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JULY 1981

CALIFORNIA ROCKETRY

QUARTERLY

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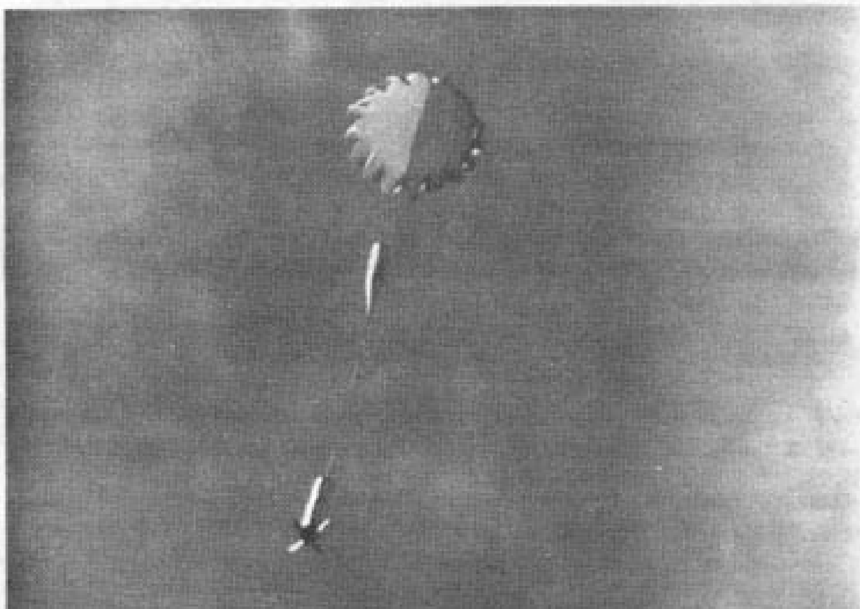
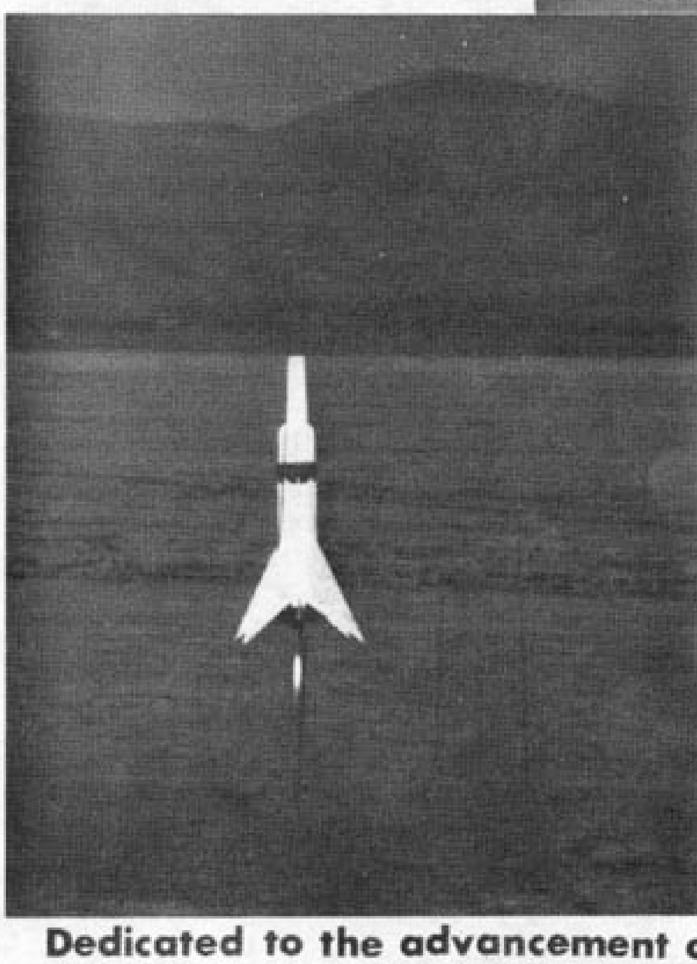
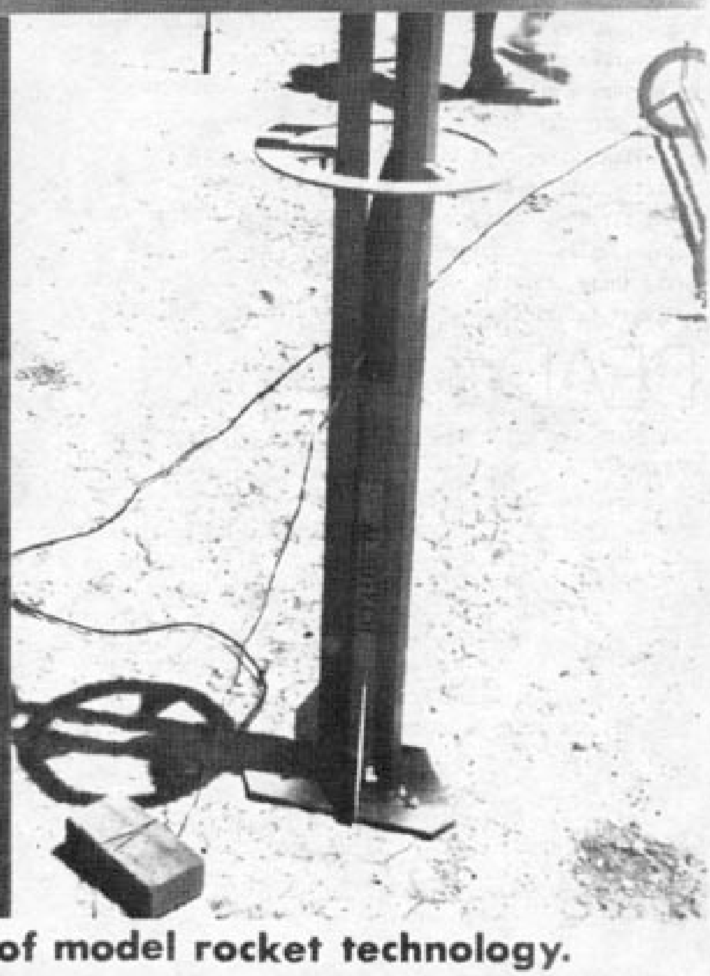
- 1981 MODEL AND CRAFT SHOW
- GEODESIC TRACKING UPDATE
- MOTORS OF THE 80's !!
- PACIFIC AREA REGIONAL-10
- PHOTO PAGE
- MANUFACTURERS LISTING







Dedicated to the advancement of model rocket technology.

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Contributors Needed!

CONTRIBUTORS NEEDED: CALIFORNIA ROCKETRY is still young, and this means we have a shortage of material. We encourage all readers to submit an article, plan, or photo each quarter. There are many topics you could write on, but if you can't think of one, simply do a product review. In any case, photos can be B&W or color, and articles can be either typed or handwritten. Plans should be "photo ready", that is, neatly drawn in black ink with all lettering done very neatly.

Cover Photo

Photos by Matt Ota

Top photo: Flown at Smoke Creek, this model is 10.5 feet tall and is recovered on an eight foot plastic parachute. The model is constructed from foam rings, wood stringers, and a paper covering. With a G60-3 it goes over 200 feet high.

Lower left: This familiar bird is a scaled up version of the circa 1971 Estes Starlight. Constructed with ACE BT-23 and 1/4" balsa fins, it flys well with composite motors.

Lower right: The Smoke Creek launch attracted over 100 people from all over the country including Gary Rosenfield, who constructed this model with a movie camera payload. Powered by an endburner, this motor thrusted for 21 seconds!

FEATURE ARTICLE

By Gary Rosenfield

TRENDS IN HIGH-POWER MODEL ROCKET MOTOR DESIGN FOR THE 80's
PART 2 - GRAIN DESIGNS

In the first article of this series, I delt with some history of the composite propellant model rocket motors and current and future propellant trends in these motors. This part will deal primarily with propellant charge or "grain" design, as applied to these motors.

Amazingly, every composite propellant model rocket motor produced for commercial sale since Irv Wait's Enerjet motors of the late 60's has used the same grain design, the restricted center burning variety - as shown in Figure 1.

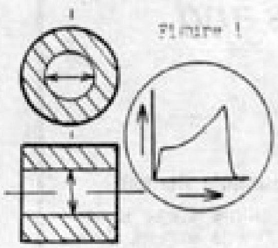


Figure 1

This design is characterized by a center cylindrical perforation running the entire length of the grain, with a diameter of approximately one half to three eighths the outside diameter of the grain. Low cost and versatility are the prime features of this design. The core can be drilled or molded, and the propellant acts as insulation during the burn, protecting the chamber walls from the 5000°F plus combustion temperatures until the moment of burnout.

Unfortunately, the "core burner" suffers from several serious drawbacks. The typical time-thrust curve shown is undesirable from both performance and flyability standpoints. The variable chamber pressure produced by the increasing burning surface demands a casing that is thicker and heavier than one that would be required for a neutral-burning (fig 2) design.

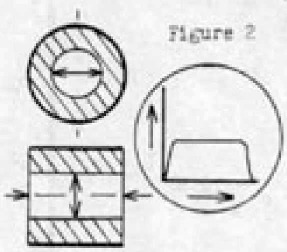


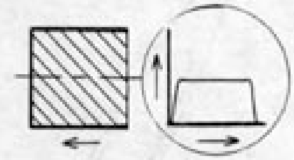
Figure 2

With formulations that are in current use, the short burn time of this configuration (which is determined in part by the web thickness, the distance from the propellant inner surface to its OD) is inferior in altitude performance to other designs due to high average drag on lightweight models. However, on heavier rockets this may be a plus. Because the final thrust level may be two to four times the initial, many models are simply ripped apart near burnout due to the tremendous aerodynamic and acceleration forces acting on them during this period. This affects the flyability significantly.

The following is a brief discussion of several alternative grain designs that are applicable to model rocketry and may be used in future commercial model rocket motors. All of these configurations have been either used or proposed for use in E and F type model rocket motors. Please remember that the comments made about each design are in consideration of size limiting factors and current casing material and propellant formulation trends.

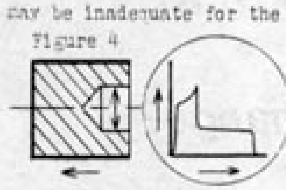
Shown in figure 2 is an outside restricted, center-burning design. This differs from figure 1 in that both ends burn toward the center, decreasing the linear burning surface of the charge. With an L/D ratio of one and a grain OD to core diameter ratio of two, a neutral burning surface is obtained, which is its chief positive feature. By increasing the L/D ratio, an increasingly progressive thrust profile is obtained. Only one end may be left unrestricted for additional control of the thrust curve. Disadvantages include possible heavier casing or insulation and more complex manufacturing techniques. This design is also limited to rather short, fat motors - like an E (40 n-s) in a 1.125" OD case.

Figure 3



The endburning design shown in figure 3 consumes itself in the manner of a cigarette - from one end to the other. One of its main advantages is that, with current propellant burn rates, it allows much longer burn times than a coreburner. Another bonus is that a neutral thrust level is delivered over the entire burn time. Less desireable features include the need for more insulative case materials or a seperate case liner to protect the case from thermal destruction. Manufacturing methods may be more complex and the motor's average thrust may be inadequate for the heavier models. The modified cored-endburner shown in figure 4 adds a substantial initial thrust spike to the curve, allowing fast takeoff and moderate sustain. Proper tailoring of average thrust level can produce a motor which will lift __any__ model rocket safely, and this feature will push the endburner increasingly into the commercial model rocket market in the 80's.

Figure 4



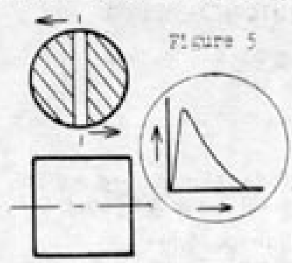


Figure 5

The "slotburner" in figure 5 produces a time-thrust trace almost exactly opposite that of the port burners in figure 1. As the propellant is consumed, the slot widens until a tiny sliver of fuel is left, producing the completely regressive curve shown. Advantages include extreme initial thrust and low final thrust for flyability (Ray Goodson of RRI has flown 160 n-s motors in ordinary paper rockets). However, case insulation is generally needed and the slot must be molded in. The low chamber pressure near the end of the burn causes propellant I_{sp} to suffer.

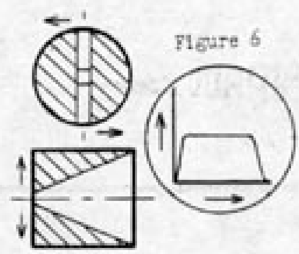


Figure 6

The tapered slot in figure 6 reverses this effect, modifying the curve into an essentially neutral trace. Figure 7 shows a "finocyl", a design used in many professional rockets. This modification of the slotburner delivers the desired neutral trace with less exposure of the case to hot combustion gases, due to the insulative effect of the partial cylindrical core. The core adds the right amount of progressivity to the regressive burning slots.

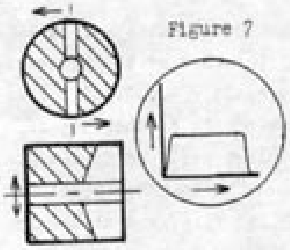


Figure 7

The "star" design in figure 8 is common to many military and sounding rockets. Depending on the size and number of points on the star, a more or less neutral burn surface is obtained, although this can be modifyed greatly. However, the short burn time of this design, due to the small web thickness, generally limits its application to large, heavy rockets or very strongly built small rockets. Specially formulated slow-burning propellants can make it more useable however. The star must be molded in and tooling is expensive. A sliver of propellant left at burnout reduces the propellant I_{sp} somewhat. John Davis of Composite Dynamics has experimented with motors using this configuration, but production of them is probably out of the question due to high manufacturing cost and little advantage over cylindrical core burners. Rumor has it that Estes is working on an E type motor using the star design.

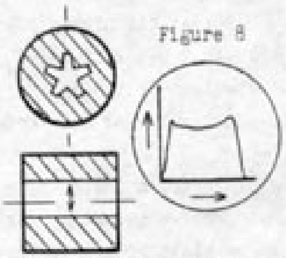


Figure 8

Finally, Bill Wood of Chemical Systems Division of United Technologies has recently proposed the design shown in figure 9 - affectionately called the "mystery-jet", or more properly, "moonburners". Surprisingly, this design produces an almost perfectly flat time-thrust curve if the OD to core ratio is kept to about 2.67:1. Up to 4:1 may be employed if a slightly higher thrust during the middle of the burn can be tolerated. The prime advantage of this design is that end burning length burn times can be obtained due to the large web thickness. The core may be either molded or drilled. Among its disadvantages are the difficulty of obtaining an initial high thrust spike and the requirement for a more insulative case or liner over at least part of the internal circumference. In this respect it has an advantage over the endburner which requires insulation around the entire chamber.

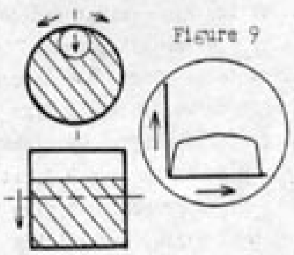


Figure 9

The future of model rocketry is partially influnced by the imagination of designers. Considering this, designs other than those mentioned may be developed and become feasible, and eventually be employed in model rocket motors. These and other factors will continue to influence the trends in high power model rocket motor design for the 80's.

SPOC - 6 Preview

SEE THE BACK COVER FOR THE OFFICIAL ANNOUNCEMENT! EVERYONE IS ENCOURAGED TO COME AND FLY ANY ROCKETS.

THERE WILL BE A FULL RECORDS TRIALS FOR ALTITUDE.

SPOC-6 records trials and sport launch will be held at the optimum location in the west for altitude records trials. Lucerne Dry Lake is high in the warm upper desert of California, thus the air conditions are perfect for fast high altitude models.

There will be a trophy for the highest altitude model rocket. This means anything goes with safety certified motors. You will probably have to exceed 2000 meters, to place!! Unlimited altitude is the name, performance is the game.

Another first! Geodesic tracking will be used for the first time in the west! SPOC-6 / RT will utilize the newly recognized "Geodesic tracking equasions". The corrected version. Emphasis will be placed on F alt, E ELA, D BG, and Unlimited altitude. SET RECORDS THIS WEEKEND. NAR membership is optional, but is required to file for US and FAI records. Be there July 4-5, 1981.