Meet on May 15 through 17. Egg Lofting, Class 1 Parachute Duration, Peewee Payload, Design Efficiency, Hornet B/G, and Condor B/G. This is probably the first time that Condor B/G has been held in a sanctioned competition and unusual results are expected.

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During the winter, the Birch Lane section (Davis, California) held its "Inter World Series Section Contest" where, to keep members in practice, the section flew specific events on three widely separate weekends. Special "World Series points" were awarded to the participants. The section feels this is the best way to keep the members in shape for serious competition.

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An NAR section is being formed in the Central Kentucky area. Rocketeers in that area are urged to contact Greg Bright, Route 1, Campbellsville, Kentucky 42718 for information.

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On February 1 the Metro-Cleveland section held a Class 1 Parachute Duration contest and flew some demonstration models with the new Estes "D" engines. Contest prizes were donated by the local hobby dealer. Rocketeers in the Cleveland area should call Bob Allen (237-6411) for information on joining the section.

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NAR SECTION NEWS appears each month as a regular feature in *THE MODEL ROCKETEER*. Those sections wishing to have news and/or information of their activities printed in this column should submit such material to:

NAR SECTION NEWS EDITOR
Charles M. Gordon
192 Charolette Drive
Laurel, Maryland 20810

ADDITIONS TO SECTION ROSTER

OUTA-SIGHT Patrick Hickert Route 7, Box 60 Wayzata, Minn. 55391	METRO-CLEVELAND Robert H. Allen 1437 Seneca Blvd. Broadview Hts., Ohio 44141
NORTHGLEN ROCKETEERS Daniel Eastman 10909 East 109th Pl. Northglen, Colo. 80233	LONAR John Fensterer 4854 Juneway Drive N. Liverpool, N.Y. 13088
NORTHSIDE ROCKET CLUB Joe Guthridge 2765 Northside Drive Atlanta, Ga. 30305	COSMOS-ORBITS David Valkema 13737 Summerset Rd. Poway, Calif. 92064

BLUE RIDGE ASSN.
Brent R. Heizer
408 Ridge Circle
Waynesboro, Va. 22980

LOS ALAMITOS – ROSSMOOR
Craig Garnes
11912 Foster Road
Los Alamitos, Calif. 90027

MARINER ROCKET SOCIETY
David Lien
424 South Pleasant
White Water, Wisc. 53190

CSAR
Gerald Gregorek
4451 Danforth Rd.
Columbus, Ohio 43229

SATURN MR SECTION
David Shind
104 Chip Chip Way
El Paso, Tex. 79915

THE ORBITS
Tom Daniels
c/o Mr. L. Derkovitz
1562 Katie Avenue
Las Vegas, Nev. 89109

MARS AREA ROCKETEERS
Tom Logan
RD 3, Box 212
Valencia, Pa. 16059

LOYOLA ROCKET CLUB
Marin Popoff
3715 Tracy Street
Los Angeles, Cal. 90027

BETHLEHEM SECTION
Frank Osborn
1408 Cottage Ave.
Bethlehem, Pa. 18018

MONROE ASTRONAUTICAL
Greg Howick
2424 Turk Hill Rd.
Victor, N.Y. 14564

STEEL CITY SECTION
Marvin Lieberman
3 Coleridge Place
Pittsburgh, Pa. 15201

BERKELEY HEIGHTS
Michael Quelly
40 River Bend Rd.
Berkeley Hts., N.J. 07922

ADDRESS CHANGES TO SECTION ROSTER
(replace old address with new)

WEST COVINA
Dane Boles
3723 Gilman Rd. #22
El Monte, Cal. 91732

QUEEN CITY
James Backlas
317 Leopere Street
Buffalo, N.Y. 14211

Starting a
Club Newsletter

By Douglas List NAR 12273
(Editor – The *Intercept*)

Preparation

As model rocketry grows, it is becoming more and more important that clubs be in closer contact with one another. One of the best ways of accomplishing this is through a club newsletter. This article will tell you how to start a club newsletter and keep it operating.

The first step is to locate printing facilities, such as a mimeograph or hectograph machine. Colleges, businesses, schools, civic organizations, churches, and some individuals own these, but the trick is to get access to them. Fathers of club members are usually the most promising access route. If you cannot get access to a machine without buying one, FORGET IT! Mimeograph machines cost a pretty penny and don't last forever.

Next, you should select your staff. Select a single, responsible club member as editor. Remember, his ideas are going to represent your club in the eyes of others. Then, select one or two co-editors who live near him or go to the same school so that the editor will not become so bogged down with work that the newsletter fails.

The last step is mailing facilities. Many clubs are affiliated with a YMCA or other organization which will often help pay for postage and address envelopes. If not, make sure your treasury can support mailing costs and that you have several faithful club members willing to spend an hour or two addressing. Whatever the case, keep the size of the mailing list down. This is important to streamline the cost and keep sponsors interested. Only those clubs that you are in contact with through contests; those undertaking projects similar to your own, or those who are willing to exchange newsletters should be on your mailing list.

Watch the Section News and Club Notes sections of this magazine to find out shich clubs are near you and/or undertaking projects that are of interest to your club.

The First Newsletters

The first step is obtaining articles. For the first few times, keep them simple. Avoid excessive editorializing and concentrate on club news and technical articles. Accuracy in details and spelling is important. Encourage all members of the club to contribute to the newsletter.

We have found that the best format for an 8½"x11" newsletter is a three-column one. Divide the stencil by drawing vertical lines at the ½", 3", 5½", and 8" points. Each column now holds 21 spaces and a small excess for a margin. We find such a newspaper-like column very eye appealing. You can obtain this in the following manner:

When the author is writing his article, have him do so on a piece of paper 2½" wide with 21 spaces marked on the top. He must not exceed the 21 spaces on a line. Every space left over at the end of the line should be represented by an asterisk preceeding the line. When he gives the copy to the editor, this will allow the editor to retype each line in such a way (using double spaces between words) as to take up the entire line. This method can be applied to any sized column once the number of spaces has been calculated. (The last line of an article need not be so justified.)

In typing the stencils, a system should be worked out so that each editor types a page or so (to speed operations). The editor should be in possession of all of the articles and should distribute them from front to back in order of importance. A blank column should be left on the back page in case any article takes up more room than was allotted to it. This space, and any other unused space, can then be filled with a small article or several shorts (i.e., "JOIN THE NAR") written as needed.

A good size for a newsletter is two or three pages.

Enlarging the Newsletter

When you wish to start expanding the newsletter, be sure to exercize good judgement in what you're putting in. Rocket plans are fine, but be selective. There is no need to put in plans a person can easily find in Model Rocketry or get free from some manufacturer. Avoid simple sport rockets as well as overly expensive or impractical ones. Encourage scale, competition, and unusual designs. Make sure all designs have been flown safely. Try to coordinate the plans with club activities and contests.

I have seen, among others, two good expansion ideas. *Contrail*, of Three Rivers Section, recently carried a history of rocketry. *Emanon*, of the Space Pioneers, printed the first cartoon I have seen that came out legibly. Word of caution: many stencils cannot be written or drawn on, so be careful what kind of stencil you are using.

Anyone with questions or comments is welcome to write to me. Good luck!

Doug List
38 West University Ave.
Bethlehem, Pennsylvania
18015

NAR and HIAA Adopt New Safety Codes

At the NAR Board of Trustees meeting held on January 31 at Chicago, the trustees voted to adopt two new Model Rocket Safety Codes proposed by the Hobby Industries Association of America. These two codes will serve as an industry-wide safety standard for the design and use of solid and liquid propellant model rockets. These codes take effect immediately and supercede all previous NAR Safety Codes.

COLD PROPELLANT MODEL ROCKET SAFETY CODE

1. ENGINES – I will use only factory made model rocket engines in the manner recommended by the manufacturer. I will re-load cold propellant rocket engines only with the propellant recommended by the manufacturer.

2. RECOVERY – I will always use a recovery system in my model rockets that will safely return them so that they may be used again. I will conduct pre-flight tests to assure the recovery system functions properly before launching the rocket.

3. WEIGHT LIMITS – My model rocket will weigh no more than 16 oz. at lift-off.

4. STABILITY – I will check the stability of my model rockets before their first flight, except when launching models of proven design.

5. FLYING CONDITIONS – I will not launch my model rocket in high winds, near buildings, power lines, tall trees, low flying aircraft or under any conditions which might be dangerous to people or property. I will never attempt to recover a model rocket from a power line or other dangerous place.

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

7. LAUNCH TARGET & ANGLE – I will not launch rockets so their flight path will carry them against targets on the ground, and will never use an explosive warhead or a payload that is intended to be flammable. My launching device will always be pointed within 30 degrees of vertical.

8. LOADED ROCKETS – I will never store or leave a loaded rocket untended. I will always keep a loaded rocket on a launcher or firmly restrained. I will never point a loaded rocket or its rocket nozzle at anyone, nor allow anyone to be in the flight path of a rocket during launch preparations.

9. CONSTRUCTION – I will never use metal nose cones or metal fins.

SOLID PROPELLANT MODEL ROCKETRY SAFETY CODE

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

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

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

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

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

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

7. LAUNCH SAFETY – I will not let anyone approach a model rocket on a launcher until I have made sure that either the safety interlock key has been removed or the battery has been disconnected from my launcher.

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

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

10. JET DEFLECTOR – My launcher will have a jet deflector device to prevent the engine exhaust from hitting the ground directly.

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

12. POWER LINES – I will never attempt to recover my rocket from a power line or other dangerous places.

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

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

(Club Notes, continued)

On January 28th the Triple R Rocket Society presentation team consisting of Mark Corbo, Doug Duckson, Gene Szabados, John Walker and Tony Corbo gave a talk on model rocketry to the Science Club of Mission Junior High School near Riverside, California. Their presentation included a discussion of many of the scientific applications of model rocketry. Following their presentation, seven new members were recruited for the club.

A model rocket club has been organized in Lihue, Hawaii. Under the supervision of Donald Van Ausdeln, of the National Calibration Laboratory in Kokee, the group was formed in early January. Among the people who turned out for the meeting were area youngsters, several Pacific Missile Range engineers, and members of the Port Allen Civil Air Patrol. Following the organizational meeting, a demonstration launch was held.

Several students at Glendora High School in Glendora, California have organized a rocket club. At a recent meeting Jack Kobzell was elected president; Kevin Schindler, vice-president; and Mike Alexander, secretary-treasurer. Jim Militello of Covina is the advisor for the group which meets at 10:00 A.M. on Saturdays in Glendora's Recreation Park. Bob Schindler of Glendora's Hobby Bench also works with the group.

On November 30th the Northeast Region of the Washington State Model Rocket Association held the first two events in the Northeast Washington Regional Competition. The events held were Class I Altitude and Class II Altitude. In Class I Altitude, with a limit of 10 newton-seconds total impulse, Bob Rile took first place with 920 feet. Steve Rile was second with 900 feet, and Bill Geisler was third with 880 feet. In Class II Altitude, with a limit of a 10.01 to 25.00 newton-seconds total impulse, Bill Geisler captured first place with 1450 feet, while Ron Clinton was second with 1390 feet, and Bob Rile was third with 1380 feet. The meet itself is a semi-annual event, with two events being held each month. The two events scheduled for December were cancelled due to inclement weather. It will be resumed as soon as the weather clears.
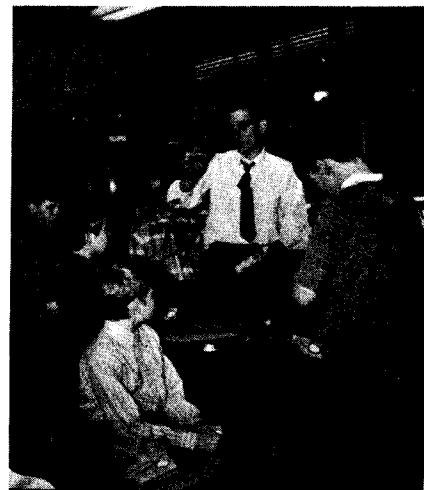
A recent issue of *The Western Rocketeer,* newsletter of the Washington State Model Rocket Association, reports that the Boeing Employees Rocket Research Society has received a letter from the president of the Barnaby Model Rocket Club in British Columbia, Canada suggesting joint competitions between the clubs. Plans are going for an international competition between clubs in this area.

The Xaverian Rocketeers report in their latest newsletter that the club has obtained use of a display case outside the school library. They have set up a display illustrating club activities in this area.

Send your club or section newsletters, contest announcements and results, and other news for this column to:
Club News Editor
Model Rocketry Magazine
P. O. Box 214
Astor Street Station
Boston, Mass. 02123

The rocket club at the Frank G. Lindsey Elementary School in Montross, New York has expanded to 35 members. Under the leadership of teachers Allan Dampf and James Morina, the boys and girls meet each Tuesday after school to design, build, and launch model rockets. Shown above are some of the club's construction sessions. The club has launched over 100 rockets at three launchings to date from their six pad multiple launcher. Members have built every type of Estes rocket from the simple Alphas and Scouts to advanced two and three stage models. They have achieved excellent results from the Camroc, and are anxiously awaiting the delivery of D-engines to launch a recently completed Cherokee D. The *Peekskill Evening Star* featured an article on the club's activities, and requests for membership are increasing.

Minnesota Winter Launch

Photo by Jeff Polzin

Manning Butterworth prepares to launch one of the spot landing vehicles as Contest Director Ellsworth Beetch looks on. Parked in the background is the recovery snowmobile.

In one of the last and coldest rocket competitions of 1969, rocketeers from the Wayzata, Minnesota area met with members of Zenith Section in a section meet on December 29th, 1969.

Launching began about two in the afternoon on a country road near the home of NAR trustee Les Butterworth. With temperatures between five and ten degrees and a ten to fifteen mile per hour wind, flights in the three events were limited to one per contestant.

With almost thirty-six inches of snow on the ground in the surrounding fields, recovery on foot would have been extremely difficult. Fortunately our recovery crew, Konr Beetch and Harold Butterworth, had a snowmobile at their disposal, making the recovery operation very efficient.

The cold weather took its toll in frozen chutes in the Class 1 Parachute Duration event. Cloth chutes, either silk or nylon, were the most dependable. Manning Butterworth took first using one, with 74 seconds in the Senior-Leader class. Chris Regan of Wayzata was the exception to the cloth chute rule. Using a hand warmer on the rocket tube until just prior to launch, he succeeded in deploying his large fluorescent orange plastic parachute for a time of 52 seconds and a first in the Junior division.

Despite the absence of thermals in the cold weather, some good flights were made in the Sparrow Boost/Glide competition. Edward La Croix, a junior from the Wayzata group, with 65 seconds, had the longest flight of the day with his canard pop-pod design. Manning Butterworth got the longest flight in the Senior-Leader division, with a 45 second flight from his modified Falcon design, but was disqualified when the streamer separated from the engine. The Beetch team was close behind with 43 seconds from their own version of the Falcon.

Open Spot Landing certainly saw no pole-hanging flights in this meet. Tim Mooers of Wayzata won in the Junior division with 74½ feet, while 73 feet from the Beetch team took the other first. The measurement in this event was no easy task, with the tape crew spending almost 15 minutes wading through knee-deep snow to get to all the models.

The winter meet with snowmobile recovery was a first for the Zenith Section, and shows that section contest shooting need not go into hibernation with the first signs of cold weather and snow.

—Jeff Polzin

Photo by Dan Polzin

Les Butterworth, left, prepares to time the B/G's as Jeff Polzin launches Leo Bosard's boost/glider.

(From the Editor, continued)

his first months in the hobby could easily become confused. For a number of NAR Trustees and the major manufacturers have recognized the need for a common safety code. There were difficulties involved with the drafting of a common safety code. However, due to the persistent efforts of several Trustees and manufacturers a common safety code has been prepared and adopted. A text of this new code, for solid and cold propellant model rocketry, appears in this month's *The Model Rocketeer*. The manufacturers and the NAR should be commended for their efforts to make this hobby-wide safety code a reality.

Club Notes

The Merril Model Rocket Club in Denver, Colorado staged a competition at the Hogback range over the February 7, 8 weekend. The meet was open to all Denver area rocketeers. Events scheduled were Open Payload, Spot Landing, Parachute Duration, Scale, and Boost/Glide. Trophies, prizes and ribbons were awarded to the winners.

A rocket club, under the direction of Sister M. Roberta C.S.S.J., was recently organized at South Catholic High School in Hartford, Connecticut. The club meets every Monday.

A model rocket club is being organized in New Albany, Indiana. Rockets are flown every Sunday by the present club members (weather permitting). Interested rocketeers in the New Albany area are invited to contact Earl Hawkins, Jr., 319 East 11th Street, (945-9850), or Richard Curl, 1628 Slate Run Road, (945-2485).

The Rocket Flight Systems Specialists, a model rocket club in Glendora, California, have recently been conducting rocket demonstrations at area schools. Clubs, schools, and rocket societies in the Los Angeles County district interested in having a demonstration launch for their organization are invited to contact Rocket Flight Systems Specialists at 983-3711 (Kevin Schindler), or 335-8451 (Mike Alexander).

New Jersey's Pascack Valley Section has tentatively scheduled a "mini-convention" for rocketeers in New Jersey, New York, Connecticut, and Pennsylvania for sometime in September 1970. The Convention is expected to be one day long, and will involve discussion groups, a flight session, and post flight analysis. All rocketeers, both NAR members and non-NAR members, are invited to attend. Rocketeers wishing to attend should write to: Mini-Convention, c/o Bob Mullane, 34 Sixth Street, Harrison, New Jersey, 07029. More information will be sent as soon as plans are finalized.

Kip Gardner is trying to form an NAR Section in the Tidewater, Virginia area. Interested rocketeers can contact him at 238-2700 or write him at Sleepy Lake Parkway, Crittenden, VA. 23342.

The latest issue of *Engine Exhaust* reports that a new club has been formed at the Lake Air Junior High School near Waco, Texas. The club, called the Lake Air Association of Rocketry, will be supervised by a science teacher at the school. Membership, which is restricted to students at Lake Air J.H.S., is growing rapidly.

The Hilldale Model Rocketry Association (HMRA) of Hinton, West Virginia recently held their elections. Results were: Billy Meadows, President; William Meadows, Vice-President; Sharon Boone, Secretary; Neil Morgan, Treasurer; Tommy Talbot, Sargent-at-Arms. The club presently has 21 members.

HMRA has scheduled their first regional competition, HMRARM-1, open to all rocketeers in the counties of Simmers, Mercer, Greenbrier, Monroe, and Fayette, West Virginia for May 23, 1970. Events to be flown are: Open Spot Landing, Class 2 Altitude, Drag Race, Class 2 Parachute Duration, Class 3 Parachute Duration, and possibly Hornet B/G. Rocketeers wishing more information on this competition should send a stamped self-addressed envelope to: HMRA, Route 1, Box 141, Hinton, West Virginia 25951.

The South San Francisco Post of the Veterans of Foreign Wars will sponsor a model rocket club as a community service project. The program consists of the assembly and launching of model rocket kits. Membership is open to all persons in the South San Francisco, California area interested in model rocketry.

The *Maryland Gazette-News* recently featured a full-page story on the activities of Maryland's Annapolis Association of Rocketry. The article, which included an interview with AAR president Sam Atwood and his father, senior advisor Robert Atwood, brought the club's activities to the attention of approximately 16,000 readers in Maryland.

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