MODEL ROCKETRY

The Journal of Miniature Astronautics

June 1969
50¢

Astroscale TOMAHAWK

IGNITION TECHNOLOGY

BUILD THE CENTAUR-B

TEMPERATURE SENSOR

BODY TUBE GUIDE

AUSTRALIAN REPORT

ODDBALL: CANDELABRA

THUMBA ROCKET RANGE

REGULAR FEATURES

On the Scene Report...
The MIT Convention

Model Rocketry

Volume I, No. 8
July 1969

Editor and Publisher	George J. Flynn
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Cover Photo

A single stage, F-engine powered rocket lifts off during the MIT Model Rocket Convention during the weekend of April 11-13, 1969. Full convention coverage begins on page 30. (Photo by George Flynn).

Features

From the Editor

We have received a considerable amount of mail from model rocketeers who propose to strap a commercial movie camera to a model rocket, cluster several large engines, and fly a movie camera. While this "brute force" approach is indeed useful, there are other movie camera projects more worthy of serious effort.

Let's consider some of the reasons a commercial movie camera is not suitable to model rocket flight. First, the lightest commercial movie cameras weigh almost a full pound–too heavy for a good model rocket flight. Second, the commercial movie camera is designed to easily fit the average hand, making it much too bulky for model rocket flight. Third, the commercial movie camera has a shutter speed of approximately 1/30 second–far too slow to record sharp images during flight. The commercial movie camera is designed with a specific set of criteria in mind; it is designed to immortalise children playing in the front yard or a scenic summer vacation. It is *not* designed to perform well during a model rocket flight. The solution is to establish a set of design criteria for a model rocket movie camera, and then to construct a camera to those specifications.

Just what are the specific needs of a model rocket movie camera? To avoid blurring, a shutter speed in excess of 1/200 second is a necessity. To obtain panoramic views, a wide-angle lens (about 6mm focal length on an 8mm film format) is desirable.

(Continued on page 4.)

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Back issues of Model Rocketry are available at 35 cents (plus 15 cents postage) each while the supply lasts. Feature articles include:

October 1968 Sold Out
Dragstab: A fi[illegible]ss Rocket ..... Wallo[illegible]sta[illegible]n.....Model Rocket [illegible]culations [illegible] Apex I: [illegible]-altitude [illegible] .. Egglofter II .... F[illegible] of Dynamic Stabili[illegible] P[illegible] I.....Bomarc B Scale Design...............

November 1968
Model Rocket Recovery by Extensible Flexwing .....High Quality Aerial Photography: Part I.....Calculating Drag Coefficients ..... Scale:MT-135 .....Project Apollo .....XR-5C: Three Stage Cluster Rocket Design .... Fundamentals of Dynamic Stability: PartII .....The Versitex: A payload rocket .....

January 1969 Sold Out
The Stygion: A Ro[illegible]ith Cardboard Fins ..[illegible] a Club Launch[illegible] ...Using Super [illegible]...High Q[illegible]ity Aerial [illegible]graphy: Part 2[illegible].Fundamentals Dyn[illegible]bi[illegible] Part III .... [illegible] Rockets .....A Minim[illegible]esistance Launch Panel ....Avenger II: Two Stage F-Engine Altitude Rocket ....

February 1969
Zeta Single Stage Sport Rocket Plans .....The Flight of Apollo 8 ..... Fundamentals of Dynamic Stability, Part IV .....Non-Vertical Trajectory Analysis .....The Old Rocketeer: Spotlight on the Manufacturers..... Cosmic Avenger: Model for Class E engines .....Sacle Design: Nike-Deacon ... .Model Rocketry for the Depraved .....World Championship Scheduling Report ....

March 1969
The Old Rocketeer: Saffek's Saturn .... High Quality Aerial Photography: Part 3 ..... the Bifurcon: Rocket Design .....Constructing a $25 Club Launch Panel ..... How to Finish a Model Rocket ..... Scale Design: Genie MB-1 . ....The Dynaflora: Single Stage Sport and Payload Rocket ..... Fundamentals of Dynamic Stability: Part V ....

April 1969
Scale Arcas ..... Report on Apollo 9 ..... Demonstration Launches ..... R.H. Goddard Payload Rocket ..... Multistage Altitude Payload Rocket ..... Multistage Altitude Calculations.....Tower Launching..

May 1969
Staged vs Clustered Model Rocket Performance...The Fra-jyle Sport Rocket... Astroscale Data: The ASP Rocketsonde...Transmitter Construction Plans...The Infinite Loop: Oddball Design...WRESAT Australian Satellite...Pittsburgh Convention Report...The Hawk: Sport Rocket... Closed Breech Launching..................

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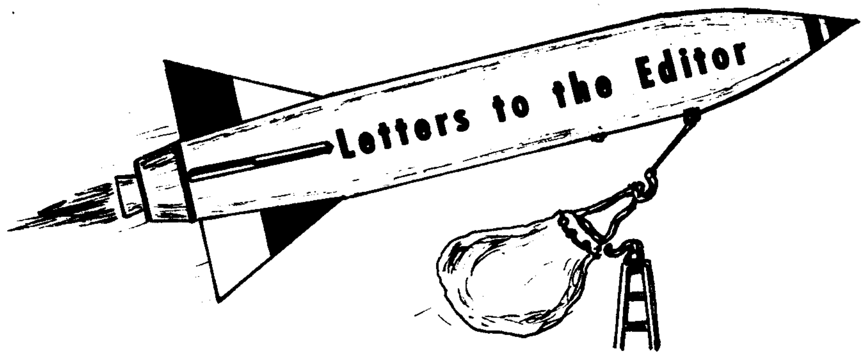


Relativistic Rocketry

I thought *Relativistic Model Rocketry* was the most beautiful April fools joke I have ever seen. It never gave any indication of being a joke until it said that a model to check them out would be test flown on April 1. At first glance, it even fooled the head of the science department at my school. I hope you will announce that it was a joke in your next issue, because it probably fooled many people.

John A. Lane
Westport, Connecticut

Parts Error

There is an error in the "Constructing a $25 Club Launch Panel" article (March 1969). Stock number for S3 (SPST switch) should read 56C*4520* not 56C*4250*.

Peter Chin
Brookline, Massachusetts

From Canada

I have been a rocketeer for only two months. I am very close to completing a club organization project which precedes my enthusiastic and eagerly awaited submergence into the world of Rocketry.

As for your magazine, I have very little to say about it, in fact, only two words–it's terrific!

As most of our members are fairly "green" at model rocketry, we plan on starting out with a series of tests and experiments, and will be only too happy to supply you with the resulting data, be it good or bad.

Don't expect too much, though; as a starter, we Canadians have a notorious knack of dragging our feet in the mud, but we also have a bit of British bulldog in our veins, so look out!

Harvey Attermann
Port Alberni, British Columbia

I have seen your magazine during a recent trip to the States. It's just what the doctor ordered.

The ants and mice in Canada are safe. The Approved Regulations for Rocketry by Amateurs in Canada forbid the lofting of any live animals... thought you would like to know. The Canadian Association of Rocketry has, at last, been overpowered by the SPCA.

Lawrence W. Brown
Quebec City, P.Q. Canada

Davis Defended

In regard to Charles Russell's letter in the April issue, I would like to say that model rocketry need not be such a dull and boring hobby as to never find any humorous points to rocketry mishaps. It is completely normal for a person to look upon past experiences, which seemed extremely serious at the time, in a light vein at a later date. If a rocketeer feels no pleasure in the "woosh" and the "fire and smoke" from his bird as it sails into the air, I believe he's in the wrong hobby.

Joel Davis' article in the February issue was great. He showed that model rocketry has its lighter points as well. His personal experiences were terrific. His letter in the March issue was hilarious. It kept me laughing for days. The account of pyrotechnics he attempted (unsuccessfully) to describe would have proven interesting. I highly doubt that anyone would attempt to build them, but it could have served as an example as to what not to do. Apparently the **Model Rocketry** staff wants to keep such things as guns, war, explosives, and other not-nice things a secret from their puritanical readers.

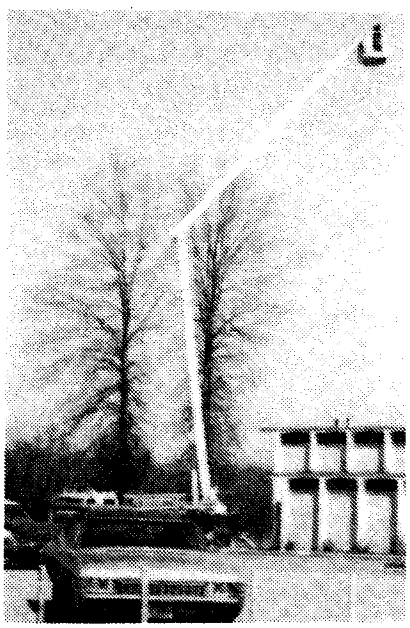
Please continue your articles on scale modeling. It is one of the most fascinating branches of the model rocketry field.

Brian J. Witzke
Milwaukee, Wisconsin

"Hats Off"

Recently a rocket club was organized in Warren, Ohio, to promote rocketry and rocket safety. We fire rockets on Sundays at a local plaza parking lot. Located directly across the street is a fire station.

Last week, one of our rockets landed on telephone lines. In our attempt to recover the rocket, we were approached by a fireman. When he saw what we were doing, he went back to the fire station and drove a new truck called the "snorkel" to the scene.



The "snorkel" is a large truck used to rescue persons, and to get into the center of a fire. It has an arm which moves in all directions and extends to a distance of 90 feet. The truck was purchased for $80,000–which the fireman used to rescue our $1.50 rocket. "Hats Off" and Thank You to our fireman.

John Gwilt III
Warren, Ohio

Nike-Deacon

You have getting so many letters of praise lately that I thought I would send some constructive criticism your way.

In your February issue, you carry a scale design of the Nike-Deacon. All the dimensions work out fine except two. The first dimension to the bottom of the level (change of diameter from first engine section to first body section) is 4.05, and diameter to top of level is 3.98. This is probably a switch-around during typesetting and doesn't bother me too much. But the other one really curls my hair! The diameter of the first engine section is stated as 25.35 and the overall fin spread is 9.05. This number must have slipped in during a sonic boom!

But, it's still a darn good mag.

H. Attermann
Port Alberni, B.C., Canada

You are correct that the 4.05" and 3.98" dimensions were reversed on the Nike-Deacon drawing in our February issue. The correct first stage engine diameter is 2.53" not 25.35" as dimensioned. We apologise for any inconvenience this mistake may have caused you. Thanks for calling it to our attention.

Compliments

My husband and I picked up two issues of your magazine last night, by sheer luck and my keen browsing eye. Immediately upon reading a few articles and skimming others, we decided we had to have a subscription.

Needless to say, we are much impressed by the high quality of your articles. It is a pleasure to pick up a hobby magazine which, while the format is not as slick as some, has skillfully and intelligently written articles.

As beginners in the field of model rocketry, we feel that a regular feature aimed at beginners and covering their problems encountered before experience is gained might be helpful. My husband has been in airplane modeling for ten years, but learned a great deal Sunday when we spent a day launching. We lost a Centuri Javelin which had "flown" best of anything put up that day. We overpowered the rocket and had the luck to catch a thermal. Quite a ride that bird took! Following in a car was unsuccessful. I am now building another. To the point: if we had used a streamer instead of a parachute, we might have recovered it, since a streamer would have brought it down faster. It's probably still up there!

Quite a lot of excitement in model rocketry. They don't just "go up and then come down." I think we're hooked.

Margaret L. Burroughs
Springfield, Massachusetts

A beginners column has been under consideration for several months now. While we agree that its a good idea, we have not been able to find a suitable author willing to prepare a series on a monthly basis. Anyone out there interested?

Night Launching

I thought you might like to know about a form of model rocketry which some of my friends and I are doing, launching at night. I was using an Estes "X-Ray" rocket, because of its clear plastic payload section. The payload was a pen light battery, a bulb, and some wire. At about 8:30, a friend of mine and I went out to his backyard, which is a huge field. He had an Estes "Big Bertha" with the light attached to the shock cord. Unfortunately, he used a C engine it it, and it got stuck in a tree. I had no better luck. After seeing that wonderful trail of fire and smoke, especially bright in the night, the ejection charge blew, and the rocket, light swinging in the breeze, slowly settled itself in a faraway tree. It's still up there. You could see it up there, the light still on, for a long time afterwards.

Bruce Carlsmith
Amherst, New Hampshire

see page 38

(From the Editor continued)

To easily fit a model rocket, the camera should be cylindrical in shape, and perhaps 2 inches in diameter. To permit maximum altitude, the camera, of course, should be as light as possible, consistent with reliability and the other design criteria.

A movie film from such a home-built camera was shown by G. Harry Stine at the recent MIT Model Rocket Convention. Stine said that the film was sent to him by a rocketeer who designed and constructed his camera to conform to the requirements of model rocket flight. This proves, to those who still have some doubts, that such a camera can be built. It will require many weeks of work to design and build such a device, but the high quality of the films obtained should be adaquate reward for your efforts.

The question of model rocket movie cameras serves to illustrate the two possible approaches towards model rocket instrumentation the "brute force" approach and the sophisticated approach. The "brute force" method should be neither condemned nor rejected. It is useful in that it allows you to prove that an idea can work with little expenditure of time and effort. However, instrumentation cannot be left at the "brute force" level. There is a need to optimize the performance of the instrumentation around the design criteria relevant to model rocketry. *A good payload will usually be one specifically designed for a model rocket*, not something commercially available that has been jammed into the rocket and blasted into the sky with a cluster of F engines.

SOLICITATION OF MATERIAL

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

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

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

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

Those wishing to submit material should send it to:

Editor

Model Rocketry Magazine

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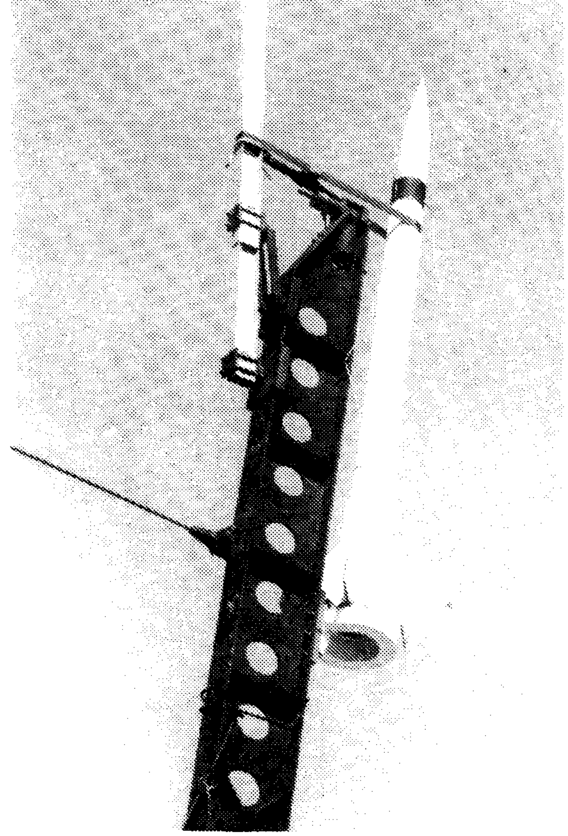
*Astroscale*Data*

I.Q.S.Y.-Tomahawk

Thiokol Sounding Rocket

by G. Harry Stine



NASA Photo L-64-9827

The I.Q.S.Y.-Tomahawk round No. 4 is shown on the boom launcher in Launch Area No. 2, NASA Wallops Station, in 1964. Strap supporting nose was removed before launch.

The I.Q.S.Y. Tomahawk rocketsonde was a single-staged, solid propellant vehicle designed and manufactured by the Astro-Met Division of the Thiokol Chemical Corporation for the purpose of carrying 44 pounds of scientific instruments into the D and E Regions of the earth's ionosphere during the International Quiet Sun Year (I.Q.S.Y.) of 1963-64. The vehicle utilizes instrumentation carried in a 5-caliber spun-aluminum ogive nose affixed to a cylindrical telemetry section 9 inches long. This is bolted to the forward flange of a Thiokol TE-416 "Tomahawk" solid propellant rocket motor of 9-inch overall diameter. Four machined metal fins are attached to the rear end of the TE-416 motor by bolting them to a metal ring- and-flange assembly that fits flush with the 10 bolts. The ring-and-flange is held to the TE-416 by bolts which engage threaded holes in the aft closure and nozzle assembly of the motor.

The I.Q.S.Y. Tomahawk is launched from a modified zero-length launcher consisting of a support ring, and a conical ring assembly that fits up into the aft 1-inch of the TE-416 motor nozzle. This zero-length launcher may be attached to any rail or boom type launcher by bolts.

The I.S.Q.Y. Tomahawk is normally loaded onto the launcher in a horizontal position. Once all instrumentation and tel-

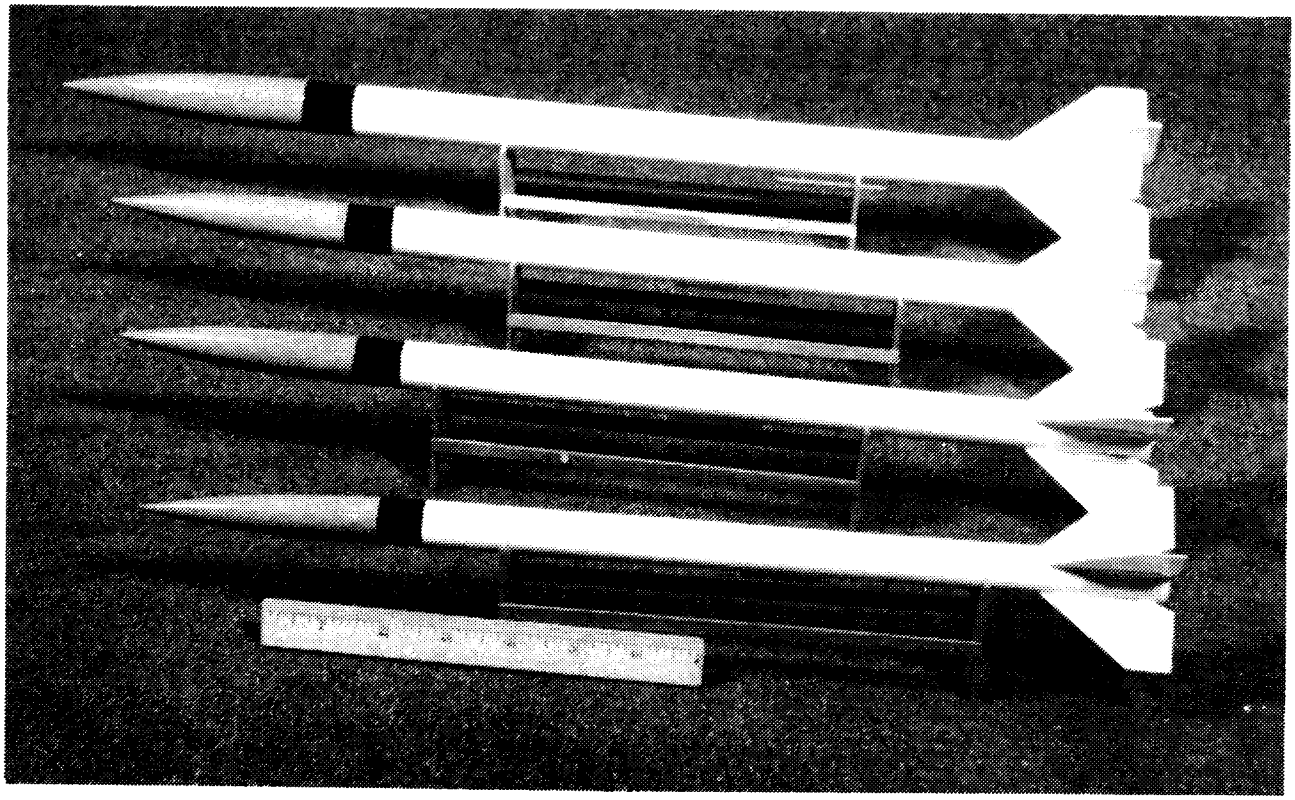
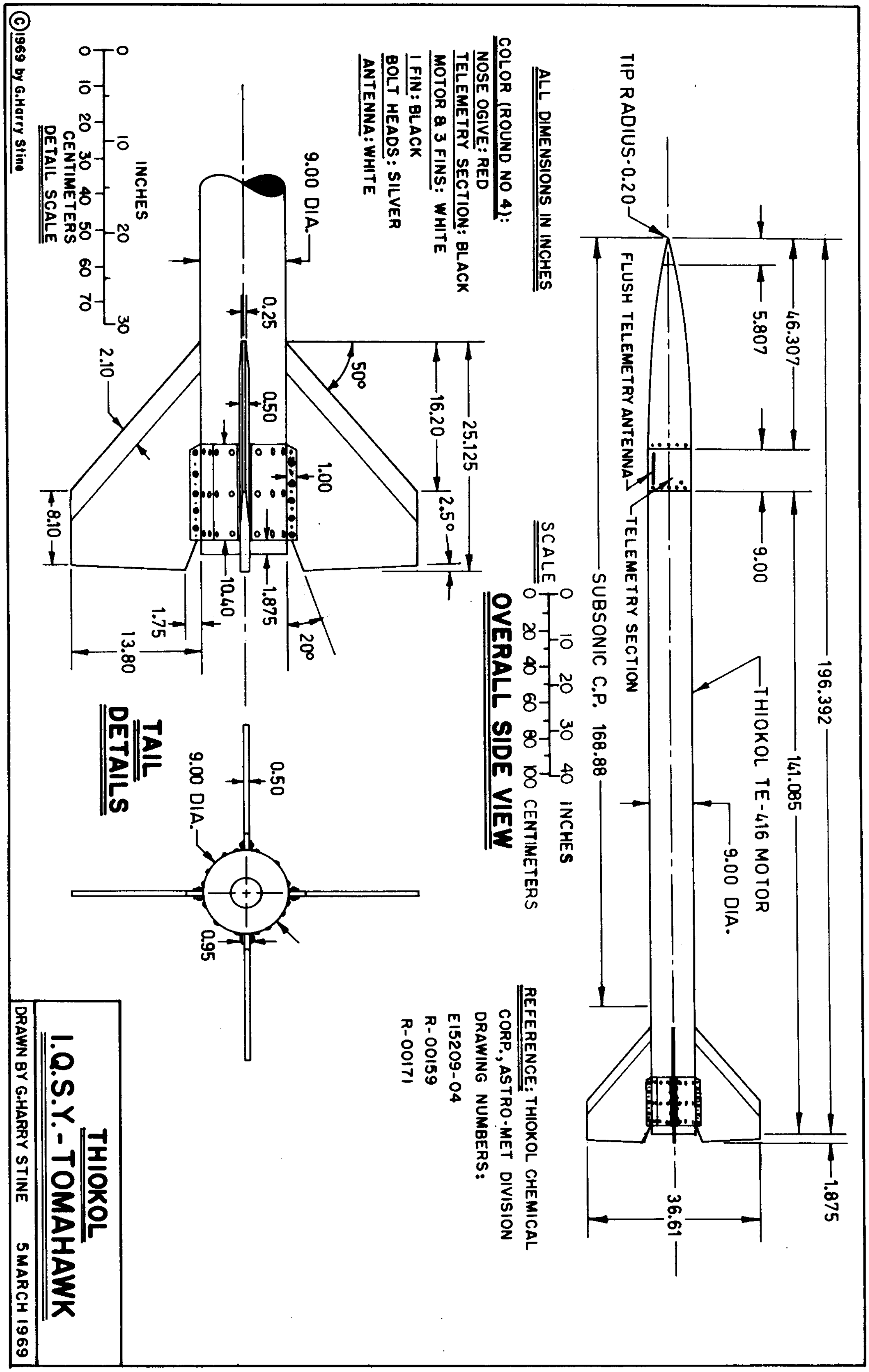


Photo by Stine

The I.Q.S.Y.-Tomahawk can be easily built from commercial parts in a variety of scales. Shown here, top to bottom, are I.Q.S.Y.-Tomahawks built from Centuri No. 10 tube and BC-107 nose cone, Centuri No. 8 tube and BC-89 nose cone, Estes BT-40 tube and custom nose cone, and Estes BT-20 tube with custom nose cone.


THIOKOL
I.Q.S.Y.-TOMAHAWK
DRAWN BY G.HARRY STINE 5 MARCH 1969
OVERALL SIDE VIEW
TAIL DETAILS
TIP RADIUS-0.20
FLUSH TELEMETRY ANTENNA
TELEMETRY SECTION
SUBSONIC C.P. 168.88
THIOKOL TE-416 MOTOR
9.00 DIA.
46.307
5.807
9.00
196.392
141.085
1.875
36.61
SCALE
INCHES
CENTIMETERS
ALL DIMENSIONS IN INCHES
COLOR (ROUND NO 4):
NOSE OGIVE: RED
TELEMETRY SECTION: BLACK
MOTOR & 3 FINS: WHITE
1 FIN: BLACK
BOLT HEADS: SILVER
ANTENNA: WHITE
REFERENCE: THIOKOL CHEMICAL CORP., ASTRO-MET DIVISION
DRAWING NUMBERS:
E15209-04
R-00159
R-00171
DETAIL SCALE
0.25
0.50
1.00
50°
16.20
25.125
2.5°
2.10
8.10
10.40
1.875
1.75
13.80
20°
0.95
©1969 by G.Harry Stine

emetry checks have been completed, the vehicle is raised to the proper quadrant elevation, the umbilical plug is extracted, and the vehicle is fired by an electrical squib on command. The vehicle then ascends to an approximate altitude of 100 kilometers, telemetering its scientific payload data back to the ground. No attempt is made to recover the vehicle.

History

The Astro-Met Division of Thiokol Chemical Corporation has had a long history of providing rocketsondes and rocket components to NASA, DOD, the Lawrence Radiation Laboratory, and the Sandia Corporation. Several variations of the basic Tomahawk vehicle were used by Sandia Corporation. The I.Q.S.Y.–Tomahawk was developed by the Astro-Met Division of Thiokol under the direction of R. Gilbert Moore, General Manager, to investigate the uses of the basic TE-416 Tomahawk rocket motor as a rocketsonde vehicle for the I.Q.S.Y. The first round was fired at Tonopah, Nevada, on June 12, 1963, and was entirely successful. Round two was flown several weeks later from Point Mugu, California and failed when the fins burned off because of the greater aerodynamic heating caused by launching at sea- level in denser air. Round three was likewise a failure when the fins burned off at burnout of the TE-416. Round four was the final test launching in the Research & Development series of the I.Q.S.Y.–Tomahawk design and was launched from Launch Area No. 2 at NASA Wallops Station in 1964. According to R. Gilbert Moore, "The sort of odd-looking contraption at the front end of the launcher boom was intended to allay the launch crew's fears concerning a zero-length launcher which consisted of a ring which engaged the aft 1-inch of the rocket's nozzle. To everyone's relief, the rocket did not fall off when the strap was removed. We use this general technique, incidentally, on all single-staged Tomhawks."

The I.Q.S.Y.–Tomahawk evolved into the so-called Medium-Performance Tomahawk (M.P. Tomahawk) and High-

Astroscale data is drawn from the most accurate sources available and meticulously checked for historical authenticity. Every effort is made to call out all data sources. Since Astroscale data is not official NAR plans or information, it may be used as total scale substantiation data in NAR and FAI competition. Please DO NOT attempt to obtain original copies of photographs, drawings, or other data referenced herein, because, in most cases, additional copies do not exist, are extremely difficult to obtain, or have been provided to Astroscale for the purpose of this wide publication.

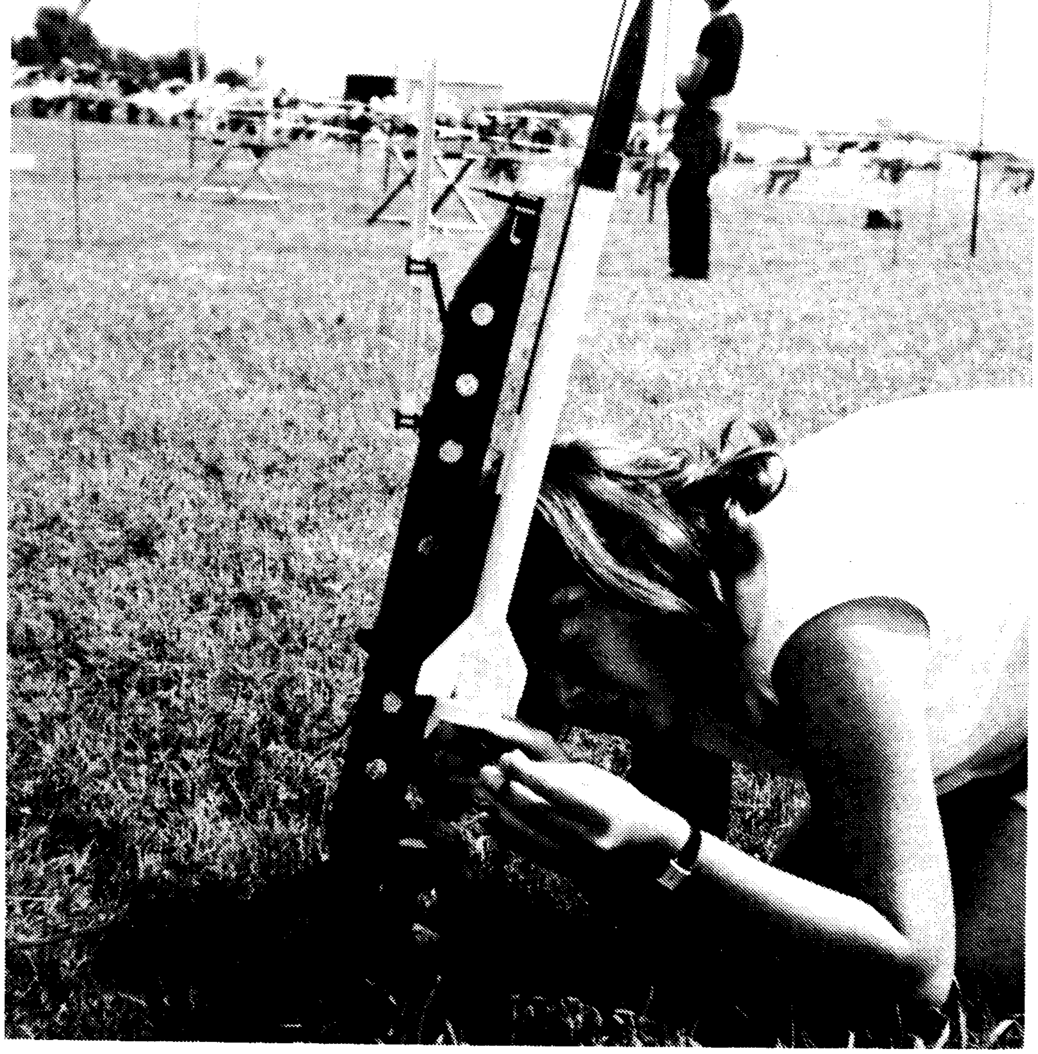


Photo by Stine

1968 NAR Junior Champ Connie Stine checks the ingiter hook-up on her 1:9.91-scale I.Q.S.Y.-Tomahawk and launcher in NAR Space Systems competition.

Performance Tomahawk (H.P. Tomahawk), both single-staged TE-416-powered rocketsondes developed for NASA. The Tomahawk, of course, was used extensively as the second-stage assembly of the Nike-Tomahawk rocketsonde.

The vehicle shown in the drawing is Round No. 4, the final vehicle in the I.Q.S.Y.–Tomahawk series.

Weights

Thiokol TE-416 motor: 484.8 pounds
Tail Assembly: 47.9 pounds
Vehicle less payload: 534.5 pounds
Nominal payload: 44.0 pounds
Vehicle with payload and external insulation: 584.5 pounds

Propulsion System

Make: Thiokol TE-416
Type: Solid propellant
Length: 141.085 inches
Diameter: 9.0 inches
Propellant: Composite solid–hydrocarbon-aluminum fuel and ammonium perchlorate oxidizer
Nominal thrust: 10,970 pounds
Burning time: 9.5 seconds
Total Impulse: 93,500 pound-seconds

Color Data

For Round No. 4–
Nose ogive: red
Telemetry Section: black
Motor and 3 fins: white
1 fin: black both sides
Bolt heads: silver
Antenna: white

Note to Modelers

The I.Q.S.Y.–Tomahawk can be modeled using Centuri Engineering Company Kit No. KC-40; a more accurate scale model will result if the kit's two-piece body tube is discarded and replaced with a single 15.125" length of Centuri No. 8 body tube to represent the TE-416 and Telemetry Section, since no joint appears on the prototype where the two body tubes of the kit join. Modelers should also note that the fin does not come flush with either the aft end of the body tube nor the aft end of the fin-body attachment strips. Since the I.Q.S.Y.–Tomahawk uses a 5-caliber ogive nose, many catalog parts can be used to build this model in various scales. If the model is built from various tubes, its scale will be as follows:

Body Tube	Scale
Estes BT-20	1:12.23
Centuri No. 7	1:11.91
Estes BT-40	1:10.96
Centuri No. 8	1:9.91
Estes BT-50	1:9.22
Centuri No. 10	1:8.65

Data Sources

Thiokol Chemical Corporation Astro-Met Division Drawings numbered E15209-04, R-00159, and R-00171.

Letter from R. Gilbert Moore, General Manager, Astro-Met Division, Thiokol Chemical Corporation, dated March 14, 1967, giving history, background, and color data.

Telephone conversation with R.G. Moore, March 13, 1967.

I.Q.S.Y.–Tomahawk fact sheet, Astro-Met Division, Thiokol Chemical Corporation.

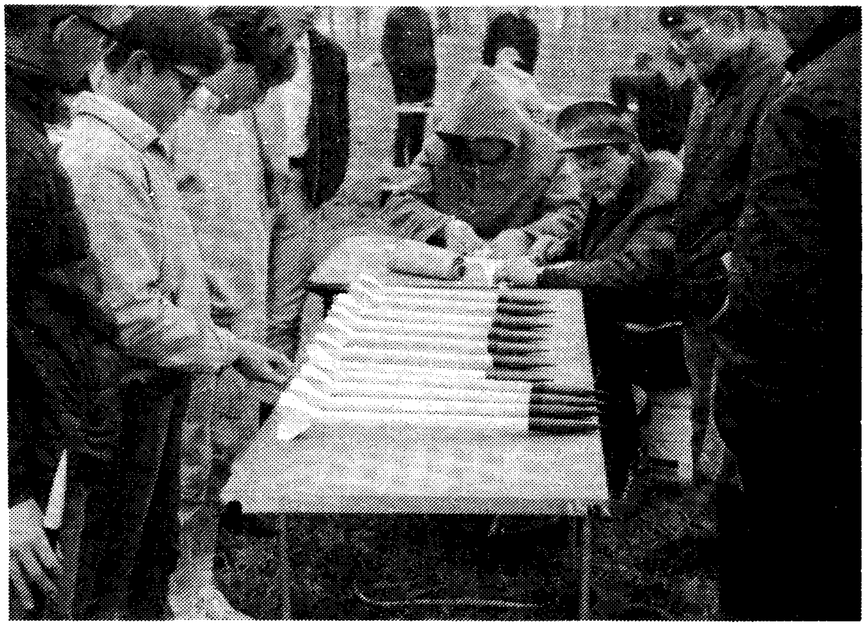


Photo by Stine

New Cannaan Y.M.C.A. Space Pioneers club pioneered the I.Q.S.Y.-Tomahawk model as beginner's scaler. Here NAR Trustee A.W.Guill (in hood) and Wendell Stickney, NAR No. 999, check adherance to scale in contest held for Tomahawk models only. All entrants got same points for scale data and degree of difficulty, were judged on adherance to scale, workmanship, and flight.

Legal Restrictions on Transmitters

by Carl G. Kratzer

Many rocket enthusiasts have either contemplated or actually begun to design or construct a model rocket telemetry transmitter or radio beacon. Before attempting such a project, the designer or builder should be aware of the various frequency bands available and the rules and regulations governing radio-frequency devices. In the United States, all devices which emit radio- frequency energy are subject to control by the Federal Communications Commission (FCC). The frequency spectrum has been divided into bands which are allocated by FCC to various services. The bands available for radiotelemetry will each be described briefly. The complete FCC Rules and Regulations are available from the Government Printing Office at a nominal cost.

Before describing the various bands, it is necessary that the reader become familiarized with certain terms used in this report:

Frequency band–A collection of frequencies lying between two extremes denoted as band edges. Operation is permitted on any frequency within the band, however, operation near the band edges is discouraged since frequency instability or excessive bandwidth may cause emission outside the authorized band. Crystal control of frequency is not required.

Input power–The final input power expressed in milliwatts (watts/1000) is equal to the D.C. collector voltage (in volts) multiplied by the D.C. collector current (in milliamperes) at the final power stage of the transmitter.

Field strength–Radiated field strength is measured in microvolts signal per meter of antenna length at a specified distance from the radiating source. Equipment necessary to measure this accurately is complex.

Total antenna length–The total antenna length includes the length of the radiating element plus the length of the transmission line.

Low Power Radio Frequency Devices (FCC part 15)

Low power communications devices may be used for the transmission of signs, signals (including control signals), writing, sound, or intelligence of any nature. Operation of transmitters in this category require no station or operator license. Frequency bands available are 10-490 kHz, 510-1600 kHz, and 26.96-27.27 MHz. No interference may be caused to other equipment operating in these bands. In the 10-490 kHz band, field strength must be limited to 2400/(frequency in kHz) uv/m at a distance of 1000 feet from the transmitting antenna. An alternate requirement for devices operating between 160-190 kHz is that input power be restricted to 1 watt and total antenna length be limited to 50 feet. On the 510-1600 kHz band (standard AM broadcast band) the final power must not exceed 100 milliwatts and total antenna length must not exceed 10 feet. On the 26.96-27.27MHz band (Citizen's band) the input power is restricted to 100 milliwatts and total antenna length to five feet. In all cases, spurious emission (e.g. harmonics) outside of the authorized bands must be surpressed at least 20 decibels below the carrier signal.

FM Broadcast Band (FCC Part 15)

Operation in the 88-108 MHz band is permitted for one-way communications devices such as telemetry equipment and wireless microphones. No interference may be caused to the reception of licensed broadcast stations operating in this band. Devices operating in this band must have FCC type approval, which is granted only to manufacturers of 10 or more units after rigorous testing by FCC. This requirement can be waived for educational institutions provided the device is certified by a qualified technician. Emission from such devices must be contained within a 200 kHz bandwidth centered on the operating frequency and may not extend beyond the band edges. The field strength may not exceed 50 uv/m at a distance of 50 feet and spurious emission outside the authorized band must be suppressed at least 10 decibels below the carrier signal. This band is not very practical to the individual rocketeer but is well suited for mass-production of telemetry equipment.

VHF Amateur Bands (FCC Part 97)

The 50-54 MHz and 144-148 MHz bands are available for operation of any radio frequency device by holders of a Technician or higher class amateur license. Other higher frequency bands are also available but are not very practical for rocket telemetry purposes. Maximum final power input is 1000 watts and no restriction is imposed on antenna length. To obtain the Technician license, the applicant must pass a 5 word/minute International Morse Code sending and receiving test, and a multiple-choice written examination on basic radio theory and FCC regulations. For further information on amateur licensing contact the American Radio Relay League, 225 Main Street, Newington, Connecticut 06111 for a list of amateur publications.

Of the bands described above, the FM broadcast band and VHF Amateur bands probably offer the least interference to reception. Also, the higher frequency bands require less antenna length (length is inversely proportional to frequency). The standard AM Broadcast Band is recommended for beacon transmitters since most portable transistor radios incorporate a directional loopstick antenna useful for direction-finding. Transmitters operating in the 26.96-27.27 MHz band may be received on an ordinary Citizen's band walkie-talkie or transceiver. At present, no other bands are available for radiotelemetry which serve any practical use to the rocketeer. Contrary to popular belief, a Class C or D Citizen's band license does not permit higher power operation of telemetry equipment in the Citizen's Band. Part 95 of the rules specifically prohibits the use of radiotelemetry in that service.

The author will gladly answer any inquiries related to telemetry or FCC Rules and Regulations. Address all questions directly to Carl Kratzer, 7201 Selkirk Drive, Bethesda, Maryland 20034.

References:

1. FCC Rules and Regulations, Volumes II and VI, Government Printing Office, Washington, D. C.

The Thumba Rocket Range

by Hormuz P. Mama

Sounding Rocket Launching Site in India

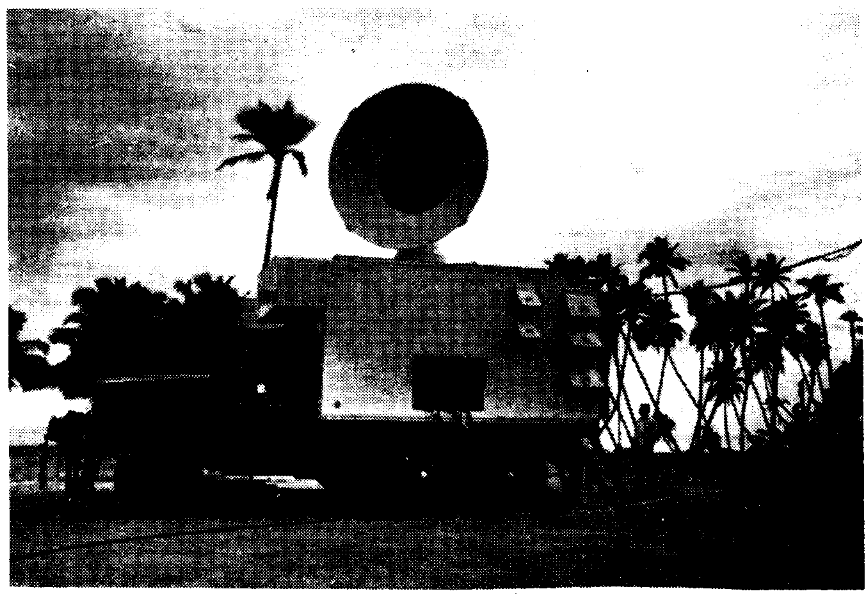
The earliest attempt at the scientific investigation of upper atmospheric conditions by means of instrument-carrying, high-altitude, rockets was undertaken at the White Sands Proving Grounds, New Mexico, in 1945. Since then, over forty such launching sites have been set up all over the world.

India, which today has a fairly diversified space research programme, took a step in this direction with the setting up of the Indian National Committee for Space Research (INCOSPAR) in 1962 under the Department of Atomic Energy. At the outset, the Committee undertook a detailed study of the entire southwestern coastal belt from Trivandrum to Alleppy for a suitable rocket launching site close to the geomagnetic equator– the line passing through points at which the magnetic field is parellel to the Earth's surface. The geomagnetic equator crosses the Indian subcontinent very close to Quilon at about 8½ degrees N latitude. For reasons of range safety, however, the final choice fell on Thumba, a small sparsely populated village only 4 miles north of Trivandrum.

The north magnetic pole is over 560 miles away from the geographic north pole, and on the same basis, the magnetic equator does not coincide with the geographic equator. On the other side of the Earth it crosses Peru in South America at about 11 degrees S latitude. While the intensity of the magnetic field along the magnetic equator is the highest between India and Borneo, it is the lowest over South America. Thus there is over Thumba a belt a few hundred miles thick, between the top of the F region and the region of trapped particles, which offers considerable scope for scientific investigation. Today the International Equatorial Rocket Launching Station, as it is officially known, occupies a vital position as a land-based launching site situated almost on the magnetic equator.

The location of the launching site offers unique facilities for research on the iono-

Reprinted with permission from **Spaceflight**, the journal of the British Interplanteary Society, July 1968.



The Small Judi-Dart Launcher

sphere and the meteorological problems peculiar to this region. The ionosphere over this region has features like the equatorial electrojet which can best be studied from here.

Site Development

Prior to the establishment of the site, Thumba was a small coastal fishing village surrounded on three sides by palm trees as far as the eye could see. Today the few old buildings, including a church and a school, have been joined by a 187 foot-high instrumented meteorological tower, a block-house with 12 inch thick reinforced concrete walls, and 4 inch thick explosion-resistant glass, rocket launchers, and a wide range of equipment.

On 11 October 1962, the U.S. National Aeronautics and Space Administration and India's Department of Atomic Energy signed an agreement to co-operate in a programme of space research for peaceful purposes. Much of the ground- based equipment at Thumba, including the rocket launchers, a telemetry equipment trailer, radar and computer vans, a DOVAP (Doppler Velocity and Position) trailer, etc., has been loaned by NASA. It also provided special training facilities to ten scientists of the Thumba technical staff, including the Test Director, Mr. H.G.S. Murthy, at Wallops Island, and at the Goddard Space Flight Center in the United States. While the launching site was designed and built by Indian engineers, NASA offered valuable technical advice. Other countries have also contributed equipment for Thumba. The Centre National d'Etudes Spatiales of France supplied a Cotal LV radar , photographic equipment, and the launcher for Centaure rockets. Similarly the Hydrometeorological Services of the USSR donated a Mil Mi-4 helicopter for payload recovery and range safety operations, a Minsk 2 digital computer, and some electronic equipment.

India offered at an early date to make the facilities at Thumba available to other nations for space research and soon obtained formal United Nations sponsorship as an international rocket launching facility. Setting up of the site proved to be both timely and invaluable for two major international synoptic sounding rocket launching programmes– the International Indian Ocean Expedition and the International Quiet Sun Year. International collaboration is being further extended and recently a Soviet radio frequency mass spectrometer provided by the Hydrometeorological Services of the USSR, along with some Indian instruments, was launched for the investigation of the neutral composition of the upper atmosphere.

The main objectives of space research undertaken at Thumba are: (1) study of the upper atmosphere, including the neutral particle and ion composition of the ionosphere; (2) the magnetic and electric fields associated with the equatorial electroject and their time variations in relation to solar activity; (3) meteorology of the stratosphere and mesosphere, and (4) selected aspects of rocket astronomy.

The Nike booster is brought out of the storage area.

Rocket facilities

Within a year of selection of the site, the first rocket, a Nike-Apache carrying a CNES sodium vapour payload, was launched on schedule on 21 November, 1963 after a 150-minute countdown. The bright orange sodium vapour trail stretched from an altitude of 50 to 110 miles. It was photographed from the four camera stations at Kanyakumari (the southern-most tip of India) , Kodaikanal, Kottayam, and Palayamkottai with Kodak Type K-29 cameras. This launching, along with two more in January 1964, gave valuable information on atmospheric turbulence, temperature, diffusion, and wind shears.

They were followed by four more Nike-Apaches equipped with magnetometers supplied by the University of New Hampshire to directly determine the geographic location, height, and intensity of the equatorial electrojet during the period of minimum solar activity in the 11-year cycle. Well over sixty rockets have since been fired from this site.

Various types of rockets are launched from Thumba. Initially all heavy payloads, for investigations in aeronomy, ionosphere physics, and magnetic fields, were carried by the Goddard Space Flight Center's Nike-Apache two-stage rocket utilizing solid propellent motors. It consists of a Hercules M-5 first stage having a thrust of 42,500 lb. and a Thiokol Apache second stage of 5000 lb. thrust. Other details include length (with payload) of 326.4 inches, first and second stage diameters of 16.5 inches and 6.5 inches, respectively, and a total launch weight of 1604 lbs. A payload of about 60 lb. can be carried to an altitude of 110 miles.

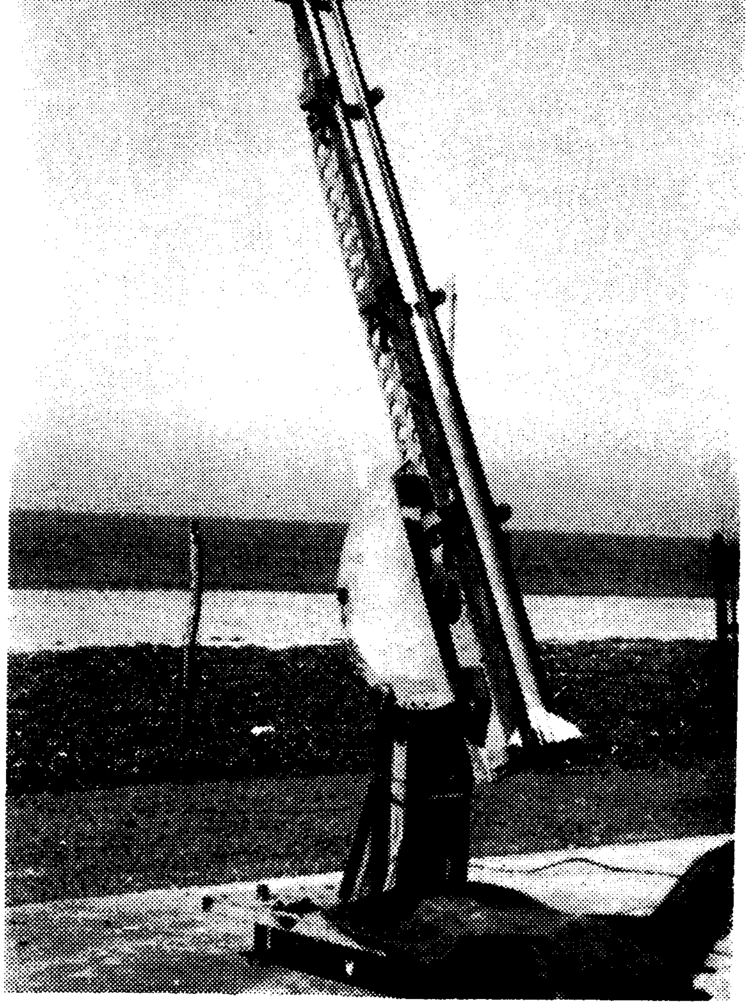
Apart from the direct purchase of the two-stage Centaure rockets from Sud-Aviation, India has also entered into a licence agreement for their manufacture. Construction of rocket cases for the first stage (booster) and the Belier second stage is under way at the Central Workshops of the Bhabha Atomic Research Centre at Trombay, Bombay.

The two-stage vehicle, with payload, has a length of 19.75 feet, first-stage diameter of 11 inches, second-stage diameter of 11.9 inches and a launch weight varying between 1014 and 1080 lbs., depending upon payload. Centaure is suitable for launching payloads of about 66 lbs. to 100 miles altitude. The first Centaure, launched from Thumba on 29 April 1965, was the first to be equipped with a completely Indian-made payload.

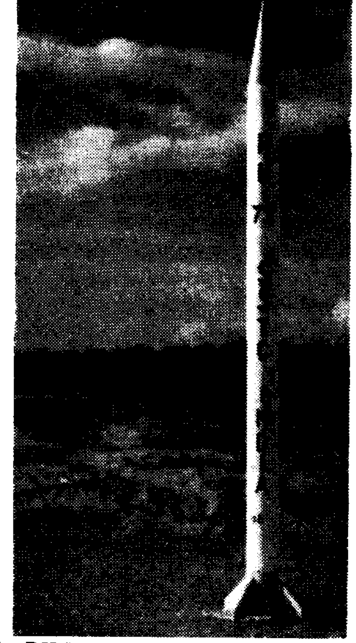
Lightweight chaff payloads are launched from the Judi-Dart for meteorological studies, for a better understanding of winds, temperature, and atmospheric composition. Produced by Rocket Power, Inc., it consists of a Judi-I solid propellent booster and an unpowered dart carrying the payload. It has a length of 8.6 feet, a weight of 33.3 lbs. and can carry a 3.0 lb. payload to an altitude of up to 240,000 feet. Judi-Dart is fired from a simple tubular launcher which can be inclined at any desirable angle.

While the rockets launched from Thumba until recently have all been of foreign design and manufacture, India has been concentrating for some time on the indigenous design, development and manufacture of rockets, utilizing the facilities now available. For example, the Space Science and Technology Centre have concentrated on the development of a single-stage rocket known as the Rohmi RH-75. This small sounding rocket made its highly successful maiden launch from Thumba on 20 November 1967, carrying a dummy payload. The RH-75 is to be followed by a two-stage vehicle capable of launching payloads to altitudes of up to 180 miles. It is expected to improve on the performance capabilities of the Centaure. Beyond these, a number of other rockets are to be produced– the present ultimate being a multi-stage satellite launch vehicle in the same category as the Scout.

These rockets are mainly to be used for research in the fields of aeronomy and astronomy. A subject of interest in the former is the region between the F-layer of



The simple mobile launcher with the Rohini installed.



The RH-75–the first of the Rohini series of sounding rockets.

the ionosphere and the inner Van Allen radiation belt. For research in X-ray astronomy, solar and stellar pointing systems are being developed.

Payloads and Equipment

While most of the payloads initially were of foreign manufacture, completely Indian-made instruments, produced at the Physical Research Laboratory, Ahmedabad, are now regularly used. They include integrated proton precession magnetometers and two types of Langmuir probes to study the magnetic field in the E region and electron densities, temperatures, and currents in the equatorial electrojet.

Among other Indian designed and produced equipment are the radar transponder and antennae for the French Cotal LV radar, telemetry transmitter, voltage control oscillator, ac-dc converter, and antennae for the telemetry transmitter.

Magnetometers are being used for the observation of changes in the vertical structure of the electrojet at different times during the day, at different times during a lunar cycle and during various degrees of magnetic disturbance, particularly at the sudden commencement and during the initial phase of a magnetic storm.

A concentrated zonal flow of electric current in the 50-80 mile region above the magnetic equator, the equatorial electrojet presents many interesting problems in aeronomy, particularly those related to the interaction of neutral and charged particles in the presence of the Earth's magnetic field which is exactly horizontal at the magnetic equator. This narrow current sheet has been responsible for the unexpectedly large daily variation of the magnetic elements near the geomagnetic equator, observed both in India and elsewhere.

The sodium vapour technique is among the most successful methods for the measuring of high-altitude winds by the ejection and tracking of aerosol type particles or vapours from rockets. Solar radiation reacts with the sodium atoms and molecules and the resulting resonance effect at 5890 and 5896A makes the cloud luminous and visible to ground observers for as long as 40 minutes. Changes in wind direction can be immediately observed by following the position of the cloud with time against the positions of certain stars. This method of wind measurements was first suggested by D.R. Bates and first put into practice by E.R. Manring and his co-workers, It can be used only at altitudes above 45 miles where the sodium vapour can be made to resonate by the ultra-violet solar radiation. In the lower regions of the atmosphere, the natural sodium present would absorb these radiations and no resonance would occur. Moreover, these experiments can be undertaken for only a few minutes every day during dawn and dusk when the sun's rays illuminate the vapour cloud and the observation posts on the ground are in darkness. A clear sky is also a major prerequisite and on many occasions, poor weather conditions have obstructed ground observers. For this reason, four camera stations have been set up, though two would normally suffice for triangulation.

To overcome some of these shortcomings of the sodium vapour payload, experiments have been undertaken with trimethyl aluminium. These vapour clouds permit wind measurements under conditions of complete darkness as the luminescence is produced by the reaction of this vapour with atomic oxygen.

The Central Workshops at present fabricate most of the major mechanical components of the various payload systems. Among them are different types of nose cones, stainless steel, and aluminium payload canisters for use with sodium, trimethyl aluminium and triethyl aluminium, precision components for payload recovery systems and equipment for the hazardous operation of charging the canisters with TMA and TEA.

The chaff payload of the Judi-Dart consists of several thousand copper-coated mylar needles which are 1/5000" in diameter and 2.1 inches long. The radar-reflecting chaff disperses in the atmosphere to form a column which is tracked by ground based radar equipment and the data obtained is processed with the help of a mobile computer unit. In this manner, information on wind velocity profiles and the distribution of eddy velocities in the column are computed. During some of these tests, easterly winds of between 60 and 90 knots were observed at altitudes of about 30 miles.

Chaff has the advantage of having a gentle rate of descent and is sensitive to any wind fluctuations. On the other hand, the needles gradually get dispersed as they descend and cause tracking difficulties at lower altitudes.

The Space Science and Technology Centre

The Space Science and Technology Centre is being set up at Veli Hill a short distance from the rocket launching site. Among its wide-ranging functions will be the development of sounding rockets of superior performance and of acquiring expertise in aerospace engineering as well as in ground based experiments and scientific payload construction. Many Indian experts, including some who were previously working in the same fields abroad, are now employed here. They are engaged in studies in such diverse fields as propellents, propulsion, structural engineering, aerodynamics, materials and quality control, control and guidance, technical physics, electronics, and mechanical and systems engineering.

A number of studies in the field of rocket technology have also been undertaken– the first tangible results being the development of the Rohini RH-75 rocket by a project group under Dr. Y. Janardana Rao. The SSTC has also developed the rocket's launcher and payload and is working on the composite propellent for it.

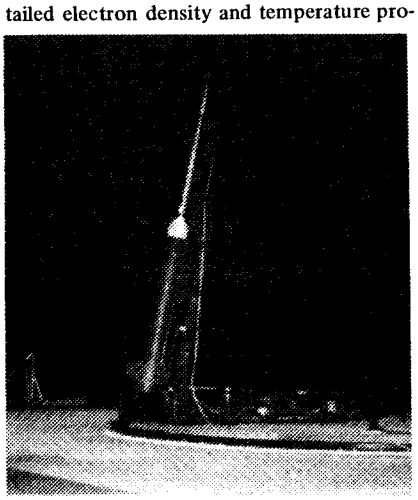
While the Centre is primarily meant to provide training and research facilities mainly for Indian scientists, a few foreign scientists will also be given the opportunity to work here. Both the SSTC and the rocket station will be available to universities to promote higher research in space science.

Inside the range block house.

Results Achieved

The rocket-borne experiments undertaken to date have added considerably to the existing meager store of information on the dynamics and composition of the upper atmosphere at equatorial latitudes. Valuable data on wind velocities, shears and regions of turbulence in the vertical profile of the neutral atmosphere from a height of 50 miles, through the E Region of the ionosphere to a height of 110 miles, have been obtained through chemical cloud experiments.

Ion probe measurements have yielded detailed electron density and temperature profiles of the ionosphere, particularly in the region of the equatorial electrojet. Proton precession magnetometers have been launched for a study of the structure, extent and movements of the current systems in the electrojet. Over Thumba, this current has been found to have a maximum intensity of about 13 amp/square mile at a height of about 65 miles.



A Nike-Apache rocket with a sodium vapor experiment contained in the nose.

Conclusion

While India has made a rather late start in this particular aspect of space research, it has been active in other fields for years. The Tata Institute of Fundamental Research, established through the energetic efforts of India's respected scientist, the late Dr. Homi J. Bhabha, has undertaken more than 100 balloon flights from Hyderabad since 1959 for cosmic ray studies near the magnetic equator. The only facility of its type in the world, this centre has carried out valuable research in this field.

Ahmedabad is the site of a Satellite Telemetry Receiving Station operated by the Physical Research Laboratory for obtaining scientific data from Earth satellites. It is also the site of an Experimental Satellite Communications Earth Station set up with United Nations assistance. Last August, the station successfully transmitted and received messages and television pictures for the first time via NASA's Advanced Technology Satellite 2.

An Automatic Picture Transmission system is in operation at the Meteorological Centre at Bombay. It collects cloud pictures over India and the adjoining areas from meteorological satellites like the ESSA. Similar units are also being established in other parts of the country. For fundamental research in radioastronomy, a powerful instrument is being set up at Ootacamund. It will be in the form of a 1650 foot long, 100 foot wide, parabolic cylinder and will be steerable in the east-west direction. Considerable work in astrophysics has been done at the Kodaikanal Observatory.

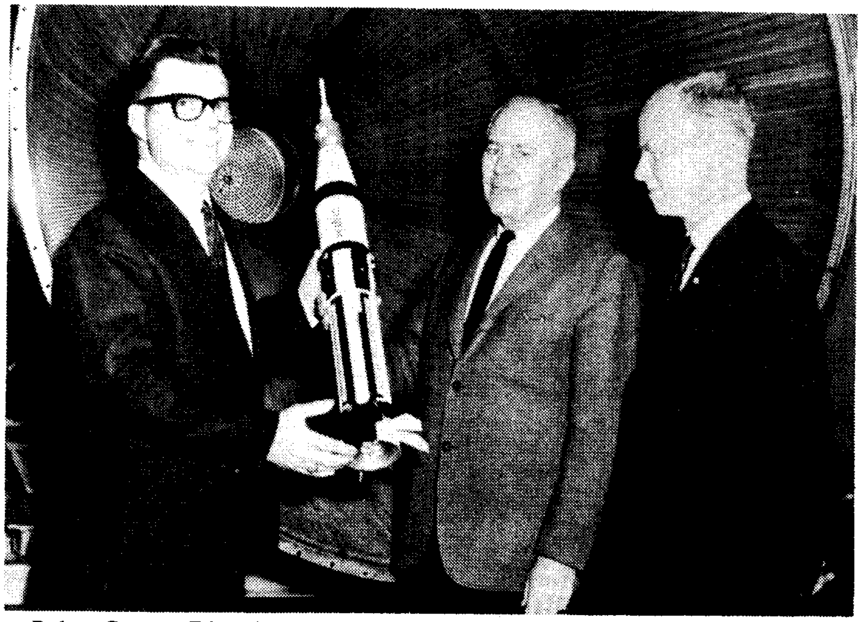
Recently, India, the USA, and Germany jointly undertook barium ion cloud experiments from Thumba. By studying the movements of this cloud under the influence of electric fields, information on these fields was obtained.

India is also planning to enter the field of rocket astronomy in the near future and payloads for the measurement of X-rays from discrete sources have been developed at the Physical Research Laboratory. Most of the work in X-ray astronomy to date has been undertaken from sites at higher latitudes and has been related mainly to the northern part of the celestial sky. X-ray astronomy studies of much of the southern celestial sky could be conveniently undertaken from Thumba– one of the few rocket launching sites to be so located. Apart from measuring the flux and the energy spectrum, the variation of the X-ray intensity of the sources with time will also be measured.

A satellite tracking station is to be set up at Trivandrum with modern equipment. Data collected from this site is also expected to help in the determination of the co-ordinates of South Indian stations to an accuracy of about ±30 feet.

As the space research program gathers further momentum, a satellite launching station will be established on the east coast of the country in the state of Andhra Pradesh and will become operational early in the next decade. Being on the east coast, this site will offer the advantage that the normal eastward launching would occur across the large stretch of water formed by the Bay of Bengal. While these efforts are admittedly insignificant in comparison with those of the United States and the Soviet Union, they are of sufficient magnitude to place India well within the first ten countries in the field.

Estes Saturn Presented to Smithsonian



Robert Cannon, Education Director of Estes Industries, presents a scale model Uprated Saturn I to the Smithsonian Institute, Washington, D.C. Receiving the model for the Smithsonian were Paul Johnston, Director of the National Air Museum, and F.C. Durant III, Assistant Director of Astronautics for the National Air and Space Museum. The model, constructed from the 1:70 scale kit manufactured by Estes Industries, will be placed on display at the museum.

NARAM-11 Events Announced

William Roe, Contest Director for NARAM-11, has announced that the following nine events will be flown:

- Scale
- Egg-Loft
- Pee Wee Payload
- Predicted Altitude
- Class 1 Parachute Duration
- Swift Boost Glide
- Sparrow Boost Glide
- Research and Development
- Plastic Model

No F-engines will be permitted in any event at NARAM-11.

As reported earlier, NARAM-11 will be held August 11-15, 1969, at the USAF Academy, Colorado Springs, Colorado.

News

Southwestern Model Rocket Convention

The ARC-Polaris Rocket Club is sponsoring the First Annual Southwestern Model Rocketry Conference to be held on the campus of Eastern New Mexico University on July 27, 28, and 29, 1969. The conference will feature a variety of events of interest to model rocketeers and science enthusiasts. A series of displays from the Manned Spacecraft Center, Centuri Engineering Company, Estes Industries, and various scientific laboratories in New Mexico have been scheduled.

William Gantz of the NASA test facility at the White Sands Missile Range will address the conference on the national space program. Colonel Larsen, Education Director for Centuri, will discuss new products that have been developed for model rocketeers and will present awards to the winners in the twelve areas of competition.

The conference will also feature a group of seminars on the applications of math, physics, and computer programming to model rocketry. A program for the analysis of the flight of a model rocket will be run Eastern New Mexico University IBM 360 Model 40K computer.

Rocketeers interested in the conference should contact James P. Miller, ARC-Polaris Rocket Club, PO Box 240, Portales, New Mexico 88130.

Krushnik Effect Takes 2nd in Science Fair

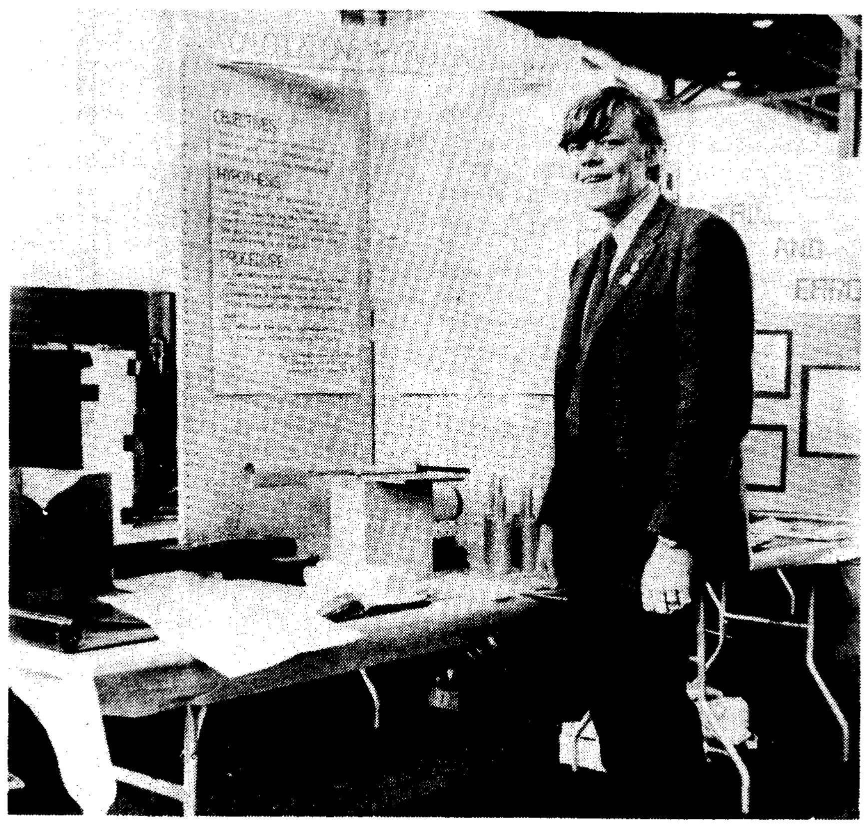


Photo by George Flynn

Paul Carlson's "Calculations on the Krushnik Effect" took a second place in the Massachusetts State Science Fair. The project had previously taken first place in the Wachusett Regional H.S. Science Fair. The Massachusetts State Science Fair is sponsored annually by the *Boston Globe* and held at the Massachusetts Institute of Technology.

YMCA Space Pioneers Schedule Record Trials

July 13, 1969

The YMCA Space Pioneers have scheduled a record trials, open to any NAR member, for July 13, 1969. The Space Pioneers Universal Record Trials No. 2 (SPURT-2) will be held from 1:30 PM to sunset at the Lapham Rocket Range, New Canaan, Connecticut. All categories of NAR and FAI records will be flown. Contact the YMCA Space Pioneers Contest Director, G. Harry Stine, 127 Bickford Lane, New Canaan, Conn. 06840 for further information.

Notes

Mass. Law Debated

A bill legalizing model rocketry in Massachusetts came a long way toward becoming law in April. The National Fire Protection Association Code No. 41L was presented to the Public Safety Committee. Speaking in favor of the bill were Gary Townsend of Andover, Mass., Harold Kritzman of Canton, Norm Smith of Cambridge, El G. Vozeolas of Lowell, and Tom Milkie of the MIT Rocket Society. The support of other individuals and clubs in the **Massachusetts Regional Conference for Model Rocketry** was also received. The supporters of the bill discussed the safety of model rocketry and its educational value. The committee later voted strongly in favor of the bill, and it appears that model rocketry may soon become legal in Massachusetts.

MRSC Schedules Division Convention

Division 1-A of Model Rocket Space Clubs has scheduled a convention- workshop on model rocketry. Convention Chairman David A. Tuskey announced that the convention will be held on July 26 and 27 at the Division 1-A headquarters, Wheeling, West Virginia. Members wanting further information should contact Division 1-A, Model Rocket Space Clubs, 2330 Eoff Street, Wheeling, West Virginia 26003.

The Underground Songs of the NAR

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

THUNDER

(Tune: "Thunder Road")

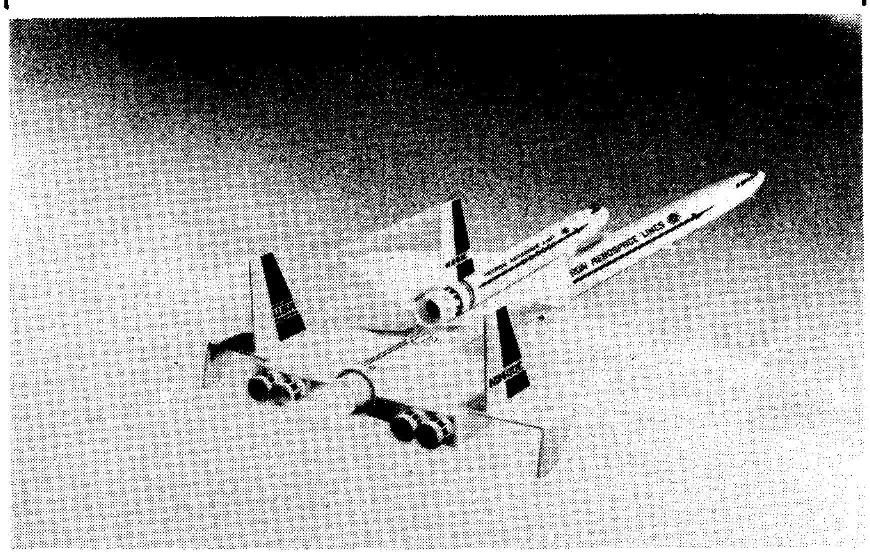
On the first of August, nineteen sixty-four
The fire marshal said, "Better fly those birds no more."
He sent five hundred agents, "We're covering the state."
They'd get the rocketeer that day, as sure as fate.

And there was thunder, thunder. O're the rocket range
Prodyne was his engine, and Chaos was his game
And there were brush fires, blown tires, by the rocket's burst
The law they swore they'd get him, but his rocket got him first!

Now it's four years later, nineteen sixty-eight
The Fire Marshal lost his battle, the new law he does hate.
Now we fly in freedom, no one to stop our shoot.
We crash and smash and prang and bang. . .and legally to boot!

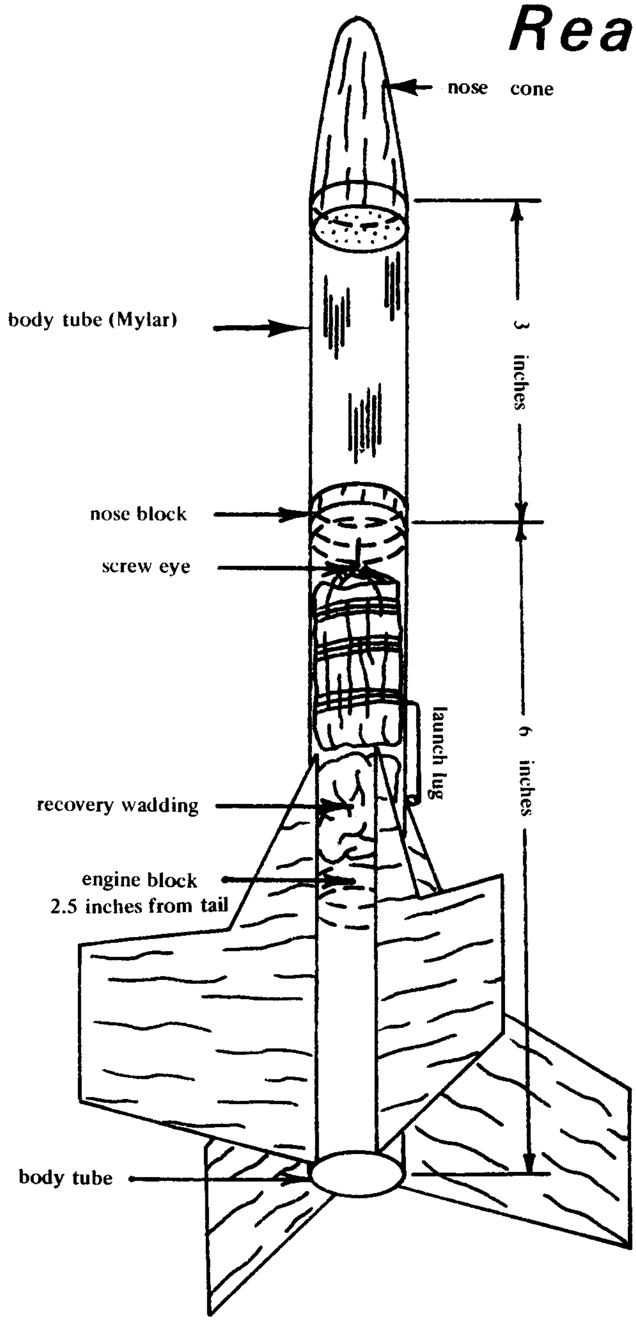
And there was thunder, thunder, O're the rocket range
Prodyne was his engine, and Chaos was his game.
And there were brush fires, blown tires, by the rocket's burst
The law they swore they'd get him, but his rocket got him first!

New Product Notes



The Orbital Transport, a new concept in boost glider design, has been introduced by Estes Industries. The model is launched vertically with a single engine in the booster stage. After burnout, a small piggy-back glider separates from the main vehicle and glides back to earth. The booster is recovered by parachute. Included with the Orbital Transport kit is a two-page booklet describing the orbital transport concept as it is comtemplated for future passenger transportation. The kit sells for $2.50 and is complete with a colorful decal sheet as illustrated.

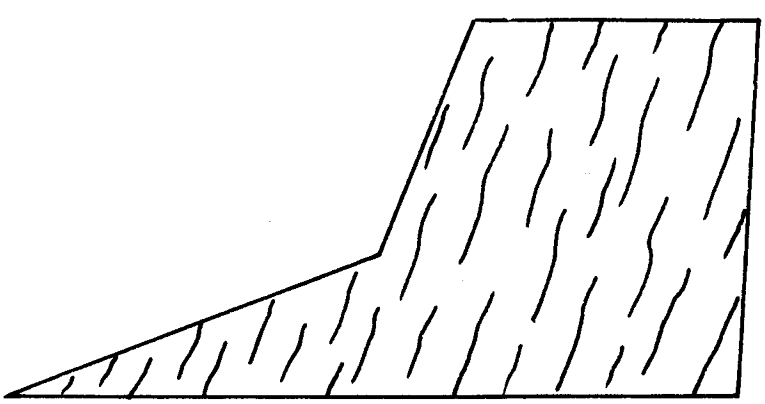
Reader Design Page



The *Lunar IV*, designed by Joseph Mann of Toronto, Ohio, is an extremely stable sport rocket due to its large fin area. It may be flown with any standard engine. Joe suggests that a booster may be added to the *Lunar IV*.

PARTS LIST

nose cone (Estes BNC-20E)
body tube (mylar) (Estes BT-10M)
nose block (Estes NB-20)
screw eye
recovery wadding
Parachute (Estes PK-12)
engine block (Estes EB-20A)
body tube (Estes BT-20D)
launch lug
fin stock (1/16 inch balsa)



FULL-SIZE FIN PATTERN

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

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

Here is another input device that can be used with the model rocket transmitter described last month....

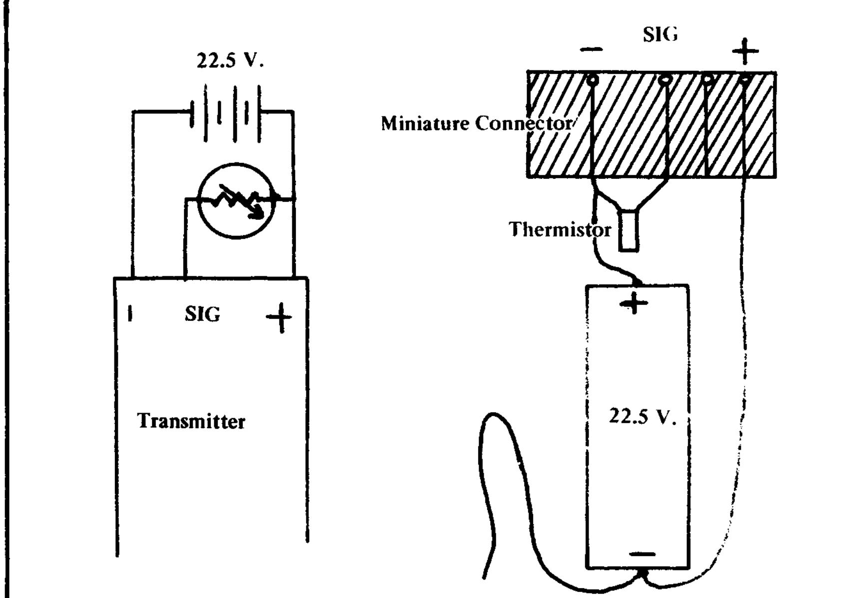
A Temperature Sensor

by Richard Q. Fox

Last month. I described the construction of a 100 m.w. 27 m.c. transmitter for use with model rockets. The transmitter has a range of over 1/2 mile, and is designed to transmit the information from any of a number of sensors. This article describes one such sensor, a temperature sensor, and its applicability to research projects. In addition, a device for calibrating signals sent by the transmitter is also described.

The application of model rockety to meteorology is tempting. In fact, there has been noticable correspondence on this subject sent to this magazine. Model rocketry is well suited to the study of meteorology, and especially to the study of the first 1000 feet of the atmosphere. Research is easy and interesting because the properties of this area change rapidly from one location to another and from one time to another. In fact, the air 1000 feet up is 10 degrees colder than the air at ground level! A model rocket instrumented with a temperature sensor could send back a temperature profile of the atmosphere in the vicinity of the launch field. The daily changes in this temperature profile, and its correlation to other meterological variables would be an excellent area for original research. In addition, the correleation of the temperature profile to the type of terrain being flown over should yield information on the updrafts and inversions in the areas.

On the more practical side, the temperature transmitter could even be used to help win in parachute duration contests. These contests are usually won by the lucky rocket that gets caught in an updraft. An updraft is usually caused by warm air rising. The temperature transmitter could be used to establish which areas of the field normally are warmer, rather than colder, at 500 feet, and the parachute duration vehicle could be launched into these areas.



Temperature Sensor Parts List

B1	Battery, Burgess Y15
TH1	Thermistor, Fenwal GA45P2, 50,000 ohms at 25 degrees C
	Connector, Lafayette No. 99-9091
	Battery Holder, No. 139

TH1 available from Allied Radio, Box 4469, Chicago, Ill. 60680. All other parts available from Lafayette Electronics, 111 Jerico Turnpike, Soyoset, N.Y. 11791

Construction and Flight

The actual temperature sensor module is simple to prepare for the transmitter. Refer to the schematic and pictorial for details. (The parts are all available from Lafayette Electronics, Syosset, Long Island, N.Y. 11791). The temperature sensing thermistor should be mounted so that the glass bead just barely sticks out of the body tube. The in-flight telemetered signal should be received on the ground and tape recorded. In addition, the rocket's altitude should be tracked and recorded frequently during the rocket's descent. The tracking observations and their relative times should be carefully recorded, as in Table 2.

Next, the recorded tones of the transmitter's flight should be converted into temperature information. (A device for doing this is described in the second part of this article). Finally, the temperature versus time information should be matched with the altitude versus time data to produce a plot of temperature versus altitude.

Transmitter Calibration Device

The output of the transmitter is a tone whose pitch is controlled by the sensor that is plugged into the transmitter. In order to obtain a relationship between the frequency of the tone and the value of the variable being measured, the transmitter-sensor combination must be calibrated. The best ways to calibrate the signal involve test equipment which is too expensive to be considered for this project. However, a good substitute–an audio frequency generator–is suggested here as the calibration device.

The calibration process consists of relating the frequency of the tone transmitted to a specific value of the variable being measured. The human ear is not very good

Table 2
Sample: Telemetered Data Table

Time (sec.)	Measured Altitude	Measured Signal Frequency	Calibrated Temperature
t+8(eject)	800'	8.5	64-degrees
t+10	770'	8.6	65-degrees
t+15	560'	8.8	67-degrees
t+21	465'	9.1	70-degrees
t+26	250'	9.4	73-degrees
t+29	0'	9.6	75-degrees

at determining the absolute value of a tone, but it is the most inexpensive and sensitive tone-comparison devise around. It can sense a difference between two frequencies of about two cycles per second. Given a tone of known frequency generated by an audio frequency generator, the ear can detect accurately whether a second tone is of the same frequency.

The calibration procedure for the temperature sensor would be as follows: With the transmitter operating, the sensor is dipped in a glass of water. The tone generated by the transmitter is then matched with the audio frequency generator tone that is closest to it. The temperature of the water is recorded along with the setting of the generator needed to produce the matching tone. Next, the temperature of the water is changed slightly. This will change the transmitted tone slightly. The auido frequency generator is rematched by ear with the new tone, the new temperature of the water, and the setting of the generator which produces the closest match to the frequency of the tone are recorded. This process is repeated until data covering the entire range of temperatures of interest is collected. This calibration data should be plotted on a graph.

Now, when the temperature sensor is sent into flight and its output recorded, the various tones of the recording can be compared with the tones of the audio frequency generator, and the settings of the audio frequency generator necessary to generate the matching tones can be converted directly into temperatures.

Construction

Construction of the audio frequency generator is straight-forward. The design does not contain any critical features. Mount the parts in a container and wire them together. Place markings from 0 to 10 on the box, around the shaft of the variable resistor. Mount a pointer on the shaft of the variable resistor.

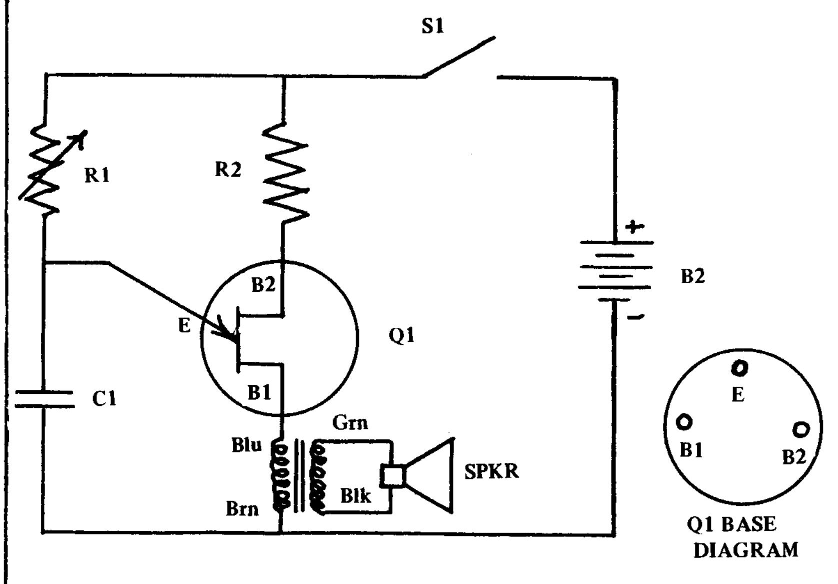
Next month, a spin rate sensor, and a direction finder for locating lost rockets with transmitters on board.

Transmitter Changes

The following substitutions can be made in last month's transmitter design if the resistors mentioned are unavailable:

R_2= 4.7 megohms
R_3= 4,700 ohms
R_4= 470 ohms
R_5= 47 ohms

27 m.c. Model Rocket Transmitter Sensor Calibrator



Q1 BASE DIAGRAM

Parts List

R1	Variable resistor, linear 0-100K ohms
R2	220 ohms
C1	.02 ufds.
Q1	2N2646
S1	SPST on-off switch
T1	Argone AR-174 transistor output transformer
SPKR	Speaker, 2 1/2", 3.2 ohms
B2	any 9 volt battery

Thc
Clustered

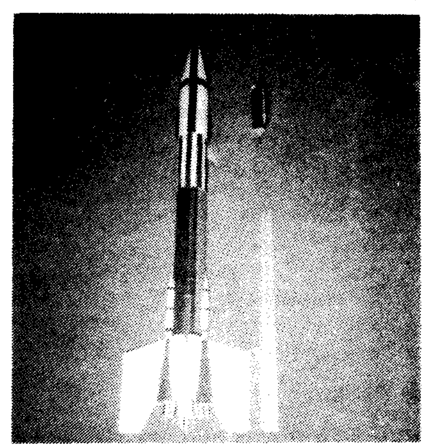
by Lawrence Brown

The design of the Centaur-B is intended more as an inspiration than as a blueprint. I have built a working model using a 1.8" diameter tubing, but the Centuri 2.00" tubing is more readily available here in Canada so I have "scaled up" the design. The distinctive features of this design are the combination of an accelerometer and a payload capsule and the parallel three-engine cluster. If flown with a one ounce payload, the rocket is capable of about 625 feet altitude, if three C6-5 engines are used. The rocket can also be flown with three B4-2 engines.

With an ST-20 body tube, the lightest engine mounting system would be to purchase an EM-20 and replace the engine holder tube with the longer ST-76. The long end of the ST-76 projects downwards and contains the central engine. Two ST-73 tubes are placed on either side of the ST-76 and glued to the base of the EM-20. Two slits are cut out of the ST-20 main body tube to receive the booster engines. An "Atlas type" streamlined skirt is added on each side. Vernier-like balsa fin supports are employed to brace the fins mounted perpendicular to the cluster line.

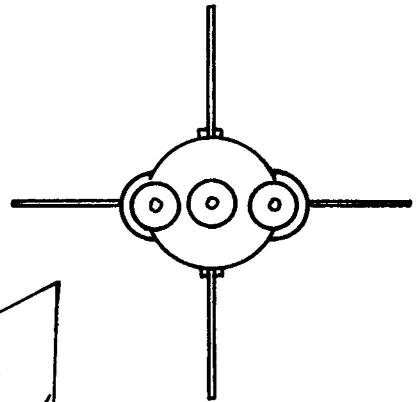
A band of chrome tape and a red, black, and white paint job take care of the aesthetics. Parachute selection should be based on the payload and local wind conditions. For initial test flights, three A8-3 engines can be employed.

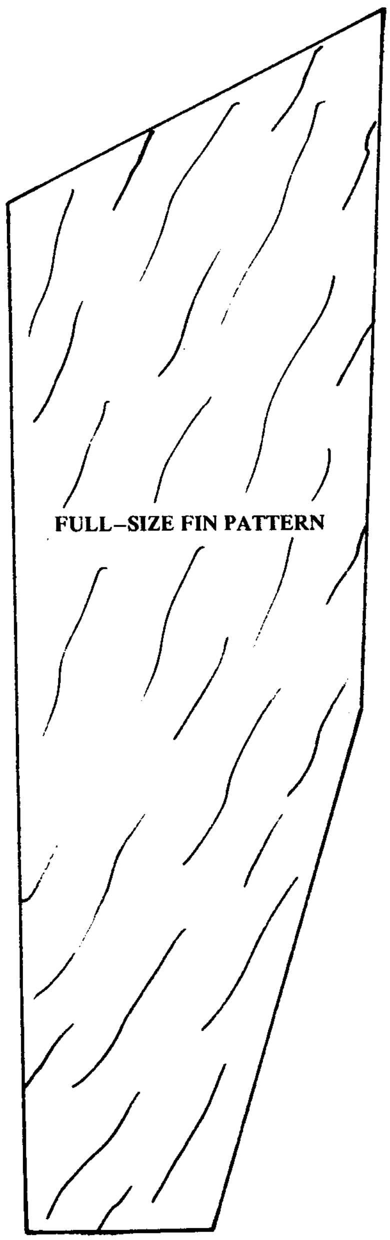
The parallel cluster design has a lot to offer. Rocketeers could profitably experiment with such combinations as two B14-0 outboard boosters with a long burning type E sustainer.

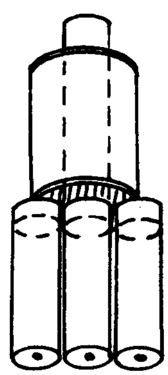


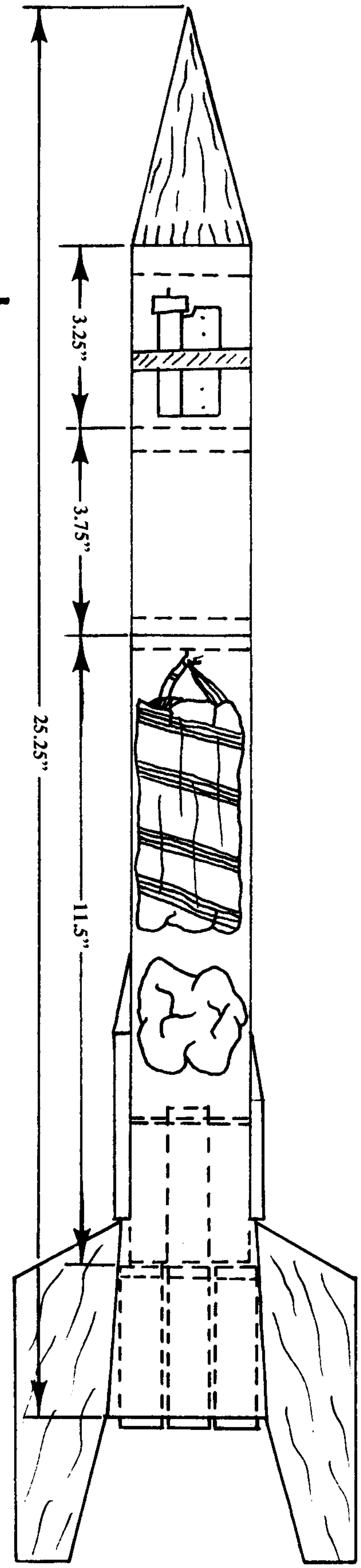
Centaur B

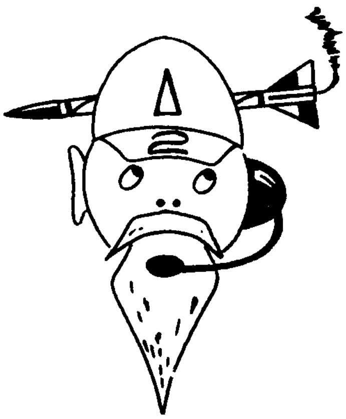
Payload Rocket











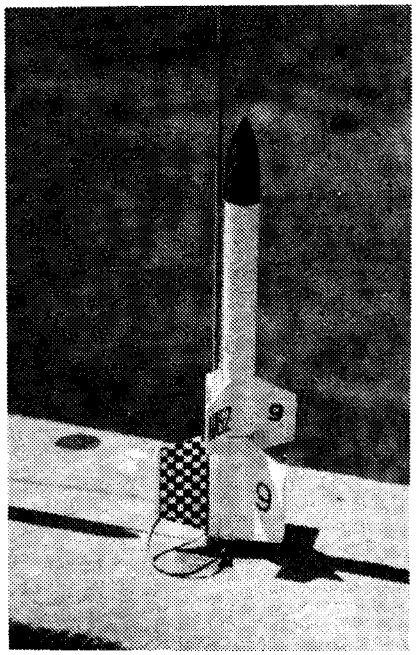
The Old Rocketeer

by G. Harry Stine NAR#2

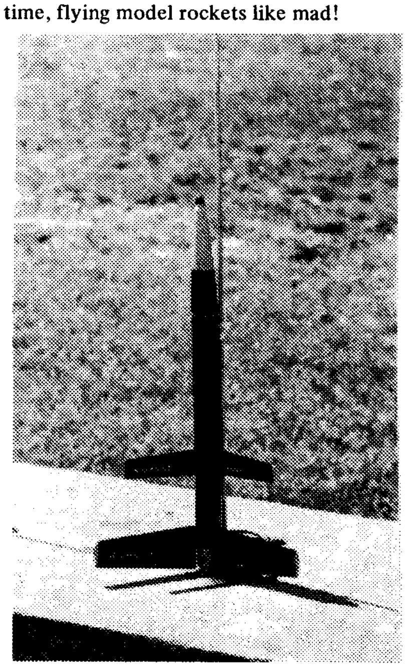
The European nations aren't the only ones outside the USA who are deeply into model rocketry. The Australians have gotten into it, too...and they are making progress in spite of the fact that their model rockets fly in the opposite direction from ours...(natch, since they're on the other side of the world!).

Chris J. Vine is President of the NAR of Australia, and he has written to tell us that their Association is well on the road. Last year, they held their first national meet down under with entries from both Australia and New Zealand. Some of these are shown here, but Chris told me that the photos of their scale models– X-17, Scout, Falcon, Astrobee-350, ASP, and Veronique–did not come out (too bad).

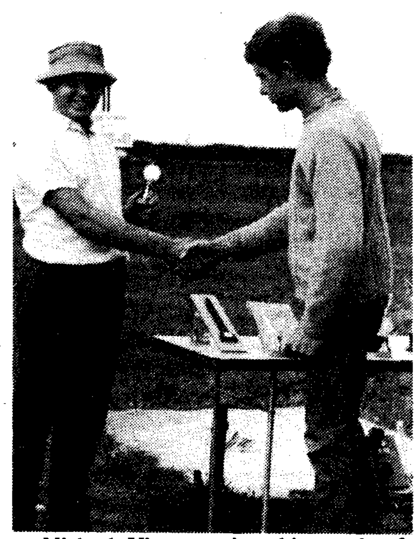
As you can see, Aussie modrockers fly with USA motors made by Estes and FSI. And, naturally, while we are huddled in our workshops with the snow blowing outside, they are outside in their December summertime, flying model rockets like mad!



A two-staged Class A-A (FAI Class 1) Altitude model.



A New Zealand two-stage entry in Aussie Class B-B Altitude (comparable to FAI Class 2 Altitude).



Michael Vines receives his trophy for winning Class A-A (FAI Class 1) Altitude event.

Exclusive Repor

Model Rocke

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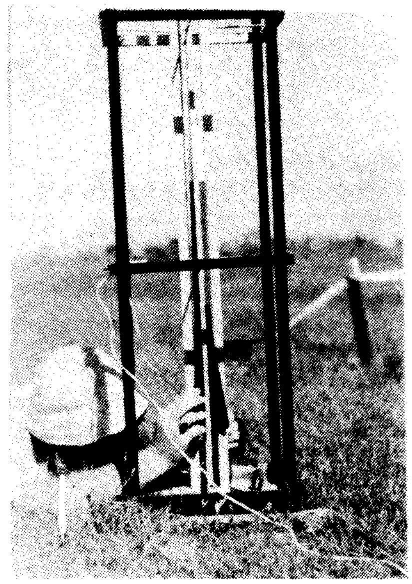
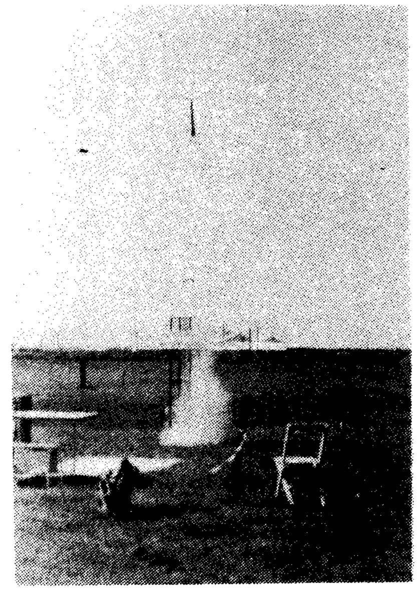
Trophies and award. sent

John Curry loading his scale ASP-1 into the launching tower. Australian Model Rocket Industries is not the same as MRI in Madison, Wisc., but is a rocket importing company down under.



Hook-up of the scale ASP-I by John Curry.



Lift-off of Curry's ASP-I with FSI Type E motor.

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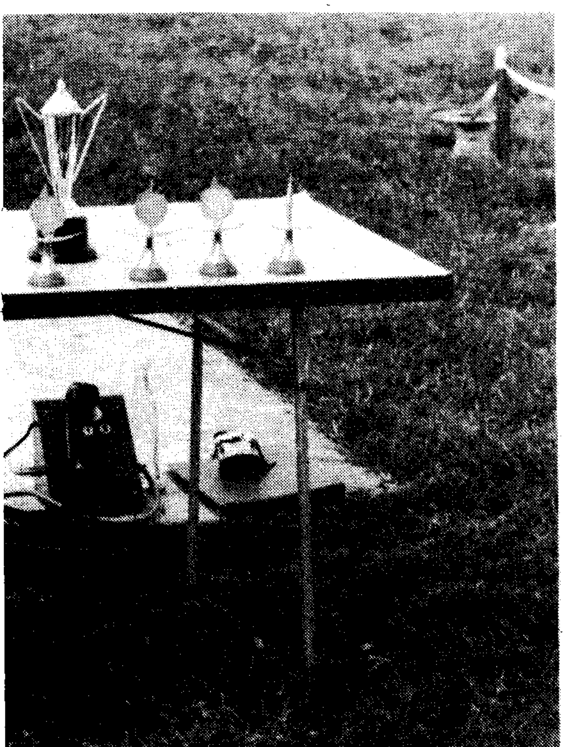


ed at irst Australian nationals.

Range control...and they get sunburned tonsils in Australia, too!

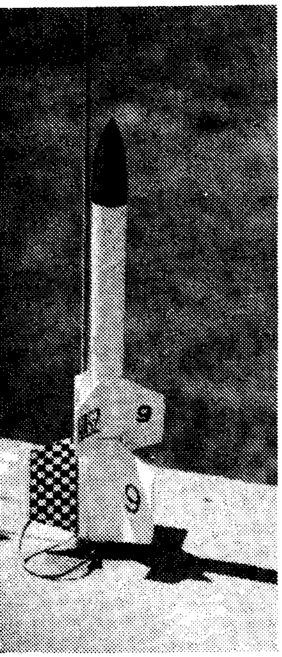
page 20/21 overlap

e Old Rocketeer

by G. Harry Stine NAR#2

Exclusive Report.....

Model Rocketry "Down Under"



aged Class A-A (FAI Class 1)
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Vines receives his trophy for
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John Curry loading his scale ASP-1 into the launching tower. Australian Model Rocket Industries is not the same as MRI in Madison, Wisc., but is a rocket importing company down under.

Hook-up of the sc
Curry.

Trophies and award. sented at irst Australian nationals.

Range contr

What's in a Range Box?

by Kevin Barkes, NAR 12335

Have you ever travelled fifteen miles to the nearest launch site only to discover that you've forgotten the engines? Or the igniters? Or quick-setting glue to fix that cracked fin? Don't consider yourself a scatterbrain if any of the above has happened to you, because it's plagued modrockers ever since the sport began. The mind of the rocketeer has oft been befuddled by such trifles, and the only solution to the problem is a well-stocked range box. . . . .

The range box is really a portable workshop which can handle about 99 44/100% of your range problems. (Just don't try to rebuild your three-stage bird in the middle of the launch activities.) It can be a lifesaver at a regional meet, and can also work wonders for the test flight of the new design you've been racking your brains on. Well, whatever, let's just see *what is* a good range box.

The range box is nothing more than a slightly altered fishing tackle box. The best sizes, I have found, are the 11 1/2 x 5 1/4 x 4 inch size (for use for one or two small rockets, or maybe a section meet) and the larger 19 x 7 1/4 x 6 inch size (for regional, etc., carrying launch rods, small altitude trackers, small rockets, and the like). Don't let the price sway you–it's a terrific buy in the long run (just count up the time you'll save from having to run home for something you forgot). Most (actually, all) of these boxes have sectionally divided trays that fold out as the box is opened. In most cases, the sections are too large, and can be subdivided by merely glueing pieces of cardboard in... (pillboxes work almost as well).

Divide the sectional tray(s) as above, and then reserve one section for hardware. This includes screw eyes of various sizes, nose cone weights, snap swivels, launch lugs, and any other small objects which are used in the rocket itself. Reserve another section for igniters. Experience shows that it's wise to take about twice as many igniters as you intend to use. It prolongs flying sessions and curbs heartbreak. Don't forget an extra set or two of micro-clips for that cluster rocket, or, for that matter, extra zip cord (carry about 5-10 feet of No. 18 size double conductor). While on the subject of launching equipment, I've found that an Estes Electro-launch (perhaps a tilt-a-pad) or any one of Centuri's firing panels will fit with room to spare. Bring along an assortment of

A typical range box contains the required components for a successful launch.

sandpaper and an emery board or two for cleaning off electrical terminals. If you use a C-rail instead of the standard launch rod, a strip of 1/8" balsa is handy. Engine holders are absolute necessity, as are tweezers and razor blades (modeling knives to you sophisticates). Have a few extra blades on hand if you have a kid brother that gets a kick out of spearing engine casings. Carry along some reinforcing material for that big bird or tumble recovery job. A bottle of white glue, as aforementioned, can save your neck in a quadrathon. Masking tape and cellophane tape are good to have around for securing engines in the airframe, or for patching the fins on the bird with the built-up fins. Some extra covering material (Monokote, silkspan, etc.) should be included for the more serious problems.

Now to the subject of recovery equipment. For you men out there who fly the big ones, bring along an extra silk chute, or your mothers portable sewing machine (them zig-zag stiches give one heck of a crazy glide pattern). I'll leave the rest of the equipment to the big boys–they have the experience (hurrah seniors, hurrah leaders). A ripped chute or burned streamer can send your plans of victory (as well as your flying field) up in smoke–and I'm speaking literally. Two rolls of flameproof recovery wadding is a must (Estes, Centuri, or even the rock-wool variety). Make sure that no spark can catch hold on the streamer or chute. Flying fields are hard to come by these days, and pyromaniacs add nothing to the sport except bad publicity. Carry a yard of streamer material, and three pre-assembled chutes of different sizes ready-to-go on snap swivels. The parachute kits available from the manufacturers are durable, reliable, and, I might add, vary inexpensive. If you're the industrious type, you can buy a square yard of raw material and have yourself a blast. Carry two yards of 1/8" and ¼" shock cord, and the new anchor rings offered by Centuri make repair jobs a breeze. Tape strips, which come either in the chute packs or separately, are extremely useful in repairing torn shroud lines. While on the subject of shroud lines, a 72 yard spool costs only $.25-cheap but a lifesaver. Parachute powder is a nice luxury to have and aids somewhat in tracking (the puff of smoke made by the powder can be seen at a distance).

If you're the type that gets a lot of excitment out of recording his fiasc- er -- flights for posterity, flight data sheets are handy and can be secured, again, from any of the manufacturers.

If you've ever cracked a fin on a rough landing (like dropping your Saturn-5 10 feet to a concrete floor) or demolished your entire stablilzing guidance control (how's *that* grab you?) *pre-cut* fins are convenient to have, but tedious to build. (ever try building a set of back-up fins for a three stage rocket? Brrrrrr!) Usually a variety of fin stock will do the job if you've got the time to do the job on the field.

Don't forget the engines!! I always carry a wide variety, and have about 15 at any one time in the range box. But just because you have such a choice, please, **PLEASE**, don't try to fly that featherweight bird with a B-14- or a C 6-. Not only is it risky (if you fly in your back yard), it gets hard on the budget after awhile.

Now we come to the cost. The large manufactures have specials at discount cost on their range boxes. Not only are they excellent, but even we juniors can afford them. The total cost, with the accessories that I've listed here, is in the area of about $15; well worth it, I may add.

Oh, one more thing--small parts can be kept in their tray by taping a piece of clear plastic fin stock (Estes cat. no. 651-CFS-40) on top of them. A lock is a good idea too--if you have some nosy observers on the launch site. And don't forget to take your rockets along, also: this can be slightly discouraging.

RANGE BOX CONTENTS

	Estes Part No.	Centuri Part No.
Range Box	**651-RB-1 or 2**	**FB-250**
Igniters	**651-NWI-1**	**IG-12 or nichrome wire**
White Glue	**651-WG-1**	**GL-40**
Knife	**651-KNS-3**	**XK-8**
Blades	**651-KNB-3E**	**XB-8**
Tweezers	**651-T-1**	**XT-7**
Flight Sheets	**651-DS-1**	**FDS-10**
Engine Holders	**Types vary, use catalog for specific information.**	
Reinforcing Mat'l.	**651-GR-2**	**SR-12**
Shroud Lines	**651-SLT-1**	**SL-70**
Tape Strips	**651-TD-2**	**TD-35**
Recovery Wadding	**651-RP-1A**	**PW-19**
Parachutes	**Wide variety available, use catalogs for reference.**	
Streamer Material	**651-SM-1**	**RS-20**
Snap Swivels	**651-SV-12**	**SW-12**
Shock Cords	**651-SC-1 or 2**	**SC-18 &18A, SC-20 &20A**
Screw Eyes	**651-SE-1, 2, or 3**	**SE-10, 12, or 20**
Nose Cone Weights	**651-NCW-1 or 2**	------
Masking Tape	**651-MT-1**	**MT-25 or 50**
Balsa Fin Stock	**Wide variety available, use catalogs for reference.**	
Plastic Fin Stock	**651-CFS-20 or 40**	------
Launching Lugs	**Wide variety available, use catalogs for reference.**	
Sandpaper Asst.	**651-SPA-2**	**MF-15**
Emery Boards	**651-BE-1**	------
Micro Clips	**651-MC-1**	**EMC-34**
Parachute Powder	------	**PDR-17**
Nichrome Wire	**651-NW-30A or 32A**	**EW-32, 32A or 32B**
Wire	**651-LW-12**	**EZP-12**
Cellophane Tape	**Any dime store.**	
Anchor Rings (for shock cord)	------	**AR-7 through 20**
Parachute Material	**651-PM-2**	**PCM-36**
Engines	**Take your pick!!**	

Technical Notes

George Caporaso

In recent months, the subject of dynamic stability has been thoroughly discussed.[1] The solutions to the dynamics problems now make possible the coupling of the oscillations to the vertical trajectory equations. Since Mandell's analysis makes use of the assumption that the *center of mass of the rocket does not move as a result of the oscillations*, we will restrict the following analysis to the same cases. For this assumption to be reasonable, we use as a criterion that *the natural oscilation frequency be large.*

Once this has been assumed, it can be seen that a reduction in velocity and hence in altitude will be caused by two separate effects. The first is *the reduction in the effective thrust due to the deviation of the thrust axis from the vertical.* The second is the *increase in drag with angle of attack.* Both of the effects just mentioned are dependent directly on the *angle of attack as a function of time.* For any particular disturbance, we can calculate the angle of attack from Mandell's analysis. We are then left with the problem of calculating the reduction in thrust and the increase in drag with angle of attack.

If a rocket pitches or yaws an angle α from the vertical (the assumed direction of the trajectory), the component of thrust in the upward direction is:

$$F_y = F\cos\alpha$$

where F is the thrust of the engine and F_y is the vertical component of thrust For small values of the angle of attack, which is just the range Mandell's analysis is valid for, we have:

$$F_y \cong F\left[1 - \frac{\alpha^2}{2}\right]$$

To compute the increase in drag with angle of attack, we write:

$$\text{Drag} = \left[k + \epsilon f(\alpha)\right]v^2$$

where k is the standard drag parameter for an angle of attack of zero and is equal to $\frac{1}{2} A_r C_d$, ϵ is some constant and $f(\alpha)$ *is some function of the angle of attack that goes to zero as the angle of attack goes to zero.* We have an accurate way of determining both ϵ and $f(\alpha)$ from Barrowman's concept of *the normal force coefficient.*[2] According to Barrowman the normal force on a body rotated through an angle of attack α is;

$$\text{Normal Force} = \tfrac{1}{2}\rho A_r C_{n\alpha}(\alpha)v^2$$

where $C_{n\alpha}$ is the *normal force coefficient.* Now the increase in drag of such a rocket is *just the vertical component of the normal force* which is:

$$\text{Increase in drag} = \tfrac{1}{2}\rho A_r C_{n\alpha}(\alpha)(\sin\alpha)v^2$$

which for small angles of attack (the region of interest) is:

$$\text{Increase in Drag} = \tfrac{1}{2}\rho A_r C_{n\alpha}(\alpha)^2 v^2$$

We see that the increase in drag goes as *the square of the angle of attack.*

Thus we have:

$$\epsilon = \tfrac{1}{2}\rho A_r C_{n\alpha} \quad \text{and} \quad f(\alpha) = \alpha^2$$

We are now in a position to write the general differential equations of vertical motion for the thrusting and coasting phases:

$$\frac{dp}{dt} = F(1-\alpha^2/2) - mg - \left[k + \epsilon\alpha^2\right]v^2$$

Coasting phase:

$$m_b\frac{dv}{dt} = -m_b g - \left[k + \epsilon\alpha^2\right]v^2$$

where m_b is the burnout mass, and p is the burning phase momentum.

It should be noted here that the solutions to the thrusting and coasting phase equations are not meant to be used for the detailed calculation of the altitude performance of a model since such calculations require an exact knowledge of the wind profiles for the entire flight plus a complete knowledge of any transient forces that might occur due to staging, launch tip off, etc. and would require almost endless amounts of computation. The solutions should, rather, be used to indicate how one should design so as to minimize the effects of dynamic oscillations on the altitude performance of his vehicle.

Such solutions have been obtained by the author for part of a section in a book on advanced model rocketry which will probably be published by MIT Press in late 1969, and will be presented in simplified form in a later issue of **Model Rocketry**.

For analytic simplicity and as an aid to understanding the principles involved, we will present solutions for inputs of the type used by Mandell; impulse, step, and sinusoid. We will then derive general design criteria for the minimization of the oscillation effects. We'll continue the solutions in next month's issue.

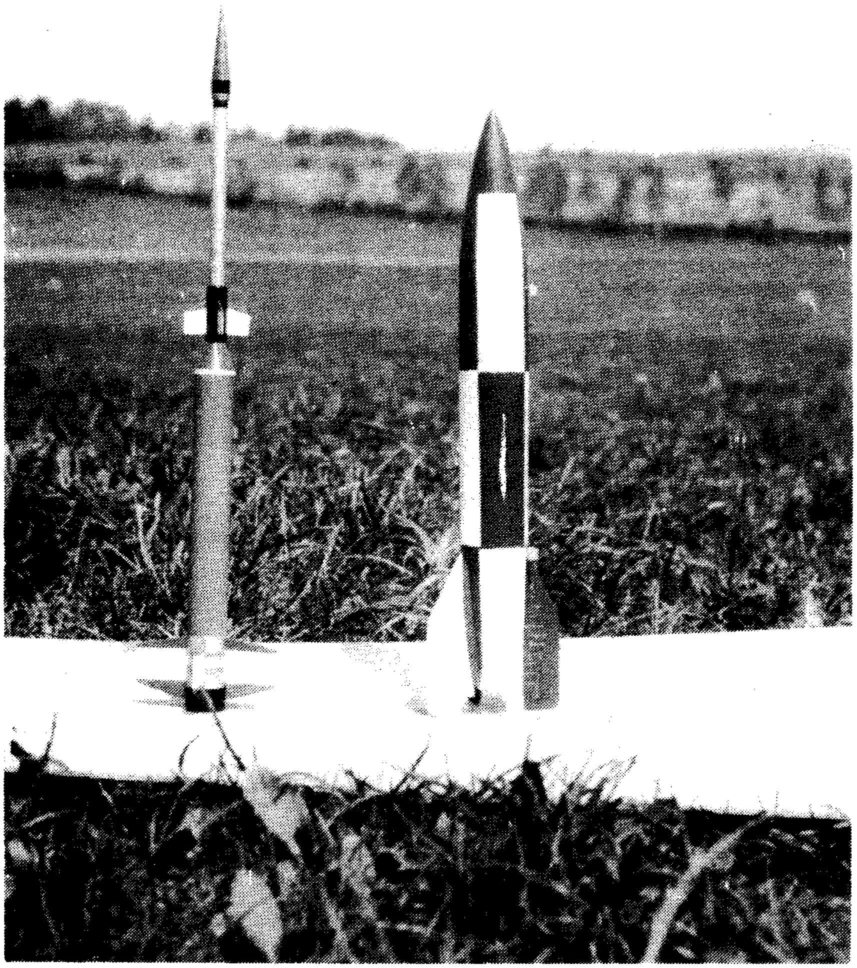
Switching to another subject, I'd like to give my views on some of the points made at the 1969 National Model Rocketry Convention held at MIT on the weekend of April 11. The Old Rocketeer said a few things that might make a few of you out there in fireworks land wince a little. He said that something was wrong with model rocketry. And he said that what was wrong with model rocketry is the fact that *it is known as a hobby.* It is billed by the press as a toy, and not as a possible scientific tool. Harry Stine called model rocketry a "technological recreation," and I couldn't agree with him more.

Everyone likes to "make smoke in the sky" with his rockets, but there is so much more to the field than that. Model rocketry is an incredibly complex, and at the same time, untapped scientific and technological field. Before there were Barrowman reports, Mandell dynamic parameters, or Malewicki altitude charts, there were model rockets, whose design was governed mostly by aesthetics, that flew and flew darn well. But no one knew why. Once someone tried to find out, model rocketry was no longer just a toy field. It was science, it was research, it was engineering, and it was still fun. It is a field where one does not need a PH.D. to reach the frontier of knowledge. Model rocketeers work at that frontier every time they launch a rocket, any rocket, because in reality, we know so little about the way things fly. I don't really believe that anyone can remain interested in this "hobby" unless he has the urge to do research, experimentation, or design work. I don't think anyone can remain interested in it if he doesn't try to apply some technology and ingenuity to his construction or design. Once you have that attitude, you're not playing with a toy, you're trying to launch a transmitter or camera, you're trying to understand and discover some of the essential features of aerodynamics, you're trying to design for optimum altitude, you're developing a new recovery method or working the bugs out of a new boost glider design and trying to figure out the why and the how of it.

In my opinion, the hobby can only grow and become stronger if the amount of scientific interest in it increases. And this is precisely what is occuring right now. We see it all around us, Barrowman, Malewicki, Mercer, Gregorek, Fox, Mandell, Audin. We see it increasing in regionals, the MIT Northeast Regional Research and Development Competition for one and in the form of technical articles by different authors in **Model Rocketry**. The "hobby" is succeeding in holding some of its older members, but this upward drive, this increase in the scientific aspects of rocketry must be sustained and increased to the point where no one will leave this field because he finds no challenge left in it.

1. October through March issues, "Fundamentals of Dynamic Stability" by Gordon K. Mandell.
2. "Calculating the Center of Pressure of a Model Rocket" by James Barrowman, Technical Information Report TIR-100, Centuri Engineering Co

PHOTO GALLERY

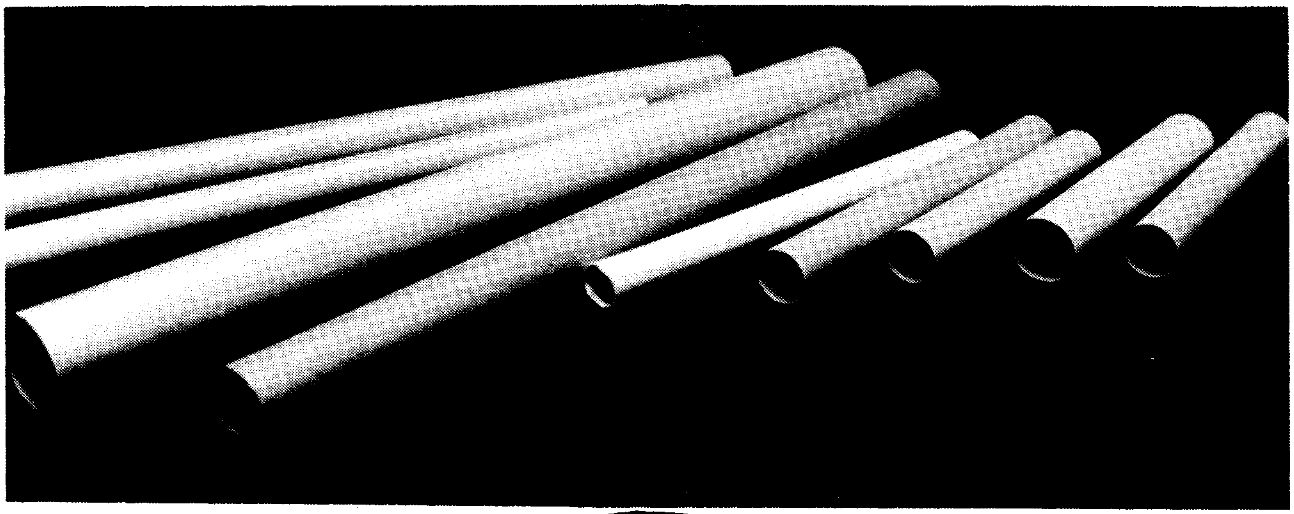


Scale competition at Vrchlabi, Czechoslovakia, in October 1967 (above).

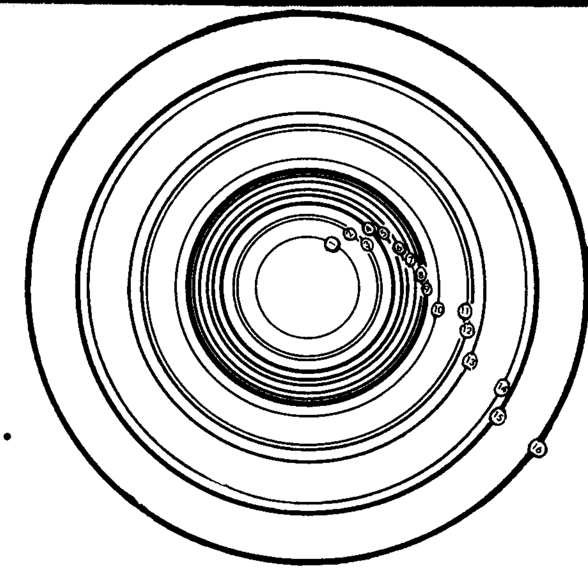
Readers are invited to submit photographs of their model rockets for publication on this page. Our staff will select those photographs having superior quality and composition for inclusion in the **Model Rocketry** *Photo Gallery. Send your photos to:*

Photo Gallery
Model Rocketry
Box 214
Boston, Mass. 02123

Harry Stine's loyal and hard-working recovery crew (below).



Which body tube should you use for that rocket you've designed?...



by Thomas Milkie

Body Tube Guide

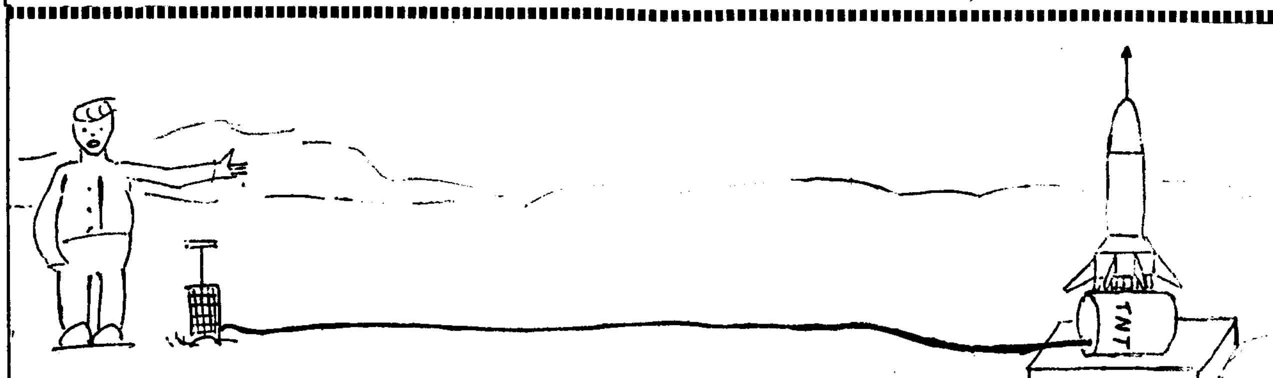
The model rocketeer today has a very large selection of body tubes to chose from for making that exact scale rocket, making a rocket for carrying that special payload, or making a rocket of a certain length with ease. Some body tubes are only available in certain lengths. Among the body tubes of one size there are many different wall thicknesses. The best choice is a tube which is strong enough for use yet as light as possible. Demonstration and sport rockets should therefore be built with stronger tubes for long use, while competition rockets should probably be built with the thinest available tube. All cardboard tubes today are spiral wound for perfect roundness, except for the Estes BT-30, which is parallel wound and is slightly stronger.

If the choices are too limited for some special rocket of yours, don't be afraid to go elsewhere for tubes. Mailing tubes, toilet tissue tubes, and wrapping paper tubes, although the finish is poor, are cheap. With a little patience you may be able to roll your own tubes with paper and corn starch glue.*

The code for the manufacturers is: E–Estes Industries, C–Centuri Engineering, RDC–Rocket Development Co. SEM–Semroc,Inc., FS–Flight Systems, MRI–Model Rocket Industries.

*An article on body tube technology will be featured in an upcoming issue of Model Rocketry.

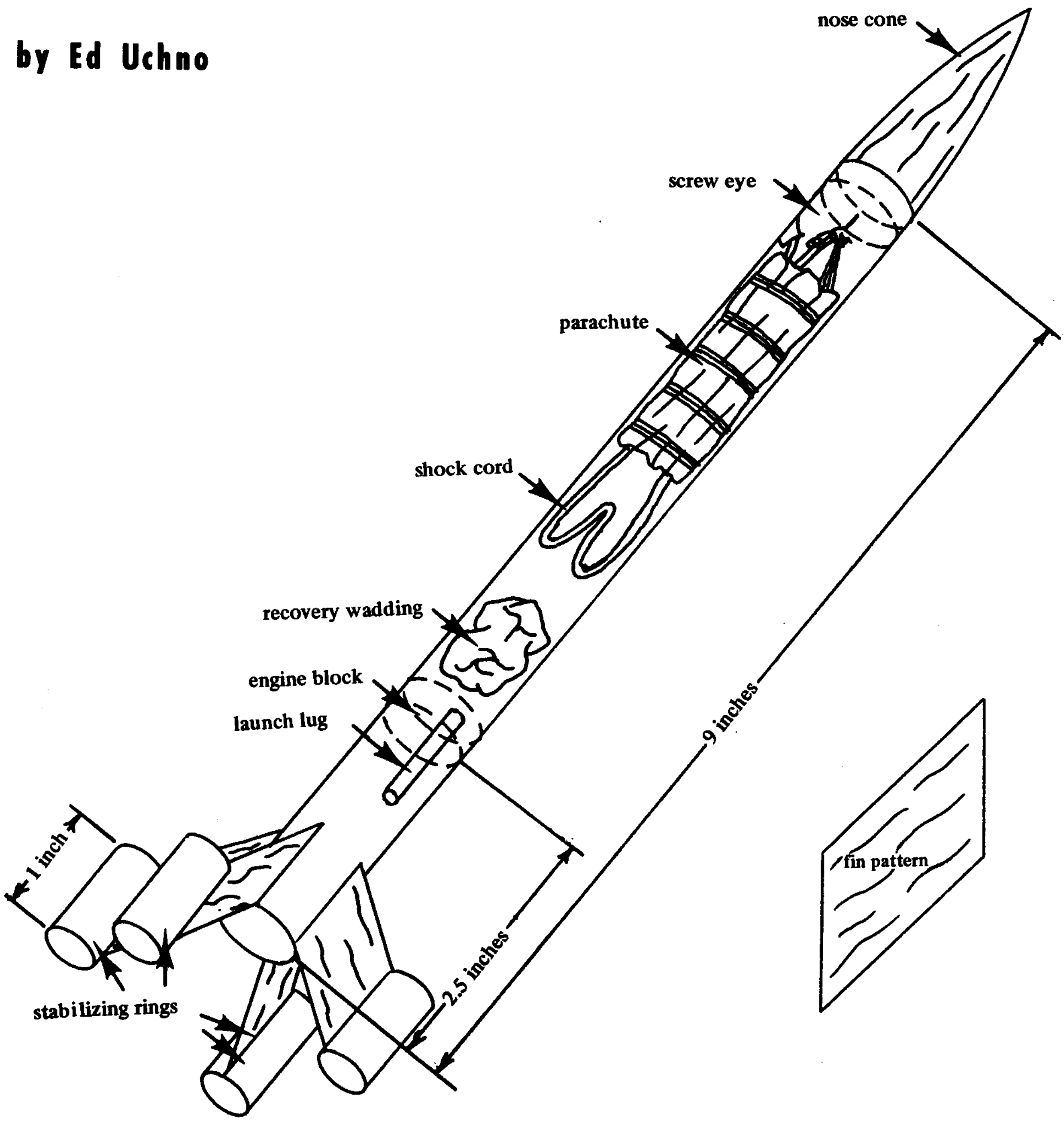
Diagram Number	Manufacturer	Cat. No.	Inside Diameter	Wall Thickness	Lengths	Remarks
1	E	BT-5	.510	.013	18, 5.1	
	C	ST-5	.515	.014	6, 12, 18	
2	E	BT-10	.710	.005	9, 3.06	Mylar plastic
		BT-20	.710	.013	18, 8.65, 6.5, 3.5, 2.75, 2.25	
	C	ST-7	.715	.022	18, 12, 9, 6.5, 3, 2.25	
		CPT-7	.715	.013	8, 3.25, 2.75 1.87	Plastic
	RDC	G-13, 14, 17, 18	.710	.02	12, 10, 6, 2.75	
	SEM	B-2	.717	.02	18, 12, 10, 3	
3	E	BT-30	.725	.021	9, 7, 6.1, 5.5, 3.5, 2.75	Parallel wound
4	C	ST-8	.865	.022	18, 11.3, 10, 8, 7.3, 3	
		CPT-8	.865	.013	11.25, 3.5, 2.5	Plastic
	FS	T-103, 104, 105	.875	.03	16, 8, 3	
5	E	BT-50	.950	.013	18, 12.7, 9.5, 7.75, 4, 2.75	
		PST-50S	.950	.013	4	Plastic
	MRI	T-22	.950	.02	6	
6	C	ST-10	1.00	.02	18, 10.5, 8, 5, 3	
		CPT-10	1.00	.015	18, 10, 3.5, 2.5	Plastic
	SEM	B-4	1.00	.02	18, 12	
7	RDC	G-15	1.07	.025	8	
8	FS	T-101, 102	1.125	.03	17.5, 5.75	
9	C	LT-115	1.14	.04	22, 16	Large series
		LBT-115	1.14	.04	8	For P.L. sec.
	MRI	T-30	1.15	.02	6	
10	C	ST-13	1.30	.02	18, 13.5, 8, 3	
		CPT-13	1.30	.015	18, 12, 6, 4	Plastic
		LT-125	1.25	.045	30, 22	Large series
		LBT-125	1.25	.045	8	For P.L. sec.
	E	BT-55	1.283	.021	18, 16.35, 4	
11	E	BT-60	1.60	.021	18, 11, 7, 5, 2.75	
		PST-60R	1.60	.021	5	Plastic
	C	ST-16	1.60	.02	18, 12.8, 5.25, 3	
	SEM	B-8	1.60	.02	18, 12, 6	
12	RDC	G-16	1.625	.02	12	
13	E	PST-65R	1.75	.023	5	Plastic
	C	LT-175	1.75	.045	30, 22	Large size
		LBT-175	1.75	.045	8	Large size
14	E	RT-70A	2.175	.021	0.7	For tail rings
		RT-70	2.175	.021	17.5	
15	C	LBT-225	2.25	.045	8	Large size
		LT-225	2.25	.045	30, 22	Large size
16	C	LBT-275	2.75	.045	8	Discontinued
		LT-275	2.75	.045	30, 20	Discontinued



This will be the first model rocket to fly supersonic.

The Flying CANDELABRA

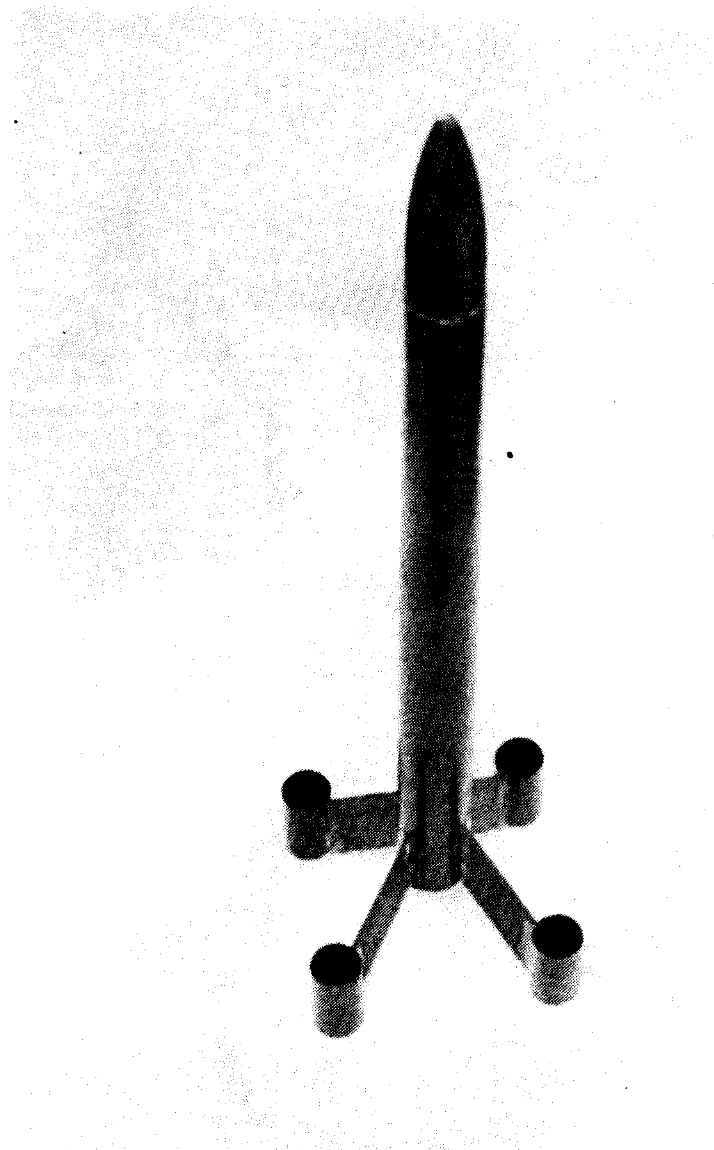
by Ed Uchno



Second in a Series of Oddball Rockets:

Utilizes both Fins and Hoops for added

Stability and Unique Appearance....



You may remember (I hope) the ring-tailed rocket called the Infinite Loop which was published previously in **Model Rocketry** magazine. Here's the second in the series of such ring-tail designs, the Candelabra.

Why the Candelabra, you ask? The name wasn't my idea. Upon completion of the rocket, a friend mentioned that it reminded him of a candelabra. No name had been planned on ahead of time, as usual, so Candelabra it was.

Unlike the Infinite Loop, Candelabra does not rely solely on rings to achieve stability. It has fins, but they are very small in relation to the rocket. These fins act as attachment points for the four stabilizing rings. It's hard to tell exactly how much stability is afforded by the fins and the rings individually, but my guess is that they contribute about equally.

It would be an interesting research project to change the size of the fins and rings in the Candelabra, trying to detect the effects of these changes on the stability of the rocket. In this way, the specific effect of ring stabilization can be determined.

By the way, some kind of idea as to fin versus ring stabilization can be seen in the fact that while the Infinite Loop needed two nose weights for stability, the Candelabra needs none. This added stability is partly due to the added area of the fins, and also because the swept-back fins places the stabilizing rings further behind the center of gravity.

Building the Candelabra is both a short and simple task. First, cut out four fins from the accompanying fin pattern. Sand these, rounding off the leading and trailing edges. Cover with clear dope and sand again. Cover with sanding sealer and sand, repeating this process until you are satisfied with the finish of the fin. Glue the engine block into the body tube, then glue on the fins. Apply glue fillets at all wing roots. Glue on the launch lug.

Take the BT-5P body tube and cut off four 1-inch pieces. Sand the rough edges, and then glue these rings to the tips of the fins.

Finish the nose cone in the same way as the fins. Glue the screw eye into place, and attach the shock cord and assembled parachute system. Attach the shock cord to the body tube in either of the two ways suggested in the Estes catalog. For a body tube of this size, it might be easier to use the quick-mount method which consists of slitting the body tube and inserting the end of the shock cord in the slot. Paint the rocket any color(s) you like.

That's all there is to it. You get pretty good performance and a unique–looking rocket for several minutes of work. Now you're ready to launch. Small engines should be used at first to test the strength of the construction job.

Parts List for the Candelabra

Nose cone	Estes 651-BNC-30E
Body tube	Estes 651-BT-30
Launch lug	Estes 651-LL-2A
Recovery system	Estes 651-PK-12
Shock cord	Estes 671-SC-1
Screw eye	Estes 651-SE-2
Recovery wadding	Estes 651-RP-1A
Engine block	Estes 651-Ens
Fin hoops	Estes 651-BT-5P
Fins	Estes 651-BFS-20

Saturn-1B lifts off before a crowd of spectators from the convention launch site at L.G.Hanscom Field, site of NARAM-5. Photo by George Flynn

On the scene report.....

The MIT Convention

Scale model Nike-Smoke streaks skyward.

Photo by Dick Koolish

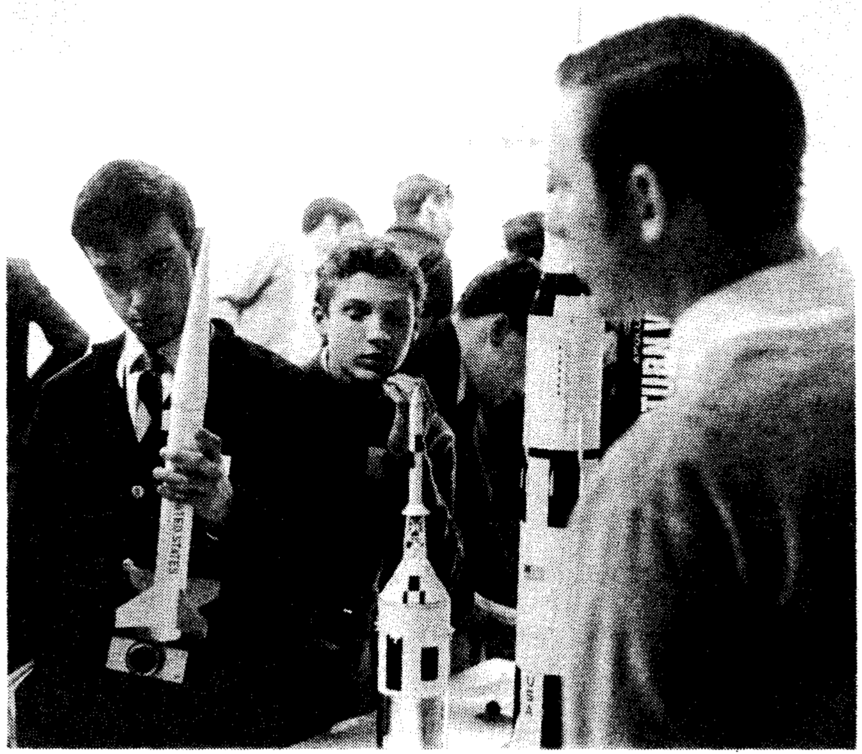


Photo by George Flynn

Leroy Piester displays Centuri's new product line including a scale Nike-Smoke, Little Joe II, and 1:100 scale Saturn V.

By George J. Flynn

The 2nd Annual MIT Model Rocket Convention opened with a plea by G. Harry Stine, the keynote speaker and former President of the NAR, for interested modelers to help change the image of the hobby. Stine emphasized to over 100 rocketeers gathered at MIT that model rocketry is more than just a hobby, it is a "technical, recreational, and an international sport." In order to obtain industrial support to finance US participation in International Meets, Stine expressed the belief that the technological and educational value of model rocketry should be stressed.

In keeping with the tone of the keynote address, the convention broke up into discussion groups later in the evening. A technical discussion on boost gliders, led by Gordon Mandell, considered the present state of boost glide technology. Discussion leader Mandell complained that B/G technology in the US has not evidenced any significant advancement in the past two years. Reasons for this were cited as (1) model rocketeers appear not to be thinking in terms other than hand launched gliders containing a pop-pod, and (2) that they do not possess the necessary technical and manual skills to produce a properly constructed glider of this form. Thus, B/G technology suffers from lack of diversification and underdevelopment of skills. Mandell stated that it has not been conclusively demonstrated that hand launched glider type configurations are optimal contest vehicles under all weather conditions. Dick Fox, George Caporaso, and Norman Smith guided the Research and Development seminar through such diverse fields as payload instrumentation and model rocket performance calculations.

Friday's festivities concluded with a discussion on "Model Rocket Failures and Catastrophies in Historical Perspective." Panalists included Stine, Norman Avery of Estes Industries, Leroy Piester of Centuri, Mandell, Jay Apt, and, according to the published description "everyone else who has experienced a catastrophic modroc failure." One of a group of Canadian modelers who attended the convention described an amusing incident. It seems they had planned to demonstrate a model rocket static firing at a formal dinner; however, the rocket broke loose and landed in the Fire Marshall's soup bowl. Manufacturers are understandably reluctant to discuss their failures, but Norm Avery provided a graphic account of a real Honest John firing in which the rocket picked up the firing truck and carried it a mile downrange because the launch lug got hung-up. The general conclusion of the group was that in model rocketry, whatever can go wrong will–and usually in a public demonstration launch.

This was proven the next morning, when the bus transporting the conventioneers to

Photo by George Flynn

Bo-Mar's display of new products attracted many rocketeers at the convention. Their new line of chrome-plated plastic nose cones proved popular.

Photo by George Flynn

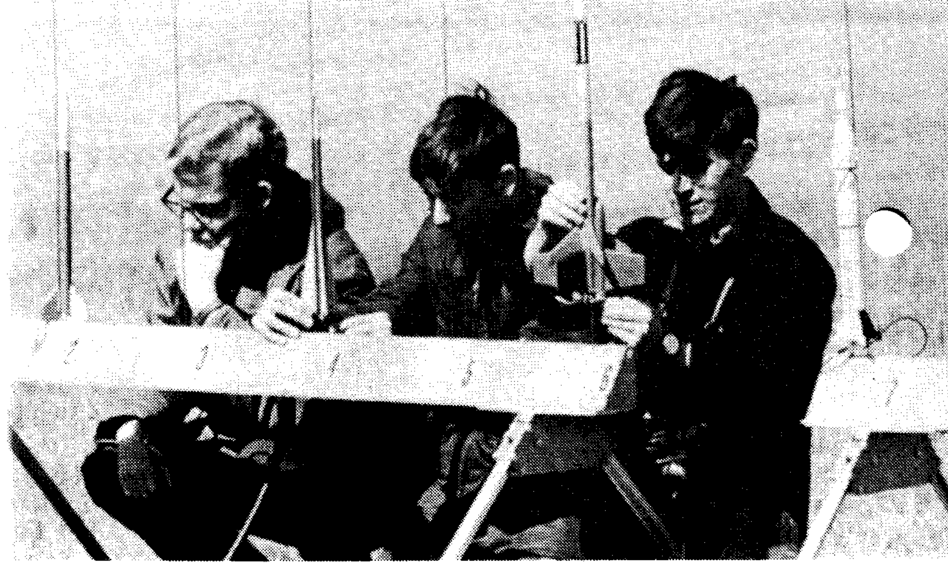
Charles Andres, of the Berwick Academy Rocket Society, presents an R&D report on the "Investigation of Rocket Mathematics" in the convetnion competition.

L.G. Hanscom Field for the launch arrived at the hotel late, quickly loaded, and sat there. Instead of beginning at 8:00 am, the launch actually started shortly after 9:00 am. Over 50 rockets were flown, including an Estes Saturn IB modified by Hal Kritzman to fly powered by a single F engine. True to form, another large engine exploded a few seconds after the TV cameraman was told how safe model rockets are. There was also some difficulty when the USAF van, on loan to assist in recovery operations, started sinking in the mud and the tow truck got stuck trying to pull it out.

Following the launch, the convention reconvened at MIT for the Research and Development competition (a regional event sanctioned by the NAR). Several papers were presented. Winning first place for his paper on *The Effect of Spin Stabilization on the Altitude Performance and Payload Carrying Effectiveness of Model Rockets* was Tom McKim, NAR No. 12438 Jr, from New Castle, Pennsylvania. Charles Andres, NAR No. 7829 Lr, of the Berwick Academy Rocket Society, Berwick, Maine, took second place with his *Investigation of Rocket Mathematics*. Third place was awarded to Charles Zettek, of Hopkinton, Massachusetts, for his investigation of *The Heli-Pop Recovery System.* Awards for the R&D projects were presented at the banquet, later on Saturday evening.

A program of movies shown after the banquet featured a brief 8mm sequence shot from a model rocket. The camera employed was home-made and weighed a mere six ounces. Historical films of the V-2 and Explorer I projects were also shown. Harry Stine brought along a 16mm film of the International Meet at Dubnica, Czechoslovakia, and Norm Avery provided a film tour of the Estes Industries plant at Penrose, Colorado.

The convention concluded with a final series of discussion groups. Carl Kratzer and Dick Fox discussed tansmitters, and suggested several experiments which could be performed with onboard instrumentation. Just down the hall, Harry Stine and Leroy Piester entered into a spirited discussion of what constitutes a scale model. Stine pointed out, in the Scale discussion group, that in railroading a model is considered scale if it is scale in all respects *except* for the couplers and the wheel flanges. This brought about the suggestion that competition rules be modified to permit larger-than-scale fins without loss of contest points if this was necessary for stability. The purists responded that this was not scale, but semi-scale modeling. While nothing was resolved, the discussion did expose the question of modification of competition rules to public discussion.



Loading the launch rack at the convention. Photo by Dick Koolish

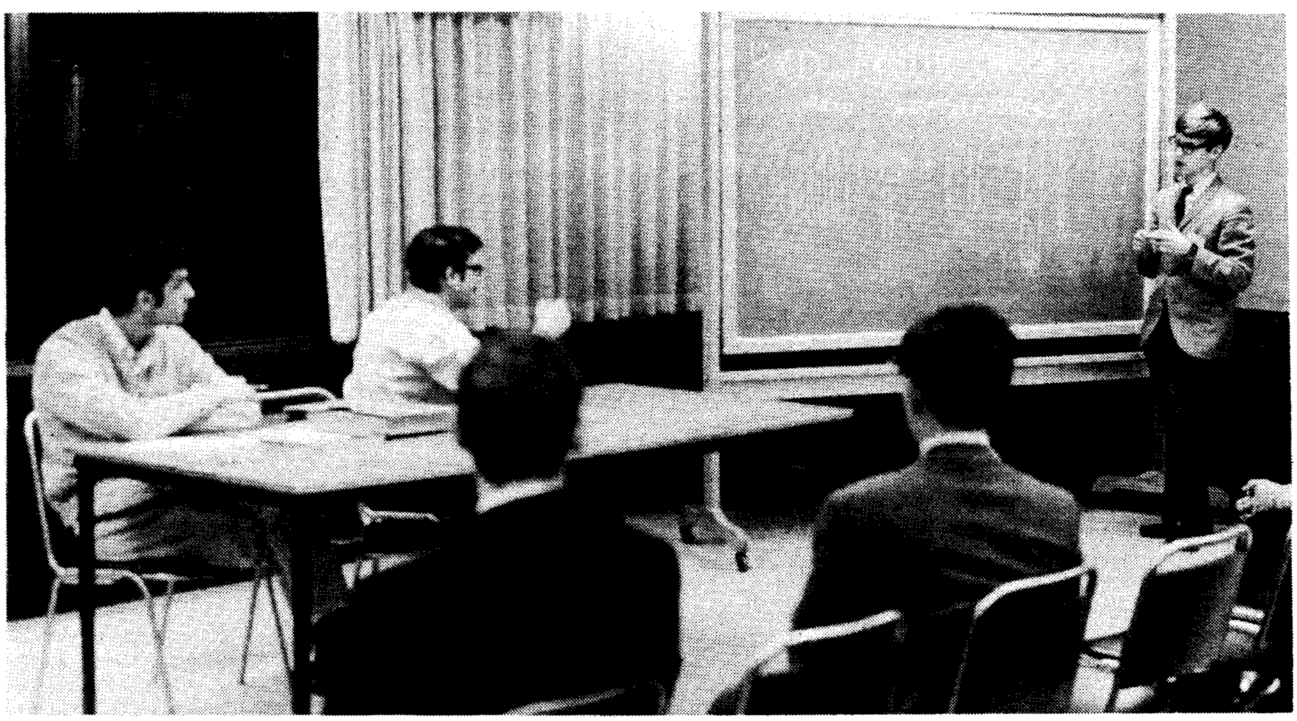
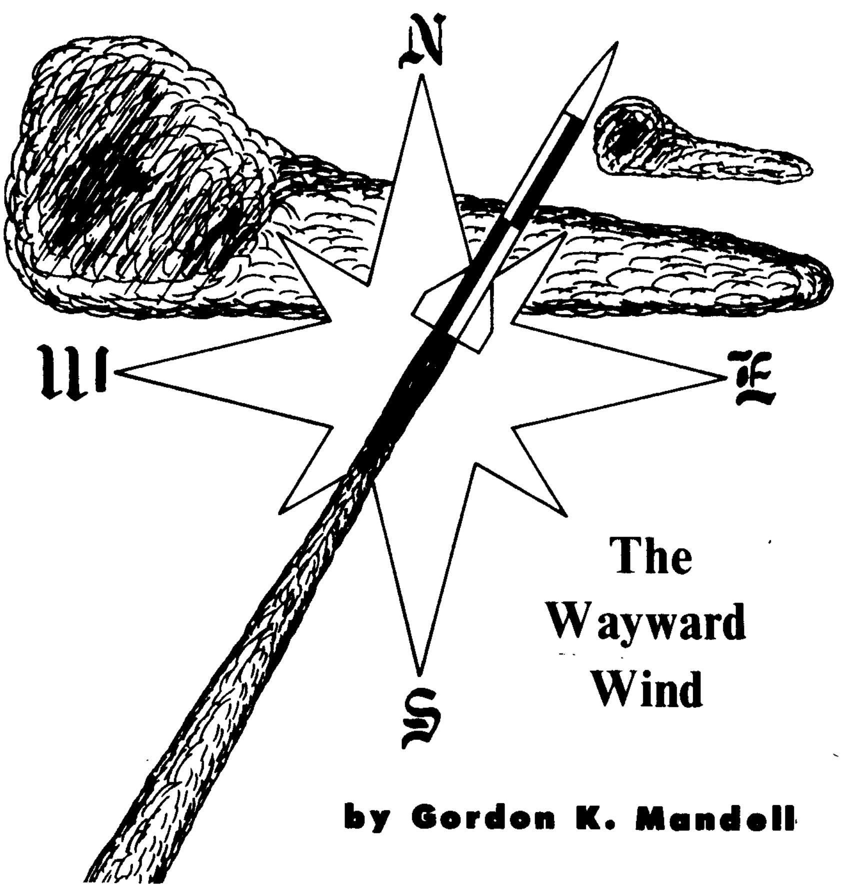


Photo by George Flynn

Marvin Lieberman discusses methods of measuring the pressure generated during the operation of a closed breech launcher.



The Wayward Wind

by Gordon K. Mandell

Ignition Technology

The spring convention season just past was a terrific morale booster for those of us who have been trying to improve communications within model rocketry and raise the hobby's level of technical competence to the point where it might justifiably be called—as Harry Stine put it at MIT—a "technological recreation." We are moving ahead on almost all fronts, both technological and informational. Advanced analyses and experimental data are being generated by a broader base of competent hobbyists than ever before, the industry is responding with more advanced kits, components, and support equipment, and the NAR is on the verge of a new era of greatly expanded growth and development.

Model rocketry is by no means out of the woods yet, though, and nowhere is this more evident than in the records of the launches held at both Pittsburgh and MIT. For while we seem to be emerging from the badlands of technological drought, we do not, as a group, seem to have developed that painstaking care and pride in workmanship characteristic of the true craftsman that is the rule rather than the exception in hobbies like model aviation. Improvements over 1968 in construction and finishing technique were in general evidence in most of the rockets flown at both conventions, but in relatively few cases did we see the kind of work found at most model airplane meets. In particular, there were unjustifiably many stability problems at Pittsburgh and an absolutely disgraceful number of misfires at both Pittsburgh and MIT.

It is true that some of the ignition difficulty was the fault of cold weather which contributed to human error in preparation as well as reducing battery voltage under load, and of improperly maintainted equipment. But there is no more excuse for a third of the birds in a launch sequence misfiring than there is for a quarter of them going ape. Anyone who can't get *at least* 90% reliability in ignition, given proper equipment and techniques currently in use, is just plain careless. Our present-day electrical firing methods are the product of more than twelve years of painstaking research and development, with the emphasis on real, nuts-and-bolts, in-the-field *development*. Model rocket manufacturers supply instructions for the use of their various ignitors so explicit that it is just unbelievable that even the youngest novice could fail to understand them. Ignition technology and its literature constitute one of the few aspects of model rocketry which has reached anything approaching a full state of development and in the face of this, the kind of technical sloppiness that lies behind the chronic misfireitis of far too many of today's modelers is simply not to be tolerated.

"But 'twas not always thus," whispereth the wayward wind. There was a time when a successful liftoff at the count of zero was the answer to a rocketeer's prayer rather than a precisely-controlled event to be expected as a matter of course. When Orville H. Carlisle invented the model rocket engine in 1954, reliable electrical ignition for any but professional rocket vehicles was a science fiction. The ancestors of today's model rockets were launched using fuses like those found in ordinary fireworks, made of tightly-rolled paper with a bit of black powder along the central axis.

By 1956 Harry Stine had learned of the Carlisle rocket and had tested several of the original Rock-a-Chute motors and vehicles. A professional engineer with extensive training and experience in rocket testing and safety, Stine realized that the Carlisle system offered great promise for replacing the increasingly dangerous unsupervised amateur rocketry activities then reaching epidemic proportions in the United States—*if* some means could be found for replacing the ignition fuse with a device which offered more positive control over ignition and the moment at which it occurred. The system he and his associates worked out for accomplishing this consisted of a length of Jetex wick doubled, inserted into the motor's nozzle, and connected to a source of electrical energy by means of a pair of Muller No. 85 alligator clips as shown in Figure 1. Jetex wick, produced by Wilmot, Mansour, Ltd., of England primarily for lighting the Jetex engines used to propel model aircraft, consists of a thin copper wire coated with a combustible compound whose major constituent is guanadine nitrate. Model rocket ignitors were prepared from the three-foot coils in which the wick is sold by pinching off two-inch lengths with the fingers, doubling them in the middle, and bending out both ends. Electrical contact with the alligator clips was provided by carefully stripping off quarter-inch lengths of the nitrate coating from the copper core at each end of the ignitor. To launch a rocket, the modeler inserted the doubled section of the wick into the nozzle until its end brought up against the propellant grain and held it in place with a length of masking tape or a parachute tape disk. He then placed the model on its launcher and clipped the Muller 85's to the protruding bare ends of the copper wick core. The alligator clips themselves formed the positive and negative terminals of an electrical system consisting of a battery, a spring-return push-button switch, and two ten-foot lengths of No. 18 AWG insulated wire as shown in Figure 2. With the electrical hookup completed, all that remained was to give a five-second countdown and press the button, closing the circuit and causing the Jetex wick to heat up to the point where its nitrate coating began to burn. There followed a puff of bluish smoke at the base of the rocket, a brief sparkle at the nozzle exit,

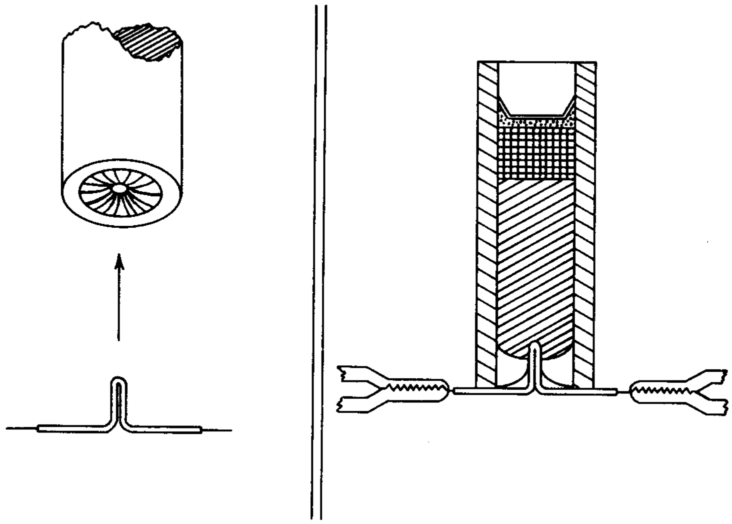


Figure 1. Electrical ignition using Jetex wick, 1957. Left: Jetex wick formed and stripped for use as an ignitor. Right: ignitor inserted into enging nozzle, bringing up against propellant grain, and gripped by Muller No. 85 alligator clips from firing circuit.

and–a quarter-second or so later– liftoff. Electrical ignition was born.

Electrical firing systems like that of Figure 2 appeared in the instruction sheets of the Model Missiles, Inc. Arcon and Aerobee-Hi scale models–the first model rocket kits (1958) to be offered for sale to the general public. Tins of Jetex wick were sold as accessories by MMI, and when the Model Missile Association was formed in October, 1957, electrical ignition was adopted as a part of the new organization's safety code–a feature that was retained when the name was changed to the National Association of Rocketry in 1958.

The development of electrical ignition systems continued at a rapid pace. Multi-position firing control panels, complete in many cases with voltmeters, continuity checks, and range communications installations, followed close on the heels of the appearance of multiple-rocket launch racks during the 1958-1959 period. The Mile-High NAR Section of Denver was the pioneer outfit in the multiposition ignition technology of this era, and virtually all club firing panels in use in the United States today still follow the basic layout of the Mile-High panel described in the old NAR Technical Report No. 2, dated 1959. The Mile-High panel, incidentally, still exists and is presently being renovated by Al Fox of Denver for use by the new Metro Denver Rocket Association.

Also in 1959 a technique was developed for adapting Jetex wick to the ignition of clustered rocket motors, opening up a whole new field of model rocket technology. The procedure here was to double over the *end* of a two-inch length of Jetex wick and insert it into the nozzle of one of the engines in the cluster. A similar length would be prepared and inserted into each of the other engines, as shown in Figure 3, after which the protruding ends of wick would be twisted together to form a single length of fuse. An additional one-inch length of Jetex wick served to ignite the whole arrangement, being twisted into the original three-wick array as shown. While this system generally worked pretty well, it had a few pitfalls. It wasn't quite as positively controllable as we've come to expect ignition systems to be nowadays. Although the fuses were initiated simultaneously by electrical means, they were still basically fuses and they took their own sweet time about burning up into the nozzles of their respective engines. A modeler in those days could expect to wait anywhere from two to five seconds after "zero" to see his cluster light–two to five seconds during which he had no control over the starting sequence he had initiated, two to five seconds during which one of the most important safety features of electrical ignition–positive control–was lost. Furthermore, unless the fuse lengths were precisely equal, one engine was likely to ignite before the others with the catastrophic result you can well imagine. Ignition failure on one or more of the engines in the cluster was also a rather frequent occurrence, and though expert rocketeers could get fairly consistent results, this cluster-ignition technique never achieved a level of reliability that would be considered good by modern standards.

The big birds of the day, the models powered by "Coaster's Super Jet" engines, were also lit by a mixed electric/fuse system using Jetex. The technique here, shown in Figure 4, was to crumple about six inches of Jetex wick or Coaster's own fuse into a mass which would fit loosely into the half-inch bore of the big core-burner, holding it in place with masking tape and leaving one end of the fuse hanging free from the nozzle by an inch or so. As with the cluster scheme, a one- inch length length of Jetex which was to serve as the elctric ignitor was twisted together with the end of the fuse. The ignition of a Coaster bird in this way was a real hair-raiser, since these engines, like today's Mini-Max PB series motors, had a noticeable thrust build-up time before lift-off. Many were the times we stood shaking in our boots, watching that sizzling sparkle worm its way up into the nozzle and disappear, to be replaced by the gathering hiss which heralded the F-monster's ear-splitting roar. There was no reliability problem with these babies; if you got an ignition flame anywhere *near* the grain surface–away she went! The only problem was–*when*? Sometimes it would be a full seven or eight seconds between the time the button was pressed and liftoff, during which time the Safety Officer would just pray that the status of the range would remain "go."

All things considered, though, we got by well enough with the Jetex/electric ignition systems–until the winter of 1962-1963, that is. Some time during this period Wilmot, Mansour suffered a fire that razed their plant to the ground and forced production of all Jetex products to be temporarily suspended. The last shipload of Jetex materials to leave England before the disaster was impounded in New York Harbor for a good six months before US Customs permitted it to enter the country. For six months, the Jetex wick and fuel pellets sat in a dank cargo hold under conditions of abnormally high humidity. Which, of

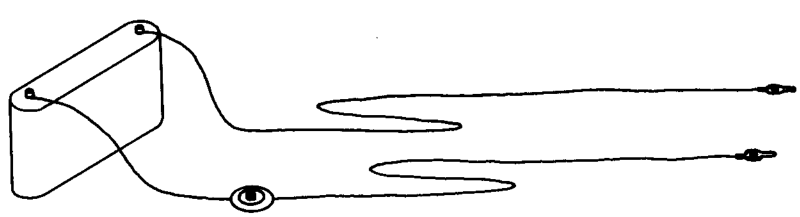


Figure 2. Firing circuit, 1958, similar to that illustrated on Model Missiles, Inc. instruction sheets. The system used a 6V hot-shot battery, a doorbell button, two 10-foot lengths of No. 18 wire, and two Muller No. 85 alligator clips to provide electrical energy for ignition.

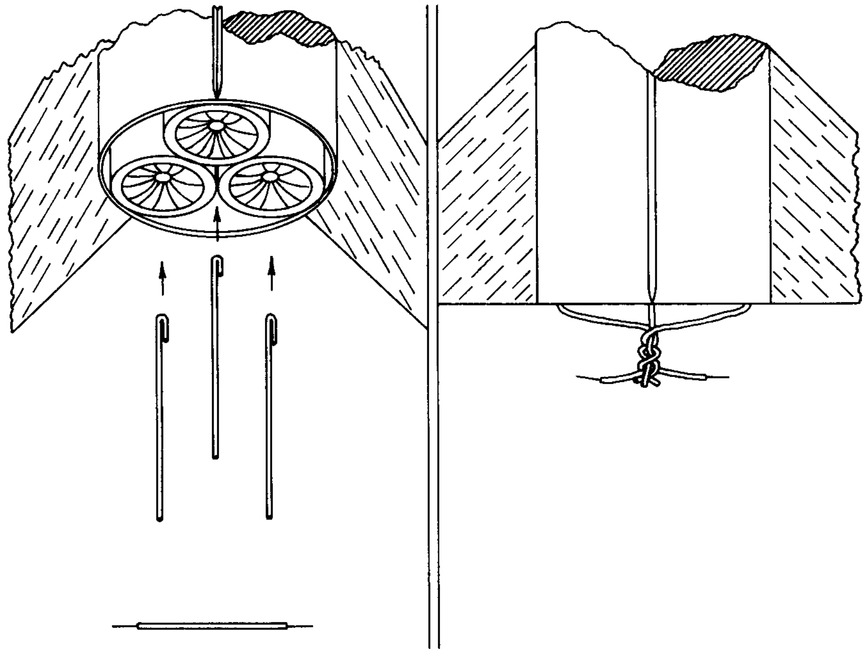


Figure 3. Cluster ignition using Jetex wick, 1959. Left: lengths of Jetex wick prepared for insertion into the engines of the cluster. Right: engine wicks have been inserted and twisted together with the starting wick to form electrical ignitor.

course, completely ruined the entire shipment.

Model aviators could salvage the pellets by heating them to 250 degrees F in an oven overnight, but nothing could save the wick. The firm, plastic, gray texture of the nitrate coating changed to a gritty, crumbly, dirty red. The wick no longer burned evenly; it smoldered and sputtered and usually went out in confined locations like the nozzles of model rocket engines. Though Wilmot, Mansour subsequently went back into production, their shipments to America consistently suffered the same fate as the one that had been impounded–ruined by moisture. Something new had to be found–and fast–or model rocket ignition reliability would really hit the skids.

To say that something *was* found would be restating the obvious. It would also be overdramatic, since the material that eventually was to replace Jetex wick as a means of igniting model rockets had already been introduced to the hobby in late 1961. The alloy nichrome, or chromel, consisting principally of nickel and chromium, is a strong, ductile, silvery metal which has unusually high electrical resistivity. A two-inch length of bare AWG No. 30 or 32 wire made of this metal will glow bright yellow-orange when connected to a model rocket firing circuit, indicating that its temperature is more than sufficient to ignite rocket propellant if the two are placed in contact. Harry Stine first successfully fired a model rocket in this manner in the fall of 1961 and promptly became an enthusiastic devotee of the new ignition material. (The huge coil of it he gave to the North Shore NAR Section in New York lasted over a year!) The use of nichrome spread rapidly, and by NARAM-4 in the summer of 1962 the range Firing Officer at the Nationals was requiring nichrome ignition for all single-engined rockets of classes 1/2A through B. Jetex was still used for clustered rockets and F-class birds, but it was usually initiated by nichrome.

At first, nichrome replaced Jetex on a "straight-substitution" basis: the nichrome was just bent and inserted into the nozzle the way Jetex had been, except that a piece of cotton or tissue was used as packing to hold it in place rather than the masking tape seal used with Jetex. It was soon found that forming the part of the nichrome contacting the propellant grain into a small coil by wrapping it around a ball point pen tip or a piece of music wire .045 inch in diameter greatly improved the ignitor's reliability, though, and the nichrome ignitor used during early 1962 assumed the form shown in Figure 5. By the summer of 1962, nichrome wire was being made available through both Estes and Centuri and was growing rapidly in popularity.

The subsequent rapid and complete development of nichrome ignitor technology was due in large part to the efforts of a single man–the late Marshall P. Wilder of CBS Laboratories in Stamford, Connecticut. Wilder recognized that ignitors of the Figure 5 type were wasteful of energy in that they dissipated the same amount of heat at every point along their length–the leads to which the firing clips were attached became nearly as hot as the coil inside the nozzle. If some means could be found to confine most of the energy dissipation to the coil of the ignitor the coil would reach a higher temperature and both the reliability and the efficiency of the ignition would be increased. Wilder first accomplished this by making ignitors with extra-long leads and bending each such lead back upon itself until the bent-back end nearly touched the coil. Wilder ignitors of the form shown in Figure 6A were widely used at NARAM-4. Not content with this first improvement, he subsequently devised twisted-lead ignitors

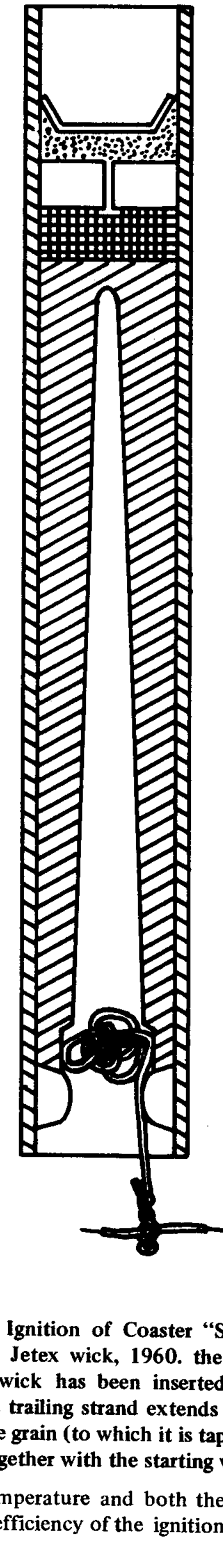


Figure 4. Ignition of Coaster "Super Jet" engine by Jetex wick, 1960. the "Starting ball" of wick has been inserted into the nozzle; its trailing strand extends down one side of the grain (to which it is taped) and is twisted together with the starting wick.

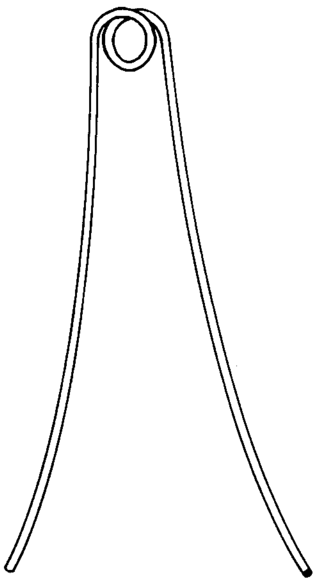


Figure 5. Nichrome ignitor, early 1962, showing detail of the heating coil.

like that of Figure 6B, in extensive use by NARAM-5 in August, 1963, and a further-developed form which could be made in large quantities using a hand drill for twisting the leads and which featured a lacquer coating on the coil to prevent shorting and increase the ignition temperature of the coil (Figure 6C). Wilder ignitors of the forms 6B and 6C were mainstays of model rocket ignition technology in 1963.

Significant improvements in ground support equipment for ignition paralleled advances in the ignitors themselves. The alligator clips, whose serrated jaws were rather clumsy for gripping the thin Jetex core or nichrome wire, were replaced by flat-jawed Muller No. 88 "pee wee" or "micro" clips which gave a superior grip and could easily be cleaned using Flexigrit, an emery-coated mylar film. The major model rocket manufacturers first began to offer electrical firing systems in prefabricated form in 1962, generating a wide range of design concepts whose development is still continuing. The simple doorbell-button systems of 1958 gave way to professionally-built systems of advanced design incorporating such features as safety interlock keys, continuity check lights, and integrated power supplies. Electrical connectors appeared in varieties which made it possible to use almost any type of battery as a power source, from photoflash D cells, through hotshot lantern batteries and various small wet cells like the Willard NT-6 right on up to motorcyle and car batteries.

But the event which was probably the most significant of all, and the one which brought model rocket ignition technology to a virtually complete state of development, was the introduction of specially prepared model rocket ignitors by the manufactueres. Coaster, recognizing the problems of Jetex, stick fuse, and similar systems, had brought out an electric spark ignitor in 1962. These devices could only be used for Coaster's big F core-burners, though, and when the company was sold to Centuri in the fall of 1964 their production was discontinued. Rocket Development Corporation, which was at that time located in Ogden, Utah, in 1962 began offering Pyrofuze, a special alloy of palladium and aluminum in wire form which undergoes a thermite-like reaction when heated by the passage of an electric current. Apparently, the Pyrofuze was either too expensive or too much like nichrome in its handling characteristics for good sales potential, though, since RDC subsequently withdrew it from their catalog.

The first real breakthrough in premanufactured ignitors came in 1965, when Estes introduced a mass-produced, initiator coated, milled nichrome ignitor. This design dispensed with the necessity for doubling the nichrome back on itself by starting with a heavier-gauge wire and producing the region of concentrated heating by milling thin the center portion of the ignitor. The center region was then coated with a plastic initiator compound which would flash when the wire was heated by an electric current but would not otherwise burn an added safety feature which, also, like Marshall Wilder's lacquer coating, served an insulating function. The degree of innovation inherent in the Estes ignitor earned Vernon Estes United States Patent No. 3,363,559.

Leroy Piester of Centuri Engineering and Irving Wait of RDC were also working on prefabricated ignitors at about this same time. Both manufacturers adopted a somewhat different approach from the Estes design, offering in kit form an ignitor that could be assembled from a tape strip, a wire resistance element, and a stick of initiator compound which would burn up into the nozzle of the rocket engine when ignited at the nozzle exit plane. The RDC Ignitrite appeared in 1967 and the Centuri Sure-Shot in 1968.

The impact of the Estes, Centuri, and RDC prefabricated ignitors on the hobby has been literally staggering. All three designs offer component reliability at least equal to that of the best handmade nichrome ignitors, and since they virtually eliminate the possibility of improper ignitor preparation, they increase the overall reliability of ignition by a substantial margin. Cluster technology has also taken a quantum jump forward. Although Estes had published a technical report (TR-6) on "Cluster Techniques" in early 1964, the advent of the new coated nichrome ignitors prompted the firm to modify its recommended cluster ignition method to a parallel ignition system using a bus ring as shown in Figure 7A. Centuri and RDC both chose multiple clips (7B) rather than the bus ring arrangement for accomplishing parallel ignition, and Centuri described the use of such a multiclip system, the "cluster clip-whip" in their technical report TIR-52 on "Reliable Cluster Ignition." Today, though, nichrome wire is still sold by the major manufacturers. Jetex wick is no longer offered by the

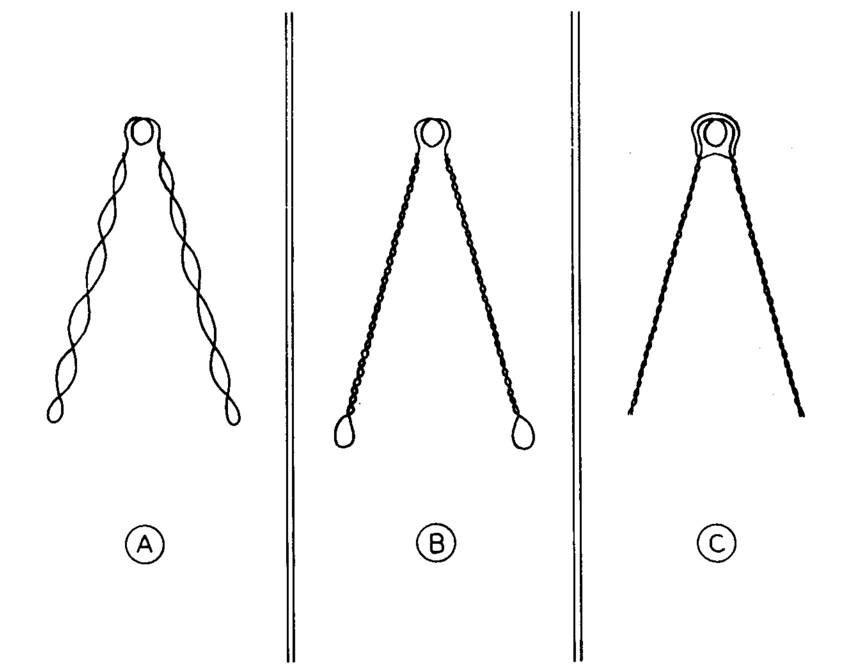


Figure 6. Nichrome ignitors diveloped by Marshall Wilder. A: loosely-doubled form used at NARAM-4, August, 1962. B: twisted-lead ignitor, early 1963. C: drill-twisted ignitor with laquer coil coating, late 1963.

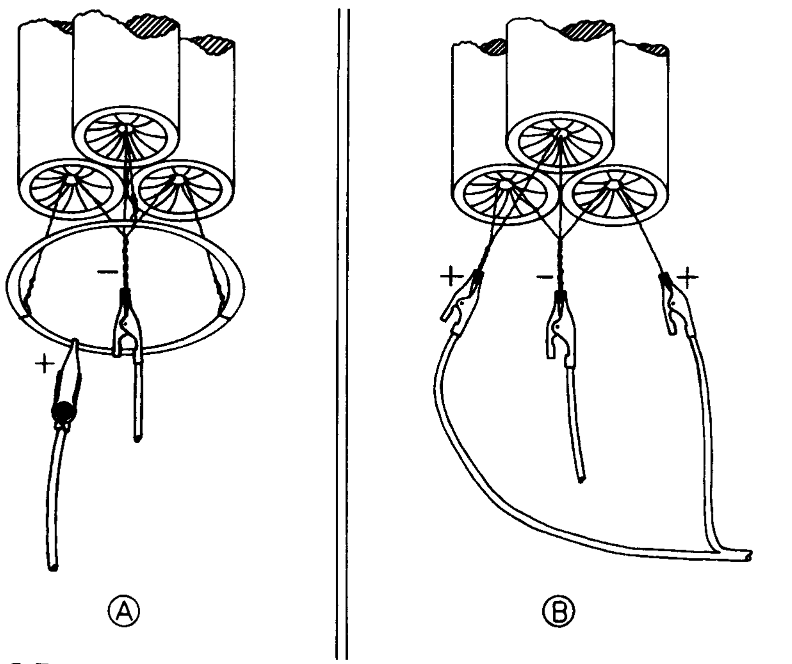


Figure 7. Two modern methods of parallel cluster ignition using nichrome or prefabricated ignitors. A: the Estes method, using a "bus ring" of metal for one common terminal. B: the Centuri method, using a "cluster clip-whip" to provide two clips of identical polarity. A similar multiple-clip arrangement is used by RDC.

model rocket companies and the vast majority of model rocket launches in the US are initiated by premanufactured ignition devices.

All of which brings us back to the point of this whole business. Some of the most painstaking R&D in the entire American hobby industry has gone into the design of the ignition equipment offered to today's model rocketeers by the manufacturers of model rocketry supplies and equipment. The modeler can and will get highly reliable ignition from materials currently available if he will only exercise a reasonable amount of care and craftsmanship in assembling his system and preparing his model for flight, if he will *read and follow* the manufacturer's instructions applicable to his system, and if he will take reasonably good care of it. Chronic ignition failure is fast becoming the mark of a hobbyist who has no pride in himself or his work, and the day may soon arrive when such careless persons will be barred from the launching range of any self-respecting club.

q & a

My question is what are consistently good times for boost gliders? In this area, there are no NAR sections and few NAR members. Competition is greatly hampered. No one knows what good b/g times are or what the NAR records are in the six classes of competition (if all six classes are flown).

Terry Lee
Bedford, Virginia

Upon consultation with the NAR, we have discovered that there are presently no NAR records whatsoever and that there have been none since the adoption of the new metric event classifications.

Of the six B/G events, Sparrow, Swift, and Hawk are the most commonly flown. I have heard of one Eagle competition, but have no records of any Hornet or Condor events since these categories were created.

In Sparrow, Swift, and Hawk, I would consider three-minute flights consistently good, and five-minute flights consistently excellent. Anywhere between two and six minutes, depending upon the weather conditions and the quality of the competition, has been nationals-winning time in the past few years. There have been many longer flights, but these were the result of thermals and could not be consistently repeated by any given boost-glider. There was one case, for instance, of a B/G staying aloft for about 27 minutes and another case of a flight lasting several hours. The first occurred during sport flying, and the second involved a lost glider, so neither time is either official or a national record.

Any NAR member may attempt to establish or surpass a record by participating in a sanctioned Record Trials competition. Record Trials sanction applications may be obtained from the NAR Contest Director, Mr. Albert G. Kirchner, at 49 Cheshire Road, Bethpage, New York 11714. Applications must conform with the 1967 edition of the U.S. Model Rocket Sporting Code.

Gordon Mandell

I have built several clustered birds and have a hard time getting all the engines to ignite. What is the best way you have found to ignite them?

Gary King
Houston, Texas

The major model rocket manufacturers have a great deal of very explicit information available on engine clustering techiques. A thorough study of the various technical reports on this subject available through the manufacturers should enable you to achieve highly reliable cluster ignition in a variety of ways, provided only that you are very careful in preparing the rocket precisely as directed.

You are not alone in your ignition difficulties; so many people have written to us on this topic in the past few months that we are presenting a complete treatment of ignition technology from a historical point of view in the *Wayward Wind* column this month.

My own favorite cluster ignition method is parallel ignition: using a nichrome ignitor in each engine of the cluster array and connecting all the ignitors in parallel to an electric firing circuit having lots of power – at least one or two "hot shot" lantern batteries or a car battery. Nichrome coil ignitors, Estes ignitors, Centuri Sure-Shot ignitors, RDC Ignitrites, and FSI electric match ignitors will all work fine in such an arrangement. The FSI ignitors need almost no power to fire, but by the same token, you must be extremely careful with them lest you have an accidental ignition. I am enclosing a copy of our manufacturer list so that you can investigate the full range of ignition products now available.

Gordon Mandell

Any questions submitted to this column and accompanied by a self-addressed, stamped envelope will be personally answered. Questions of general interest will also be answered through this column. All questions should be submitted to:

Q and A
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(**Club Notes** continued.)
the students of St. Stephens School.

The results of the Metro Denver Rocket Association's first NAR sanctioned meet are reported in the latest edition of *Misfire*. The meet was flown under clear Colorado skies in 60-degree weather on March 16 from the MDRA launching range at Roony Ranch, Jefferson Country, Colorado. In Class 3, Parachute Duration, Pete Quinn took first with 371 seconds flying a Saturn V; Bill Meine came in second with 338 seconds for his Mercury Capsule; and Casey Hall took third with 253 seconds. No spot landing results are available since distances were not recorded in this event.

The latest edition of *The Tracker*, newsletter of the Southland NAR Section, reports that the Los Angeles Department of Recreation and Parks has decided not to include a model rocket launching range in its model airplane site within the Sepulveda Flood Control Basin. The decision was reached because model rockets flying from the Basin would create a hazard for airplanes operating out of nearby Van Nuys Airport. A demonstration launch held by Southland members was continually interrupted by aircraft overhead. However, the club hopes that the Department will follow the example of the West Covina Park and Recreation Department in establishing a summer model rocket program this year.

The Star Blazers Rocket Club conducted their last winter launch of the season on Saturday, March 29. The club, organized at Broadalbin Central School near Gloversville, New York, launched from the Victor Kibler farm. About 25 spectators were attracted to the launch site to witness the event.

Fourty-four of the 100 sixth graders at East Noble High School, Kendallville, Indiana, are members of the school's newest organization, the *East Noble Rocketeers*. The club got started when East Noble HS teacher Bill Whitcomb, an avid model rocketeer, brought some model rocket literature to school. The club, organized in February, has elected its first officers: Jim Pankop as President, Bart Atz as Vice-President, and Charles Tuffley as Secretary.

The Havasua Rocket Club of Lake Havasu City, Arizona, held a rocket exhibition on the local school ground on March 2. Competition was scheduled in three events: Craftsmanship, Performance, and Parachute Duration; however, the last two events were canceled due to high winds. Bobby Price won first place in Craftsmanship with his Chuter-Two model, and Steven DeMase was second. Prizes for the winners were donated by Mr. Armstrong, owner of Havasu Hobbies, who came out to witness the launch.

The Lenape Vocational-Technical School Aeronautics Club, under the direction of drafting and design instructor Frank Dranko, has recently begun firing model rockets from the school's front lawn. The 30 members designed the rockets, launching pad, and electrical igition system. A closed-circuit TV system is used to record the launchings. Club President Dan Rehak has used the school's computer to investigate the rocket flight path. Dranko states the club's aim is "to expose the students to various phases of aeronautics so that as they get older, they will have a better understanding as to which field is best for them to choose."

Results of SP-13 YMCA Space Pioneers Section Meet have been reported. Three events–Class 1 Parachute Duration, Swift B/G, and Drag Race–were flown in both Senior and Junior Divisions. In Senior Class 1 Parachute Duration H. Stine placed first with 40 seconds, S. Englund second with 39 seconds, and B. Dunbar third with 27 seconds. In the Junior Division, E. Stine placed first with 65 seconds, P. Joseph second with 44 seconds, and L. Englund third with 39 seconds. Senior Division Swift B/G entries were not recovered so there was no winner in that event. In Junior Division Swift B/G E. Stine placed first with 25 seconds, and S. Englund second with 12 seconds. Drag Race winners were H. Stine first, B. Dunbar second, and A.D. Joseph and A. Jacobsen tied for third in the Senior Division. Junior Division Drag Race winners were G. Jacobsen first, E. Stine second, and P. Joseph and J. Gunter tied for third.

The Metro Denver Rocket Association *Misfire* reports the results of their Astron Alpha kit finishing contest. First place went to Rick McCormack, second to Pete Quinn, and third to Bob Cross. The purpose of the contest was to stimulate interest in the basic principles of model crafting.

The NAR Orbiters, Rochester, New York, have just completed their new club launching system. Launching is from a six position rack, or one of the three "Tilt-A-Pad" launches for spot landing. The Orbiters are now looking for a large, unused field in order to establish an official launching range in Monroe County, New York.

The latest edition of the North Jersey Rocket Association Newsletter reports the results of a field trip to the Hall of Science in New York City. Club members had an opportunity to observe full-scale mock-ups of the Ranger and Surveyor spacecraft, models of standard US boosters, and the instrumented nose cone of a sounding rocket. One of the highlights of the tour was a film on the history of the US space program which ended with an actual docking maneuver involving full-scale models suspended from the ceiling of the auditorium.

The *Rocketeers*, model rocket club of Roosevelt Elementary School, Allentown, Pennsylvania, held its first launch on March 27. The launch attracted about 100 spectators to the town park. The club advisor, 6th grade teacher Ronald Narzisi, said that the school model rocket program grew out of an interest in science among the students. Roosevelt Elementary School Principal Dr. Jack McHugh said in an interview with the Allentown **Call**,"This is education. The textbook is outdated. This is the space age, and these are the kids who will do it. They stay interested because they can see their progress." Amplifying on this statement, Narzisi said, "Enthusiasm is high and learning is of paramount importance among club members. The boys and girls have learned how to apply the principles of trigonometry to compute model rocket altitude. Also, electricity and electrical circuitry were studied and then applied to projects completed by members." The club members constructed a graphic altitude computer, an electrical launch panel, and a model rocket launch pad, as well as their own rockets.

The sixth grade classes of Unity Elementary School, La Grange, Georgia, have recently been engaged in the design and construction of model rockets. The students and faculty of the school witness launches from the school playground. The purpose of the project is to educate the students in the safety program necessary in model rocketry, and to stimulate an interest in the science of space travel.

A showcase on the corridor of Whiteford High School, Monroe, Michigan, featured a display of model rockets during the month of March. The rockets, some of which had been flown as many as 20 times, were constructed by members of the school's Science Club.

The eighth grade Rocket Club of St. Ann's School, Naples, Florida, held a public launching in March. A feature of the event was the launching of a scale Gemini/Titan rocket built by Peter Watkins. Local press coverage was provided by the Naples News.

SCRAM-19 results are reported in the latest issue of *Starburst*, newsletter of the Steel City Section of the NAR. Winners of each event are as follows: Open Spot Landing, Michael Grindel; Streamer Spot Landing, Bruce Campbell; Parachute Duration, Alan Stolzenberg; Sparrow Boost Glide, Fred Miller; Class 0 Altitude, Bruce Campbell; and Pee Wee Payload, Larry Caracciolo.

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

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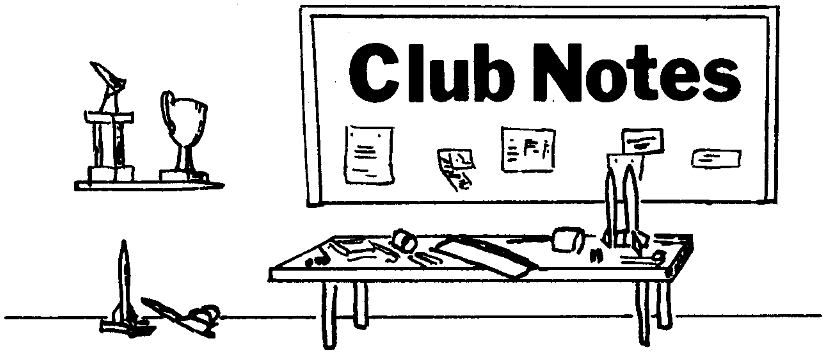

The Columbus Society for the Advancement of Rocketry will sponsor the First Annual Midwest Model Rocketry Regional (MMRR) in Columbus, June 28-29, 1969. The events to be flown are: Class I Parachute Duration, Sparrow Boost Glide, Egglofting (20 newton sec. max.), Class I scale Altitude, Peewee Payload, and Open Spot Landing. NAR members living in the Midwest are invited to compete. For further details, contact George Pantalos, 1191 Shanley Drive, Columbus, Ohio 43224.

The Crestwood Rocketeers, Crestwood, Illinois is being formed. Information on membership and meetings can be obtained from Nick Abramovitz, 12733 West Playfield Avenue, Crestwood, Illinois 60446 (597-2130). The club presently has 12 members and is planning a Spring Rocket Contest about May 1.

Employees of the Boeing Aircraft Company Seattle Division have formed the Boeing Employees' Rocket Research Society. Their first launch was held on March 15 at Marymoor Park. Despite a strong, gusty wind and overcast skies, a total of 68 rockets were flown. The club is also rebuilding a wind tunnel housed in the main administration building of the National Guard Headquarters at Boeing Field for use by the club.

The President, Vice-President, and Associate Committee of the Model Rocket Space Club, Wheeling, West Virginia, will visit the Kennedy Space Center during the summer. The latest edition of the *Model Rocketeers Snooper* reports that they have been invited by the Bradenton Division MRSC to Florida for a summer vacation and tour of the Spaceport.

The first issue of *Nozzle News*, newsletter of the Saturn Model Rocketry Section, El Paso, Texas contains results of their March 1 Quadratheon Contest. Since the SMRS Contest Director did not receive the contest material, the event was flown without official sanction.

Tracking was a problem for SMRS, with 22 rockets tracked, only one was tracked sufficiently well enough to come within the ten-percent rule. Thus, results are only available in Parachute Duration and Streamer Spot Landing.

In Parachute Duration, Eddie Johnson placed first with 70 seconds, Christian Engelhardt second with 60 seconds, and Donald Griswold third with 48 seconds. In Steamer Spot Landing, the section advisor, Rudy Griswold, placed first with 31'7", Scott Norris second with 80'4", and Christian Engelhardt third with 82'4".

The Icarus Rocket Society is looking for new members in the Greater Lowell area. Anyone who is interested in joining, call or write to George Vozeolas, 86 Pentucket Avenue, Lowell, Massachusetts 01852–Tel. 452-6230.

A model rocket demonstration was presented for 150 students at St. Stephen's School, Perth Amboy, New Jersey, in early March. Four students of St. Joseph's High School in Metuchen launched model rockets they had constructed. Following the launching, the high school students explained the scientific principles of rocket behavior to

(Continued on page 39.)

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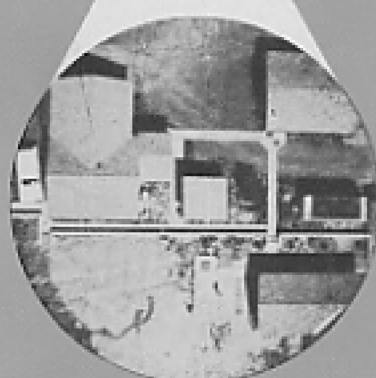

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