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FOR THE ADVANCEMENT OF
ROCKETRY AND ASTRONAUTICS

99

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For the advancement of rocketry and astronautics.

RRS NEWS NO. 99 SUMMER, 1965

FROM THE EDITOR

Professional: having much experience and great skill in a specified role.
Professionalism: professional quality, status, etc.

For well over twenty years, amateur rocketeers have been engaged in the designing, testing, and firing of rockets. These rockets have ranged from the conventional to the outlandish in design, but unfortunately, unusually shaped rockets are the exception rather than the rule. And furthermore, these rockets in general use zinc and sulfur as a propellant because of its cheap cost, availability, and ease of handling. When fired the payload usually consists of no more than a small transmitter, a mouse, or both. Payloads hardly ever get more sophisticated than this.

When it comes to compounding propellants, a range of mixture ratios are used but no one knows for sure which ratio is best. The result has been that with all the so-called experience amateurs are supposed to have, there is little if any information available to substantiate such claim to any experience. The fact is that precious little more is known about these two elements now than in 1943 when it all began.

And worse yet, experience so far has shown that the same mistakes are made over and over and worthless projects are pursued again and again simply because no information is available to point out these projects as worthless.

What is needed is people who will tackle projects that have some sensible goal. Merely building and firing a rocket for the fun of it is not enough. It's a waste of time and money, scarce commodities to most amateurs. Without members who can exhibit a professional attitude in their work, amateur rocketry is going to remain a hobby similar to model railroading, that is, it's a lot of fun, but it's just for fun. Isn't it about time amateurs showed a little professionalism?

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THE RRS NEWS, No. 99. Published quarterly by the Reaction Research Society, Incorporated, Box 1101, Glendale, California 91209, and edited by the executive council.

POST FIRING REPORT

APRIL 24-25, 1965

By Maryann Butterfield,
Reaction Research Society

On April 24 and 25, 1965, the Reaction Research Society conducted a rocket firing at its test area in the Mojave Desert. There were nine rockets fired; four on Saturday and five on Sunday. Each rocket is described in Table 1, and its performance is listed in Table 2.

The first rocket fired was a standard payload-carrying rocket of the type used on the Seventh Mail Flight (see RRS News #98). The rocket motor was a "Fort Sill Beta," described in Brinley's Rocket Manual For Amateurs. The payload section consisted of a collapsible nosecone, a payload cannister, and an adapter section with stabilizing fins. On past firings, the payload section of this type rocket did not achieve stable flight after separation; for this test the payload stabilizing fins were enlarged in an attempt to correct the problem.

The rocket was loaded and the burst diaphragm and nozzle were placed into position. Just prior to firing, a dummy ten-pound load was placed into the forward section of the rocket. On the command "FIRE," the rocket ignited but did not accelerate for about three seconds. (This is not a new problem with the stoichiometric mixture of micrograin. Only one rocket fired within the last five years by the RRS using this mixture ratio has accelerated immediately upon ignition.) Just after burnout, the mercury switch closed, firing the separation charge. The payload section separated from the motor section, and both rose to their respective peak altitudes and impact points with perfect stability. Upon recovery, it was noted that the collapsible nosecone had been successful in preventing damage to the payload section.

The second rocket, built by John Mariano, was equipped with a ceramic nozzle formed in place. This rocket was also loaded with the stoichiometric mixture, but all attempts to ignite it failed. The rocket was removed from the launching rack, unloaded, then reloaded with micrograin in the mixture ratio of 80% zinc to 20% sulfur by weight. This time, the rocket ignited immediately and accelerated so rapidly that it was soon lost from sight, making it impossible to record a maximum altitude. When inspected after recovery, the nozzle showed no signs of erosion. John was satisfied with the performance of his rocket and intends to conduct further tests using ceramic nozzles.

The third and fourth rockets were built by Jim Boland. The third was a small micrograin rocket which performed very well for its size. The fourth was a solid micrograin rocket with a cylindrical core. Since, unfortunately, the mandrel could not be removed, the rocket was buried vertically in the ground with the forward bulkhead removed and fired. For details about this rocket and others that appear in this report, see the articles further on in this section.

TABLE 1.

PHYSICAL DESCRIPTION OF ROCKETS

Rocket number	Total length	O.D.	Burst diaphragm		Propellant (by weight)	Mass ratio
			thickness	material		
1. motor	48"	2"	.009"	steel	67% Zn 33% S	1.487
payld.	39"	5"				
total	87"					
2.	32"	2"	---	rubber plug	80% Zn 20% S	2.138
3.	32.5"	1.5"	---	rubber plug	80% Zn 20% S	?
4.	40"	3"	---	---	25% resin 75% $KClO_4$ 3% $CuCrO_4$	1.793
5.	35"	2"	.003"	brass	80% Zn 20% S	1.955
6.	61"	2"	.003"	brass	80% Zn 20% S	2.345
7.	42"	2"	.005"	brass	80% Zn 20% S	1.865
8.	53"	2"	.009"	steel	75% Zn 25% S	2.210
9.	51"	2"	.25"	plaster	75% Zn 25% S	2.277

The fifth and seventh rockets fired were two short micrograin rockets belonging to Roger and David Butterfield. Before the propellant was loaded into these rockets, one-third cup of transmission oil was placed into each combustion chamber. This oil was to saturate the micrograin in the forward end of the combustion chamber and to leave a smoke trail after the majority of the propellant had burned. Rocket number five was loaded just prior to firing: it left no useful smoke trail, only a very thin trace for less than fifty feet after burnout. Rocket number seven was loaded eighteen hours prior to firing: it left a fairly dense trail of smoke to peak, then a thin trail to impact. At impact the rocket gave off a very large puff of smoke easily seen from the launching area. When this rocket was recovered, however, it was discovered that two and one-half pounds of unburned propellant remianed in the combustion chamber. The transmission oil had saturated too much of the micrograin, thereby reducing the overall performance of the rocket.

The sixth rocket, brought by Mark Dosa, was another "Fort Sill Beta" rocket. This rocket had in its nosecone a peak ejection mechanism built by Dennis Shusterman. Unfortunately, one of the fins hung up on the launcher on the way out, causing the rocket to pitch during acceleration. The nosecone was thrown from the rocket before reaching peak altitude. Upon recovery of the nosecone, it was found that the ejection system was still working properly.

TABLE 2.

PERFORMANCE

Rocket number	Owner	Burnout		Maximum altitude	Range
		time	altitude		
1.	RRS				
motor		?	about 100'	470'	about
payld.				790'	1000'
2.	J. Mariano	.125"	85'	?	2000'
3.	J. Boland	.083"	42'	1400'	2000'
4.	J. Boland	5'	not flight tested		
5.	R. Butterfield	.10"	58'	2200'	3000'
6.	M. Dosa	.20"	146'	1200'	2000'
7.	D. Butterfield	.125"	61'	2300'	2000'
8.	RRS	.328"	170'	3800'	5000'
9.	D. Girard	.281"	160'	5500'	not recovered

Rockets number eight and nine were fired to compare the hand packing method of loading micrograin to the mechanical method. Originally, no plans had been made to fire a companion to rocket number nine, but it was decided to use the undamaged motor section of rocket number one (redesignated number eight) which, although somewhat longer, would at least allow a rough comparison. Number eight was fitted with a fiberglass nosecone, then loaded with ten pounds, no ounces of micrograin packed to a density of 0.0826 pounds per cubic inch, giving it a mass ratio of 2.21. Number nine was loaded, by means of the compressor, with ten pounds, two ounces of propellant packed to a density of 0.1162 pounds per cubic inch, giving it a mass ratio of 2.28. The pictures taken of these rockets during the acceleration phase of their flights reveal that the machine packed rocket burned more evenly than did the hand packed rocket. Unfortunately, the reproductions of these rocket flights on the picture page do not show the difference in burning as well as do the original photographs. A graphical comparison has been worked out, and appears in this issue.

The firing was quite successful. A great deal has been learned, and many new ideas have been suggested which promise to make future firings even more educational. The launching rack has already been converted to accept rockets with three as well as four fins. A number of mandrel releases have been suggested, notably Teflon. Finally, a project has been suggested for the purpose of investigating the use (or misuse) of stoichiometric micrograin.

PHOTOELECTRIC PARACHUTE EJECTION SYSTEM

By D. J. Shusterman,
Reaction Research Society

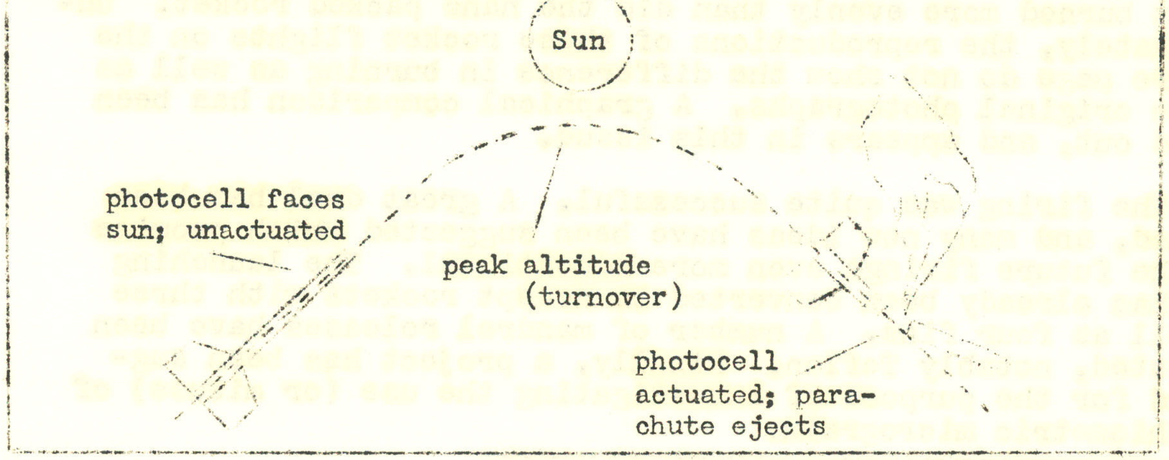
In an effort to reliably recover rockets and instrument packages by parachute, amateurs have devised many systems. The most reliable are those actuated by the change in attitude experienced when the rocket reaches peak altitude. A sophisticated design for an attitude-sensor device would be a gyroscope-actuated switch. However, a gyro switch is both complicated and relatively expensive.

A much simpler attitude sensor is one which uses the sun's light as an attitude reference. When the sun is above the rocket as it travels upward, the light intensity, as observed in a forward direction, is more or less constant. At peak altitude when the rocket turns downward, the observed light intensity is greatly reduced (Fig. 1).

In terms of design, a photosensitive device pointing upward is placed in the nosecone of the rocket. This device changes either in resistance or voltage output as the light intensity changes at turnover. This electrical change is used to actuate a circuit, which in turn fires a separation or parachute ejection charge.

The system does have its limitations. First, the sun must be more or less overhead. Second, the sky must be relatively clear. However, the system can function over at least a four hour period each day (from 10:00 A.M. to 2:00 P.M., sun time). Therefore it is felt that the system's simplicity outweighs its limitations.

FIG. 1. Turnover



The firing circuit's basic component is a silicon-controlled rectifier (SCR). The SCR acts like a sensitive latching relay, but is insensitive to vibration and acceleration. The sensitivity adjustment allows the circuit to actuate at any predetermined light level, as shown in the basic circuit configuration (Fig. 2).

A parachute ejection system of this type was tested on the April 24-25, 1965, firing. Unfortunately, one fin of the rocket caught in the launching rack, and the rocket pitched violently. The ejection and parachute system was thrown free

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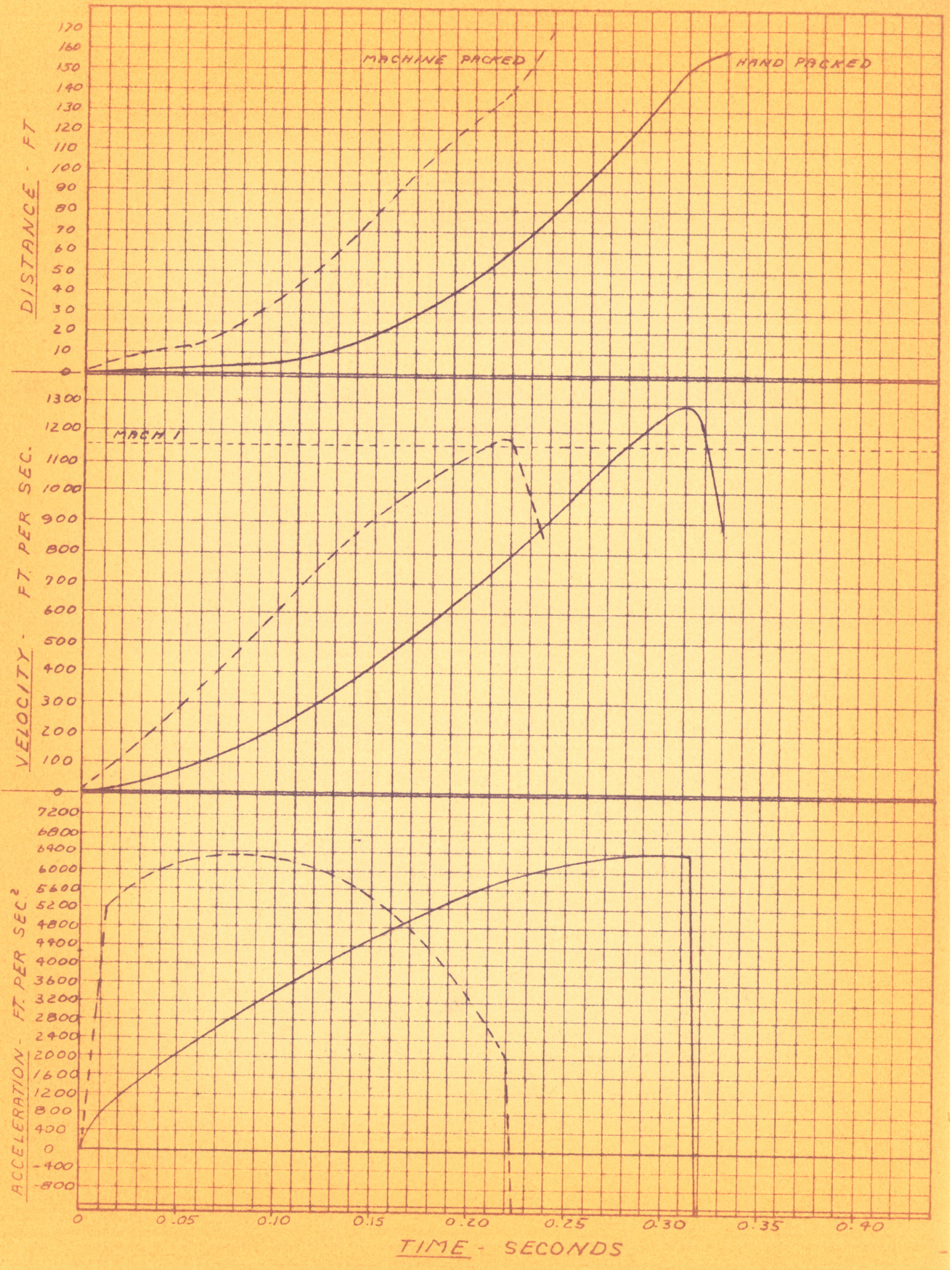
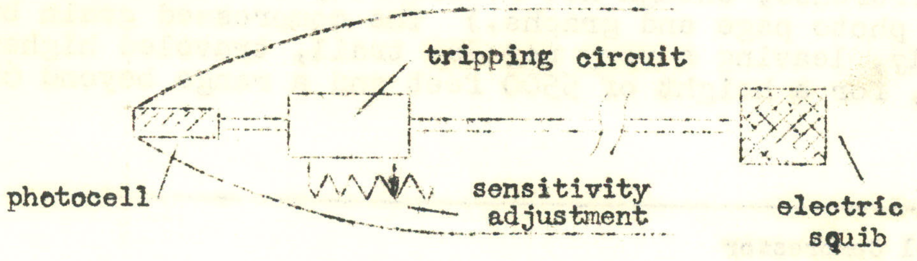
As a note of general interest, the performance graphs of the hand-packed rockets were made in the following manner. High speed motion pictures of the take-off were taken with a stationary camera set far enough back to record the entire burn. To give a proper scaling factor, a target was placed one hundred feet from the launcher (normal to the camera-launcher line) so that it might appear on the film. The film was projected, one frame at a time, and the height of the rocket in the picture was measured and recorded. The first graph, showing the distance covered during burning plotted against time, assumes that the camera has recorded at a constant number of frames per second. This graph, as well as the second and third, is shown as the smoothest curve through the plotted points.

The velocity curve is the first derivative of the distance curve (and the acceleration curve is the second derivative). The change in position between points is noted in the first graph, and is divided by the change in time, yielding the average velocity between the two points. The second curve then is a plot of these velocity values against the corresponding time values. The third curve, acceleration versus time, is derived from the velocity curve in the same manner.


DISTANCE - FT
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
MACHINE PACKED
HAND PACKED
VELOCITY - FT. PER SEC.
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
MACH 1
ACCELERATION - FT. PER SEC²
7200
6800
6400
6000
5600
5200
4800
4400
4000
3600
3200
2800
2400
2000
1600
1200
800
400
0
-400
-800
0
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
TIME - SECONDS

before the rocket reached peak altitude. The ejection system landed intact, and still in operating condition.

FIG. 2. Circuit



A simple and reliable version of this system can be built for about ten dollars. Construction details will be available from the society in a future RRS publication on ejection and stage separation systems.

AN EXPERIMENT IN MECHANICAL COMPRESSION

By Don Girard,
Reaction Research Society

Let us take a stroll into the never-never land of Captain Bertrand R. Brinley and his Fort Sill Beta. There it stands: a four-foot rocket that contains 11.58 pounds of propellant, a standard test rocket that will achieve altitudes of 20,000 feet. We'll build it.

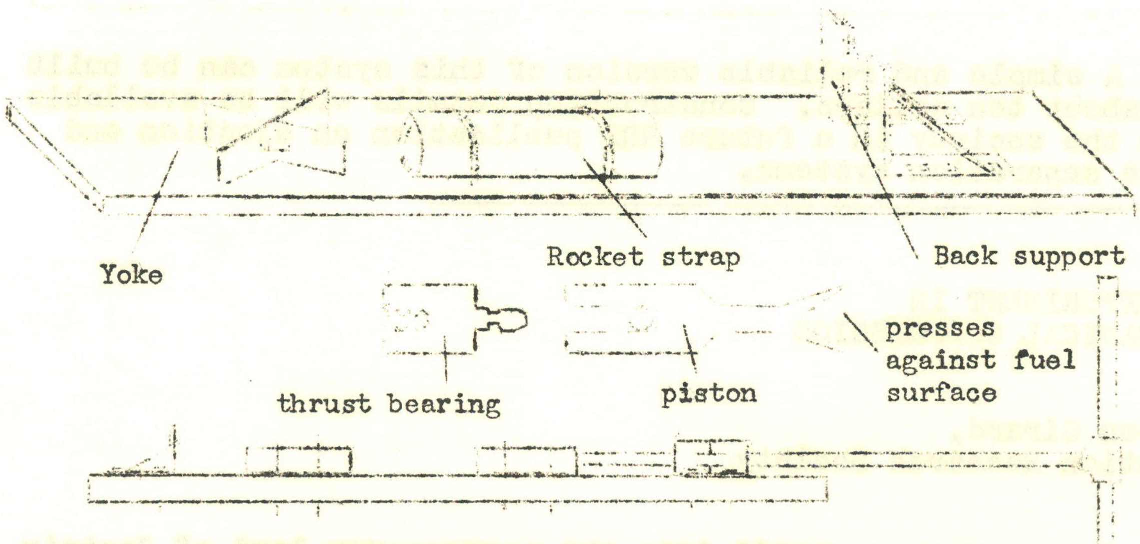
It's a pretty rocket, but I'm afraid Peter Pan will fly higher than the Beta will.

In test after test, using the stoichiometric ratio of zinc dust and sulfur, the Beta has never exceeded a mile up, and generally gives a hang-fire fight that has baffled the most inventive burst diaphragm. Something's wrong in Oklahoma, we think.

Brinley has assumed that the $Zn + S = ZnS$ reaction occurs to theoretical perfection, and from theory recommends a propellant density of 0.0932 pounds per cubic inch. In practice, a zinc rich mixture has given better performance; also in practice, this density has been impossible to reach.

In an effort to achieve a density closer to the theoretical density for the Beta rocket, this author together with two other members of the RRS, Dan McNicoll and Bob Schreiner, and a third friend, Pat Madden, tested a compressed micrograin mixture during the April 24-25 firing. A standard (and here I turn a deaf ear to those critics who have called our rocket substandard) Beta using a 75-25 mixture was fired for comparison against another, slightly shorter rocket, with a compressed 75-25 mix. The performance difference, though not remarkable, was at least noticeable. (See photo page and graphs.) The compressed grain burned more smoothly, leaving a very regular trail, traveled higher, and further, for a height of 5500 feet and a range beyond 6000 feet.

FIG. 3. Fuel Compressor

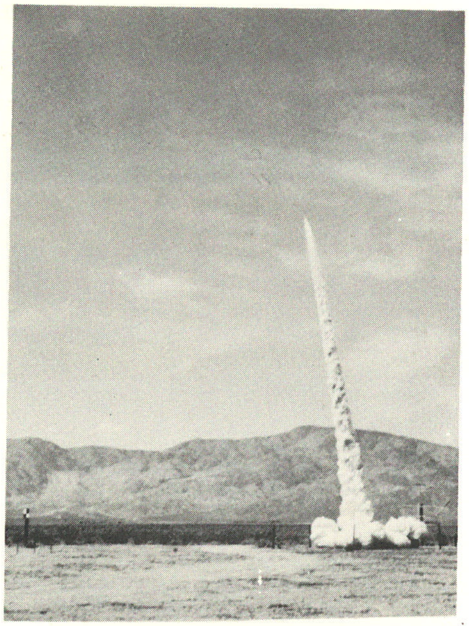


Side view of compressor, showing drive shaft action. Compressor achieved density of 0.1162 pounds per cubic inch; theoretical density is 0.1249 pounds per cubic inch.

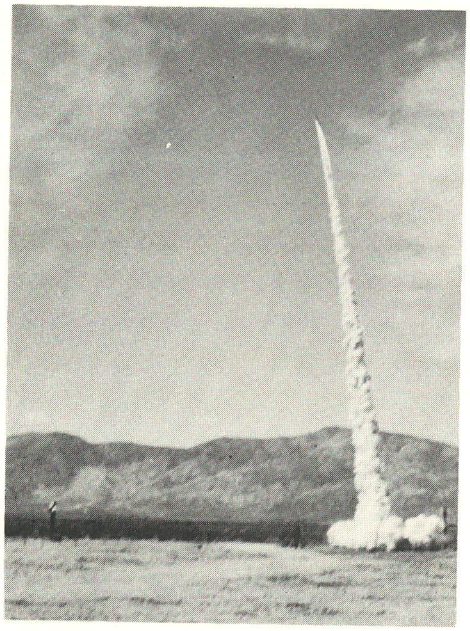
The mechanical structure of the fuel compressor is shown above. The thrust bearing calls for some explanation. To avoid friction, the piston in immediate contact with the fuel surface must not rotate, and yet the shaft must. A ball bearing arrangement as shown in the figure above worked out admirably. The compressor is a prototype field version; a hydropress would work much better.

As a preliminary investigation, though, the compressor served well, and calls for further research on the density versus performance relationship.

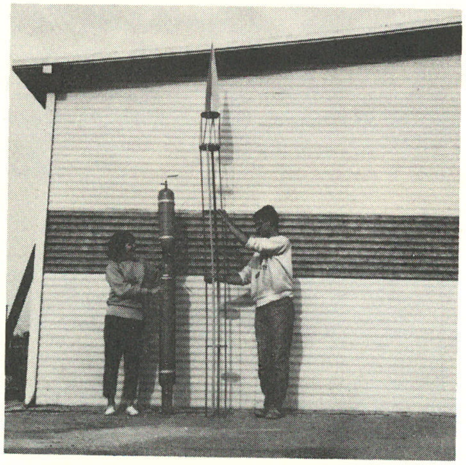
Flight photographs courtesy of Dennis Shusterman; other photographs by RRS. Layout by Roseanne Dymond.



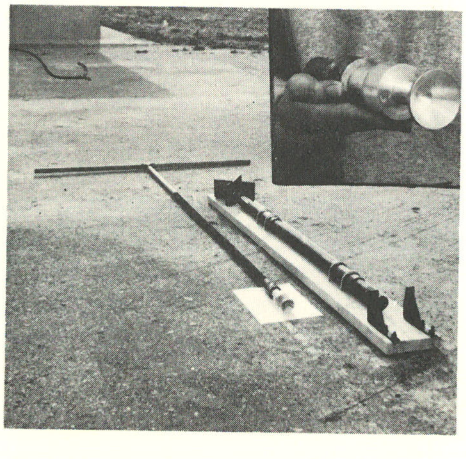
BETA ROCKET TAKE-OFF, using zinc and sulfur in a weight ratio of 3:1 packed with the fuel compressor. Note the extremely smooth burn pattern.



STANDARD BETA ROCKET TAKE-OFF, using zinc and sulfur in a weight ratio of 3:1, packed by hand.



BIPROPELLANT ROCKET MOCK-UP AND FLIGHT TANKS. The wooden framework is about 12 feet tall and octagonal in shape; two of the flight tanks are strapped to the board alongside.



FUEL COMPRESSOR AND BEARING ARRANGEMENT. The screw rod threads through the anchored yoke, pushing the piston and bearing assembly through the rocket and against the fuel.

STAR GRAIN MANDREL. Protruding from the hexagonal stock are six one-eighth inch vanes. Mandrel is seventeen inches long.

RRS STAR GRAIN
NUMBER X-1A

By Richard Butterfield, Secretary,
Reaction Research Society

For the last couple of years I've been considering various star grained solid propellant configurations, with the main design condition being a neutral burning grain; that is, the burning surface neither increases nor decreases from the moment of ignition until burnout. (A grain whose burning surface increase during firing is known as progressive; one that decreases is regressive.) It isn't too hard to produce a design that meets or nearly meets this design criterion; however, there have always been two major problems involved in this program. First, I didn have a solid propellant suitable for this sort of casting. Seco the grains were far too elaborate and expensive for my resources both mechanical and financial.

At the RRS's last firing, Jim Boland presented a rocket which used a mixture of potassium perchlorate and polyester resi as the propellant. I assisted Jim with the propellant blending and casting, and was quite impressed with the handling character istics of the liquid mixture. I examined the grain after it had cured. It seemed quite homogeneous, was rather hard, and appear to be free of bubbles and other flaws. The grain bonded itself very firmly to the casing and, most unfortunately, to the cylind cal core mandrel. The mandrel could not be withdrawn so the mot was buried, with the open forward end exposed, and the propellan was ignited. It burned quite fiercely with a small amount of smoke, giving the appearance of a good propellant. This propell would apparently solve my first major problem.

I turned my efforts toward the subject of grain design. Suppose, I thought, I abandon the ideal of a perfect burning grain and all its elaborate geometry and settle for a much simpler design, something that I could make myself, or at least afford to have made.

I selected a four-inch O.D. by one-sixteenth-inch wall steel tube, eighteen inches long, as the motor casing. This tube was selected for two reasons: the core would be large enough for my unskilled hands to operate upon, and secondly, I had the tube on hand.

My first designs employed a central cylindrical rod with four, five, six, or eight vanes (of varying thicknesses) protruding radially from it. The six vane design using a one-inch diameter rod was fairly neutral, so I made a final drawing of this core and was preparing to build it when I hit upon a solution to a problem that had been bothering me for some time. The problem: how to precisely locate the vanes in respect to the rod and to each other. The solution: substitute a bar of hexagonal stock for the rod. I redrew the core and re-figured the incremental burning perimeters, and found that I still had a nearly neutral grain, which would be vastly simpler to make.

The design called for a one-inch "across the flats" hexagonal bar with one-eighth inch wide vanes protruding 0.712 inches from the center of each flat. Rather than attaching the vanes to the outside of the hex, I had slots milled into the hex and pressed one-inch wide bars into the slots, leaving the desired amount of vane protruding. Since the machine work was done for me at no charge, the total cost so far has $1.87 for the core stock.

The completed motor configuaration is shown in Fig. 1A. Fig. 1B shows the incremental burning perimeters (one-sixth of the section is shown). Fig. 1C is a graph showing the flame perimeter versus time relationship. As the burning rate of the propellant is not known, the time can be measured in increments only.

The project has progressed to this point: the mandrel is complete. A temporary "tooling" bulkhead is to be turned for the forward end of the motor tube and a fixture made to support the tube and mandrel in the proper relationship to each other. An inert grain (no oxidizer) will then be cast as practice for the live grain, using Teflon as a mold release on the mandrel. For the inert grain, I plan to Teflon the inside of the motor casing also so that the grain can be withdrawn. This inert grain will be quite useful; its preparation can serve as a training aid and it will be cut up so that its internal structure can be inspected for bubbles and flaws. Probably a piece of it will be machined off to form the mandrel support for the live grain casting process.

The subject motor will be static and flight tested and, if proven satisfactory, will probably be used as a booster motor for future projects.

TESTING OF A $KClO_4$-POLYESTER RESIN PROPELLANT

By James W. Boland,
Reaction Research Society

On our April 24-25, 1965, firing, a relatively unproven solid propellant was tested. The propellant was a "mild" mixture of 72% potassium perchlorate oxidizer, 3% copper chromite catalyst, and 25% plastic (polyester resin) fuel.

The particles of potassium perchlorate in this mixture seem to pyrolyze much more rapidly than the surrounding fuel, leaving

RRS STAR GRAIN NO. X-1A

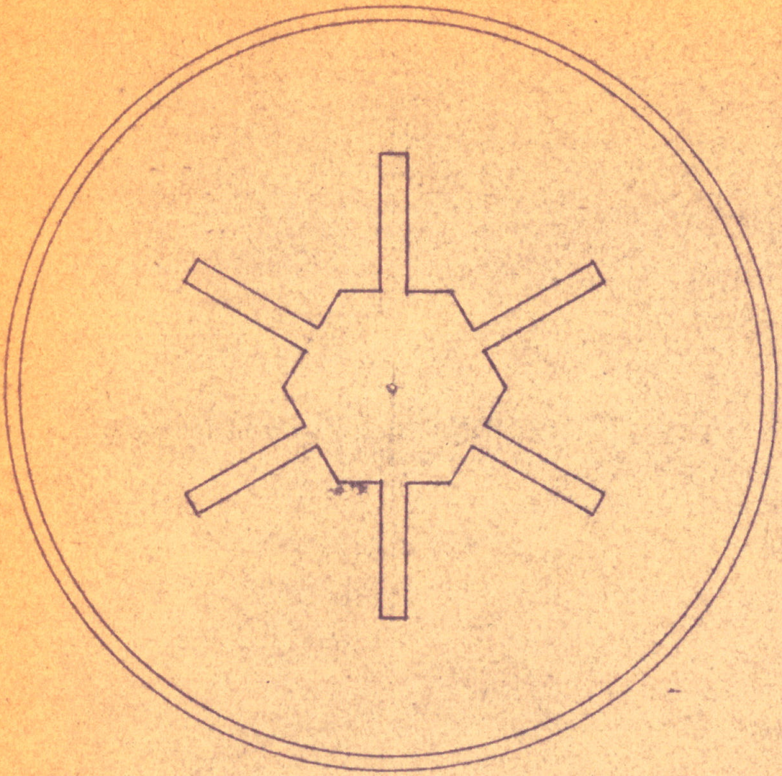


FIG. 1A
FULL SIZE

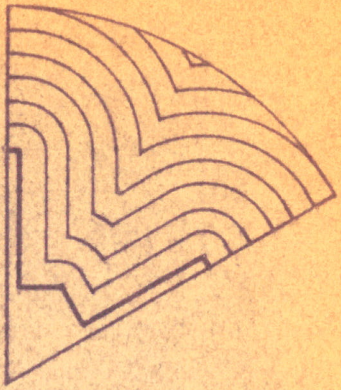


FIG. 1B
FULL SIZE

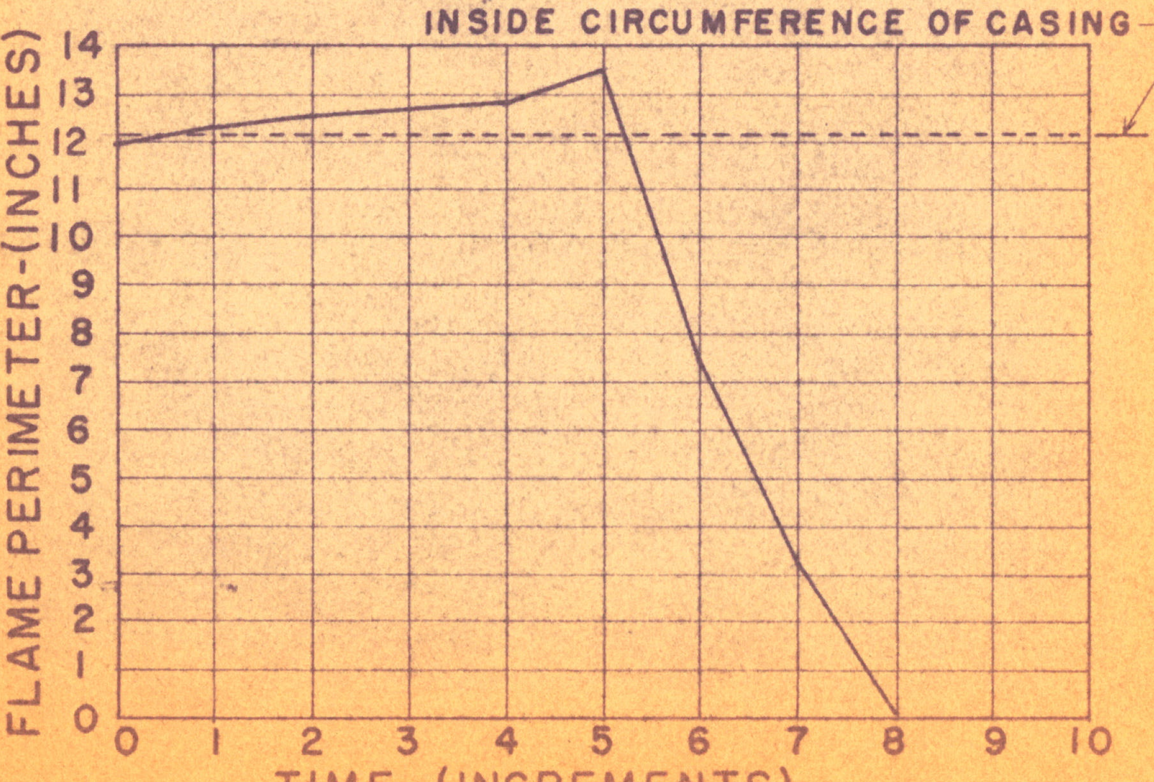


FIG. 1C

tiny boreholes in the surface of the propellant grain. The propellant, therefore, is not suitable for use with a complex grain having a large burning surface. For this reason, a tubular grain was used.

Experiments have shown that a small percentage of copper chromite powder acts as a catalyst for the thermal decomposition of perchlorates. This results in a reduction of the surface temperature without reducing the burning rate.

The motor casing of the test rocket was a twenty-six inch length of three inch O.D., 0.073 inch wall, 4170 seamless steel tubing. The nozzle was machined from 430 stainless steel, and was welded to the combustion chamber. Stainless steel was used to prevent the formation of rust pocks which might lead to the erosion of the nozzle during combustion. A tapered bronze mandrel was used to obtain an average web thickness of one inch.

Unfortunately, the mandrel could not be removed. The test motor was consequently buried, nozzle down, and ignited without the forward bulkhead. Ignition was delayed; thrust seemed to build for the first minute of burning. After three and a quarter minutes there was a slight explosion, blowing some chunks of propellant into the air. The motor burned out after approximately five minutes.

Despite the difficulties encountered in this test, the $KClO_4$-polyester resin propellant appears to be quite promising. A second motor is being built to test the propellant, and a Teflon coating will probably be used to facilitate the removal of future mandrels. Further reports will be made on our progress with this propellant.

POST FIRING REPORT

MAY 23, 1965

By Bill Claybaugh, President,
Chaminade Rocket Club

Recently, the Pacific Rocket Society, of the Los Angeles area, conducted a test firing for the Chaminade Rocket Club (Explorer Post #288) at the Mojave Test Area, owned jointly by the PRS and the RRS. Chaminade fired the rocket to test the basic unit of a proposed 7,500 pound thrust vehicle. It measured 59 inches long and is considered capable of generating a thrust of 2,500 pounds for nearly one second.

In addition to testing this rocket for the first time, the firing was also to test a parachute ejection mechanism which would release a nine inch long instrument compartment from the motor after twelve seconds of flight.

As firing time grew closer, the burnout camera was set in place, and all but the blockhouse crew retired to the observation bunker. The count progressed normally until the moment of firing, and then at zero and ignition, nothing happened. Our carefully trained crew had left the power off. After assuring ourselves that we had power in the firing box, the count was again started. This time, at zero, there was that typical whoosh as the rocket left the launcher. A few seconds later, impact was reported at launch plus 26 seconds (there being a two second delay between ignition and takeoff). After a second firing*, all ground personnel hopped into any available means of transportation and headed off across the desert.

Success was not long in coming. In not more than the time it took the rocket to fly, the instrument compartment was discovered. It had landed a quarter mile from the launcher, about 500 feet north of the flight path. Surprisingly, first examination indicated that all components were intact. We say surprisingly, since the capsule was found minus its parachute. This made it all the more important to find the rocket body, in order to determine whether the ejection charge had fired and the 'chute ripped off, or whether the capsule had

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*The second rocket, built by Richard Butterfield of the RRS for his son Roger (age five), had been fired once before during the April 24-25 firing. It was three feet long, two inches in diameter, and was fired without nosecone from a small, standby launcher. It nosed down immediately after takeoff, and traveled at a shallow angle for a distance thought to be over a mile. Burn time was unusually long, lasting for 0.70 seconds, and the rocket has not yet been recovered. -ED.

slipped off from the varying accelerations and vibration.

After nearly a half-hour of searching, our efforts were again rewarded by the finding of the rocket body. It was easy to see the rocket had been traveling at high speeds, since it was buried in the sand nearly four feet.

After removing it, we made several quick discoveries. First, the instrument compartment had indeed vibrated off the rocket, because the parachute was discovered wrapped around the nose section of the body. We are sure the capsule did not eject, since the ejection charge was found in the parachute, still unfired. More interesting yet, the lead wires to the charge had been severed one and a half inches from the base of the charge! This had first been noticed in the instrument compartment, where the shroud lines and the leads to the firing charge had been severed.

As far as we can tell, what had happened was that the rocket, about three seconds after firing, vibrated the capsule off the rest of the rocket. As the capsule came off, the 'chute caught in the airstream, and ripped away from the capsule. Despite this failure, the instruments themselves were recovered and operated perfectly in a later test, none the worse for accelerations up to 75 g's.

The flight itself was about what had been expected. Because of a 15 mph wind, the rocket leaned slightly into the wind, thus losing some height. From examining the burnout films (which caught the extreme edge of burnout, barely), and from the data collected during and after launch, we estimate altitude to be 2,500 feet and range 6,000 feet. Burnout velocity was approximately 0.65 Mach.

The successful performance of the rocket has opened the way to start work on a cluster of three of these motors, eventually to be used as a booster for a hybrid rocket rated at 1,000 pounds thrust and 30 seconds burning time.

FEATURED ARTICLES

Theoretically, micrograin burns according to the following reaction: $Zn + S = ZnS$; that is, one atom of zinc combines with one atom of sulfur to form one molecule of ZnS. In amateur rocket combustions, this reaction is rarely carried to completion, and often a zinc-rich mixture is needed. Larry Teebken, corresponding from Korea, reports of early results in his work on this problem:

ON THE COMBUSTION OF STOICHIOMETRIC ZINC DUST AND SULFUR

By Larry Teebken, Vice-President,
Reaction Research Society

Assume the following: $Zn(s) + S(s) = ZnS(g)$; we shall introduce three different substitute working fluids, and apply the proper corrections (explained in the compendium[*]), to give average values for the combustion reaction.

(1) Using H_2 as a substitute gives a combustion temperature of 3000°F, and exit temperature of 814°F, and a specific impulse of 99.4 seconds.

(2) Using CO as a substitute gives a combustion temperature of 3590°F, an exit temperature of 1520°F, and a specific impulse of 104 seconds.

(3) Using Cl_2 as a substitute gives a combustion temperature of 2781°F, and exit temperature of 1100°F, and a specific impulse of 92 seconds.

Now taking the average of the above figures (noting that the lowest combination temperature is decidedly more than the vaporization temperature of ZnS(s) (2600°F), which thus justifies at least for the time being the choice of ZnS(g) as the only phase in which the primary exhaust product exists, and noting that the highest combustion temperature is well below the point at which the ZnS(g) could be expected to dissociate into Zn(g) and S(g), which is approximately 4000 to 5000°F) gives an average combustion temperature of 3124°F, an average exit temperature of 1144°F, and an average specific impulse of 98.5 seconds. This assumes complete expansion to sea level pressure and no condensation.

However, it can be seen that condensation will, in fact, take place somewhere in the nozzle. Though I have no proof, I suspect it would be before the throat section is reached. Thus, two things may happen: (1) condensation may lead to

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[*] Texaco, Incorporated. Estimation of Performance Factors for Rocket Propellants. Compiled by J. R. Muenger and Leonard Greiner. Beacon, New York, Nov., 1962

erosion of the nozzle due to particle impingement; (2) condensation will raise the working temperature of the gas, thus raising the exit temperature with a corresponding decrease in specific impulse. In addition to these problems, if an aluminum nozzle is used, there may be erosion caused almost entirely by combination of the aluminum with the sulfur in the ZnS(g). It has been reported in other journals (AIAA) that chemical combination is suspected of being the predominant (if not sole) reason for erosion in nozzles!

If I am correct, the average specific impulse compares favorably with the upper limit of stoichiometric Zn-S. However, normally the figure is one-third of the theoretical specific impulse due to the incomplete expansion, odd shapes, etc., of amateur nozzles, allowing me to feel pretty safe about the average specific impulse. I'm not so sure about the temperatures, though; they could be wrong, but at least it's a start. I don't think there's any condensation in the combustion chamber. But I do think that the reason for the big flames and low efficiency is the burning of raw fuel outside the rocket (it just plain is thrown out by differential pressure and differential acceleration relative to the rocket body because of its looseness). If micrograin could be safely cast in place, we'd probably get near-theoretical performance out of it.

But more about the combustion temperature. Captain Brinley* reports a value of 2600°F, the vaporization point of ZnS(s), as the combustion temperature. I suspect that he didn't perform any calculations but that he assumed that the combustion temperature would be in the neighborhood of 2600°F and also that condensation took place in the combustion chamber.

Here's the way I see it: if we assume that the combustion temperature of Zn-S is below 2600°F, then condensation takes place. But this releases heat. Thus, the gas temperature is raised; as it is raised the ZnS(g) condenses more slowly. Possibly the temperature would go over 2600°F if enough ZnS(s), condensed from the gas, would begin to vaporize. As it vaporizes, it would absorb heat, thus lowering the temperature of the combustion gases. Consequently, the gas temperature would approach 2600°F again, and if enough ZnS(s) were vaporized, the gas temperature might well go below 2600°F and the process would begin all over again.

Thus two possibilities arise: (1) the gas temperature approaches and remains at or near 2600°F; or (2) the gas temperature fluctuates periodically between two temperatures extremes, one below 2600°F and one above. In either case, an average temperature of 2600°F would be justified. If the above were true, then Captain Brinley has a right to claim 2600°F as the "true" combustion temperature. But if I'm right, the temperature

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*Brinley, Captain Bertrand. Rocket Manual for Amateurs. New York: Ballantine Books, 1960 to begin with never gets low enough for the ZnS(g) to condense. Hence the gas temperature is near my reported average, although it's also possible it could be just far enough above 2600°F to prevent condensation. At any rate, it's worth looking into.

PRELIMINARY SURVEY OF A HYDROGEN PEROXIDE AND METHYL ALCOHOL ROCKET

By Don Girard,
Reaction Research Society

The Reaction Research Society, in 1952, issued an account of the development and testing of a liquid propellant rocket. It detailed the design work of David Elliott and Lee Rosenthal, and gave the results of the first series of tests.

The rocket was monopropellant, using concentrated hydrogen peroxide passing over a catalyst bed for propulsion. When completely fabricated, it stood just under six feet. On May 14, 1950, the rocket was flight tested, climaxing a series of static tests. The rocket reached an altitude (estimated) of 23,500 feet, or about 4.48 miles. It traveled downrange approximately 41,000 feet, or 7.75 miles. The total time for the flight was 84 seconds.

The rocket was never recovered, and the project ended with this first flight test. A good number of years have passed since then, and the society has worked on many other projects, though none with quite the potential and glamor of this liquid rocket.

In March of 1965, Mr. George Dosa, an administrative member of the Reaction Research Society, suggested continuing the work on the hydrogen peroxide rocket, and short weeks later, the society resumed the project. As a preliminary introduction to the field, then, we offer the following information.

PHYSICAL PROPERTIES OF H_2O_2. Hydrogen peroxide aqueous solutions of 65 to 100% by weight of H_2O_2 are of interest in propulsion applications. Most of the applications in this country use 90% H_2O_2. Hydrogen peroxide has a high density, high boiling points, and low viscosity--all desirable attributes for liquid propellants.

Since hydrogen peroxide solutions are two components, H_2O_2 and water, it has no true freezing point, but rather a range of freezing points. 90% H_2O_2, at 12°F, begins to show signs of minute crystallization under carefully controlled conditions. On freezing, hydrogen peroxide contracts and will not burst storage containers the way water does. However, H_2O_2 almost always supercools, at least 20°F below its true freezing point. This ability to supercool is probably associated with the extreme purity of concentrated hydrogen peroxide.

A summary of the physical properties of hydrogen peroxide appears in Table 1.

TABLE 1

PHYSICAL PROPERTIES OF 90% H_2O_2

Density, 68°F	
gm/cc	1.39
lb/gal	11.62
Viscosity, 64.4°F, cp.	1.30
Vapor pressure, 86°F, mm. Hg	5
Heat of formation, kcal/g-mole	
liquid	45.16
vapor (100% H_2O_2)	33.29
Freezing point, °F, a.	12
Normal boiling point, °F	284
Heat of vaporization, Btu/lb	590
Surface tension, 64.4°F, dynes/cm	75.53
Dielectric constant, 68°F	77
Conductivity, 77°F, ohm/cm	
pure	2×10^{-6}
commercial	10×10^{-6}
Refractive index, 68°F	1.398
Non-volatile residue, ppm	
commercial, specified	50
actual	20

The most characteristic chemical reactions of hydrogen peroxide are those in which it exhibits oxidizing power. Thus sulfites are oxidized to sulfates; ferrous salts to ferric; titanic salts to pertitanates; alcohols to aldehydes and acids. Many organic dyestuffs and coloring materials are oxidized to colorless compounds. The oxidizing action is relatively mild compared with chlorine, hypochlorites, and permanganate. Hydrogen peroxide also acts as a reducing agent; for example, it reduces manganese from the MnO_4^- state to Mn^{++}.

HYDROGEN PEROXIDE AS A PROPELLANT. Hydrogen peroxide has one of the longest histories of the liquid propellants. Considerable development work in Germany had been done before World War II. By 1938, the Germans were producing concentrated hydrogen peroxide which they used in a variety of weapons during the war, including the first operational piloted rocket airplane ever flown, the Messerschmidt Me 163. After the war, a great deal of this work was carried on and expanded in England and in the United States.

It is possible to operate rocket motors with concentrated hydrogen peroxide as the propellant with calcium permanganate used to decompose the peroxide. With this propellant the start is prompt, and operation is smooth. The flameless exhaust has the appearance of steam, and is actually steam and oxygen. Thermochemical calculations indicate low performance, 100% peroxide giving a specific impulse of 146 lb-sec/lb, at 300 psia chamber pressure. The chamber and exit temperatures are very low, however, 1793°F and 714°F respectively, and these low temperatures make the hydrogen peroxide propellants attractive.

The oxygen resulting from peroxide decomposition could be of more value if a fuel were injected along with the peroxide. Thermochemical calculations indicate the value of including methyl alcohol (CH_3OH) in the propellant. With the stoichiometric mixture (21.4 wt. per cent of alcohol and 78.6 wt. per cent of peroxide at 87% concentration) calculations indicate a specific impulse of 225 lb-sec/lb at 300 psia chamber pressure. The chamber temperature for this propellant is 4300°F. Calcium permanganate initiation was used in small scale rocket motor tests of this propellant and it has been found possible to shut off the permanganate as soon as combustion has begun. The chamber temperature is sufficient to ensure rapid decomposition of the peroxide.

Because of the detonability of mixtures of concentrated hydrogen peroxide with various organic materials, the methyl alcohol should not be mixed with the peroxide, but should be injected separately.

Hydrogen peroxide may also be used with nitromethane, nitromethane-methyl alcohol, nitromethane-nitroethane, hydrazine hydrate, AMF-58, and ethyl alcohol, but in this discussion we will not consider these.

Methyl alcohol (CH_3OH) melts at -144°F, boils at 148°F, and has a density at 68°F of 0.739 g/cc.

The burning of the bipropellants is made more complex than that of the monopropellants by the requirement that the fuel and oxidizer be mixed before burning can occur. The two liquids are injected into the combustion chamber to form small droplets of each material. The vapors from the droplet mix and then burn. Experiments indicate that in general, the complete mixing of the two liquids is not always a requirement for good performance. It is usually sufficient that the vapors be mixed. When hypergolic systems are used, burning of the vapors is begun spontaneously upon mixing. With non-hypergolic systems, an auxiliary ignition system (as for monopropellants) is required. Once started, the burning of most liquid propellants is self-sustaining.

In choosing a liquid propellant for use in a high altitude rocket, this author would favor the hydrogen peroxide-methyl alcohol mixture for the following reasons: (1) the relative safety of hydrogen peroxide over other propellants has been demonstrated; (2) hydrogen peroxide and methyl alcohol work on a gas-feed system, eliminating the need for expensive pumps; (3) the performance of hydrogen peroxide in combination with a fuel is significantly better; and (4) use of hydrogen peroxide as a bipropellant serves as a logical extension of the previous work of the society.

TABLE 2

CALCULATED PERFORMANCE OF TWO LIQUID PROPELLANTS
(AT 300 PSIA CHAMBER PRESSURE)

	Ratio	Exhaust Vel. (ft/sec)	Spec. Imp. (lb-sec/lb)	Chamber temp. °F	Exit temp. °F	Vol. Spec. Imp. (lb-sec/ft^3
hydrogen peroxide (87%)	--	4065	126	1216	379	11839
hydrogen peroxide (87%) and methyl alcohol	4.0	7180	223	4156	2538	16845

---END---

LONG RANGE MAIL ROCKETS

By Ed Parker, President
Reaction Research Society

The following was condensed from an article that appeared in the RRS publication, Astro-Jet, No. 18, Fall, 1947:

"Although short range rocket mail is practical for certain special purposes, the main future use of rocket mail will be in long range flights. With present knowledge it would be possible to design and build a mail rocket with a range of 500 miles. This rocket would have sufficient range to carry mail from Los Angeles to San Francisco. Except for its slightly larger size and short wings the mail rocket would resemble a V-2. The short wings are necessary to give the rocket sufficient range.

Since the rocket, like an airplane, would be used over and over, the main cost of firing would be the propellant. This improved V-2 would probably require about one and one-half times the propellant of a present V-2 or about fifteen tons (30,000 pounds). Assuming fifty cents a pound for the propellants, oxygen and alcohol, the propellant would cost a total of $15,000. The rocket would be able to carry a ton of mail (2,000 pounds). That means to merely pay for the propellant, mail would cost roughly 50 cents an ounce (most letters weigh one-half ounce). Including special delivery service at the end of the flight, and rocket maintenance cost, the charge for sending a one-ounce letter would be about $1.00.

For $1.00 you would be able to mail a one-ounce letter from Los Angeles at 10:00 A.M.; at 10:10 A.M. the rocket would land at San Francisco and by 10:45 A.M. the special delivery service would have the letter delivered--a mere forty-five minutes after having been mailed. For most people rocket mail would be more satisfactory than telegrams, because of the greater length of a letter for the same cost as a several-word telegram.

The San Francisco-Los Angeles rocket is about the largest possible in the immediate future. At the present time it appears that very long range rockets will have to await the development of controlled atomic energy.

The advantages of rocket mail would be: (1) it allows exceptionally fast mail service; (2) rocket mail is more economical and just as fast as a telegram, including processing time; and (3) the design of a 500-mile mail rocket is now technically possible."

You can see that an effort towards this type of technical progress has not been made thus far. In the past eighteen years almost all rocket vehicles have been designed for outer-space research, manned satellites, or for military purposes.

Just as the jet airplane has speeded up the airborne delivery of mail in the past, the future 2000-mile-per-hour high altitude jets will probably carry the mail of the future, and perhaps some time later rockets will be designed to be used in rapid mail service.

Most of the efforts of amateur rocket mail have been toward flying a limited number of special vignetted covers for philatelic collectors. It is becoming a commonplace thing, though, as more and more amateur rocket groups enter into the field.

In partial answer to the challenge laid down in the article above, the RRS is seriously considering the design of a supersonic mail rocket, capable of traveling from twenty to twenty-five miles.

EDITORIALS

A SACRAMENTO JOURNALIST

We pause for a quiet moment to comment. We have found journalism to be an exceptionally rough pursuit, for in combining the art of style with the science of description we can feel the sort of frustration that our happy voyageur felt riding the bomb to Russia in Dr. Strangelove.

And yet journalism can be rewarding, and exciting, and worth the tribulation. A case in mind is the recent advent of Amateur Rocketeer, a magazine devoted to those legions of us who are just that: amateur rocketeers. Peter Guerin, in a fit of saneness, saw the need for journalistic effort in rocketry, saw that the state of the art had progressed significantly since George James and 1943, and put together his attempt to conserve the post-Sputnik rocketry movement.

He has done a good job. From his first issue in January of 1964, we read: "The information is to stimulate the amateur rocketeer; to make him think about things related to rocketry. We believe there are too many amateurs who make something or do something without realizing why. We are going to show why." And Mr. Guerin has shown why, in his January issue and in the issues since.

The RRS NEWS knows the problems of continued publication (and hang our head in shame for them), and it is with a good deal of respect we salute Peter for a significant job well done.

THE CALIFORNIA COMMITTEE ON EDUCATIONAL ROCKETRY

By J. R. Stagner, Chairman,
California Committee on
Educational Rocketry

On February 29, 1964, the California Committee on Educational Rocketry (CCER) was formed to resolve some of the problems existing in the field of educational rocketry. The group consists of scientists, engineers, educators, students, and others, and represents the interests of both model and organized amateur rocketry. The term "educational rocketry" was adopted to emphasize the common objective of both amateur and model rocketry.

These two active and previously rival interests recognized their common and complimentary interests in the field of experimental rocketry and resolved to cooperate in seeking the support of legislative and administrative officials in creating a climate which encourages the realization of the benefits of educational rocketry in a safe and legal manner.

In the State of California amateur experimental rocketry is regulated to the point of prohibition. Responsible and technically competent amateur organizations operate within the state with difficulty and under an often severe financial burden because of insurance requirements. Once active model rocket clubs were forced to disband when they could neither obtain safe commercial engines nor comply with heavy insurance requirements. Individuals of all ages are conducting clandestine operations which are, by their nature, frequently unsafe and often result in tragedy.

Of particular concern are young teenagers who, unable to obtain safe commercial engines for their model rockets, are not old enough to participate in the programs of competent amateur groups or lack the manual skills necessary to build amateur rockets and therefore resort to homemade and inadequately understood substitutes with disastrous results.

Older teenagers, being unable to fire amateur rockets legally and within the framework of a qualified organization, are firing their rockets anyway, often without adequate technical preparation or supervision. Still other groups which do have competent technical guidance are forced to conduct firings in other states having fewer restrictions. It is obvious that these situations are undesirable and that modifications of present California laws and regulations may be able to correct them.

The CCER has pursued both legislative and regulatory approaches to the solution of educational rocketry problems. The above situation was brought to the attention of Governor Brown and several state legislators after attempts to obtain constructive action directly from the State Fire Marshal's office proved fruitless. These men, in turn, prevailed upon the State Fire Marshal Glenn B. Vance to give the matter positive and constructive consideration. This has resulted in a new set of regulations for model rocketeers and a promise to relax some of the regulations concerning amateur rocketry, particularly in regard to insurance.

The new regulations prohibit modelers from launching rockets on their own, but do permit students belonging to clubs or other organizations to participate under adult supervision. The regulations may therefore exclude many youths who, for various reasons, cannot find a suitable club or adult sponsor to obtain engines for them. To the extent that this is true, model rocketry will lose some of its effectiveness as a deterrent to "basement bombing."

A second and equally significant development has been the introduction of Assembly Bill No. 3033 by the honorable Charles W. Meyers (assemblyman, San Francisco). This bill is based on recommendations made by the CCER and was referred to an interim committee for further study. Hearings on the bill will be held in about one year and hopefully it will be considered by the State legislature in 1967.

The assembly bill, if passed, would remove educational rocketry from the fireworks section of the Health and Safety Code and create a separate body of laws dealing exclusively with educational rocketry. This should help to establish the educational and scientific objectives of rocketry. These new laws would take into account the variable degree of hazard to the non-participating public and the technical competency of individual groups, rather than make a blanket statement that public liability insurance is required under all conditions without qualification. The amount of red tape now required of the amateur would be lessened and this would also lessen the burden on enforcement officials while still enabling them to maintain adequate controls.

The bill would not alter the present laws from the standpoint of fireworks but would separate educational rockets from fireworks. This is justified since educational rockets differ both quantitatively and qualitatively from fireworks, and this includes both amateur and model rockets. Fireworks manufacturers agree with this, but because it is simpler for fire officials to class rockets with fireworks and apply already existing laws to them, they oppose any reforms which modify this situation or give them less control.

In the present version of the bill, no special permits are required and the modeler could order his engines directly from the manufacturer. The license and permits (about $1600 total) required for manufacture, import, and retail of fireworks would not apply to model rocket engines, and would thereby make rocketry more practical for the engine manufacturer and ultimately the modeler.

To date, most of the progress in obtaining regulatory reforms for educational rocketry has been in the subfield of model rocketry. Many readers may feel that they do not know enough about model rocketry to form an opinion. It is my understanding that other authors (including RRS members) will be writing articles about model rocketry in future editions of the RRS NEWS. In this article I will show how model rocketry fits into the scheme of things.

Because the rocket is so prominent in our culture, it is only natural that our youth be curious and want to get an early start in preparing for a challenging and exciting scientific career. Over 80% of the total number of individuals interested in pursuing some form of experimental rocketry are under sixteen years of age, the peak age being fourteen years. These figures are based on a recent survey conducted by the CCER in California and I believe they are both accurate and reasonable. These figures would probably apply equally well to other youth activities such as model airplanes, scouting, etc.

It is the exceptional student from this age group that possesses the necessary manual skills required to build a passable amateur rocket. Hence amateur rocketry alone does not satisfy the public need for an educational rocket program. On the other hand, some model rocketeers will feel they have done all there is to do with model rockets or for some other reason will wish to advance to the more complex amateur rockets. There must be suitable organizations and competent guidance available to accomodate them. It should also be pointed out that the age group under sixteen years is less patient and tolerant of unnecessary red tape.

Model rocketry is "scaled down" rocketry, so that it can fit into school programs and be practiced by the age group excluded from amateur rocketry. It is so restricted technically as to present negligible hazard to both participants and non-participants. But even with these heavy technical restrictions there are an almost unlimited number of scientific experiments that can be performed and concepts that can be elegantly illustrated, a discussion of which would require a separate article to cover adequately.

The only opposition model rocketry has had comes from the State Fire Chiefs' Association, a very powerful lobby. A resolution was introduced from the floor of the annual National Fire Protection Association by the California delegation on May 21, 1965. This resolution was a stinging condemnation of model rocketry and called for immediate and intense action by the FMANA to stop this "dangerous" activity. This group has been against any reforms which would weaken their control over rocketry, and in fact would like to see all forms of amateur experimental rocketry either stopped or so restricted that only a few could practice it.

There is also evidence of lack of understanding by officials in high places of the significance of organized amateur rocketry. This is detrimental to the amateur since these officials may act as "ambassadors" on occasion. As a case in point: Howard Galloway, NASA space technologist and Dr. Merle Ahrendt, NASA office of education spoke at the above NFPA convention on the merits of "model rocketry" in comparison to "amateur rocketry." Another case in point: a directive from the director of personnel, U.S. Air Force, effectively recognizes the educational and motivational aspects of model rocketry and encourages its personnel to practice this form of rocketry while specifically discouraging the practice of amateur rocketry.

On the surface the above situation smacks of rivalry between model and amateur advocates. In reality the situation results from officials recognizing the positive side of model rocketry while recognizing only the hazardous aspects of amateur rocketry. In other words, the amateur interest isn't being adequately represented in high places. Model rocketry, on the other hand, is represented both nationally and internationally by the National Association of Rocketry (NAR).

I have, in the preceding paragraphs, tried to explain the basic objectives of the CCER and our progress to date in achieving these goals. There remains the immediate task of obtaining regulatory reforms for the amateur as we have done for the modeler--particularly in the area of insurance requirements. We intend to proceed with legislation to counter the possible eventuality that adequate reforms cannot be obtained by regulatory means. I have tried to show that anti-rocket forces are building on a national scale. In California, where the amateur is active and is represented, he is theoretically being allowed to practice his skills, even though most groups do so under difficult circumstances. We stand an excellent chance of loosening some of these restrictions since we have the promise of officials that they will help us. It should be recognized however, that anti-rocket forces in California will not give up easily and we must be prepared to meet and oppose them whenever the opportunities arise or the future of any kind of amateur experimental rocketry is uncertain.

For those that would desire further information about the CCER, or about model rocketry, Mr. Stagner can be reached by writing to J. R. Stagner, 3148 Lexington, El Monte, California 91731. -ED.

BOOK REVIEWS

School of Aerospace Engineering, University of Oklahoma. Propulsion. Amateur Rocket Association, 1963

The book is one of a series of five text books produced through the cooperative efforts of NASA and the ARA. It gives an introduction to rocketry, covers chemical, electrical and nuclear propulsion systems, and presents the engineer's view of nozzle and vehicle design.

The RRS has found this text to give a clearer explanation and a more complete treatment of rocket equations than its counterpart, Brinley's Rocket Manual for Amateurs. The reading level is about that of senior high school; its content is not aimed at the amateur, but can be readily used for amateur purposes.

Several times, though, we have caught the author in a mathematical version of ring-around-the-rosy, as is the case in the section of nozzle design. For the interested, a better treatment of nozzle theory can be found in Francis Warren's Rocket Propellants published by the Reinhold Corporation (New York) in 1960.

Nonetheless, we find Propulsion informative and generally very helpful, and recommend it for those who need a basic text to begin a serious study of rocketry.

Cole, Dandridge M., and Cox, Donald W. Islands in Space: The Challenge of the Planetoids. Philadelphia: Chilton Books, 1964

Although in a different corner than amateur rocketry, Islands in Space gives an authoritative discussion of the planetoids, and advances the case for their exploration in the immediate future. The planetoids, it is noted, have received very little attention in relation to their potential worth. The authors have set out to correct the omission.

And in presenting a summary of the available information, they do very well. Both men are adequate chronologists. But from there, Cole and Cox in advancing their plan to develop the planetoids meet with the dangers of unmapped paragraphs. Around a number of real, now existing space projects, the two build a fanciful story of manned flight, of colonizing and moving planetoids, and of the weapon potential of these small planets.

It makes for interesting reading, at times even exciting; their presentation is bold and optimistic; their style very smooth. The Islands in Space have been treated very well indeed; but The Challenge of the Planetoids reminds us of attempts of other writers to turn science fiction into a layman's version of science fact, a process not usually trustworthy.

Grove, C. S. Jr., and Rosato, D. V. Filament Winding (Its Development, Manufacture, Applications, and Design). New York: John Wiley and Sons, 1964

The book is the first in a series in Polymer Engineering and Technology concerning the fabricating, processing, and applications of plastics, elastomers, and fibers. The price is $15.

Larry Teebken, of some experience in this field, offers the following condemnation:

"The authors don't even know how to make an accurate, cipherable drawing let alone write a whole book. I paid $15 for information most of which I could have found out for free and a great deal of which I already knew. Their descriptions of methods and of equipment for winding is at best sketchy and virtually useless for someone like myself who's interested in actually building a machine. Even with this information, we're still left to ourselves as far as the actual design of parts, tensioning devices, carriage drives, etc.

"As an example of the incompetence of these authors, consider the following formula for winding an end closure that will have the same bending and torsion characteristics as the cylinder end closure junction has:

$$\frac{R_t}{R_l} = 2 - \tan^2\theta_e.$$

According to the book, θ_e is the angle that the filament makes with the meridional plane passing through the pole. Since the filament is tangent to the polar opening, its angle θ_e at this point is 90°, and consequently the $\tan^2\theta_e$ is infinity! Now how I'm supposed to work with that I don't know and they don't say. Not only that, but when they rearrange the formula so that an isotensoid structure is described, the formula comes out with only the $\tan\theta_e$ and not $\tan^2\theta_e$. The company deserves both barrels for not catching the mistakes and omissions in proofreading."

We'll leave it to the reader to judge the book.

THE LOCAL SCENE

Excerpts from the minutes of the May 9, 1965, RRS meeting: Permanent telephone communications to be installed at the Mojave Test Area (a committee of two formed for this). . . . H_2O_2 and methyl alcohol rocket preliminary survey presented. . . . Committee set for membership recruitment program. . . . Dates set for a work party, the next firing, publication deadline for RRS NEWS 99.

Mr. George Dosa, an administrative member of the RRS, has announced his intention to build and flight test a liquid bipropellant rocket (hydrogen peroxide and methyl alcohol). A preliminary report begins on Page 22.

The RRS recently obtained a deep well water pump and storage tank for its MTA facilities. It was acquired through the assistance of Mr. W. D. Weaver and the General Telephone Company from Mrs. Helen Winters, who has generously donated it to the Society. The equipment will be used to draw water from the well now on the desert site. A sincere expression of thanks is in order to those who have helped.

The RRS expresses its thanks also to Mr. Sam Cordova and Mr. Paul Nimmons for their assistance in building the star grain mandrel.

The work party over the June 12th weekend was a success. Richard Butterfield, George Dosa, Dennis Shusterman, and Don Girard combined their efforts to build permanent bases for the two RRS launching racks, and to lay out and mark the first section of a two-mile downrange line. Ed Parker, unable to make this trip, had been out the previous weekend to make improvements on the compound and living areas. Congratulations for all concerned.

The second launcher of the RRS has been converted to accept either three- or four-finned rockets. Welcome news for all.

It seems to be the season of hard lumps for Captain Brinley. His coefficient of thrust equation appears to be incorrect. The formula used by George P. Sutton in <u>Rocket Propulsion Elements</u>, and by other respected authors, reads:

$$C_F = \sqrt{\frac{2k^2}{k-1}\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}\left[1-\left(\frac{P_e}{P_c}\right)^{\frac{k-1}{k}}\right]} + \frac{P_e - P_a}{P_c}\left(\frac{A_e}{A_t}\right)$$

Stop buying the recently reprinted research paper on the Development and Testing of A Hydrogen Peroxide Rocket, by David Elliot and Lee Rosenthal, even though this report was honored with an award by the American Rocket Society, and describes the design, construction, and testing of the first liquid propellant rocket to be fired by the RRS. Though the price is only $1.50 post paid, ordered from the Reaction Research Society, P.O. Box 1101, Glendale, California 91209.

Did you ever wonder what's going off in the world of rocketry on the other side of your blockhouse? Peek out your viewing ports and periscopes of the RRS NEWS and find out what the other Van Allen belt fans are launching. Put your nozzles in hock and buy a subscription now. For a mere $2.00 you will receive a Titan missile's value in news--without this quarterly you may never find out if the RRS beats Russia to the moon. The RRS NEWS will also accept advertising copy at the following rates: half page typed advertisement $5.00; full page $10.00; advertisement incorporating artwork (to be supplied by advertiser) an additional $4.00. All advertising prices per issue.

We also encourage our subscribers to patronize the advertisers represented in the RRS NEWS. Send your subscription money or questions to the Reaction Research Society, Incorporated,
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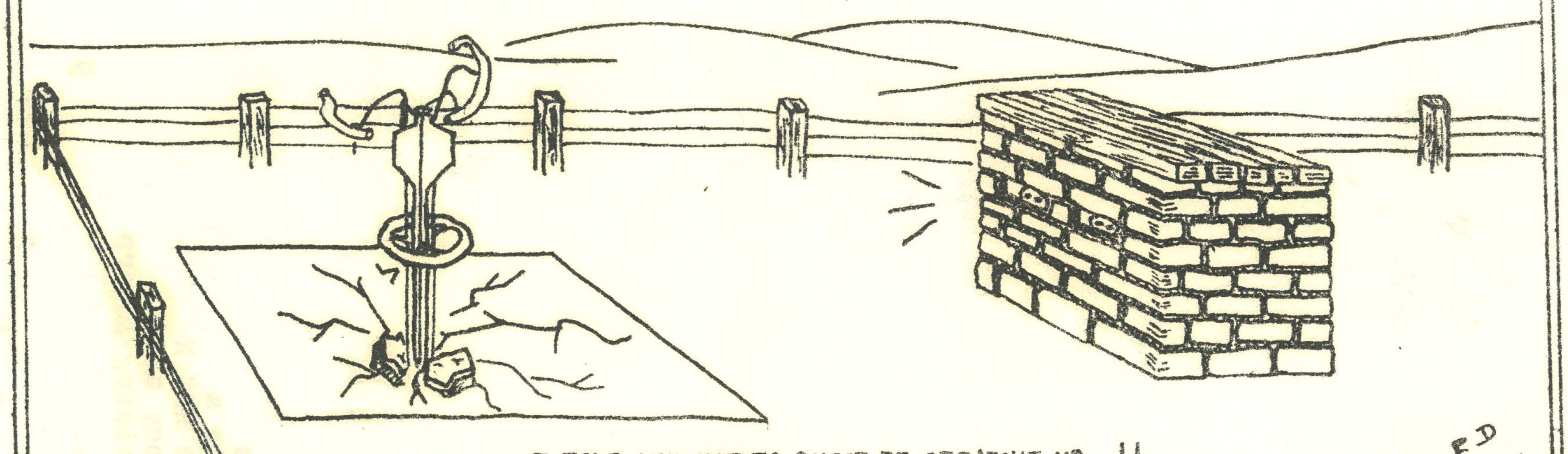

I TOLD YOU NOT TO SHOOT IT STRAIGHT UP !!

RD

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