RRS NEWS

TO PROMOTE STUDENT
EXPERIMENTAL ROCKETRY

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FROM THE EDITOR

Willy Ley is by the standards of most an excellent space reporter, but we must regard with some alarm one statement of his in the recently published edition of Rockets, Missiles and Space Travel. With a stroke of the pen, he has consigned the Society to the cold, rude coffin of non-existence. We hastily assure Mr. Ley that we are alive and doing well indeed here in Los Angeles.

Now we might not be so dismayed if the good German author had merely dismissed us to a journalistic graveyard (for writers who use deathly prose), or had even put us out to pasture to read Strunk and White's The Elements of Style, but no, it is only the obituary column for us.

But for the moment, if we were to accept Willy Ley's premise that the Reaction Research Society is no longer operational, we would find ourselves blessed with an entirely new perspective. No longer must we write articles, and no pictures need taking either, nor is there a need to edit, for it is quite plain that dead men tell no tales.

Alas, however, the Society is alive and in rather excellent health. In the following pages you will find an account of a reliable parachute ejection device, an unusual story of a high school science club that traveled several thousand miles to fire one rocket, and a complete listing of ten weekends of rocket experimentation.

You will also find a whimsical account of soap bubbles (a strange substance that has been used to solve advanced engineering problems), some insight into computer programming, information on graphite nozzle inserts, two stage devices, book reviews and advertising.

Of interest to those legions of you who had not heard of the RRS before this reading is a four-page special report on the history and current work of the nation's largest senior experimental rocket society.

We hope that you, along with Mr. Willy Ley, will undertake this grave reading matter in good spirits.

RRS NEWS

A magazine of comment on the amateur field today.

RRS NEWS NO. 103 ISSUE ONE, 1968

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MANAGING EDITOR

Don Girard

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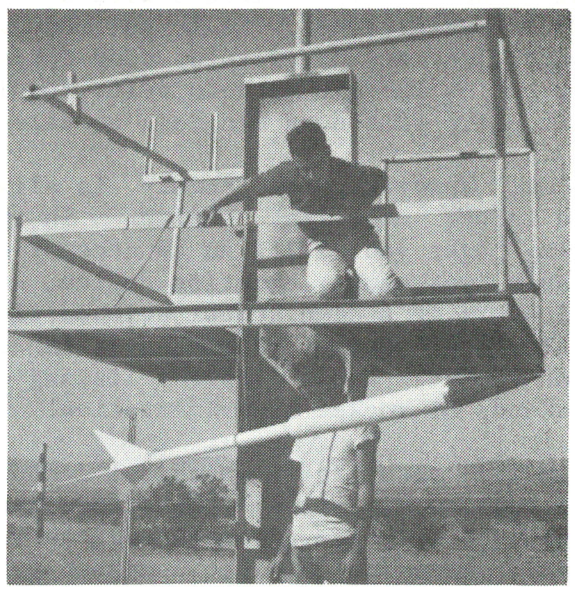
FEATURED ARTICLES

PHOTOELECTRIC PARACHUTE EJECTION

By Dave Crisalli,
Reaction Research Society

The Light Dependent Resistor (LDR) system, which has been used by the Society with some degree of success, depends on light variations as the rocket peaks and starts its descent. The entire unit used in the current rocket test series consists of two separate systems: the electronic detonating device, and a piston arrangement for the explosive deployment of the parachute.

The system was first tested on August 19, 1967. At peak, several of the tracking crew saw the nose cone separate from the rocket and the 'chutes deploy. The only problem was that someone had forgotten to connect the 'chute to the rocket in the haste of preparation. The rocket was reduced to rubble upon impact and a few minutes later the two parachutes drifted down. The same system was tested again on October 15, 1967. This rocket exploded in midair and no usable data was obtained. Again, on February 11, 1968, two rockets carrying the system were fired. The first launch could be seen during the entire flight. Upon examination of the wreckage it was evident that the charge had gone off, but the piston had jammed, preventing the deployment of the parachute. It was impossible to tell whether the charge had gone off at peak or upon impact. The second rocket that day burned in the rack. Eventually, it built thrust and rose to a record-breaking altitude of 20 feet and crashed 10 feet from the rack.



Dave Crisalli (on stand) determines the center of gravity and center of pressure for his test rocket.

The only completely successful test occurred on May 18, 1968. Two and a half minutes after launch, the rocket returned to the desert floor via 'chute. The rocket sustained absolutely no damage. Four minutes after launch, the nose, on a separate chute, drifted to earth also with no damage to either the nose or the system.

The electronic system is comprised of an LDR, a miniature relay, two batteries (3 volts and 9 volts), a mercury switch, and a safety switch. While the rocket is in upward flight, the sunlight strikes the LDR, keeping its resistance low, allowing current to flow through the relay. When the rocket peaks, the light intensity is greatly reduced, increasing the resistance of the LDR. As the resistance increases, the relay flips and the charge goes off. The mercury switch and safety switch are to prevent premature ignition. The safety switch is a small toggle switch turned on just prior to launch and the mercury switch closes at burnout.

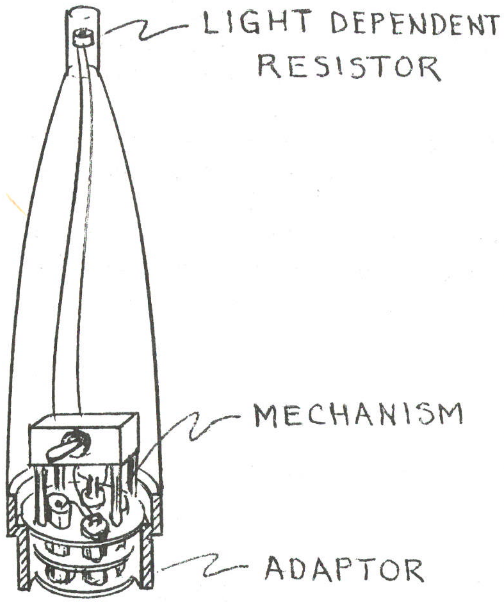


FIGURE 1. LDR SYSTEM MOUNTED IN NOSECONE

The first step in construction is the preparation of the nose for the LDR. First, the tip of the nose is cut off exposing a circle about a quarter-inch in diameter, then an eighth-inch hole is drilled through to the inside. A three-quarter-inch diameter, one and a half-inch long piece of steel tubing is placed over the end of the nose and epoxied in place. A wood^n plug is fitted inside, allowing half an inch of empty tube at the top. A hole is drilled through this also. The LDR wires are threaded through the hole and the LDR placed flat up against the wooden plug. After the LDR is mounted, a clear plastic plate is glued over the top of the tube. By making opaque caps for this tube and adjusting the size hole in the top of the cap, varying degrees of sensitivity can be achieved.

The system itself is mounted on a three-tiered plastic chassis. This chassis consists of plastic plates supported by four stainless steel mandrels. Once all the components are assembled on the chassis, the whole unit is sheathed in an aluminum adapter that also serves to hold the nose cone in the tube.

The piston arrangement provides a powerful and effective deployment of the 'chute which prevents the 'chute from burning due to charge gases and tangling of the shrouds. The piston is connected to an aluminum plate which is tied to both the rocket and the 'chute. It is driven upward by a 12 gauge shotgun shell (Red Dot, 90 pounds pressure) in an aluminum chamber ignited by an electric match. The nylon cord that connects the plate to the rocket is coiled around the charge casing and unwinds when the charge is fired. Because the plate is tied to the rocket and the chute is tied to the plate, the whole system comes down all on one 'chute. This

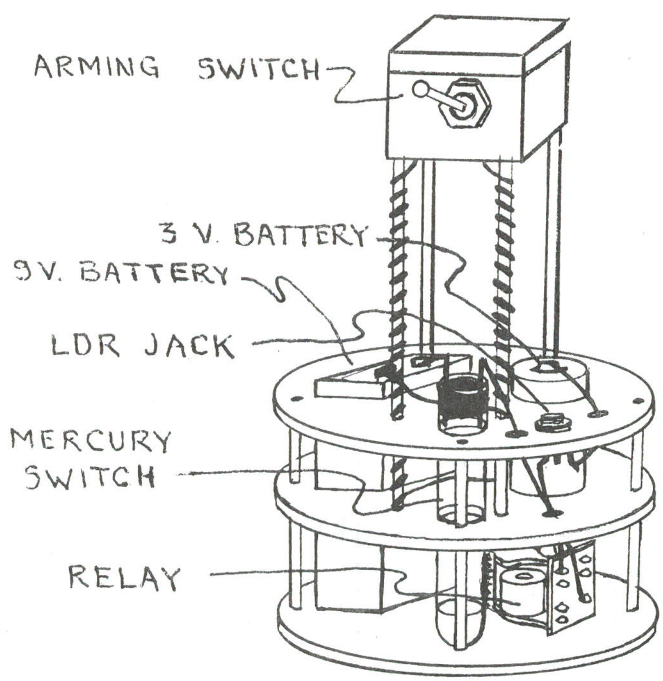
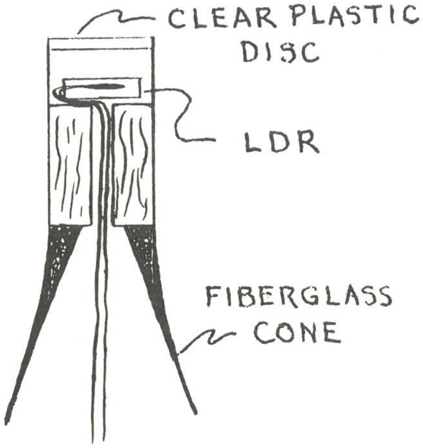


FIGURE 2. LDR MECHANISM



piston system was found useful only in tubes larger than three inches in diameter. For tubes under this size, only a charge placed at the bottom of the tube is necessary. Some work in the past has been concentrated on split tube techniques, but as yet no completely reliable system has been developed.

In the future, attempts will be made to reduce the size and complexity of the system incorporating electronic components instead of mechanical units. Soon, a reliable, inexpensive, and compact unit for parachute deployment may emerge from experiments such as these.

FIGURE 3. LDR MOUNT

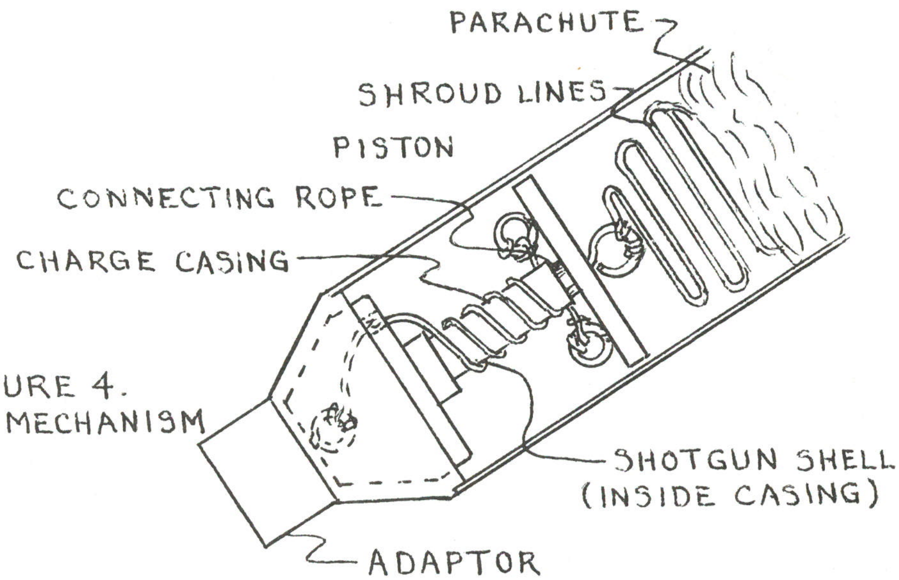
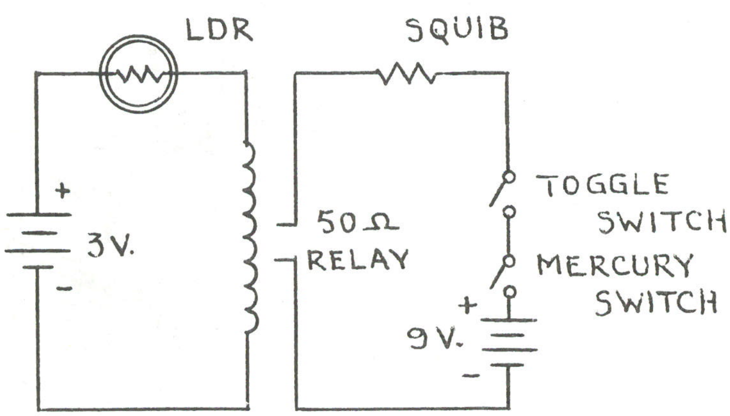


FIGURE 4. EJECT MECHANISM

FIGURE 5. SCHEMATIC



Parts list for relay system:

Mercury switch
Miniature toggle switch
50 ohm miniature relay
9 volt radio battery
3 volt battery, #532 Alkaline
Light dependent resistor, can be purchased from Herman H. Smith Inc., Norelco Kits Dept., 812 Snediker Ave., Brooklyn, N.Y. 11207

ROCKET PERFORMANCE TABLES IN FORTRAN IV

By Carlos Beer,
Reaction Research Society

In explaining these methods of computing performance tables it is assumed that the reader has a basic understanding of the principles related to computers and computer programming. As the title suggests, the computer language is Fortran IV. The computer used was the IBM 1130.

As most amateur rocketeers know, the rocket trajectory depends on several factors: thrust, gravity, and the aerodynamic forces, i.e. lift and drag. These factors are taken into account in data reduction to completely analyze the rocket path (a most tedious task). This is the standard method of the RRS as explained by George Dosa in his Thrust and Drag report that quite incidentally this author is now attempting to program for computer evaluation (holy programming, Mr. Dosa).

The purpose behind the work done in computing these tables is to have a more or less accurate field table from which rocket altitude, burnout velocity and range can be obtained. These tables are by no means to supersede the far more accurate and lengthy RRS method. Therefore, on this basis, I will explain the method.

In general, we know that there is still another parameter that affects altitude, that is, burnout velocity. This in turn will affect total flight time. Total flight time can be accurately obtained either visually or by the sound of impact. Since most amateur rockets are unguided and have short ballistic trajectories, the total flight time will be given by:

$$T_t = \frac{2V_c \sin \phi}{g} \qquad (1)$$

where: V_c = burnout velocity,
ϕ = launching angle with horizontal, and
$g = 32.2$ ft/sec^2.

It follows that:

$$V_c = \frac{T_t g}{2V_c \sin \phi} \qquad (2)$$

The altitude is then:

$$H = \frac{V_c^2 \sin^2 \phi}{2g} \qquad (3)$$

and range:

$$R = \frac{V_c^2 \sin 2\phi}{g} \qquad (4)$$

As we may easily see, if we have the true value of T_t, we are able to calculate the true value of V_c which in turn will give us the true value of H and R. The accuracy of Formula (2) depends of course on the accuracy of T_t and the formula itself.

The burnout velocity is also given by the well known formula:

$$V_c = gI_{sp}(\ln N - \frac{N - 1}{\psi N}) \qquad (5)$$

where: I_{sp} = specific impulse,
N = loaded weight divided by cutoff weight, and
$\psi = F/W_i$ = initial thrust to weight ratio.

This formula is used in computing the tables. As most of you know, the ideal performance of a rocket (constant thrust, no drag, constant g) never equals the actual performance. Actually, the true value will be as much as 50% the ideal. Now if we have two rockets of different mass ratios R_1 and R_2, $R_1 > R_2$, their ideal and true trajectories being respectively TI_1, TT_1, TI_2, TT_2, there will be some value of the ideal parameters of R_2 for which the trajectory of R_1 will come true. Let me explain. R_1 has a bigger mass ratio than R_2. Therefore, its ideal altitude $TI_1 > TI_2$. But TI_2 <u>might</u> be equal to TT_1 if the <u>true</u> cutoff velocity of R_1 is equal to the ideal cutoff velocity of R_2. Range and time of both trajectories will also be equal. This is shown in Figure 1.

Applying these principles to a program the following procedure results:

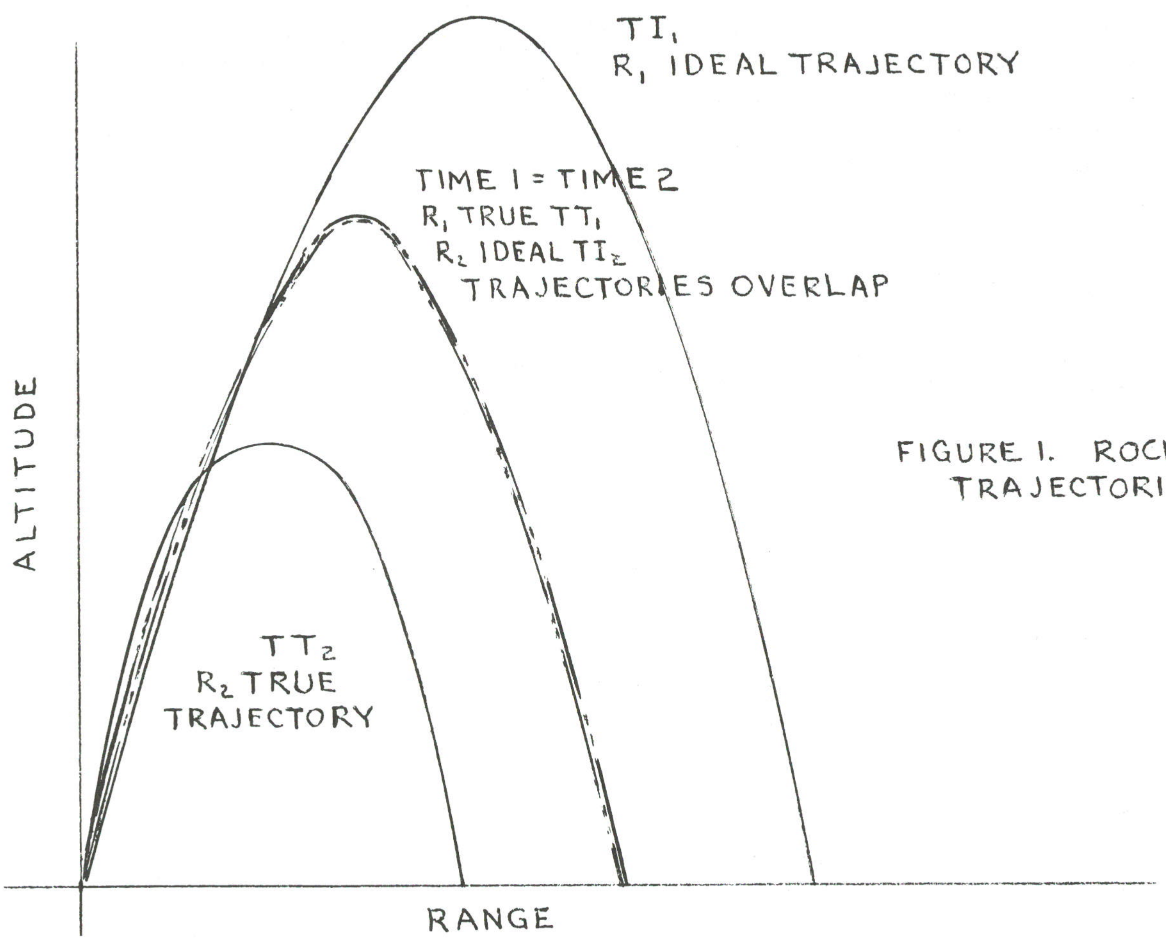


FIGURE 1. ROCKET TRAJECTORIES

A set of dummy parameters that would give fairly high flight times was chosen (i.e. 100 seconds). That is, a rocket that under maximum ideal conditions would give a maximum flight time. Keeping the total weight constant and increasing the propellant weight from a low initial value to a high final value will result in increasing mass ratios and increasing values of burnout velocity. Keep in mind that in order to increase the weight of the propellant without increasing the total weight, the empty weight must be decreased proportionately.

With the calculated values of burnout velocity, the altitude, time and range can be readily calculated using (1), (3) and (4). Please remember that as the empty weight of the rocket W_r approaches zero, N approaches infinity and V_c approaches infinity, since V_c is a logarithmic function.

TABLE 1

Launch Angle: 80°

W (lb)	Time (sec)	Mass Fraction	Burnout velocity (ft/sec)	Altitude (ft)	Range (ft)
15.0	32.1	.37	524.90	4147.1	2997.9
15.5	33.5	.38	548.49	4527.9	3273.2
16.0	35.0	.39	572.53	4933.6	3566.5
16.5	36.5	.40	597.08	5365.6	3878.9
17.0	38.0	.41	622.14	5825.5	4211.3
17.5	39.6	.43	647.73	6394.7	4565.0
18.0	41.2	.44	673.90	6835.1	4941.2
18.5	42.8	.45	700.64	7388.5	5341.2
19.0	44.5	.46	728.01	7976.9	5766.6
19.5	46.2	.48	756.02	8602.5	6218.8
20.0	48.0	.49	784.70	9267.7	6699.7

To explain the tables: six columns are printed. These include propellant weight, time, mass fraction, burnout velocity, maximum altitude and range. The values for weight serve as check items for each iteration. The increment on this column is half a pound per row. Time is the column that will determine the rocket performance since it is the known factor. Mass fraction is a reference value that indicates the mass fraction that will make possible to obtain the given values of V_c, H and R which are the last three columns.

Now, let us take the same rocket that George Dosa used to study in Thrust and Drag. We will also use Table 1, which is a fragment of Table 6 from the Fortran printout. After careful data reduction, Mr. Dosa reported the values for maximum altitude, velocity and range for the study rocket to be:

Altitude: 4892 feet,
Velocity: 600 feet/second, and
Range: 2800 feet.

Using the tables with the data supplied, that is, a launch angle of 80° and time to impact of 35.5 seconds and interpolating:

Altitude: 5077 feet,
Velocity: 580.6 feet, and
Range: 3878.9 feet,

which, except for range, gives fairly accurate values. Note that intermediate values are obtained by interpolation. More careful data reduction is required to ascertain the accuracy of the tables, which I leave up to the reader. I myself am satisfied with the results.

For those who have a computer available for their use and with the previous discussion, the programming technique follows.

1. Enter all data required.
2. Calculate V_c.
3. Calculate H, R, T_t.
4. Calculate mass fraction.
5. Output values (Format E14.7)
6. Increment W_p (propellant weight).
7. Recalculate V_c.

This procedure is iterative and gives the values for one particular launching angle. If more launching angles are desired, iterations are carried out incrementing the launching angle every degree (value in radians). These tables cover launching angles from 75° to 86°. Eleven tables with a processing time of ten minutes were run on the 1130 computer.

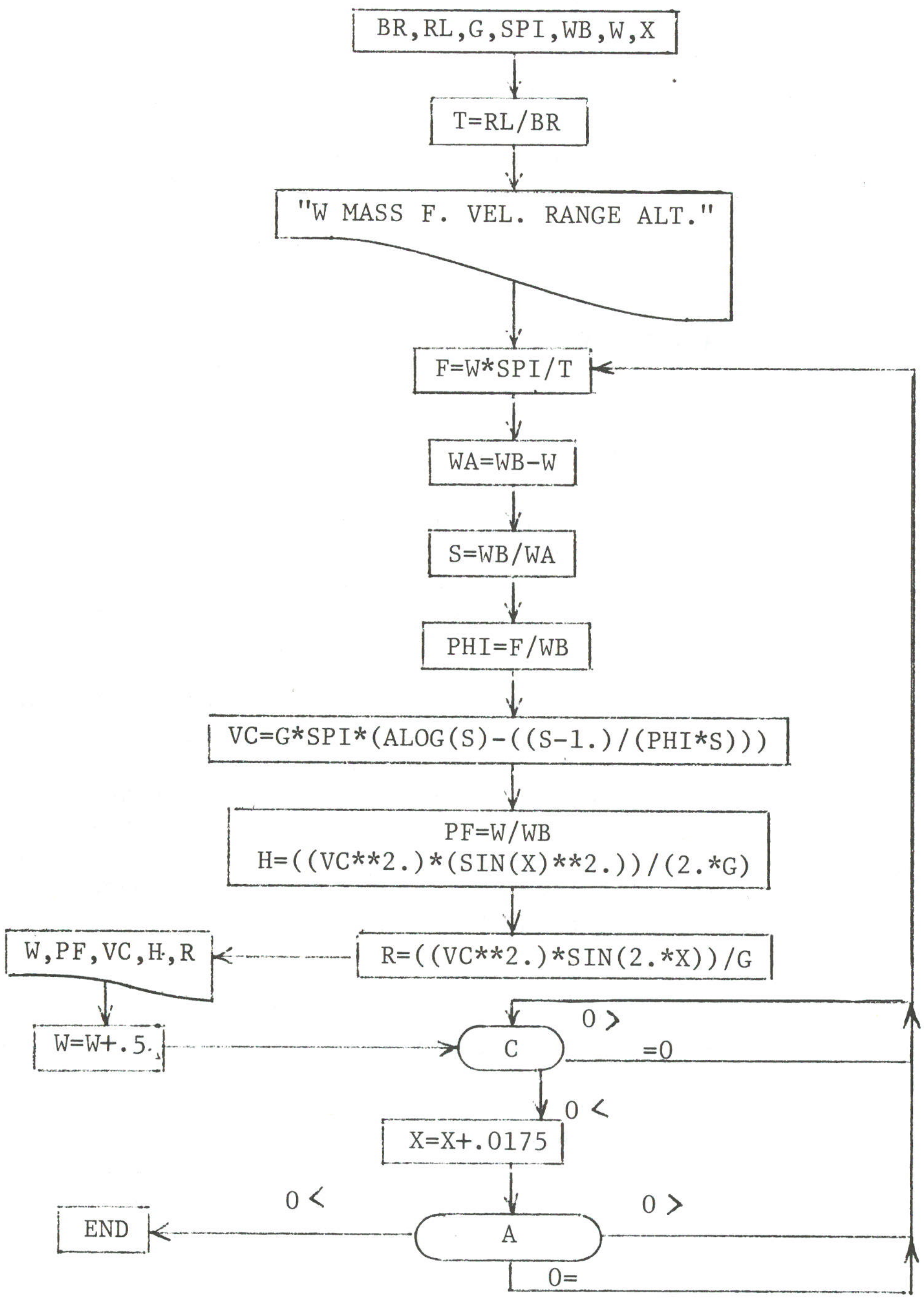
For those interested in reproducing the tables, the program and flow chart are given here. The variables are as follows:

BR = burning rate
RL = chamber length
G = 32.2 ft/sec^2
SPI = specific impulse
WB = loaded weight
W = initial value of propellant weight
X = initial launching angle.

The Program:

```
// JOB
// FOR
*1OCS (1132 PRINTER)
  BR=7.5
  RL=6.0
  G=32.2
  SPI=37.0
  WB=40.5
  W=5.0
  X=1.310
  M=75
  WRITE (3,1)
8 WRITE (3,2) M
3 T=RL/BR
  F=W*SPI/T
  WA=WB-W
  S=WB/WA
  PHI=F/WB
  VC=G*SPI*(ALOG(S)-((S-1.)/(PHI*S)))
  PF=W/WB
  H=((VC**2.)*(SIN(X)**2))/(2.*G)
  WRITE (3,4)W,PF,VC,R,H
  W=W+.5
  IF(W-WB)3,3,5
5 X=X+.0175
  M=M+1
  IF(M-86)8,8,6
6 CALL EXIT
1 FORMAT (/7X,1HW,13X,13HMASS FRACTION,
     2X,14HBURNOUT VELOC.,3X,13HMAX. ALTITUDE,
     4X,5HRANGE/)
2 FORMAT (/5X,13HLAUNCH ANGLE=,E14.7)
4 FORMAT (5(2X,E14.7))
  END
//XEQ
```

FLOW CHART



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By school bus, some twenty-five high school seniors came to California from South Bend, Indiana, to launch a single rocket. There were many elements of a Steinbeck masterpiece: courage, struggle, melodrama. If this were a different magazine, we would write this story about the people. But instead we write about the rocket, and leave the details of the other story to be filled in by the passion of imagination.

INDIANA TO CALIFORNIA AND BUST

By Ron Miller, Moderator
James Whitcomb Riley High School Science Club

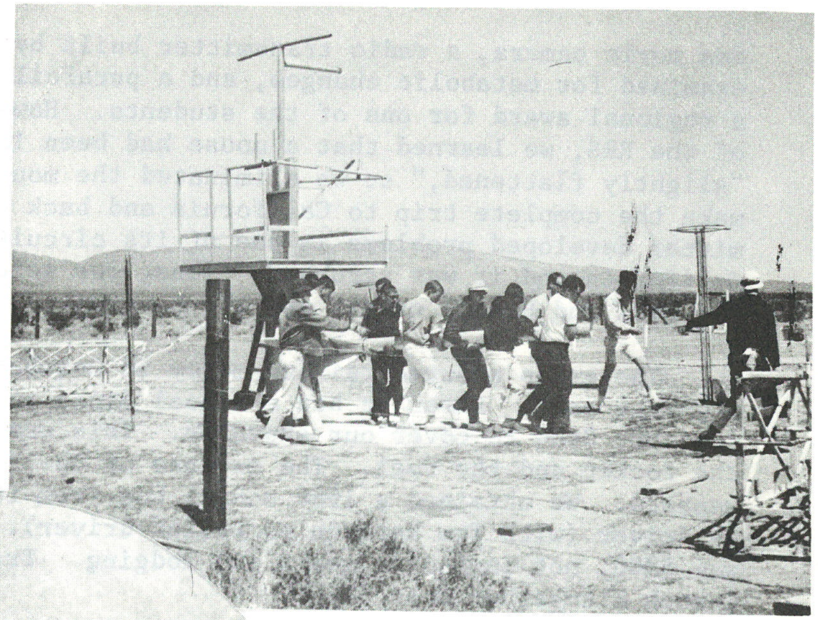
The firing started as a Saturday morning project to let the students of Riley High School do outside work of their own choosing. They chose to build a rocket. The original concept was a three-stage vehicle, but due to shortness of time, the plan was reduced to a simpler, one-stage rocket with an ejectable nose cone.

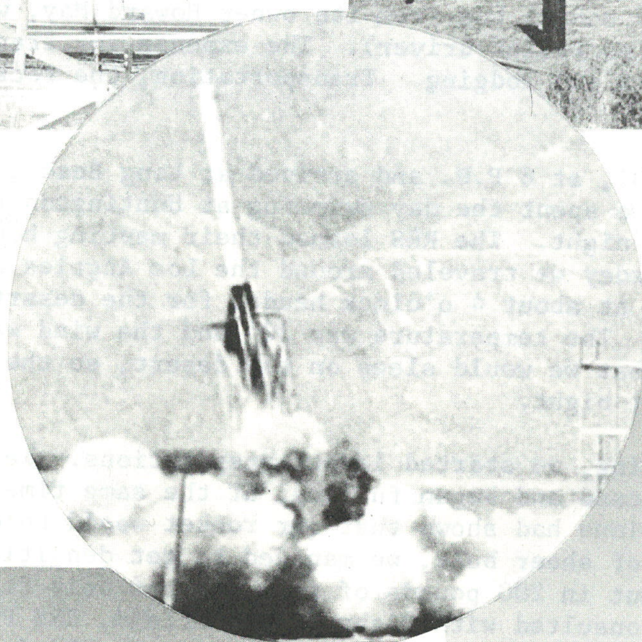
Tests were run on various materials to be used for the rocket casing; 6061 T-6 aluminum alloy was chosen as it had a very high tensile strength and a sufficiently high melting point to withstand a short duration of burn. Effort was made to find a safe fuel, but without result, as most of the fuels that were of sufficiently high specific impulse were not available. We therefore resorted to the Army accepted propellant of zinc and sulfur, running numerous tests to determine the percent composition that would give best performance. We found than an 80-20 mixture of zinc to sulfur by weight was best.

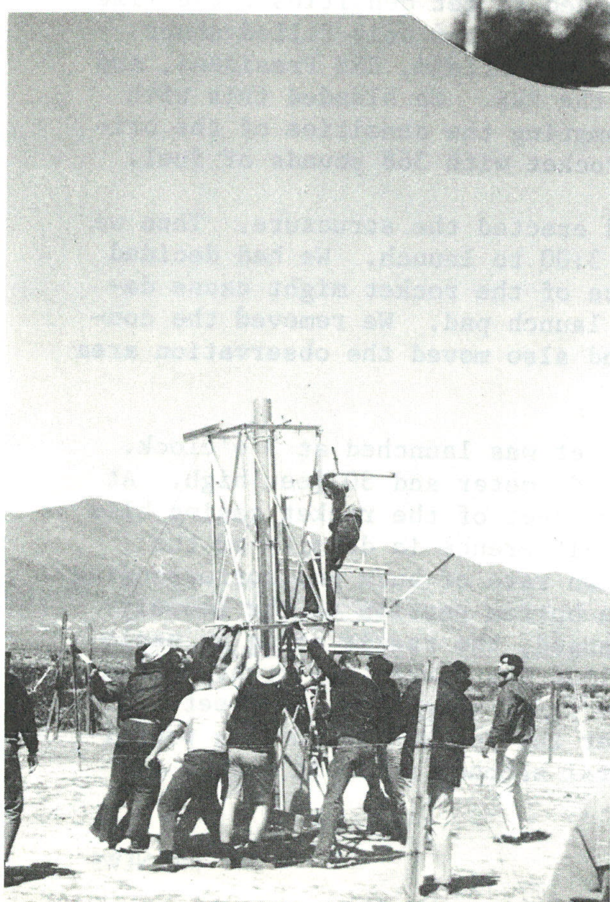
Additional work was done to increase specific impulse and decrease rate of burn by using salt peter as a retarding agent. Tests showed that a ratio by weight 75% zinc-sulfur (of the 80-20 composition) to 25% salt peter gave a boost in specific impulse of roughly fifty percent. However, the temperature at which the mixture burned was decreased quite drastically and it was found that if the igniter was not hot enough, the sulfur would melt and form a heat shield from the fuel. Because of the possibility of not being able to ignite the fuel under launch conditions, we decided two weeks before the launch date to eliminate the salt peter and use the 80-20 zinc-sulfur mixture.

The rocket dimensions were set at 15 feet length, six inches interior tube diameter, and 0.28 inches wall thickness. The nozzle was a machined billet with a 30° intake and 15° exhaust cone. The outside was tapered to conform to the inner cuts. The nozzle and forward bulkhead were made of steel, following the suggestion of our material supplier, to gain additional tensile strength and heat resistance. After the nozzle had already been machined we were informed that the aluminum and steel could not be welded together without special equipment. Therefore, the nozzle was held in the rocket casing with a press fit and four bolts.

The nose cone was of aluminum, and originally contained a Bell and Howell







South Bend

8mm movie camera, a radio transmitter built by one of the students, a mouse to be examined for metabolic changes, and a parafoil science fair project that had won a regional award for one of the students. However, upon talking to the members of the RRS, we learned that a mouse had been launched previously and had been "slightly flattened," so we eliminated the mouse from the launch, though he did make the complete trip to California and back with the group. The radio transmitter developed problems in one of its circuits the day we were to leave for California and it was scrubbed. Thus, our scientific payload was reduced to only the Bell and Howell camera and the parafoil.

The group started raising money in October for the prospective launch through a garage sale. Later we had a school dance and several car washes. We raised altogether $400 to cover our expenses. This was sufficient to cover the cost of the rocket and the fuel. The expense of the trip itself had to be borne by the members. We obtained a 1966 school bus from its owner Howard Hay, who came along as driver (with Tom Harmann as relief driver). The expense for transportation was $800, not including meals and lodging. Transportation, the rocket, and the launch altogether cost $1700.

We left Friday, March 31, at 6 P.M. and arrived at Long Beach, California, at 6 A.M. Monday morning. We spent the day swimming at Huntington Beach and attended the RRS meeting that night. The RRS loaned their meeting house to us for sleeping Monday night. Tuesday we traveled around the Los Angeles area sightseeing, and Tuesday evening at about 4 o'clock headed for the desert launch site. We arrived about 9 o'clock. The temperature was 30° and the wind was 20 to 30 mph. It had been planned that we would sleep on the desert, so the group ignored the cold and roughed it that night.

At 5:00 Wednesday morning, we started launch preparations. We lashed the rocket to the static test stand and began fueling, at the same time preparing the general area. Calculations had shown that our rocket would hold 235 pounds of fuel. However, because of sheer bulk, we managed to get densities three times what was anticipated. We put in 200 pounds of fuel and had only filled about three feet of rocket. We consulted with Richard Butterfield, RRS President, and purchased an additional 100 pounds of zinc from the RRS. We blended this with the sulfur and put it in the rocket without attempting the densities of the original loading. We succeeded in filling up the rocket with 368 pounds of fuel.

We placed the rocket in the launch rack and erected the structure. Then we had to wait only until our FAA approved time of 3:00 to launch. We had decided not to use the blockhouse for fear the sheer size of the rocket might cause damage to it if the rocket were to explode on the launch pad. We removed the controls to an underground bunker 150 yards away and also moved the observation area to 2000 feet to photograph the entire launch.

The countdown went without flaw and the rocket was launched at 3 o'clock. The initial exhaust covered a volume 100 feet in diameter and 30 feet high. At a height of 10 feet the nozzle and the bottom two feet of the rocket casing blew out.. (Later, tests found this to be due to the difference in density of the propellant pack. Each density of fuel has its own rate of burn and corresponding pressure; as the fuel burned from the very dense bottom section to the loosely packed center section the pressure radically changed, the result being an explosion.) The rocket continued up to a height of 1500 feet, when the front bulkhead blew out of the rocket. The rocket went on to a final height of 2425 feet. The time of flight lasted only 17.1 seconds. However the rocket was burning propellant throughout the entire descent and for several seconds after it struck the ground. Therefore, descent occurred more rapidly than normal.

We patrolled the area, picking up pieces of the rocket and the remains of the camera and parafoil which had been destroyed when the front bulkhead blew out. We packed up our equipment to head home about 4:30 P.M. Wednesday night, arriving Saturday at 3 o'clock, thus ending 3000 miles in a school bus. Plans immediately began for a new rocket.

SOAP BUBBLES

Excerpted from the book of the same title,
By C.V. Boys,
Prepared as part of the Science Study Series
for High Schools: Doubleday Publishing Company

I do not suppose that there is any one who has not occasionally blown a common soap-bubble, and while admiring the perfection of its form, and the marvellous brilliancy of its colors, wondered how it is that such a magnificent object can be so easily produced.

I hope that none of you are yet tired of playing with bubbles, because, as I hope we shall see, there is more in a common soap bubble than those who have only played with them generally imagine.

I should like to explain why I am going to show experiments at all. I would remind you that when we want to find out anything that we do not know, there are two ways of proceeding. We may either ask somebody else who does know, or read what the most learned men have written about it, which is a very good plan if anybody happens to be able to answer our question; or else we may adopt the other plan, and by arranging an experiment, try for ourselves. An experiment is a question which we ask of Nature, who is always ready to give a correct answer, provided we ask properly, that is, provided we arrange a proper experiment.

A soap-bubble, consisting as it does of a thin layer of liquid, which must of course have both an inside and an outside surface or skin, must be elastic, and this is easily shown in many ways. Perhaps the easiest way is to tie a thread across a ring rather loosely, and then to dip the ring into soap water. On taking it out there is a film stretched over the ring, in which the thread moves about quite freely, as you can see. But if I break the film on one side, then immediately the thread is pulled by the film on the other side as far as it can go, and it is now tight. (Figure 1.) You will notice also that it is part of a perfect circle, because that form makes the space on one side as great, and therefore on the other side, where the film is, as small as possible.

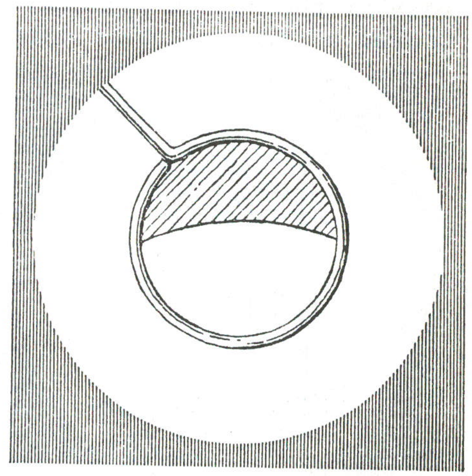


FIGURE 1.

Or again, I have blown a bubble on the end of a wide pipe; you can see that owing to the elastic skin of a soap bubble, the air inside is under pressure and will get out if it can. Which would you think would squeeze the air inside it most, a large or a small bubble? We will find out by trying, and then see if we can tell why. You now see two pipes each with a tap. These are joined together by a third pipe in which there is a third tap. I will first blow one bubble and shut if off with the tap (Figure 2) and then the other and shut it off with the tap 2. They are now nearly equal in size, but the air cannot yet pass from one to the other because the tap 3 is turned off. Now if the pressure in the largest one is greatest, it will blow air into the other when I open this tap, until they are equal in size; if on the other hand, the pressure in the small one is greatest, it will blow air into the large one, and will itself get smaller until it has quite disappeared. We will now try the experiment. You will see immediately that I open the tap 3 the small bubble shuts up and blows out the large one, thus showing that there is a greater pressure in a small than a large bubble. This is an experiment on which a great deal depends.

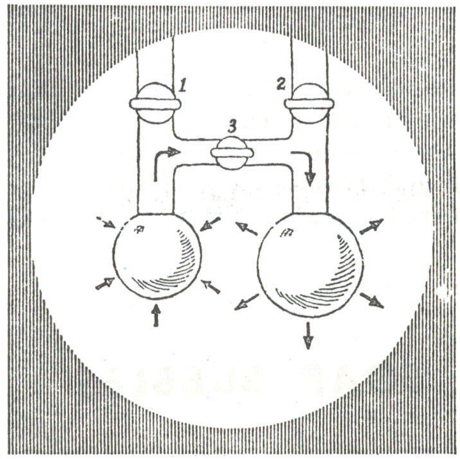


FIGURE 2

As the film is always stretched with the same force, whatever size the bubble is, it is clear that the pressure inside can only depend upon the curvature of a bubble. In the case of lines, our ordinary language tells us that the larger a circle is the less is its curvature; and if you take a piece of a very large circle indeed, then you cannot tell it from a straight line, and you cannot say it is curved at all. We have seen that in large bubbles the pressure is little and the curvature is little, while in small bubbles the pressure is great and the curvature is great. The pressure and the curvature rise and fall together.

A ball or sphere is not the only form which you can give to a soap-bubble. If you take a bubble between two rings, you can pull it out until at last it has the shape of a round straight tube or cylinder. We have spoken of the curvature of a ball or sphere; now what is the curvature of a cylinder? Looked at sideways, the edge of the wooden cylinder upon the table appears straight, i.e. not curved; but looked at from above it appears round, and is seen to have a definite curvature. What then is the curvature of a cylinder? We have seen that the pressure in a bubble depends upon the curvature when they are spheres, and this is true whatever shape they have. If then we find what sized sphere will produce the same pressure upon the air inside that a cylinder does, then we shall know that the curvature of the cylinder is the same as the that of the sphere which balances it. In Figure 3, the pressure in the two bubbles is exactly the same, as there is free passage of air between the two. On measuring them you see that the sphere is exactly double the cylinder in diameter, but this sphere has only half the curvature that a sphere half its diameter would have. Therefore the cylinder, which we know has the same curvature that the large sphere has, because the two balance, has only half the curvature of a

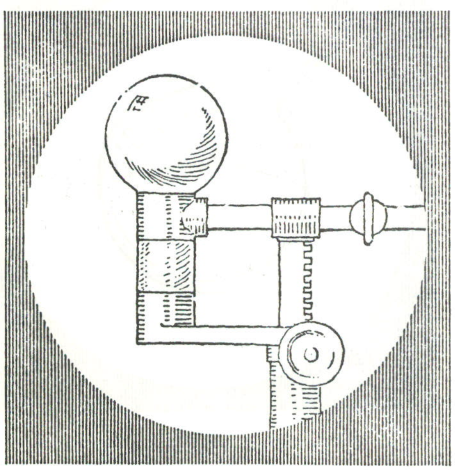


FIGURE 3.

sphere of its own diameter, and the pressure in it is only half that in a sphere of its own diameter.

I must now make one more step in explaining this question of curvature. Now that the cylinder and the sphere are balanced I shall blow in more air, making the sphere larger; what will happen to the cylinder? The cylinder is, as you see, very short; will it become blown out too, or what will happen? Now that I am blowing in air you see the sphere enlarging, thus releiving the pressure; the cylinder develops a waist; it is no longer a cylinder, the sides are curved inwards. As I go on blowing and enlarging the sphere, they go on falling inwards, but not indefinitely. If I were to blow the upper bubble till it was of an enormous size the pressure would become extremely small. Let us make the pressure nothing at all by simply breaking the upper bubble, thus allowing the air a free passage from the inside to the outside of what was the cylinder.

Let me repeat this experiment on a larger scale. I have two large glass rings, between which I can draw out a film of the same kind. Not only is the outline of the soap-film curved inwards, but it is exactly the same as the smaller one in shape (Figure 4). As there is now no pressure there ought to be no curvature, if what I have said is correct. But look at the soap-film. Who would venture to say that that was not curved? and yet we had satisfied ourselves that the pressure and the curvature rose and fell together. We now seem to have come to an absurd conclusion. Because the pressure is reduced to nothing we say the surface must have no curvature, and yet a glance is sufficient to show that the film is so far curved as to have a most elegant waist. Now look at the plaster model on the table, which is a model of a mathematical figure which also has a waist.

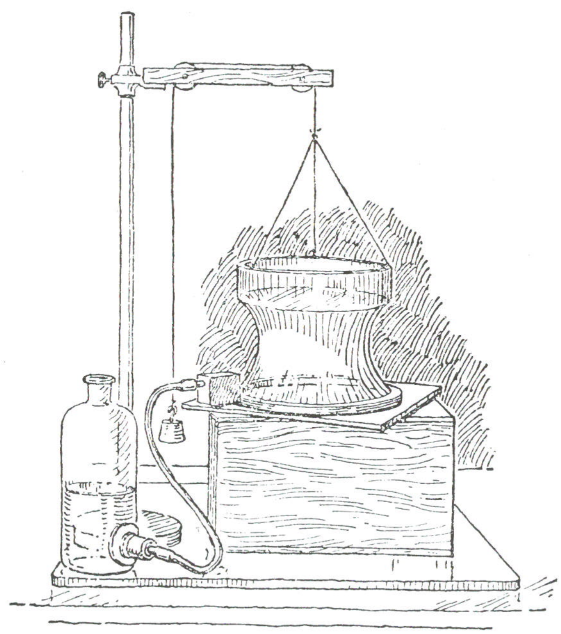


FIGURE 4.

Let us therefore examine this cast more in detail. I have a disc of card which has exactly the same diameter as the waist of the cast. I now hold this edgeways against the waist (Figure 5) and though you can see that it does not fit the whole curve, it fits the part close to the waist perfectly. This then shows that this part of the cast would appear curved inwards if you looked at it sideways, to the same extent that it would appear curved outwards if you could see it from above. So considering the waist only, it is curved both towards the inside and also away from the inside according to the way you look at it, and to the same extent. The curvature inwards would make the pressure inside less, and the curvature outwards would make it more, and as they are equal they just balance, and there is no pressure at all. If we could in the same way examine the bubble with the waist, we should find that this was true not only at the waist but at every part of it. Any curved surface like this which at every point is equally curved opposite ways, is called a surface of no curvature and so what seemed an absurdity is now explained. Now this surface, which is the only one of the kind symmetrical about an axis, except a flat surface, is called a catenoid, because it is like a chain, as you will see directly, and as you know, catena is the Latin for a chain. I shall now hang a chain in a loop from a level stick, and throw a strong light upon it so you can see it well. This is exactly the same shape as the side of a bubble drawn out between two rings, and open at the end to the air.

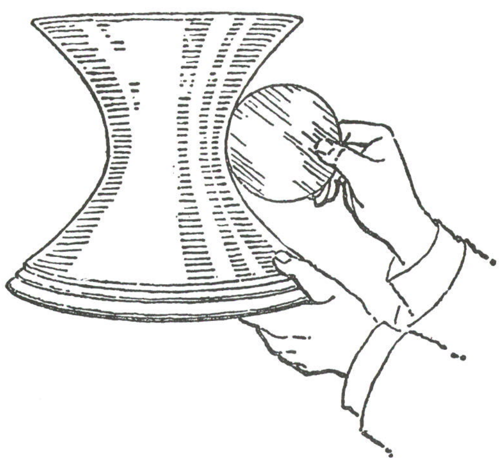


FIGURE 5.

Let us now take two rings, and having placed a bubble between them, gradually alter the pressure. We can see seven curves as we gradually reduce the pressure, namely: (1) Outside the sphere; (2) The sphere; (3) Between the sphere and the cylinder; (4) The cylinder; (5) Between the cylinder and the catenoid; (6) The catenoid; (7) Inside the catenoid.

Now I am not going to say much more about all these curves, but I must refer to the very curious properties that they possess. In the first place, they must all of them have the same curvature in every part as the portion of the sphere which forms the cap; in the second place, they must all be the curves of the least possible surface which can enclose the air and join the rings as well. And finally, since they pass insensibly from one to the other as the pressure gradually changes, though they are distinct curves there must be some curious and intimate relation between them.

All this is rather difficult to understand, but as these forms which a soap-bubble takes afford a beautiful example of the most important principle of continuity, I thought it would be a pity to pass it by. It may be put this way. A series of bubbles may be blown between a pair of rings. If the pressures are different the curves must be different. In blowing them the pressures slowly and continuously change, and so the curves cannot be altogether different in kind. Though they may be different curves, they also must pass slowly and continuously one into the other. We find the bubble curves can be drawn by rolling wheels made in the shape of the conic sections on a straight line, and so the conic sections, though distinct curves, must pass slowly and continuously one into the other.

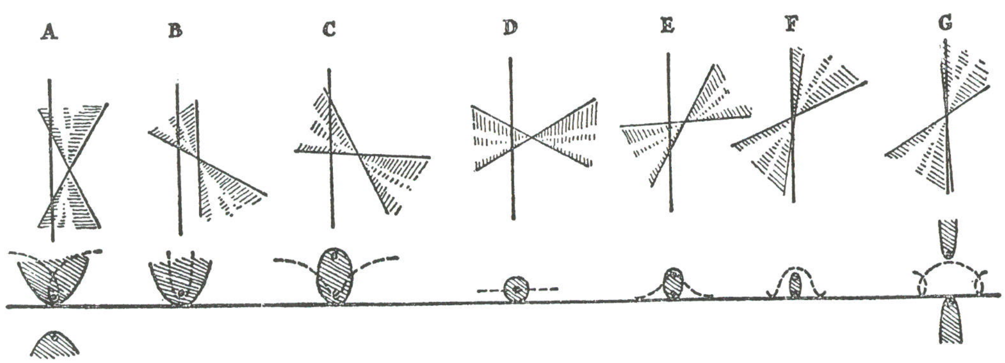
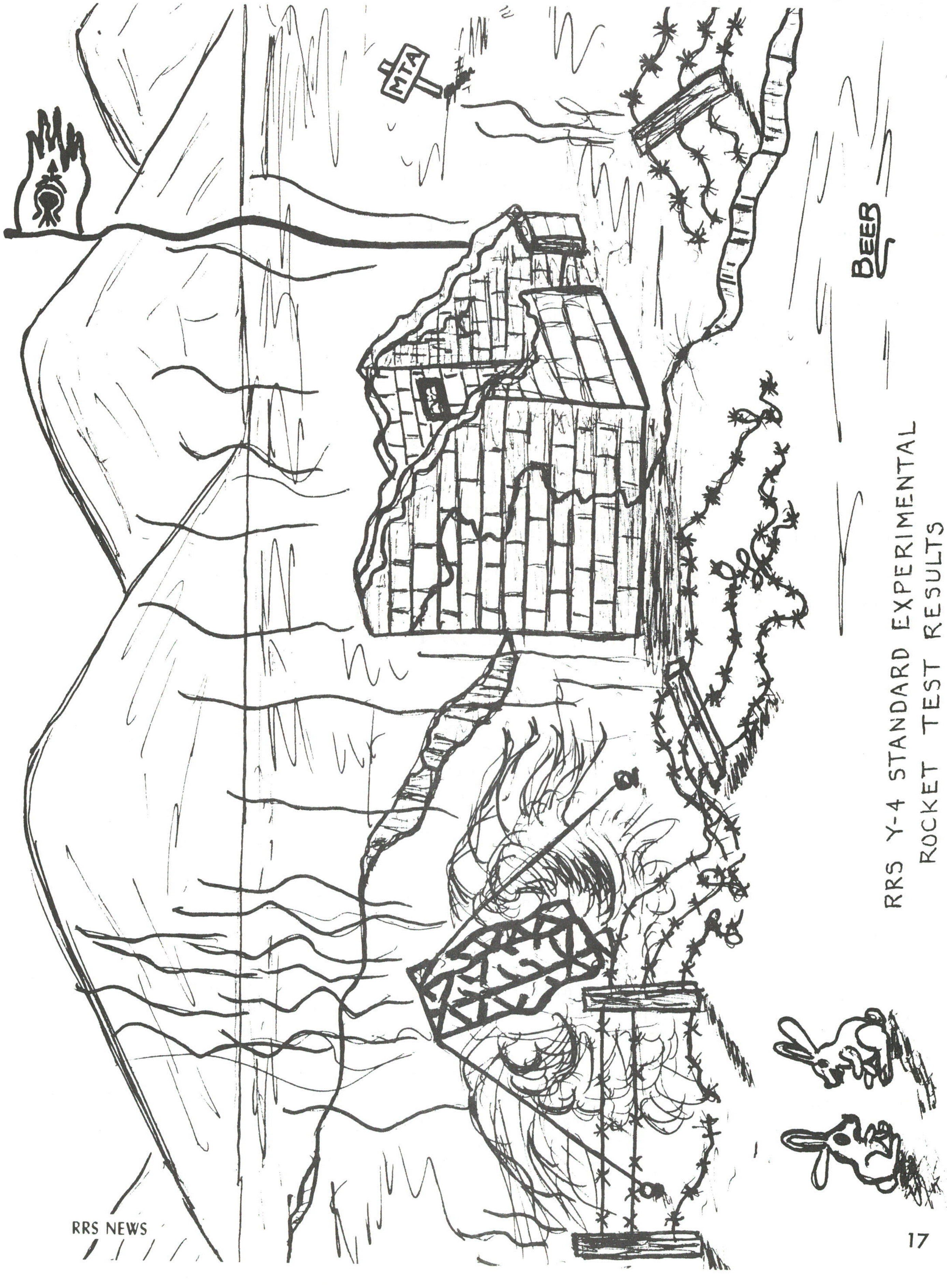


FIGURE 6.

POST FIRING



RRS Y-4 STANDARD EXPERIMENTAL ROCKET TEST RESULTS

COMMENTARY ON FIRINGS

By Don Girard, President
Reaction Research Society

Forty-six rockets were fired by the Reaction Research Society at the Mojave Test Area this past year. The basic information is given in chart form on the following two pages. We shall concern ourselves here with some explanation (primarily of historical bent) about the ten weekends of experimental work.

The South Bend rocket, reported on in depth in the Featured Articles, was fired on a Wednesday, by special arrangement with the State agencies; the FAA form was filed for a potential maximum altitude of 100,000 feet. The high school had been in contact with White Sands, the Army, the Navy, and other defense military bases, who had all been unable to provide a convenient flight time to the students, and almost by chance, contacted the RRS only a week before launch. The RRS was in the throes of planning Project Live Fire! for the weekend of April 9, and was not able to provide the sort of assistance that might have provided for a successful launch.

The rocket lost its nozzle upon takeoff, and traveled to only about 2500 feet. But more important was the trip the rocket had taken before ever being loaded: 1500 miles by school bus from Indiana to California. The high school students exhibited a competency and maturity beyond their years, and left a lasting and warm memory for this author at least.

April 9, 1967, marked the second Project Live Fire!, a public firing attended by about 250 people in promotion of student experimental rocketry. In RRS NEWS #101, we reported on Live Fire the original, and noted at the time how it had bonded together the RRS into a team, and was the catalyst that caused "the growth of the RRS into a mature and full Society." The second Live Fire was smoother, more elaborate in the type of rocket fired, and less fun.

The first rocket, appropriately enough, exploded violently, thus providing us all afternoon with no further problem in crowd control. The second and third rockets were fired to exhibit the performance of standard student experimental solid rockets: the Goddard, developed by the Rocket Research Institute of Sacramento, and the RRS Beta, a 2-inch vehicle. The fourth rocket was provided by La Habra High, one of many rockets this group fired with the RRS. The fifth rocket, a two-stage combination of a RRS Beta and the Sixth Mail Flight booster rocket, was a brilliantly designed work of John Novak. The lower stage exploded, destroying the launching rack beyond all possible repair, and the second stage took off normally.

The sixth firing was a simultaneous launch of two RRS Beta rockets. Film analysis shows remarkable similarities, considering the normal variation expected with the zinc-sulfur propellant. The seventh rocket was a smaller version of the RRS Beta, using an epoxy-cast nosecone, rather than the usual fiberglass nose.

The final rocket was billed as the Y-4 RRS Guided Missile, complete with French curved fins and spiraling antenna. The experiment called for the rocket to be guided in flight to a target marked downrange, and to explode on impact as a signal to how close it had come to the target. Unbeknownst to the audience, a drum of gasoline was planted downrange, and was connected by wire to the blockhouse to be exploded on command. The rocket took off beautifully, got itself out of the way (for it was of no use to us) and after an elaborate series of control room instructions broadcast over the PA system for all to overhear, the drum of gasoline failed to explode. (The second testing of the Y-4 appears on Page 17.)

On June 17, 1967, the RRS fired what were in general rockets left over from Live Fire: two shortened versions of the RRS Beta, again with epoxy nosecones, and a rocket of West Covina High School, their first of about five such rockets. Walt Cosdon tested an ammonium perchlorate and asphalt mixture without success.

The firing of August 19 was unusual in that every firing was conducted to prove some support system for a rocket. All of these experiments are covered in Dave Crisalli's article, and in the section on Technical Reporting.

On February 10, 1968, Chris Claybaugh fired his first rocket, using a stoichiometric mixture of zinc dust and sulfur. The rocket exploded in the rack, confirming previous RRS experience with the unreliability of this mixture (notably during the Seventh Rocket Mail Flight). West Covina and La Habra schools fired several student experiments, and Dave Crisalli and Jerold Thomas of Chaminade Preparatory continued experiments with peak-sensing ejection mechanisms.

Easter weekend, April 13, the Pacific Rocket Society fired several rockets, but did not provide this publication with information. Larry Teebken fired a 2-inch static test motor to prove out a wall insulation composition. That information will be the subject of an article in a future edition of the RRS NEWS.

On May 15, 1968, Chaminade Preparatory fired two rocket experiments to test parachute mechanisms. Ron Arnold's test failed, but Dave Crisalli was completely successful in utilizing a light-dependent resistor to actuate a mechanical relay for parachute deployment. Jerry Pollack, of the Pacific Rocket Society, fired a rocket with a 1887 silver dollar in the nosecone, and irretrievably lost it. Ed Parker, the senior member of the RRS (he joined in 1951), fired a two-stage vehicle with a timer-deployed parachute system. Both stages fired properly, but the parachute did not function. West Covina High School fired a rocket with a parachute, also timer-operated, and again the timer failed to operate properly.

The firing of June 22, 1968, was a potluck of expectation. David Butterfield fired a small rocket that burned in the launching rack, while Carlos Beer sent a two-and-a-half inch tube to 600 feet. Carlos intends to fire the same vehicle in his native country of Costa Rica in April of 1969. We shall report the full details of our Central American representative's luck.

Renauld Harris launched his first rocket (an RRS Beta) to 6000 feet, a considerable improvement over the performance of the identical rocket launched by Chris Claybaugh using a different fuel composition. Steve Burns, of West Covina, burned a two-inch vehicle in the rack. Walt Cosdon, in a rack especially provided for the occasion, blew up his potassium nitrate and sugar test rocket.

On August 18, 1968, the last firing reported on in this issue, one of three parachute systems tested worked. West Covina's parachute section fell apart from the rocket; Nick Kirchner, of Chaminade, failed to deploy a parachute of the LDR ejection design, and Dave Crisalli, also of Chaminade, repeated his success of May 15 by ejecting two parachutes from his rocket. The smaller 'chute drifted so far back-range that it was never recovered.

DATE	NO.	TOTAL LENGTH (Inches)	O.D. (Inches)	PROPELLANT	MASS RATIO	OWNER
4-5-67	1	180	6	80% Zn, 20% S	?	South Bend
4-9-67	1	54	3	80% Zn, 20% S	?	Chaminade
	2	?	1	80% Zn, 20% S	?	Crisalli
	3	70	2	80% Zn, 20% S	1.98	Dosa
	4	50	2	80% Zn, 20% S	?	LaHabra
	5a	48 (1st stage)	4	80% Zn, 20% S	?	Novak
	5b	54 (2nd stage)	2	80% Zn, 20% S	?	Novak
	6a	70	2	80% Zn, 20% S	1.90	Dosa
	6b	70	2	80% Zn, 20% S	2.30	Dosa
	7	32	2	80% Zn, 20% S	1.78	Novak
	8	66	3	80% Zn, 20% S	2.28	Girard
6-17-67	1	54	4	80% Zn, 20% S	2.07	W. Covina High
	2	32	2	80% Zn, 20% S	1.77	Novak
	3	32	2	80% Zn, 20% S	1.77	Novak
	4	6	1	NH_4ClO_4, Butarez CTL, Asphalt	?	Cosdon
8-19-67	1	97	2	80% Zn, 20% S	1.93	Dave Crisalli
	2	18	2	80% Zn, 20% S	2.22	Girard
	3	18	2	80% Zn, 20% S	2.29	Girard
	4	18	2	80% Zn, 20% S	2.22	Girard
	5	18	2	80% Zn, 20% S	1.94	Girard
	6	60	2	80% Zn, 20% S	?	Teebken
	7	91	1.75	80% Zn, 20% S	2.56	Stewart
10-15-67	1	118	2	80% Zn, 20% S	1.78	Crisalli
2-10-68	1	68	2	75% Zn, 25% S	?	C. Claybaugh
	2	50	2	80% Zn, 20% S	2.33	Burns
	3	54	2	80% Zn, 20% S	2.09	Nichols
	4	65	2	80% Zn, 20% S	2.17	Jackson
	5	127	2	80% Zn, 20% S	1.80	Crisalli
	6	92	2	80% Zn, 20% S	1.82	Crisalli
	7	144	4	80% Zn, 20% S	3.00	Thomas
4-13-68	1	48	2	80% Zn, 20% S	?	Teebken
	2	?	?	80% Zn, 20% S	?	PRS
	3	?	?	80% Zn, 20% S	?	PRS
	4	?	?	80% Zn, 20% S	?	PRS
5-18-68	1	126	3	80% Zn, 20% S	2.14	Arnold
	2	69	2	80% Zn, 20% S	1.65	Crisalli
	3	51	2.5	80% Zn, 20% S	1.98	Pollack
	4	132	2.5	80% Zn, 20% S, capsulated	1.71	Parker
	5	88	2	80% Zn, 20% S	?	Bell
6-22-68	1	35	1.5	80% Zn, 20% S	?	D. Butterfield
	2	66	2.5	80% Zn, 20% S	2.69	Beer
	3	68	2	80% Zn, 20% S	2.30	Harris
	4	50	2	80% Zn, 20% S	2.25	Burns
	5	18	1.5	KNO_3 and sugar	?	Cosdon
8-18-68	1	132	2	80% Zn, 20% S	2.41	Bell
	2	96	2	80% Zn, 20% S	1.67	Kirchner
	3	69	2	80% Zn, 20% S	1.95	Crisalli

NO.	HEIGHT AT BURNOUT (Feet)	TIME TO BURNOUT (Seconds)	MAX. VEL. (Feet Per Second)	MAX. ACC. (Feet per Second^2)	ALTITUDE (Feet)	RANGE (Feet)	COMMENTS
1	-	-	-	-	2425	-	Rocket exploded after take-off; aluminum casing; 368 lbs. fuel
1	-	-	-	-	-	-	Exploded out of rack
2	40	0.167	373	5480	525	-	Exploded after thrusting; God-dard type
3							
3	144	0.312	819	10,913	6100	?	Smoke tracker worked; RRS Beta type rocket
4	?	?	?	?	415	?	Student rocket
5a	-	-	-	-	-	-	First stage exploded in rack
5b	148	0.417	687	5385	?	?	Second stage normal; RRS Beta type rocket
6a	165	0.292	952		7200	3220	Simultaneous launch of two rockets, both RRS Beta type; photographs show marked simu-larities
6b	133	0.250	980		7250	?	
7	52	0.146	730		3050	?	Shortened RRS Beta; epoxy cone
8	167	0.354	914		3100	?	Y-4 "guided" missile
1	*	*	*	*	2025	883	Cork plug diaphragm
2	*	*	*	*	2300	?	Short RRS Beta; epoxy cone
3	*	*	*	*	2700	1000	Short RRS Beta; epoxy cone
4	-	-	-	-	-	-	Static; developed insufficient thrust in test
1	*	*	*	*	2500	1200	LDR parachute system
2	-	-	-	-	-	-	Static tests, using SR-4 Load Cell and audio oscillator with 15 ips tape machine; spectragraph gave no data
3	-	-	-	-	-	-	
4	-	-	-	-	-	-	
5	-	-	-	-	-	-	
6	*	*	*	*	6600	1600	Graphite insert; RRS Beta
7	-	-	-	-	-	-	Static; depressed car spring
1	*	*	*	*	680	?	Parachute test; rocket exploded in flight
1	-	-	-	-	-	-	RRS Beta; exploded in rack
2	-	-	-	-	-	-	Burned in rack; no take-off
3	-	-	-	-	25	-	Burned in rack
4	190	?	235	-11,000	4000	?	Fired off course; films not clear
5	-	-	-	-	25	-	Burned in rack
6	200	0.583	452	1923	2000	?	Parachute failed to deploy; mechanical defect
7	99	0.459	750	6923	-	-	Exploded after take-off
1	-	-	-	-	-	-	Static; insulated wall
2	?	?	?	?	?	?	Goddard type
3	?	?	?	?	?	?	Goddard type
4	?	?	?	?	?	?	No information
1	*	*	*	*	5000	2700	Parachute did not deploy
2	*	*	*	*	?	?	LDR system worked
3	*	*	*	*	?	?	Fired normally
4	?	?	?	?	1000	?	Parachute; two-stage; both fired
5	175	0.271	169	8125	2500	?	Timer failed to operate
1	-	-	-	-	175	-	Burned in rack
2	204	0.354	961	7596	600	?	Lost fins in flight
3	?	?	?	?	6000	2625	RRS Beta
4	-	-	-	-	-	-	Burned in rack
5	-	-	-	-	-	-	Exploded
1	?	?	?	?	700	?	Parachute section fell apart from rocket
2	?	?	?	?	1600	?	Parachute did not deploy
3	?	?	?	?	?	?	LDR parachute system worked

*Data available on film; not reduced.

TECHNICAL REPORTING

TWO STAGE VEHICLE
FIFTY PERCENT SUCCESS

The Fort Sill Beta, reported on in Captain Bertrand Brinley's Rocket Manual For Amateurs, has been modified considerably by the RRS to make a workable utility vehicle of it. Changes include nozzle grips to facilitate machining, graphite inserts to maintain constant throat areas (and to make thrust calculations meaningful), an expanded front section, and a titanium tetrachloride tracking nose cone. All of these have been reported on in previous NEWS's.

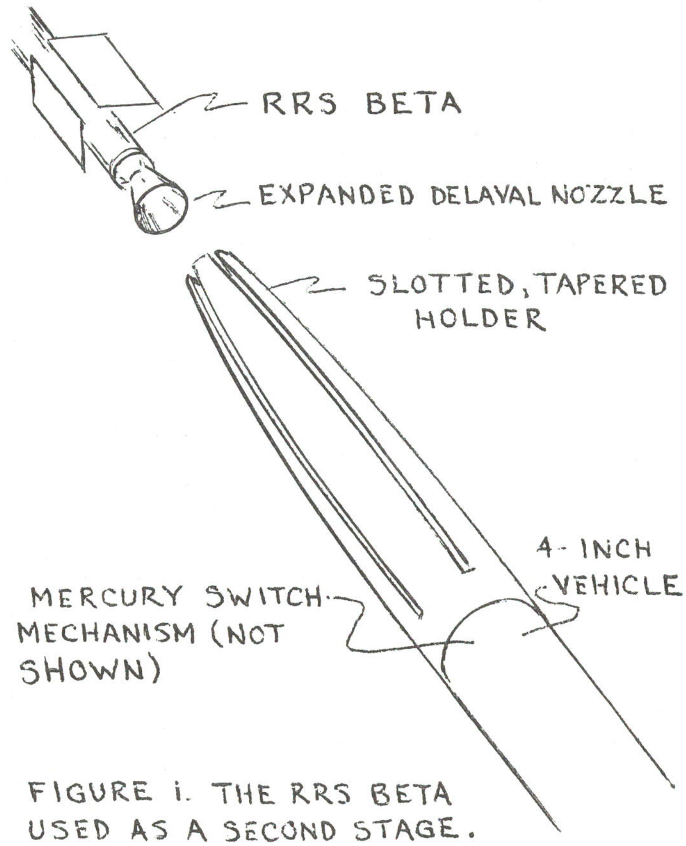


FIGURE 1. THE RRS BETA USED AS A SECOND STAGE.

The thought of using the RRS Beta as the second stage of a two-stage vehicle is an attractive one. There are two difficulties: (1) the nozzle is expanded, and is about a half-inch larger than the rocket tube; and (2) the Beta is about 54 inches long and requires a holder of at least 10 inches for stability.

A device that meets these criteria was built by John Novak of the Society, as the mating section of a four-inch booster vehicle to the RRS Beta. A sketch of this device is seen above. A mercury stage separation device rests inside the four-inch tube.

Novak did not reckon with the whim of fate however, and during test the first stage left the pad in all directions but one. But fate had not quite reckoned with Novak either, and the second stage took off normally, undisturbed by the explosion beneath it.

GRAPHITE NOZZLE INSERTS
END EROSION

By Lawrence G. Teebken, Reaction Research Society

One of the most popular models of rockets used by amateurs is the Fort Sill (Oklahoma) Beta rocket. The Reaction Research Society uses its own version of this rocket designated the "R.R.S. Beta." The main reasons for its popularity are its convenient size and ease and cheapness of fabrication. However, our experience indicates that our version has a nominal maximum altitude (drag corrected) of about 5000 feet. I feel that the three most important factors which account for this poor performance are: a) excessive empty weight; b) poor propellant performance characteristics; and c) excessive nozzle erosion. The third item, nozzle erosion, will be discussed.

Even after a single firing, normal mild steel "Beta" nozzles exhibit considerable erosion. The erosion is worst at the throat and becomes progressively milder as the exit is approached. This effect is to be expected since the heat input is greatest near the nozzle throat. The main effect of this erosion is to enlarge the throat asymmetrically and at an uneven rate. As the throat area enlarges, the chamber pressure (and hence thrust) decreases. The rocket's performance is reduced accordingly. Thus, all other factors remaining equal, if the throat area can be kept constant (i.e., all erosion eliminated) the rocket's performance should increase.

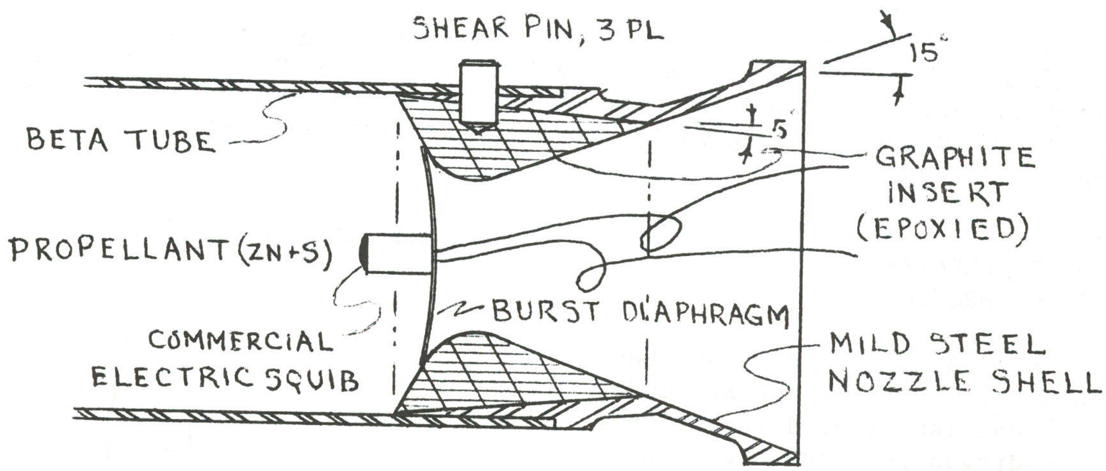


FIGURE 2. CROSS SECTION OF NOZZLE WITH INSERT.

One word about the character of erosion should be mentioned at this point. There are a number of factors contributing to erosion. For instance, if the nozzle temperature rises to the point at which the metal weakens significantly, gas flow can wear away the surface. Also, solid particles in the gas can impinge on the surface and cause more erosion. Finally, if the metal surface is capable of reacting with the hot gas, it can erode by virtue of chemical reaction.

It has been found that graphite is very resistant to the mechanical and chemical erosion by the zinc-sulfur propellant. It sublimes at over 6000°F. Although very slight erosion lines can be seen in the graphite section of the nozzle which the RRS has tested (shown in the accompanying drawing), the throat diameter after two firings (duration of each approximately one-half second) is still the same as it was originally (as measured with a vernier caliper accurate to 0.001 inch).

The end result? A "Beta" rocket reached an altitude of about 6,600 feet (drag corrected) when a nozzle with a graphite insert was used, comparing favorably with other "Beta" firings. It should be mentioned that the nozzle used wasn't even fully expanded to atmospheric pressure. The present nozzle has experienced erosion in the <u>metallic</u> portion of the divergent section. However, future nozzles will have full-length graphite inserts or liners (backed up by a thin shell of aluminum or steel) to completely eliminate erosion. It is believed that, barring a mechanical failure, such nozzles will last indefinitely.

THRUST DEVICE
OUT OF BOUNDS

An experiment was conducted about five years ago, not in the RRS, that involved constraining a rocket to compress a car spring, and noting the peak compression point. The experiment was a success or failure, depending on your need for exactness. (How does one translate a broken car spring into pounds of thrust?) Greg Stewart of the Society happened upon the report on this attempt, and saw hope in a second effort.

Stewart's approach was to attach to the leading portion of the car spring a marker that would trace the compression of the spring onto a revolving drum. The resultant graph would be some measure of thrust.

He succeeded in obtaining a graph that showed two peak points, a result not incompatible with his rocket: eight feet long by one-and-a-half inches inside diameter. Unfortunately, the thrust curve went off of scale, and accurate figures could not be assigned the rocket's performance. Progress is made by weeps and frowns.

PROJECT PHOENIX:
AN EPIC CHRONICLE

In 1965, George Dosa and Don Girard began work on the XLR-1000, a bi-propellant liquid rocket that used hydrogen peroxide and methyl alcohol. The rocket dimensioned seven inches in diameter by about twelve feet. The progress on this flight vehicle has been reported extensively in the NEWS. As the designing and building reached the testing stage, it became apparent that there was a serious lack of liquid rocket experience on the part of both men.

To combat this, several paths were taken. First, the Mojave Test Area was readied for liquid rocket work (reported on elsewhere in this issue). Secondly, more people were brought into the project. And thirdly, it was decided that an interim liquid rocket be built, on the lines of the furfuryl alcohol and nitric acid rocket marketed at that time by Herbert Christiansen. (Plans for this rocket are currently distributed through Star Space Systems.) This four-inch by nine-foot rocket, the Phoenix, runs on white fuming nitric acid and unsymmetrical di-

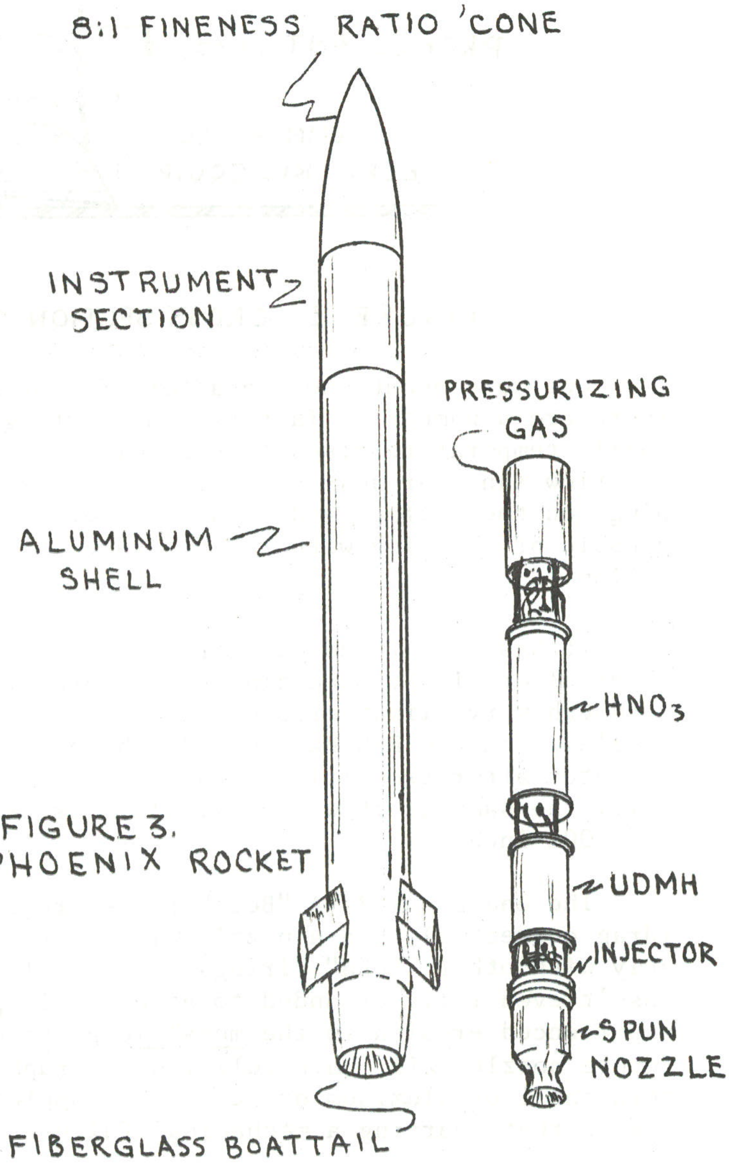


FIGURE 3.
PHOENIX ROCKET

methyl hydrazine (UDMH).

Like the Star Space Systems rocket, the Phoenix incorporates tanks that are made from machined end closures and tubing, rather than commercial hemispherical-ended tanks. Unlike the SSS rocket though, the Phoenix uses internal plumbing, and also has an outer shell. The motor is spun from stainless steel, and is of the usual design, rated for 250 pounds of thrust. The pressurizing gas in all probability will be helium.

An aluminum mock-up of the injector has been machined, with satisfactory results. The final injector will be stainless steel. A special publication is scheduled that will present a full design report on this interim rocket. Test results will be carried in the NEWS.

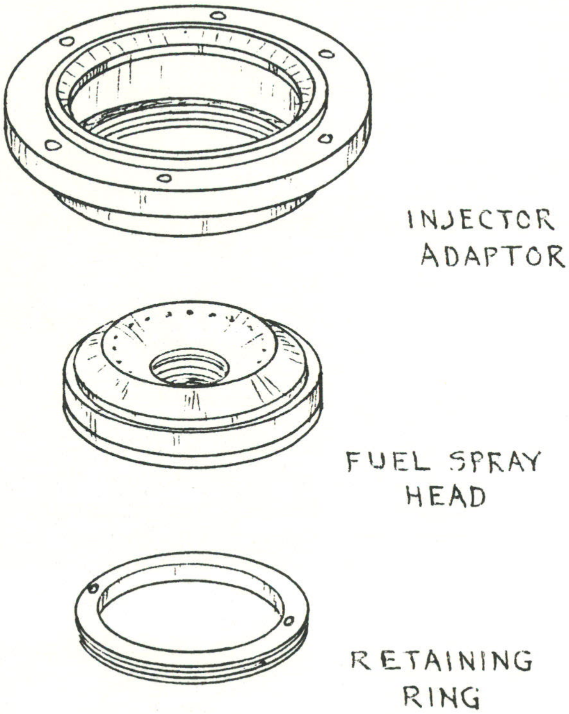


FIGURE 4. PHOENIX INJECTOR

ELECTRONIC THRUST
MEASURE FAILS

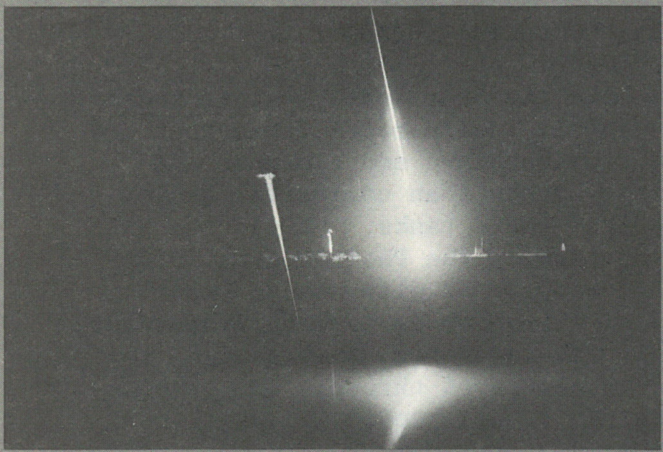
An electrical transducer for measuring thrust can be made by mounting four SR-4 strain gages in a Wheatstone bridge hook-up on the collar of a shaft of steel. For an input of 1,000 pounds of thrust, the voltage out is about one microvolt, or a sensitivity of 0.000001 v/lb. Foolishly, Don Girard and Bob Schreiner tried driving the cell with a 4000 Hertz signal (from an audio oscillator) and recording the signal on a Magnacord 15 ips tape machine.

Four separate runs were conducted, using a small, 18-inch long zinc and sulfur rocket cradled in a static stand developed expressly for the project. The load cell was designed from information found in a trade magazine of 1958. The tests were inconclusive, as the signal lacked the necessary voltage variation to represent any data.

Later tests conducted with the load cell, under non-dynamic conditions, proved it to be working and tracking in a linear mode.

A second effort to monitor the performance of the test rockets also went without success. John Novak, using a commercial spectrometer, and a Polaroid display unit, was unable to separate the fuel oxidation lines from the residue burnt in the surrounding area. An ultraviolet light was exposed on the film to establish some base line.

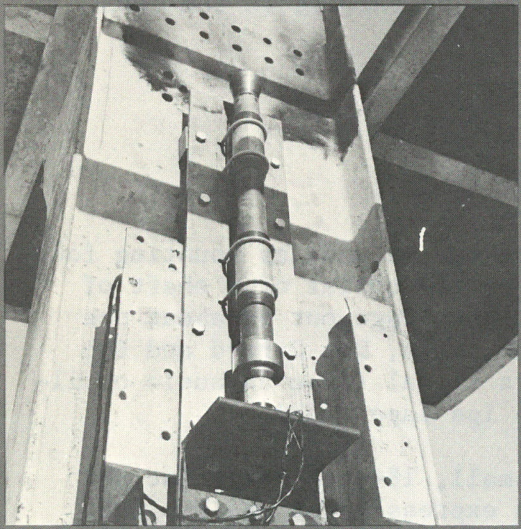
Both tests were conducted with borrowed, professional equipment valued at over $20,000 and could not be repeated. Effort has since been put into debugging and aligning the Society-owned 10-channel oscillograph to record a DC-signal amplified sufficiently from the same load cell element.



CONSIDERABLE

EFFORT

TO MAKE ...



... **FIRE!**

SECTION 8

The Mojave Test Area, long ignored by this chronicle, has been the scene of a massive Egyptian-style earth dig. Forty days and forty nights, the slaves, at five dollars a head, built up this monument to the eternal smoke trail. The test site, an asset to the pragmatic rocket club, is State-approved only for solid-fuel rockets; in order to fire liquid rockets, several facilities had to be added, and as it happened, they were. We report on that task.

THIS HAS BEEN A TEST

By Don Girard, President,
Reaction Research Society

The RRS test site is both a flight range and static test area, remote from electricity and water, and 130 miles from Los Angeles. Firings are nearly always conducted on weekends, at irregular intervals averaging seven a year. The Society owns a forty acre plot, with a great deal of vacant desert on all sides. Important influences on the development of this test site include the attendance of from thirty to fifty people during a usual firing, and overnight stay. The rocket facility could have been built many ways--what has determined our choices has been convenience and crowds.

A compound area, 200 feet by 200 feet, is fenced off and all rocket activity centers in this enclosure. Spectators and non-participating guests are protected in an observation bunker 250 feet from the compound. The tracking crew, and overflow crowds, take up position at a station set exactly 1000 feet from the main static test stand. In the opposite direction, a roadblock is set up about 1500 feet from the compound. Each of these stations is connected by wire in a telephone system and a separate public address system.

Prior to the rebuilding efforts, some of which occurred slowly during the preceding year, but for the most part during a four-weekend effort in March and April, the compound contained a quonset hut for living, a small 7-foot by 7-foot blockhouse, and a static test stand.

One effort of the rebuilding program went to create a fueling and rocket handling area. An 80-foot square within the compound was fenced off, and within was set a five-foot diameter, three-foot deep fuel storage pit, a fueling bay complex that incorporated blast shields and adjustable stops for tamping rockets, a shed for storage of unmixed propellant and other equipment, and a motor-driven fuel mixer.

By this time, the new blockhouse that had been rising to the south of the old one since early February of 1967 had been completed. The new house features large windows for photographic and observational purposes, more than twice the floor space of the old one, provision for eventual expansion, and underground electrical connections. During the work parties, both blockhouses were painted, and the old blockhouse was re-roofed.

A second major effort prepared the complex for the firing of liquid rockets. The compound was extended 25 feet out in the launch area, and the flight launchers moved into this area to separate them from the static stands. The main static stand is, at this writing, being modified to accept liquid rockets, while a separate solid propellant stand is in construction to the south. (This stand will accept a vertical thrusting rocket from one to six inches in diameter and from one to ten feet tall, and facilitates thrust and pressure measurements.)

On the north of the old blockhouse a water deluge tower has been erected, with provision for both shower and eye-and-face wash. It can (and probably will) also be used for other non-emergency cooling.

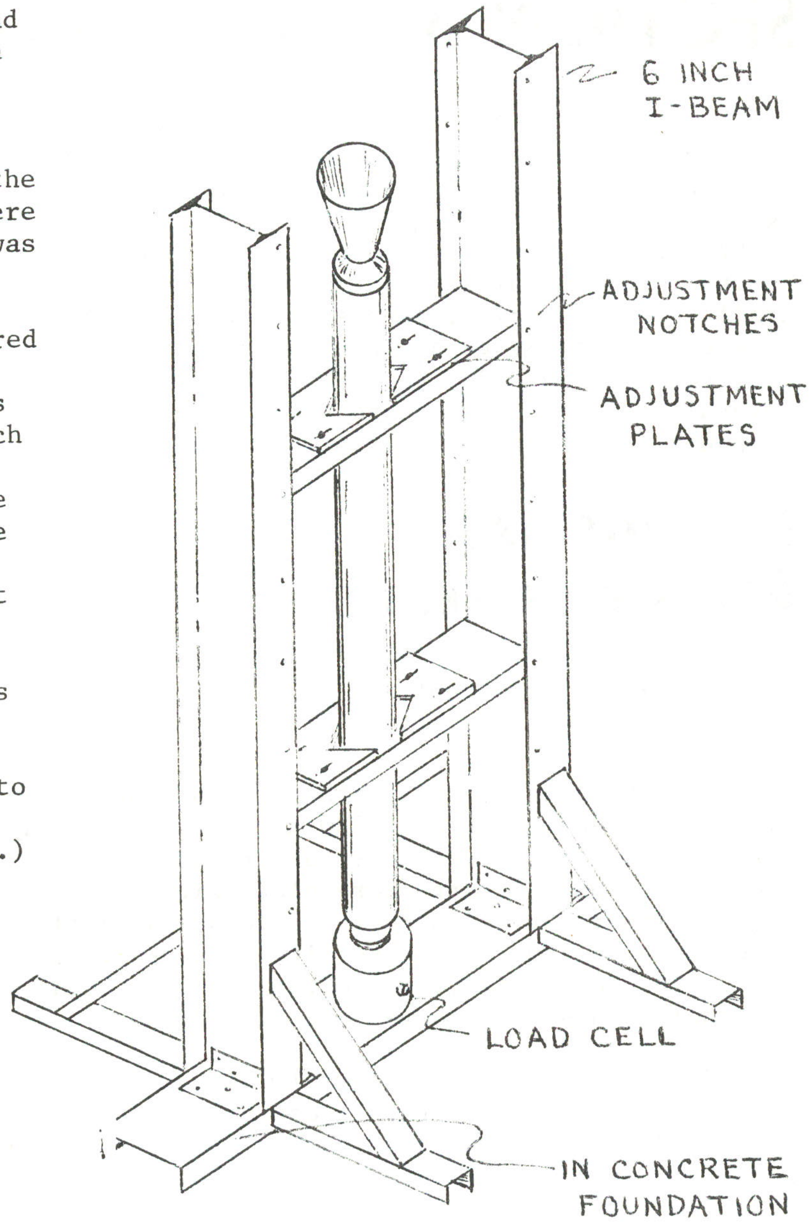


FIGURE 1. 4000-LB SOLID FUEL TEST STAND.

One other major task was the rebuilding of the spectator bunkers. This was undoubtably the most strenuous and physically exhausting of all the projects. The bunkers were deepened to accept the full stretch of a six-footer, a back wall was built of sandbags (and sand), and the telephone-pole overhead reworked to give better protection.

Deserving of great praise, the victims (or co-conspirators, depending on whether your viewpoint is that of management or labor) have thus far remained anonymous. We are in great debt to the cast, who are, in order of appearance:

ACT I George Dosa (the master-mind), Richard Butterfield (Teamster's Local #3500), Maryann Butterfield (relief driver), Don Girard (the whip), Bill Claybaugh (the whipped), Larry Teebken (Coors' representative), Carlos Beer (the only spade he turned ruined an otherwise perfect hand), Jo Marsh (cook and gracious guardian), Ed Parker (the muscle), Walt Cosdon (four-wheeler dealer), the Rheems family (portable gaming table), Jim Gross (PRS spokesman), Chris Claybaugh (member, RRS Ways & Means Committee), Jim Sauerwein (the rock), Dave Schneider (the rook), Steve Burns (the rake), the RRS as a whole (the Reich), Barry Campos (one of a cast of thousands), Robert Williams (the other of a cast of thousands), and an unidentified Bible salesman.

ACT II Bob Schreiner (Vita-pak endorser), Dave Crisalli (unmanned parachute specialist), Jerry Thomas (the bomb), and Tod Witherspoon (tent-watcher first class).

ACT III Jerry Pollack (Brand X Society President), and the Gretlein family (Bakersfield support outpost).

ACT IV Emerson Foxtail (supreme benevolence).

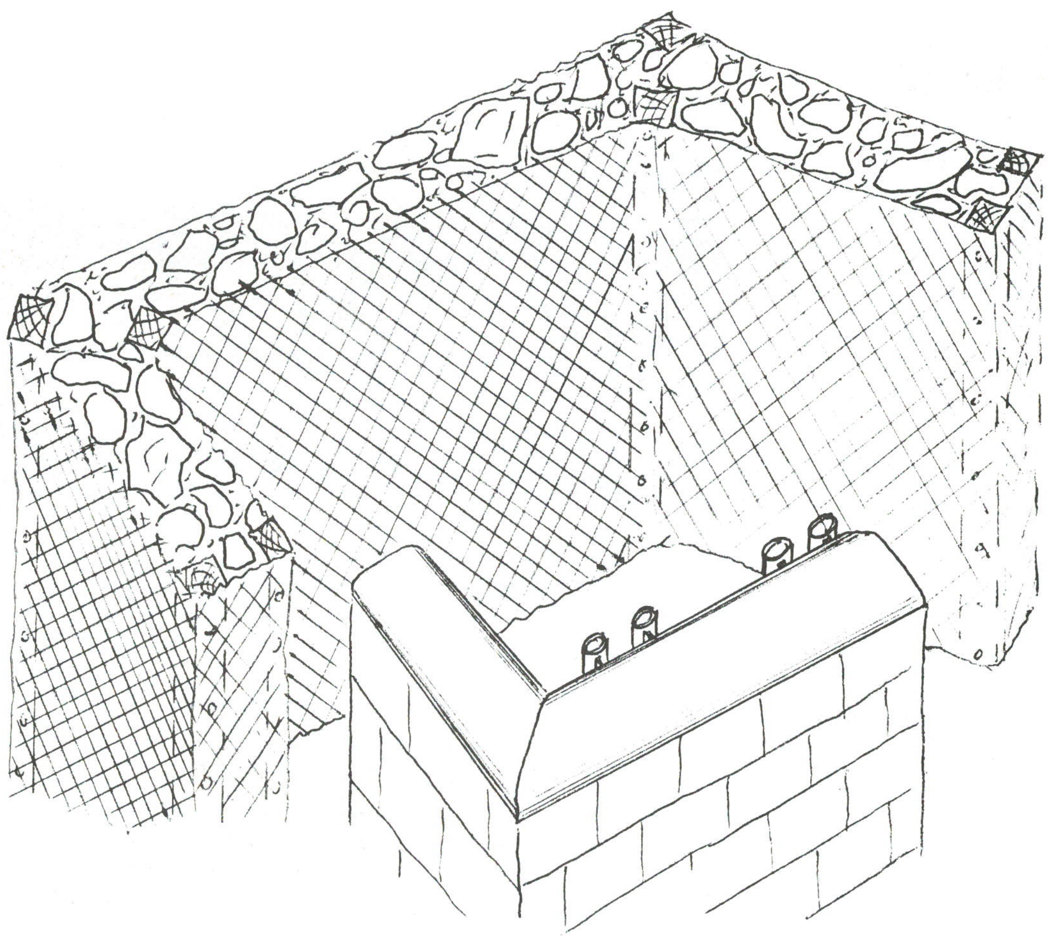


FIGURE 2. FUELING BAY.

Nourished by the excitement and controversy accompanying the launching on October 4, 1957, of the first artificial satellite, great numbers of high school students began rocket and space projects of all descriptions. The senior experimental rocket societies, formed in the late 1940's and early 1950's, suddenly found that literally hundreds of high school "rocket societies" were being improvised all around them. Many of the newly formed student societies, operating without guidance and with far more enthusiasm than sound engineering knowledge, produced both the spectacular successes and catastrophic failures which the word amateur implies in its most negative connotations.

Today, the senior experimental rocket society serves to channel the creative enthusiasm of the space age student into satisfying and safe pathways. Because the aerospace modes of transportation are perhaps the first in which the innocent experiments of youth can be deadly, adequate supervision is often a matter of life or death. As student rocket societies with properly qualified adult-supervision have increased in number, accidents among students have decreased.

THE REACTION RESEARCH SOCIETY

A SPECIAL REPORT
by
DON GIRARD

"The senior rocket society channels creative enthusiasm."

The West Coast is a natural for rocket activity, what with the great space and defense industrial complexes, and the vast amounts of vacant desert land. The Reaction Research Society, founded in 1943 for the Los Angeles area, has a history that in some ways parallels the developments in the professional space ventures. Today, the Society serves to promote experimental rocketry, and at the same time provide educational opportunities in rocket design for the student scientist. This special report is about the Reaction Research Society: where it has been and where it is going.

HISTORY

The Reaction Research Society was originally known as the Southern California Rocket Society, and was formed on January 6, 1943. The Society was reorganized on March 17, 1943. This was really the beginning of the Society since before this date no records were kept. Under the name of the Glendale Rocket Society, the group began its work with small black-powder rockets that in general were quite unsuccessful. Lack of information and of available commercial black powder were the main reasons.

In September 1943 the micrograin propellant as we know it was accidentally discovered. Zinc dust and sulfur were added to the other ingredients to improve the black powder. Gradually, only zinc dust and sulfur was used, but not until a considerable time later was it used seriously.

On March 31, 1946, the Glendale Rocket Society changed its name to the Reaction Research Society. The first Rocket Mail Flight was held on June 28, 1947, from Winterhaven, California, across the Colorado River to Yuma, Arizona. Two rockets were fired, each carrying 350 mail covers--the first rocket exploded and fell into the Colorado and the second was successful.

"There are no vested interests to restrict imagination; any project may be chosen."

On October 26, 1947, at Palmdale, California, a ten-foot micrograin rocket was fired and rose to an altitude of over a mile, setting a record. In 1948, a design for an orbiting satellite was proposed.

In 1949 there was indecision about starting experiments with a new type of liquid propellant rocket. The struggle was bitter, and ended with the Society and Mr. George James, the original founder of the RRS, parting ways. James later founded the Rocket Research Institute in the Sacramento area, and continues to be active in student experimental rocketry.

On May 14, 1950, a mono-propellant hydrogen peroxide rocket was fired and made a record-breaking flight of 23,500 feet (for amateur rocketry). Dave Elliot and Lee Rosenthal, the designers, were honored with an award by the American Rocket Society. A complete report was published on the development and testing of this rocket.

In 1953 the Society conducted static tests with red fuming nitric acid and liquid ammonia that gave a thrust of 180 pounds for 48 seconds. The first attempt to ignite a tar-perchlorate restricted burning rocket was made February 7, 1954. Also, in 1954, the RRS was represented in the American Astronautical Federation, founded in Chicago.

The new Mojave Test Area, a forty-acre test site, was purchased jointly with the Pacific Rocket Society in 1955. In 1958 a large and highly successful public firing was held, attended by approximately 600 people. Three mail flights were held between 1959 and 1961.

With the advent of Sputnik in 1957, the local authorities needed to write laws to curtail the experimentations of star-minded young people, and approached Mr. George Dosa of the Society, and with National Cash Register Company, for assistance in formulating a legal framework.

From 1961 to 1963 the society was without insurance, and unable to fire rockets because of the strictness of its own legislation. At this point the Society was in dangerous trouble of collapsing. But in 1964, an insurance source was finally located, and there then started a climb back to prominence. Membership rose from less than ten to over 75, two mail flights were held, the last in Roswell, New Mexico, to commemorate the birthday of Robert H. Goddard, and carried the Goddard stamp and first day issue postmark, two public firings which received TV coverage, and over 20 regular Society firings.

THEMES

From '43 to '49 there was regular progress with black powder and then zinc and sulfur fuels, with a strong emphasis on reporting. From '49 to '53 there was sophisticated work being done with the early professional fuels. In '55, the group collapsed, primarily because of the moving of the test area.

In '58, there was a great upsurge in lay interest, because of Sputnik, but little technical advance. From '58 to '61 the work was that of hobby-minded people. From '61 to '63 the lack of motivation prevented finding a path around the insurance requirements. In '64, until '68, a policy slowly evolved regarding the educational potential of the Society.

THE LAW

Rocketry and its associated fields hold a great deal of interest for today's public. Unfortunately, those people interested in amateur rocketry seldom have a chance to conduct experimentation; those that do experiment often find themselves in violation of state and federal law.

"The Mojave Test Area is perhaps the most fully developed, privately owned site in the country for experimental rocket launchings."

The Society has presented a supervised and legal rocketry program since its inception in 1943. Many of its charter and early members are now professionals in the space industry, others have received nationwide recognition for their work.

During the years immediately following Sputnik, youthful experimentation resulted in many accidents and some deaths: as a consequence, there have been many law changes. In some states there are laws preventing the static testing of vehicles, let alone flight testing.

As a private group, the Reaction Research Society is not restricted by military supervision for rocket launches, but does conform with the California Health and Safety Code regarding insurance and permits, and is licensed to conduct amateur experiments.

"The Society-developed XLR-1000 should carry a payload to 20 miles during late 1969 or 1970."

A curiosity of the California law distinguishes solid fuel experiments from liquid fuel experiments. To test fire liquid-fueled rockets, a pyrotechnic operator possessing a first-class license issued by the State, and a test site approved for rockets-first class are necessary requirements. The Society has one man licensed to supervise liquid operations, and is working with the Kern County Fire Marshal to modify the test site for liquids (primarily involving the installation of a water deluge system).

TEST FACILITIES

One of the most widely publicized launching sites for experimental rockets on the West Coast is the Mojave Flight Test Range, jointly managed by two of the oldest senior experimental rocket societies--the Reaction Research Society, Inc., and the Pacific Rocket Society. On a forty-acre Mojave desert site twenty-two miles NE of Mojave (about 120 miles from Los Angeles), these two organizations have conducted many launchings and have supervised the safe firing of many student rockets. Since 1966 model rocket launchings have also been conducted at this site.

Two concrete blockhouses, a telephone pole covered spectator observation station, a quonset hut workshop, two 2,000 pound thrust static test stands, and numerous launching racks make this location near Edwards AFB perhaps the most fully developed, privately owned site in the country for experimental rocket launchings. The rocket range extends for miles into vacant desert.

Strictly research field trips may be conducted and attended only by members, but demonstration firings and tests are also held which are open to the public. Because of extensive precautions and safety measures which are carefully observed, no one has ever suffered injuries during any Society project.

Recently, a fueling bay has been added to the site facilities, surrounded by a foot-and-a-half thick earthen wall. There exists also a small shed for fuel preparations. Fuel mixing is done automatically with a motor-driven rotating drum.

Static test facilities include a 10-channel oscillograph, two chart recorders, six electrical output pressure transducers, and a dual trace oscilloscope. Available and on loan to the Society are a 15 ips Magnacord taperecorder, a 16mm Bolex camera, an audio oscillator, and several frequency to voltage and voltage to frequency converters.

TECHNICAL WORK

The great challenges for the Society membership consist in building and testing solid and liquid fueled rockets, in providing the ground support and equipment, and are found also in journalism and photography. Several projects in recent years have produced Society-wide participation.

The two liquid-rocket projects, Project Phoenix and the XLR-1000, are excellent examples of group work. The Phoenix rocket stands nine feet tall, and will develop a thrust of 250 pounds by burning white fuming nitric acid and unsymmetrical dimethyl hydrazine. Three identical vehicles are under construction in Society workshops. The payloads are being developed by several high school science groups, and local industry is assisting the educational project with material donations.

The XLR-1000, a fourteen-foot by seven-inch thousand pound thrust rocket, is an extension of the work done by David Elliot and Lee Rosenthal in 1950. This bi-propellant rocket should carry a payload to some twenty miles of altitude in late 1969 or 1970. The rocket is 60% complete, but testing has not yet begun.

Advanced solid fuel projects include the X-1A, a potassium perchlorate star grain static vehicle, and the development of the RRS Beta, a consistent performance vehicle using zinc dust and sulfur.

The most significant payload development has been designed by David Crisalli of Chaminade Preparatory in Canoga Park. A light sensitive resistor detects rocket turnover, and deploys a parachute at peak. Technical work is also in evidence in the Society publications, and includes the RRS NEWS, documents on test results, rocket plans and performance evaluations, and occasional historical works.

EDUCATIONAL PHILOSOPHY

The RRS provides a unique service for the Southern California young scientist. The Mojave Test Area is the only licensed flight range in California for amateur rocketeers. Adult supervisors, with over 15 years experience in rocket testings, insure the safety of all participants and spectators during tests.

But more important than the legal outlet for youthful experimentation is the structure of the Society itself. All work is voluntary: there is no paid staff, and as a consequence, any youth who exhibits the intensity of creativity can begin any project of his choosing. There are no vested interests to restrict his imagination, but there are experienced and talented people of like interest who can safeguard the experimenter from folly.

Society membership is open to anyone, and annual dues are nominal. The Society has available a library and a bibliography to help the interested student or science teacher. All correspondance should be addressed to:

SECRETARY

Reaction Research Society, Inc.

Box 1101, Glendale, Calif. 91209

BOOK REVIEWS

"Once again Palmer Publications has decided to launch another missile in the field of magazines."

--Rocket Exchange, Pilot Issue

And with the boom still resounding throughout amateur-land, the publishers of Space World did just that. Rocket Exchange, a magazine devoted to press releases and reprints, took off in the spring of 1967, and has been on a downward path ever since.

Ostensibly to serve as an information exchange to amateurs in rocketry, and to promote a national image of rocketry compatible with a hoped-for NASA sponsorship, the magazine is instead a clearinghouse for drawing-board fiction. The contents vary from a mercury-switch ejection system (operating in defiance to every law of physics) to a 5-1/2 stage, ion-powered, two foot tall, 147 mile high pipe dream done in three tenses and two persons, and no doubt painted white to make it an acceptable type lie.

Or one may wade through the phenomenonally pompous and pointless pontification of Ernest C. Doubletalk, whose motto might well be "Confidence, Drive and Determination, no matter what the subject may be."

But let's be fair. Despite the loss of Francis Bremmer as editor (probably the only staff member with any concept of layout) and the overwhelming dependence on reprints of at least four years vintage, the magazine has come out rather consistently and does satisfy the reading habits of 13- and 14-year olds who have just turned on to the possibility of personal invention in a corporate technocracy. The sad thing is, that once the readers of Rocket Exchange gain the competence to satisfy their dreams, their interests will have turned toward their jobs, and towards research into the truly pioneer fields of oceanography and urban reconstruction.

The truly successful rocket organizations are those that satisfy the hobby-desire in men, or are inspired by the educational instinct. The staff of Rocket Exchange is bonded only by the failure of dream.

How To Raise Funds From Foundations, by Joseph Dermer. Public Service Materials Center: New York. 1968.

Foundations, understandably, have always exercised a particular fascination for those seeking funds to advance worthwhile causes. To begin with, the business of foundations, in the most literal sense, is to give away money. And when they give it away, it is usually in amounts far greater than the grant seeker can obtain from any other single source--except possibly government--and at far less fund raising cost.

There is the theory of raising funds from foundations, and there is the reality. They are not the same. A knowledge of both, however, is indispensable to success in the foundation field.

In this manual, the author has sought to equip the reader to handle both the theory and the reality of undertaking successful efforts in the foundation field. One can learn only imperfectly by being told the right thing to do. Rather, he must be shown. Thus, the author cites many case examples. The examples are real. They did occur, although, at times, the identity of the organizations has been cloaked.

The manual offers no easy road to success, for, indeed, there is no easy road. It will, however, help you avoid the pitfalls many grant seekers stumble into. It should work well for you.

THE LOCAL SCENE

The Society extends a very warm note of thanks to Mr. Emanuel Crisalli, who has donated to the RRS the necessary funds to equip and maintain the field generator. . . . The RRS is similarly indebted to the UCLA Zoology Department for an oscilloscope, several DC amplifiers and calibration bridge, and sweep generators. . . .

The Society marks its 25th Anniversary with this issue. . . . The Eighth Rocket Mail Flight, a simultaneous launch of 1,000 covers, will commemorate 25 years of continuous rocket experimentation and education. . . . Two rockets will transport the mail at the Society's testing and proving grounds near Mojave, California. . . .

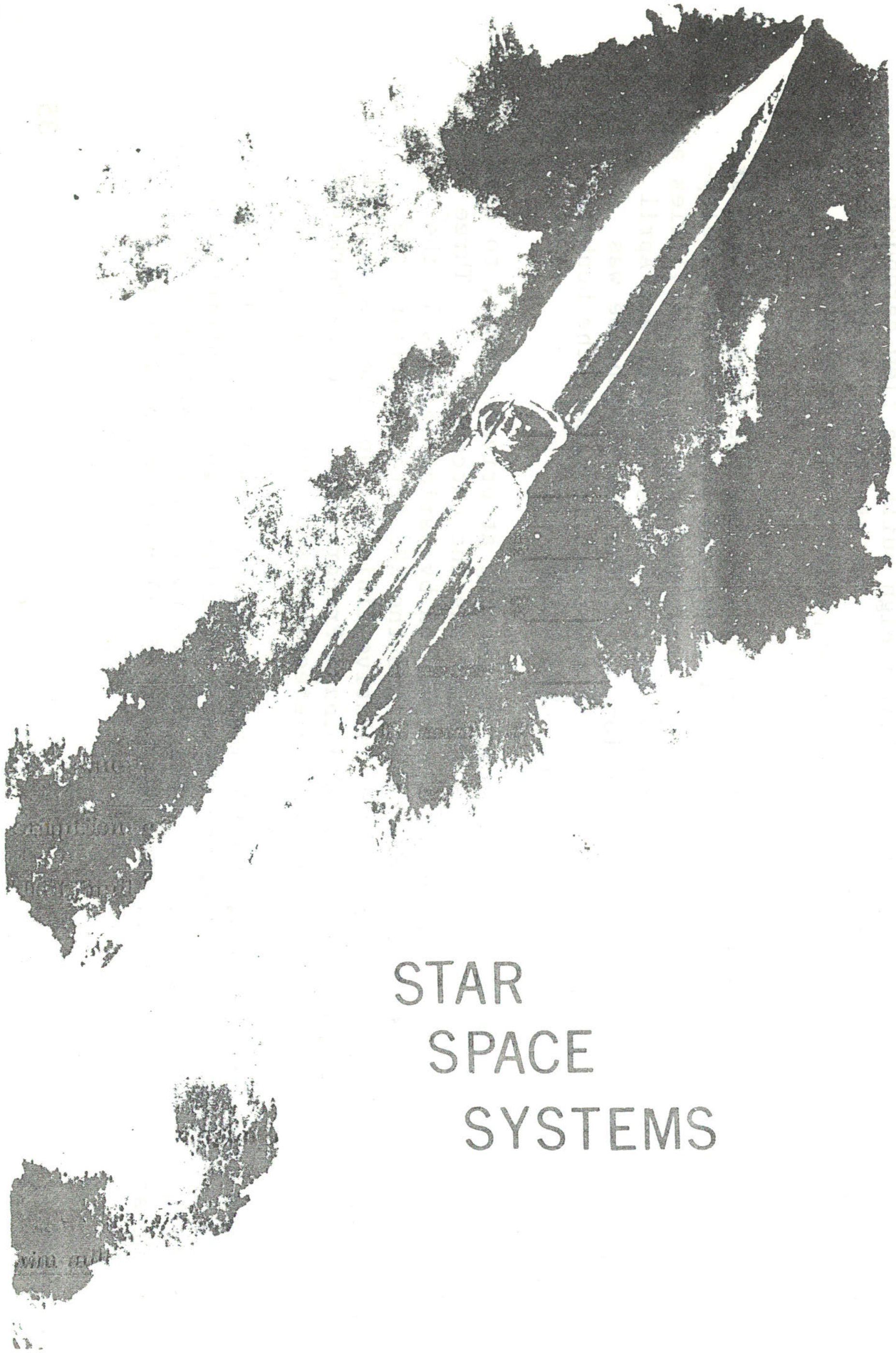
Star Space Systems has been acquired by the RRS and will serve as a distributor for RRS publications, in addition to selling liquid rocket plans. . . Profits will be used to support the two liquid research projects of the Society, the Phoenix rocket and the 1,000 pound thrust hydrogen peroxide and methyl alcohol vehicle. . . .

Twenty young scientists from Lakewood Junior High built and flew cardboard and wood rockets at the Mojave Test Area. . . . The airframes, constructed during the school year as part of a classroom project, used commercially available engines. . . .

Goals for '68, a statement of Society intentions during the year, divided attention into educational tasks, static test work, and liquid rocket development. . . . Included in the proposal was a heavy emphasis on new facilities at the Mojave Test Area. . . . The series of four weekends in March and April accomplished the bulk of the construction. . . . The new blockhouse was finished, the old one re-roofed, the water tower set in place, the bunkers revamped, and a fueling bay and storage shed built. . . .

A series of technical sessions were begun, meeting at private homes, to design a small liquid rocket. . . . Project Phoenix was the outcome. . . . Three complete flight vehicles are under construction by various groups in the Society. . . . Technical work also went into the RRS Beta, modifying the nozzle for carbon inserts (and other ablative linings), and the inside wall with an insulating material. . . . Chaminade Preparatory of Canoga Park conducted extensive peak-sensing parachute ejection experiments. . . .

After the South Bend rocket, and the legal complications involved in obtaining the necessary waivers, the Society now files regular statements to the Federal Aviation Agency. . . . The Society clubhouse received a face-lifting and a coat of paint, with the help of Gil Healton and father. . . .



STAR SPACE SYSTEMS

CATALOG AND INFORMATION

---ORDER BLANK---

Send cash, check, or money order to:

STAR SPACE SYSTEMS
P.O. Box 1101
Glendale, Calif. 91209

_____ Liquid rocket plans	@ $2.98 each-	$_____
_____ Liquid rocket materials kit	@ $29.95 each-	$_____
_____ Pre-assembled motor and nozzle	@ $4.95 each-	$_____
_____ Complete propellant injector	@ $8.95 each-	$_____
_____ Plans for RRS 2-inch rocket	@ $1.50 each-	$_____
_____ H_2O_2 Report	@ $2.00 each-	$_____
_____ Thrust & Drag	@ $2.00 each-	$_____
_____ RRS NEWS, single issue	@ $.50 each-	$_____
_____ RRS NEWS, subscription of four issues	@ $2.00 each-	$_____
_____ Nosecones, booklet and Nomograph sheet	@ $1.00 each-	$_____
_____ Tracking, booklet	@ $1.00 each-	$_____
_____ Rocket Data Sheet	@ $.75 each-	$_____
_____ Nozzles	@ $.50 each-	$_____
_____ Bulkheads and Burst Diaphragms	@ $.50 each-	$_____
	Enclosed please find-	$_____

Print or type your own address

Name_______________________________

Address_____________________________

City______________ State__________ Zip Code________

Materials kit, motor, and injector will be sent C.O.D.

LIQUID FUEL ROCKET

Tired of playing with solid propellant rockets? Here's a "workhorse" to really put you ahead in the amateur rocketry race. Liquid fuel systems too complicated? Not this one! Only one moving part - a simple brass valve. Anyone with a six-inch metal lathe and a drill press can build it!

Complete plans and instructions, only $2.98.

Supplementary booster and launcher plans, $1.00.

SPECIFICATIONS

Height	5-1/2 feet
Diameter	3-1/4 inches
Thrust	100 pounds
Specific Impulse	214 seconds
Burning Duration	7 seconds
Maximum Payload	10 pounds
Corresponding Altitude	10,000 feet
Propellants	Acid/Alcohol

ROCKET MATERIALS KIT

This kit includes the <u>material</u> for making the following parts: motor; retaining ring; mixing chamber; injector holder; injector; injector retainer; center plate; fin assembly plate; fins; tanks; CO_2 section; and instrument section.

Complete kit as described above plus plans and instructions, only $29.95, plus postage.

PRE-ASSEMBLED PARTS

A pre-assembled motor and nozzle, as shown on the liquid rocket plans, only $4.95, plus postage.

A complete propellant injector, machined to professional specifications, of an improved design, only $8.95, plus postage.

PUBLICATIONS

SOLID PROPELLANT ROCKET PLANS

For those amateurs who prefer to work with solid propellant rockets, here are the plans for the Reaction Research Society's standard 2-inch rocket. This vehicle will reach altitudes up to 8,000 feet, depending on the weight of the payload.

All parts dimensioned to standard machine-shop specifications. 12 drawings.

$1.50

<u>HYDROGEN PEROXIDE REPORT</u>

This report, by David Elliott and Lee Rosenthal of the Reaction Research Society, describes the design, construction, and testing of the first liquid propellant rocket fired by the RRS. This work was honored with an award by the American Rocket Society in 1952. Included in this paper is a discussion by Donald Haldiman on the properties of highly concentrated hydrogen peroxide.

$2.00

NOSECONES

This booklet, by George Dosa, describes in detail two methods for making fiberglass nosecones. Anyone wishing to make light-weight nosecones for improving the performance of his rocket, or to make hollow nosecones for carrying payloads, should buy this booklet.

$1.00

TRACKING

When you fire your rocket, you will certainly want to know how high it went. With this booklet, you can learn how to make use of not one, but five different ways of determining rocket altitude. One of the more interesting ways is by making movie films of the trajectory during the burning phase.

Included with this booklet is an altitude nomograph, 17"x24", prepared by Dick Henderson.

$1.00

DETAIL SHEETS

ROCKET DATA SHEET: This 34"x22" sheet contains general information on amateur rocketry, including fuels, fin design, nosecones, launchers, and hardware.

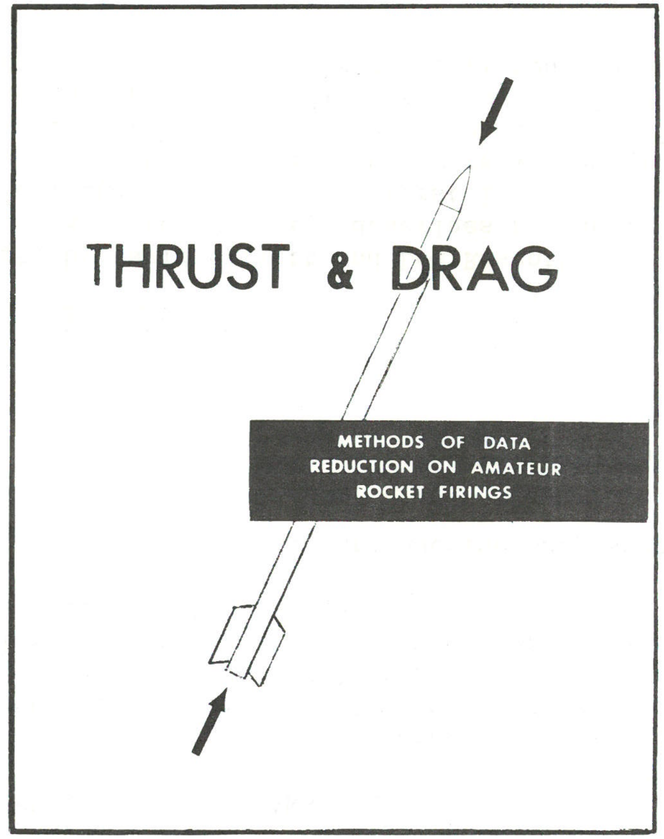
$.75

NOZZLES: Drawings of various methods for mounting many nozzle types are included in this 11"x17" sheet.

$.50

BULKHEADS AND BURST DIAPHRAGMS: Mounting methods and types of burst discs are shown on this 11"x17" sheet.

$.50



Written expressly for the amateur rocketeer, Thrust and Drag takes data obtained from properly planned movie film and arrives at values for thrust, co-efficient of drag, and specific impulse by a series of algebraic calculations.

The text is carefully written, and well illustrated, with graphical results given when possible. The manuscript has been reproduced by the photo offset process, and is attractively bound.

Published by the Reaction Research Society, Inc. Copyright 1966. 52 pages.

$2.00

THE REACTION RESEARCH SOCIETY

announces its JOURNAL of AMATEUR & EXPERIMENTAL ROCKETRY

May we present THE REACTION RESEARCH SOCIETY NEWS, a journal of amateur rocketry published in Los Angeles and distributed internationally.

The Reaction Research Society is one of the oldest rocket societies in the U.S., and is in joint possession of the largest amateur testing area in America. The Society serves to promote experimental rocketry, and at the same time provide educational opportunities in rocket design for the student.

One facet of our work is the publication of THE RRS NEWS, a news magazine of about forty pages that attempts to describe the rocket activities of the Southern Californian area, to present articles of value in amateur work, and to report accurately developments in state and national legislation, the progress of other societies, and matters of public interest.

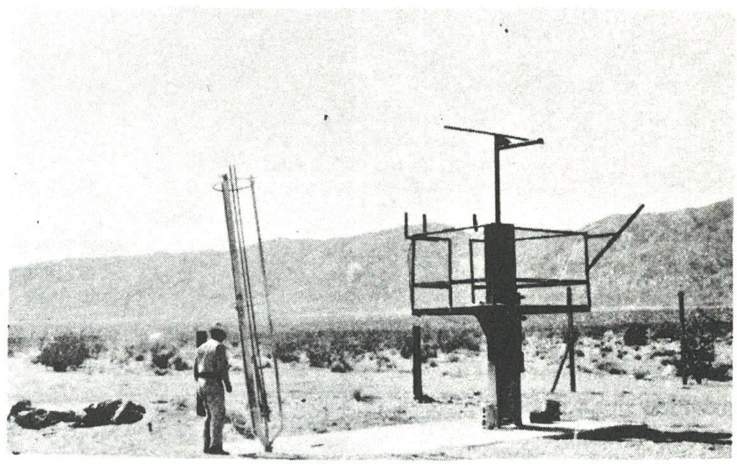
If you would find the content of this magazine of value, and wish to receive the NEWS regularly, we would be most pleased to enter a subscription in your name, at the following rate:

RRS NEWS, one year subscription, four issues . . . . . . Two dollars.

For advertising rates, please write to the Society, c/o the Managing Editor.

Send cash, check, or money order to

Reaction Research Society, Inc.
Post Office Box 1101
Glendale, Calif. 91209



Static test structure at the Society's desert launch area.

RRS NEWS

Enclosed please find two dollars for four issues of THE RRS NEWS:

Name____

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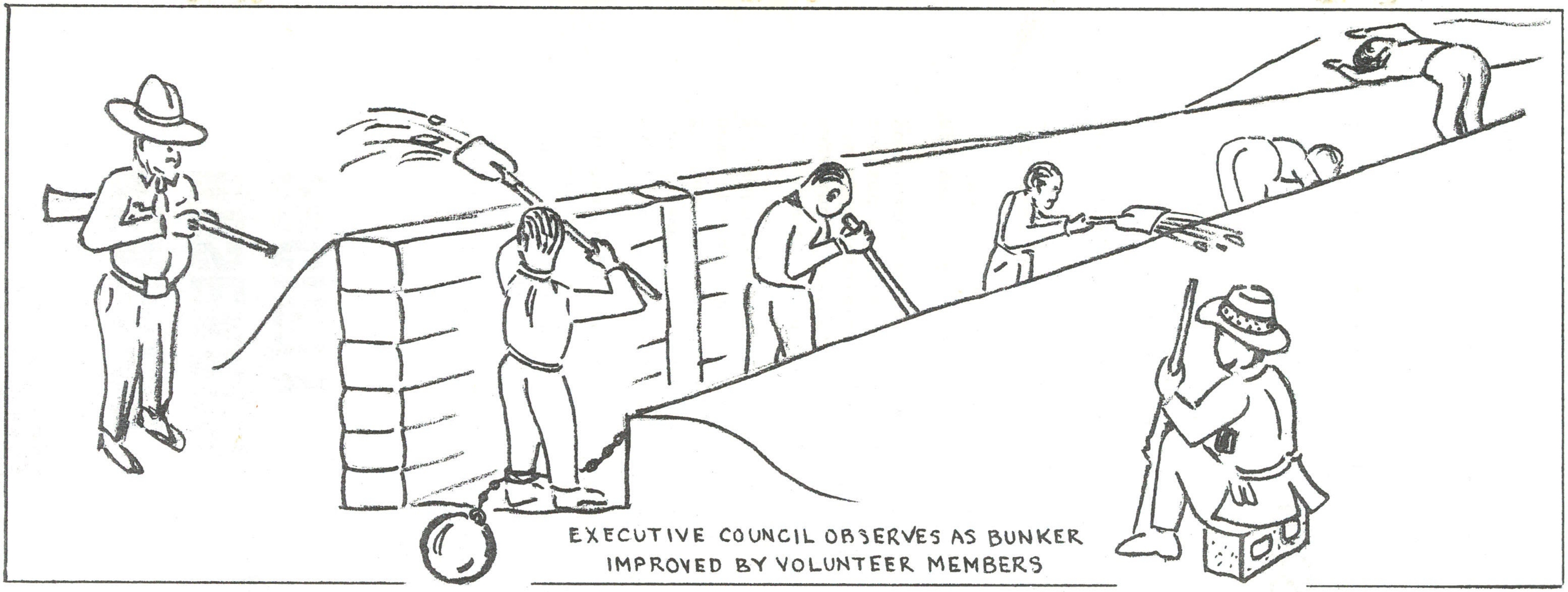
City____________________ State__________ Zip Code________



REACTION RESEARCH SOCIETY

AN ACTIVE ROCKET SOCIETY

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