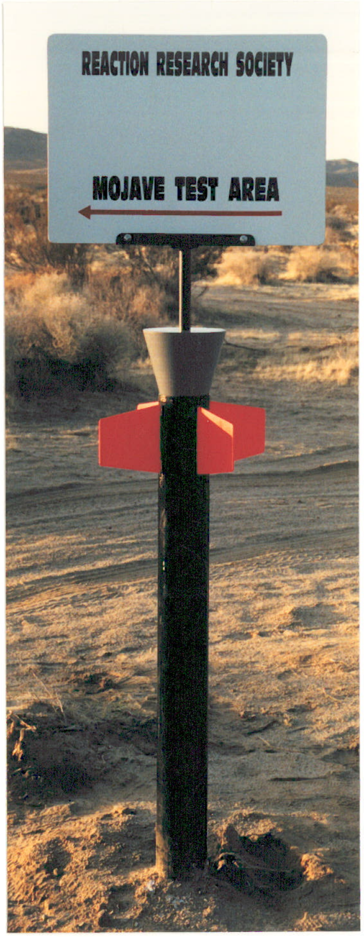
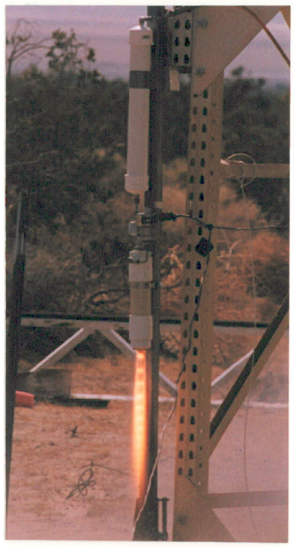


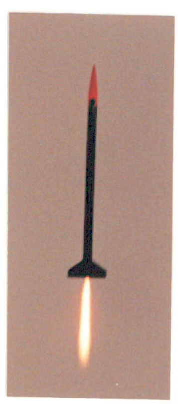


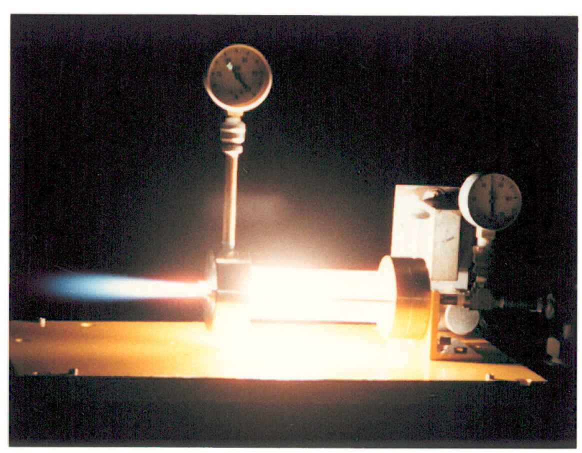
RRS NEWSLETTER

THE OFFICIAL JOURNAL OF THE REACTION RESEARCH SOCIETY, INC.

VOLUME 52,
NUMBER 1
FEBRUARY 1995

For the advancement of rocketry and astronautics





RRS NEWSLETTER

VOLUME 52, NUMBER 1, FEBRUARY 1995

The Reaction Research Society is the oldest continously operating amateur rocket group in the nation. Founded in 1943 as a nonprofit civilian organization, its purpose has been to aid in the development of reaction propulsion and to promote interest in this science as well as its applications. The Society owns and operates the Mojave Test Area, a 40 acre site located two and a half hours north of Los Angeles. Over the years, thousands of solid, hybrid, and recently, liquid propellant rockets have been static and flight tested. Currently, there are over 160 active RRS members throughout the United States and in several foreign countries.

This newsletter is a more-or-less bi-monthly publication by the Society and is intended to provide communication between members and other societies. It is also the historical documentation of the activities conducted by the Society as a whole and by its individual members. Information regarding the RRS can be obtained by writing to:

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P.O. Box 90306 World Way Postal Center
Los Angeles, CA 90009

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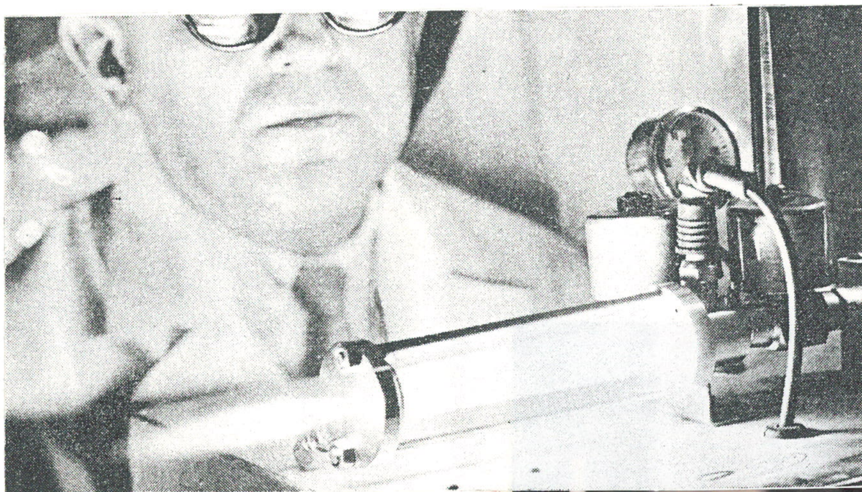
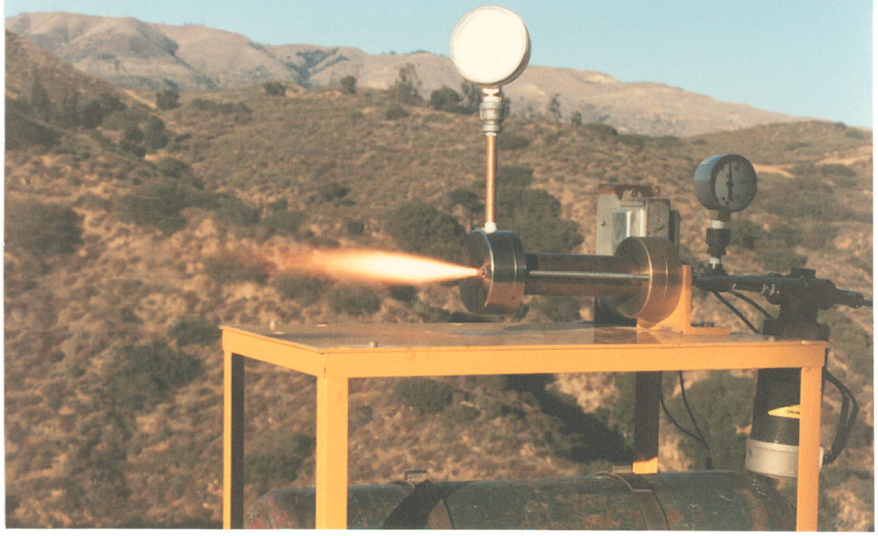
(Anytime - 24 hrs a day Leave or hear messages)

Fabrication, Testing and Analysis of an Oxygen/Plexiglas Hybrid Demonstration Rocket

by
Scott Claflin



Exactly 25 years after the original GOX/plexiglas rocket (above) was pictured in *Astronautics and Aerospace Engineering* , a similar rocket (right) was built and tested by Scott Claflin, Dave Crisalli, Brian Wherley and Mark Grant. In addition to using plexiglas as a fuel, the versatile rocket has tested numerous other fuels, including tar paper (shown below), tar, particle board, rubber, polyester and epoxy.



Back in 1984, while I was a student at the University of Kansas, my best friend and I stumbled upon a discovery of considerable interest. There, in a dusty cabinet in the catacombs under the engineering building, lay scattered parts of what would become the fascination and envy of many an armchair rocketeer. The unfamiliar looking parts would have been quickly passed over if it were not for a yellowed and faded picture from a magazine (top figure, title page) which laid with the parts. The page showed a small transparent rocket engine being tested with the test conductor only inches away from the incandescent rocket. We could hardly contain our enthusiasm when we realized that the assorted parts in the cabinet could, with a little work, be made into the very rocket shown in the picture.

The novel feature of the rocket was that the fuel and the combustion chamber were one and the same. This was a *hybrid* rocket which burned the inner surface of a solid fuel (in this case, a clear plexiglas tube which also served as the combustion chamber) with pure gaseous oxygen (GOX). The beauty of using plexiglas as the fuel was that you could watch the combustion process through the clear walls. Also, since the fuel and oxidizer could not be intimately mixed and thus could not explode, the blue flames dancing inside of the plexiglas tube could be closely viewed in relative safety.

After gathering or fabricating all of the parts required to assemble the plexiglas rocket, a problem immediately became apparent: How do we ignite it? There was a provision for a spark plug in the injector assembly and an additional threaded port was included next to the oxygen inlet port. A little bit of brilliant deductive reasoning led us to the conclusion that propane should be plumbed into the extra port and that the spark plug could then be used to ignite the oxygen/propane mixture. After the plexiglas ignited, the propane could be turned off and the motor would run as a pure hybrid. This sounded good but we could never get the spark plug to operate consistently. So an alternate, and more sporty, ignition method was devised. First the propane (from a small hand-held torch bottle) was turned on. Then a welding torch sparker was used to manually light the propane flowing from the nozzle of the rocket. Next, as all of the observers scrambled for cover, some poor guy (usually me) slowly opened the needle valve which fed oxygen to the rocket. At some seemingly random time, the flame would be "swallowed" through the rocket nozzle throat into the premixed oxygen/propane propellants with a deafening report. About half of the time the plexiglas would ignite and everyone would come out from around whatever they were hiding behind to watch with amazement the internal workings of a combustion chamber.

Several years later, after moving to Southern California and teaming up a handful of like-minded wanna-be rocketeers (all are RRS members now), I got the urge to resurrect the plexiglas rocket. I had left the original rocket back at the University of Kansas for future students to enjoy so I would have to start from scratch. Fortunately, I received considerable assistance from my compatriots, David Crisalli, Brian Wherley and Mark Grant. The motor was fired for the first time in December 1988 (center photo, title page). This article is intended to document the design, fabrication and testing of our rocket so that anyone who is so inclined can build an oxygen/plexiglas demonstration rocket.

As shown in Figure 1, the combustion chamber is composed of three major parts: a brass injector, the plexiglas fuel tube, and a stainless steel nozzle. The ends of the plexiglas tube fit into recesses in the injector and nozzle so that the tube is "sandwiched" between two. The assembly is held together by two 1/4-inch all-thread rods. The plexiglas tube is sealed to the injector and nozzle by o-rings. The o-rings are retained in o-ring grooves machined into the injector and nozzle recesses. Dimensioned drawings of the injector and nozzle are shown in Figure 2 and Figure 3. The dimensions shown in the drawings are the "as machined" dimensions and most dimensions could be changed considerably without impairing the operation of the motor. In particular, the o-ring groove dimensions do not conform to standard, recommended groove dimensions and the o-ring which is specified is the wrong size for the groove. But it works. If I was to do it all over again, the o-ring groove would be machined properly to accept a different size o-ring.

Besides being a big hit at parties, the motor is also useful for gathering data on various fuels. Fuels which have been tested include particle board, tar paper, tar, cast polyester, powdered rubber/epoxy mixtures, and powdered coal/epoxy mixtures. These fuels were either cast or inserted into a 1.5-inch diameter steel tube which was "sandwiched" between the

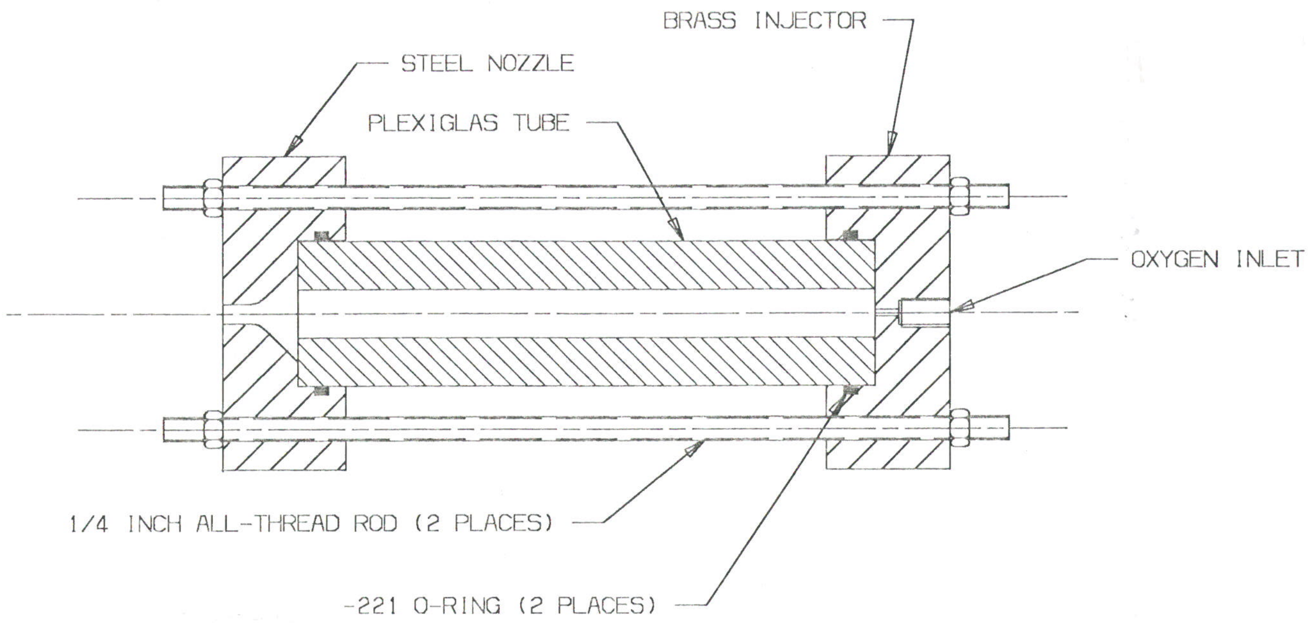


Figure 1 - GOX/Plexiglas Hybrid Motor Assembly

injector and nozzle in place of the plexiglas tube (bottom photo, title page)

As shown in Figure 4, a small self-contained test stand was built to facilitate the testing of the hybrid motor. The test stand has provisions for holding a small GOX bottle and regulator under the motor. The stand also has a 24 volt power supply to allow the use of a solenoid valve for starting and stopping a test. A manual valve such as a needle valve or a ball valve could have been used but it seems safer to have a remotely operated valve in the off chance that something went wrong. Who wants to reach in to shut off a valve if fire is blowing out the side of the motor!?

Although the previously mentioned premixed oxygen/propane ignition method was exciting (or startling), a simpler and more reliable method was implemented for this motor. Dave Crisalli suggested applying 120 volts to a small ball of fine steel wool to ignite the motor. The steel wool ball is inserted into the fuel tube prior to motor assembly. Immediately prior to the test, two wires with exposed ends are inserted into the motor through the nozzle throat. To ignite the motor, the oxygen is turned on which forces the steel wool ball down onto the wires, then a momentary-contact switch is depressed which sends 120 volts through the steel wool ball. In the pure oxygen environment the steel wool ignites violently and lights the fuel. An alternate method has been implemented on other small hybrids in which low voltage is applied to a steel wool ball to get the ball glowing red hot, then the oxygen is turned on to ignite the motor.

To demonstrate the safety of the design, the hybrid motor has been purposefully run to failure several times. In all cases, the failure turned out to be benign. Plexiglas fuel tubes have been run until the wall of the tube gets so thin that the wall balloons out and opens up. When this happens, the chamber pressure drops to zero and the fire essentially goes out. With fuels contained in steel tubes, if some of the fuel burns out so that the steel is exposed, the steel will get so hot that the o-rings will melt and fail which relieves the chamber pressure and the fire essentially goes out.

The motor can be operated in complete safety if a few precautions are taken. Only operate the motor at relatively low pressures. The GOX injection pressure should be regulated no higher than 150 psig. Also, make sure that all the materials in the GOX system are compatible with oxygen. In particular, the valve seat should be made from teflon and the regulator should be designed for oxygen service. Prior to assembly of the GOX system, every surface which will be in contact with oxygen should be thoroughly cleaned and degreased with an oxygen compatible degreaser (such as

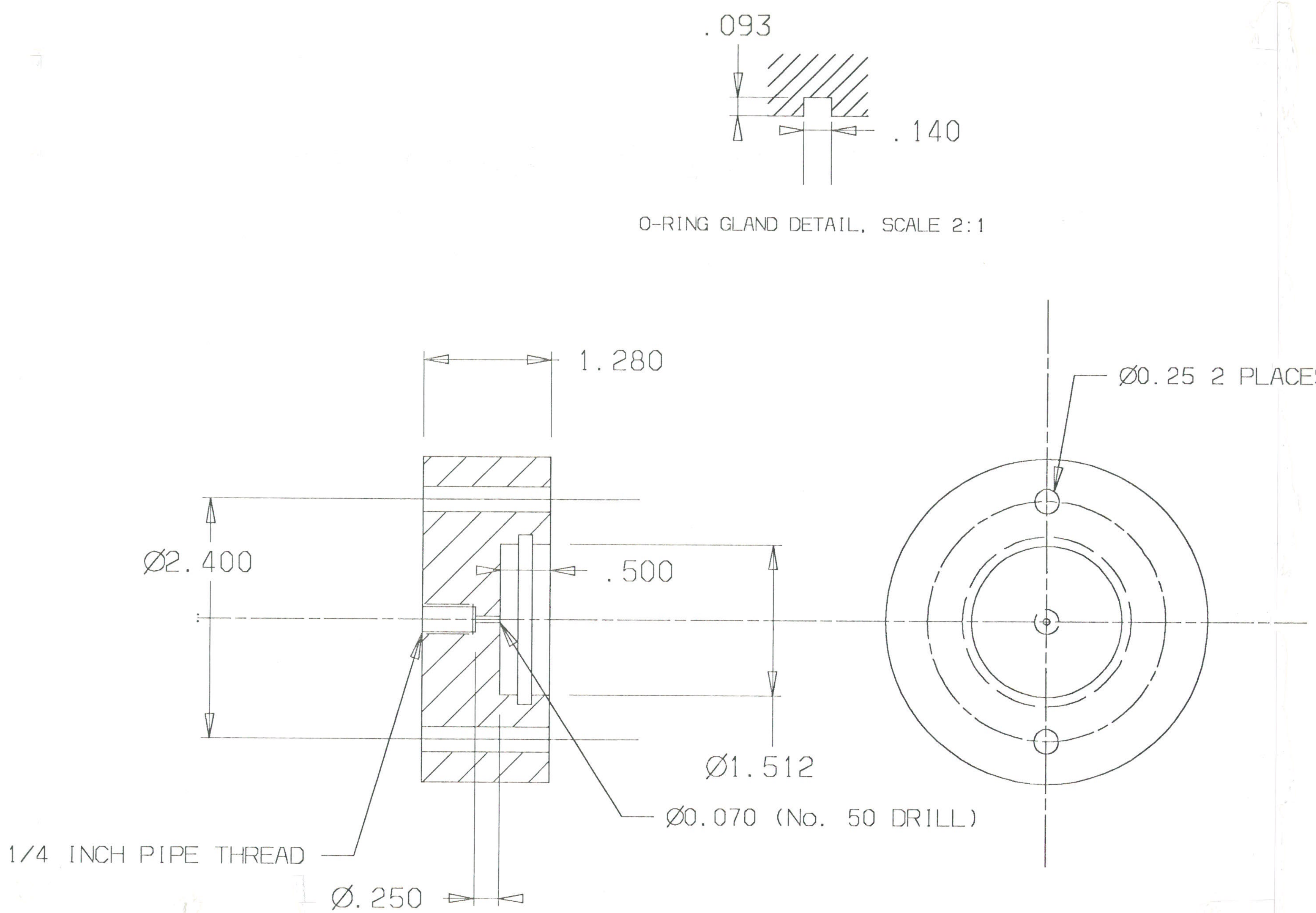


Figure 2 - Brass Injector Showing "As Machined" Dimensions

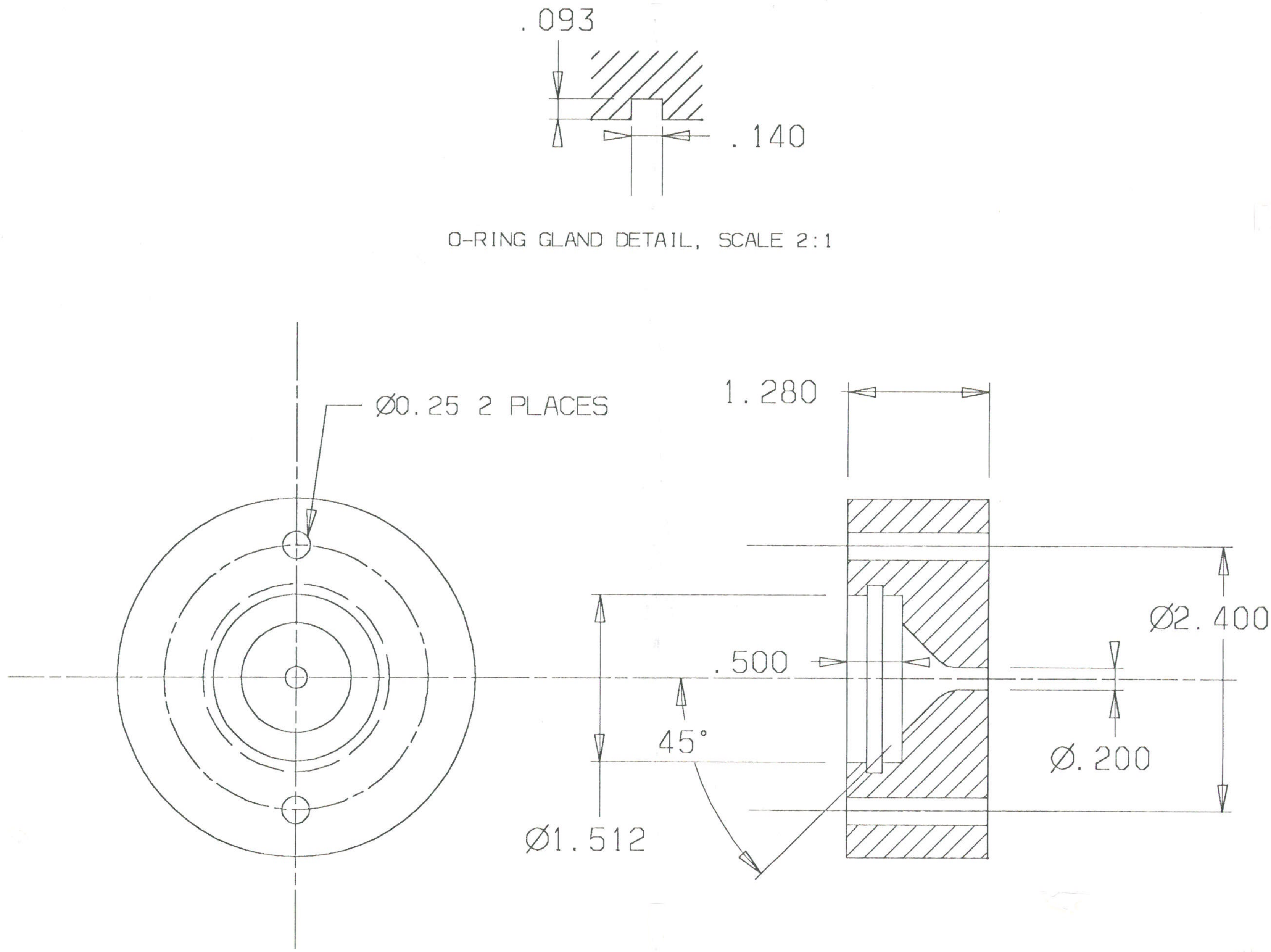


Figure 3 - Stainless Steel Nozzle Showing "As Machined" Dimensions

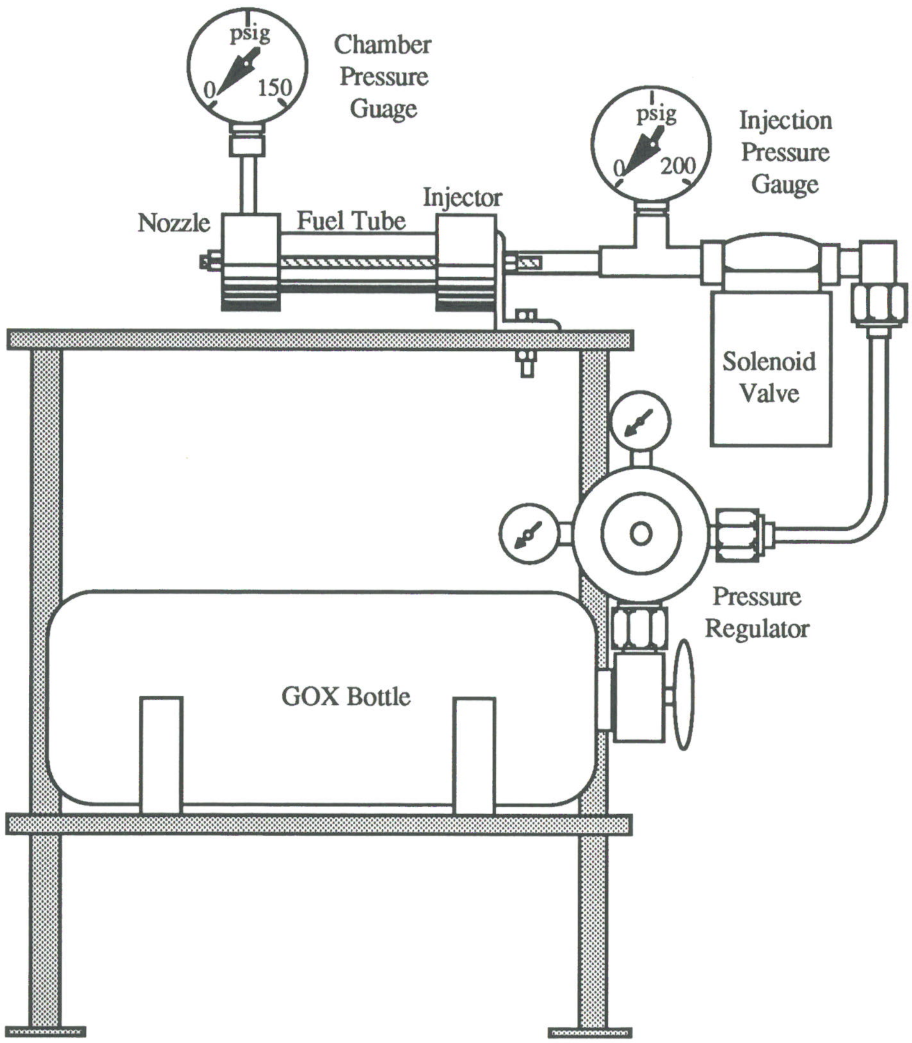


Figure 4 - Hybrid Demonstration Motor Test Stand

trichloroethane). The key to safe operation of oxygen systems is cleanliness. Remember, the basis of the hybrid concept is that virtually anything will burn with oxygen. Keeping the GOX system clean should ensure that the feed system does not become part of the hybrid combustion process!

The primary information which is of importance in hybrid motor design is the characteristic velocity, c*, which is a measure of the combustion energy being released, and the fuel regression rate, $\dot{r}$, which is simply the rate at which the walls burn back. The combination of regression rate, burning surface area, and fuel density determines the fuel flow rate. In industry, much time and effort has been spent on developing regression rate correlations like the one shown in Figure 5. Figure 5 shows the variation of regression rate with oxidizer mass flux for a small GOX/plexiglas hybrid like the one described in this article. The regression rate of most hybrids follows the equation:

$$\dot{r} = a\, G_o^n$$

where, $\dot{r}$ = regression rate, *inches/second*

G_o = oxidizer mass flux through the fuel port, *lb/sec/inch*^{2}

= (oxidizer flow rate)/(fuel port cross-sectional area)

a = empirical constant

n = empirical constant.

For the data shown in Figure 5, the equation $\dot{r} = 0.069\ G_o^{0.77}$ fits the data well. The small hybrid motor can be used to generate similar regression rate correlations for other fuels.

An example of how the regression rate equation is used in hybrid rocket design will now be shown using the small GOX/plexiglas motor as an example. It is very important that *absolute pressure* is used in the calculations and not *gauge pressure*. This is especially important when comparing measured data with calculated data. First, a few assumptions are made:

Injection pressure = 100 psia
Injector orifice diameter = 0.070 inches
Throat diameter = 0.200 inches
Fuel port diameter = 0.50 inches

If the GOX flow through the injector orifice is sonic (that is, chamber pressure is less than approximately half the injection pressure) then the GOX flow rate is

$$\dot{w}_o = \frac{C_d A \times P_{inj} \times S}{\sqrt{R \times T_{inj}}}$$

where $\dot{w}_o$ = gaseous oxygen flow rate, *lb/sec*
C_d = orifice discharge coefficient ≈ 0.77 for a straight drilled orifice
A = orifice cross sectional area, *inch*^{2}
P_{inj} = Injection pressure, *psia*
S = constant = 3.8839
R = Gas constant = 1544/molecular weight = 53.3 ft/°R for oxygen
T_{inj} = injection temperature = 520 °R (assumed)

Therefore, for this example,

$$\dot{w}_o = \frac{0.77(.00385)(100)(3.8839)}{\sqrt{53.3 \times 520}} = 0.007 \text{ lb/sec}$$

If the GOX flow through the injector orifice is not sonic (that is, chamber pressure is greater than approximately half of the injection pressure) then the GOX flow can be approximated by the equation

$$\dot{w}_o = C_d A \sqrt{(\rho\ \Delta P)/2.238}$$

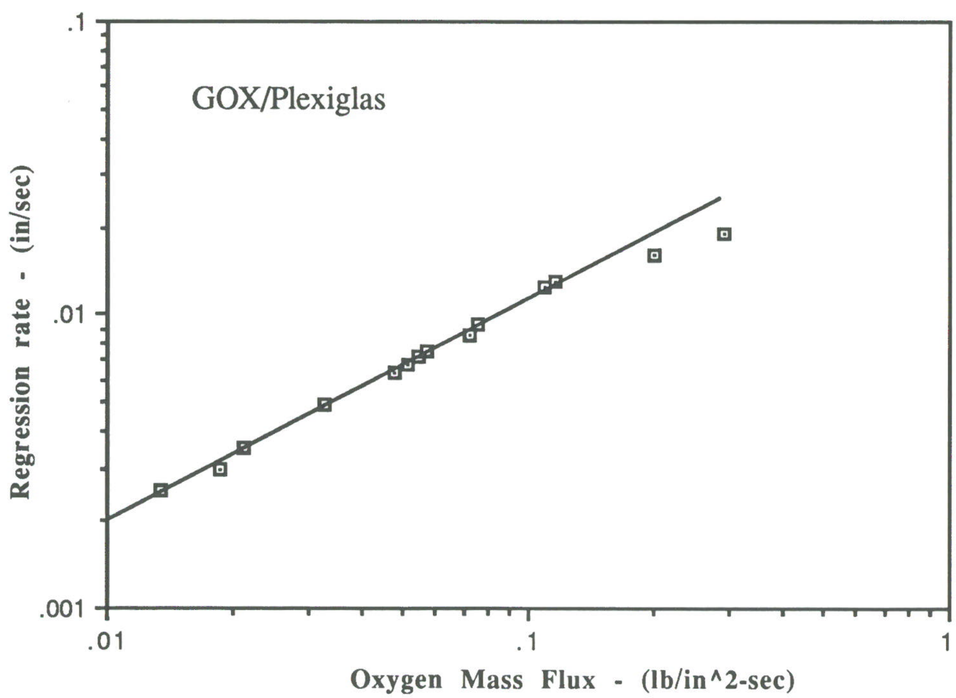


Figure 5 - GOX/Plexiglas Regression Rate Data

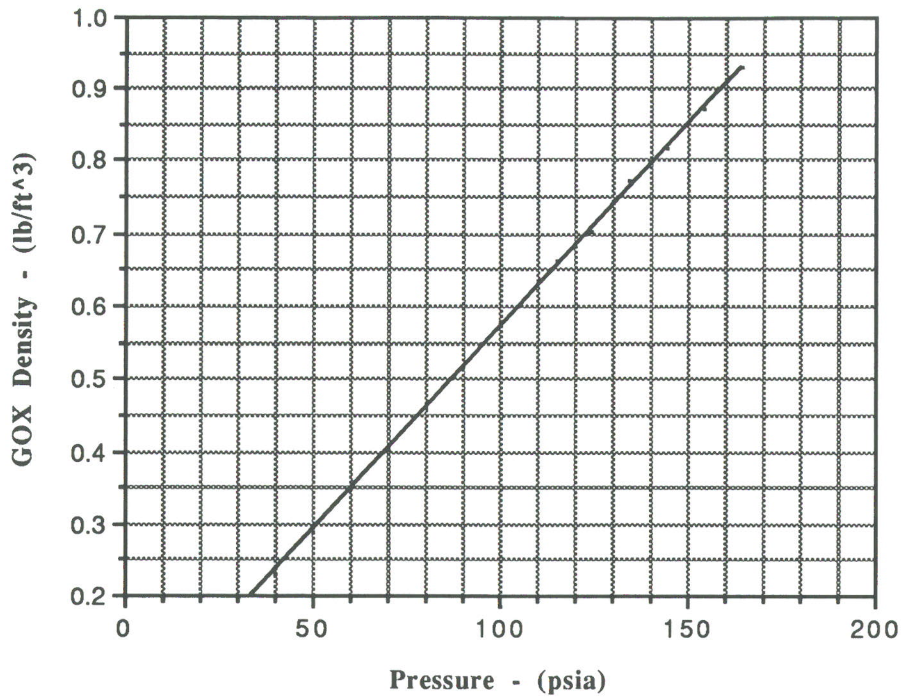


Figure 6 - GOX Density Variation with Pressure (Temp. = 70°F)

where, ρ = GOX density at the chamber pressure, *lb/ft*^{3} - see Figure 6.
ΔP = Injection pressure minus chamber pressure, *psi*

To use this equation, you have to know the chamber pressure or estimate it.

Once the GOX flow rate is calculated, the oxygen mass flux through the fuel port as well as the fuel regression rate can be determined.

$$G_o = \frac{\dot{w}_o}{\pi \times r_{port}^2} = \frac{0.007}{\pi \times 0.25^2}$$

$$= 0.036 \text{ lb/sec/in}^2$$

For plexiglas,

$$\dot{r} = 0.069\ G_o^{0.77} = 0.069\ (0.036)^{0.77}$$

$$= 0.0053 \text{ inches/second.}$$

The flow rate of fuel during combustion is a function of regression rate, burning surface area, and fuel density or

$$\dot{w}_f = \dot{r} \times A_s \times \rho$$

where, A_s = fuel burning surface area, *inch*^{2}
= port perimeter x length
= $\pi \times D_{port} \times L$
ρ = fuel density
= 0.035 lb/in^3 for plexiglas

so by substitution,

$$\dot{w}_f = 0.0053 \times \pi \times (0.5) \times L \times 0.035$$
$$= 0.00029 \times L \quad \textit{lb/sec/in}$$

To determine the fuel flow rate, the length of the fuel has to be know. The length is picked to provide the ratio of oxygen-to-fuel flow rate (known as mixture ratio) which gives the best performance (that is, highest characteristic velocity or specific impulse). For most hybrid fuels burning with oxygen, the optimum mixture ratio is between 1.0 and 2.5. A plot which shows the variation in propellant characteristic velocity with mixture ratio, such as Figure 7, can be used find the optimum mixture ratio. For this example, a mixture ratio of 2.0 is selected. Therefore the fuel flow rate is simply half of the oxygen flow rate and the fuel length to give this flow rate is

$$L = \frac{\dot{w}f}{0.00029} = \frac{0.0035}{0.00029} = 12 \text{ inches}$$

After a test is run, the actual characteristic velocity attained during the test can be determined from the measured chamber pressure. The appropriate equation is

$$c^* = \frac{P_c \times A_t \times g}{\dot{w}_t}$$

where, P_c = chamber pressure, *psia*

A_t = throat area, *inch*^{2}

g = constant = 32.174 ft/sec^2

$\dot{w}_t$ = total propellant flow, *lb/sec*

$= \dot{w}_f + \dot{w}_o$

Actual fuel flow rate can be determined by weighing the fuel before and after the test and dividing the weight difference by the burn time. If the GOX/plexiglas rocket in this example produced a chamber pressure of 50 psia, the characteristic velocity would be

$$c^* = \frac{50 \times \pi \times (0.1)^2 \times 32.174}{(0.0035 + 0.007)}$$
$$= 4813 \text{ ft/sec}$$

Comparing this to the theoretical value of 5200 ft/sec from Figure 7, the measured efficiency would be

$$\eta_{c^*} = \frac{4813}{5200} = 0.93 = 93\%.$$

One final warning: If any experimentation with different fuels is done, it is best to avoid fuels which can absorb oxygen. When a fuel absorbs oxygen, it becomes a high explosive which is impact-sensitive. Oxygen-absorbing hybrid fuels are typically thermoplastic fuels such as tar, tar paper, salami (because of the grease), paraffin, etc. Tests have been performed using some of these fuels in the small hybrid motor without incident but a larger oxygen/tar paper hybrid once detonated due to oxygen absorption into the fuel. It is good practice to avoid such fuels.

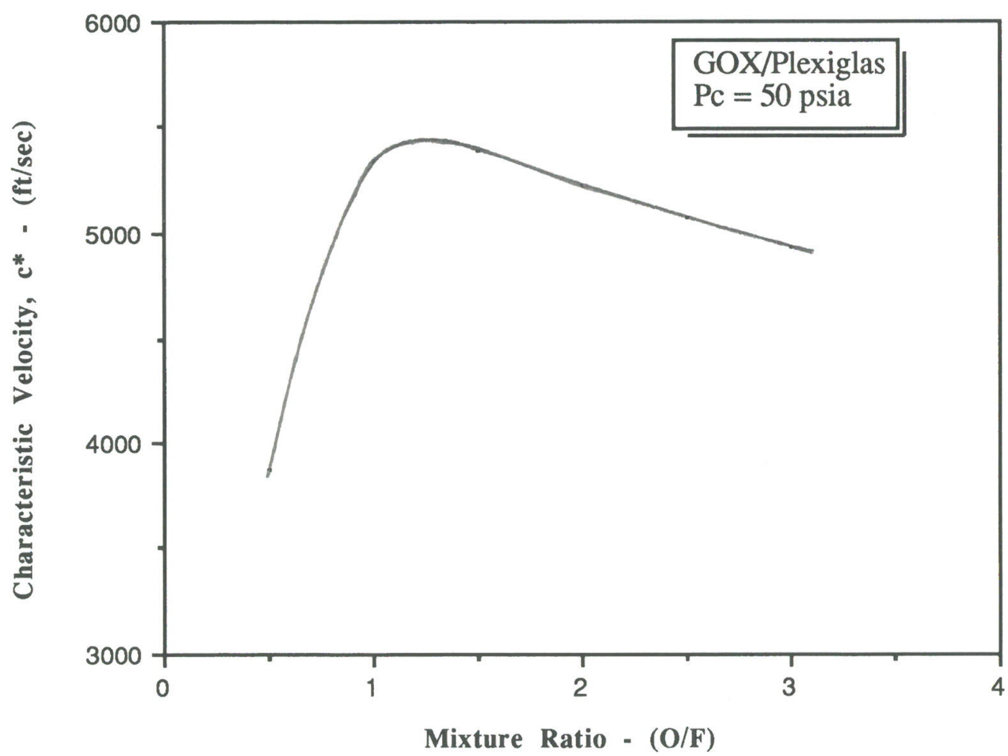


Figure 7 - GOX/Plexiglas Performance Variation with Mixture Ratio

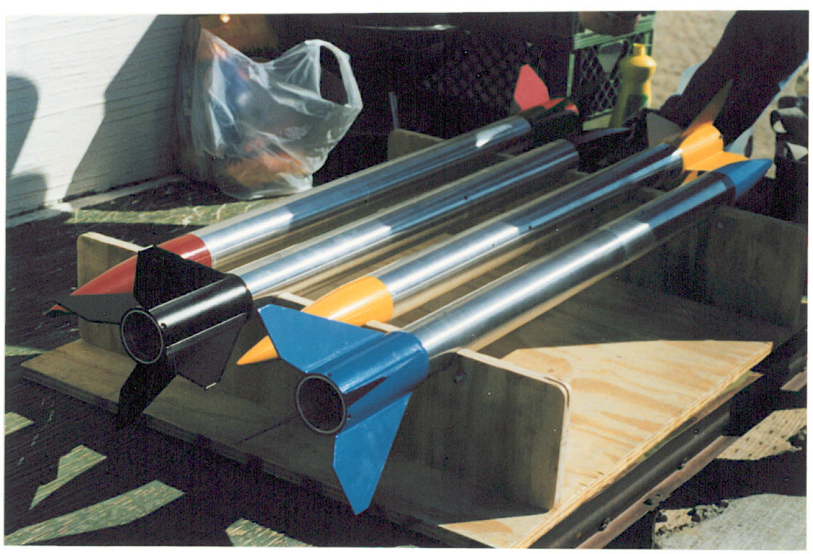
Hot Fire Report
MTA Firing, 22 October, 1994

by
David Crisalli

On Friday, the twenty first of October, 1994, the first wave of composite propellant rocket scientists reached the MTA to prepare for the launch of four high performance vehicles. They were the advanced guard for a large group of RRS members bringing solid, liquid, and hybrid rockets out to test. By 9:00 AM, George Garboden, Niels Anderson, and Chip Bassett were busy mixing, curing, and testing the propellant that would power their latest rockets. During the remainder of the day, Jim Gross, Brian Wherley, Korey Kline, Tom Mueller, and several others arrived to spend the next many hours (well into the night) preparing for the following day. At the end of all the mixing, curing, and grain preparations, the firing officially commenced with the static test, by George Garboden and Niels Anderson, of two of these composite motors. The tests were successful demonstrating that the propellant was cured properly and would produce 300 pounds of thrust for 2 seconds at an Isp of 220 seconds! This is a far cry from the 40 seconds of Isp normally attained by zinc/sulfur motors.

Niels Anderson and George Garboden set up to mix composite propellant

By early the next morning, the cast of thousands had started to arrive. Some came to work, prepare, and test. Others came to, laugh, tease, joke, and spectate. All were busy. The firing window was set to open at 9:00 AM and we wanted to begin as early as possible to ensure that everyone on the firing docket got a chance to get his test off on Saturday. The day started very close to the planned time with the first of four 2.5 inch diameter composite rockets leaving the launch tower at about 9:20 AM. A



The four composte rockets awaiting propellant loading

Composite rockets with the four builders: (l to r) Niels Anderson, George Garboden, Chip Basset and Pat Mullens (kneeling)

preflight computer trajectory analysis for these rockets predicted a peak altitude of 19,000 feet with an impact time of around 60 seconds. The actual impact times for three of the four vehicles were between 68 and 71 seconds indicating that the peak altitudes were at or above predicted levels. One of the four composite rockets broke up in flight and did not attain the same altitude as the other three. The failure was of the fin section only. The propulsion section, which these vehicles had been built to test, worked perfectly.

The impact times for these flights were considered more accurate than usual because they were reported via radio by a down range sacrificial observer (Frank Miuccio). From the description of the impact coming over the radio, there was little doubt in Frank's mind that the first rocket had hit ground, although the report was a partially garbled as Frank tried to transmit and dive under his car at the same time. Frank's wife, Susan, and Don Girard were with him down range and were also slightly startled by the proximity of the impacts. At one point, I believe, there was even a three way scramble to see who could get under the car first until Don noted that the car was probably not stout enough to stop the rocket anyway.

The fifth flight was of the UCLA group rocket called BERT (Basic Electronics Test Rocket). Designed around commercially available high power rocket air frame and propulsion

One of the composite rockets leaves the rack at high speed on its way to 18,000+ feet

HRL-25 HYPERGOLIC
LIQUID ROCKET

ROCKET WEIGHT:	3.1 LBM (FUELED)
LENGTH:	44 INCHES
DIAMETER:	1.5 INCHES
THRUST:	25 POUNDS
CHAMBER PRESSURE:	400 PSIA
OXIDIZER:	NITRIC ACID
FUEL:	FURFURAL ALCOHOL
ISP:	180 SECONDS
BURN DURATION:	≅ 4 SECONDS

LAUNCHED IN OCTOBER 1994,
ROCKET FLEW TO 8500 FEET

Designed and Built by

Tom Mueller
Reaction Research Society

Specifics about Tom Mueller's HLR-25 Rocket

components, the vehicle carried a 10 MHz Intel 80C196KB I/O processor and 24 photoelectric sun sensors. A more complete description of this rocket and payload will be the subject of an upcoming article in the RRS News (if I can beat Doug Caldwell into writing it). The rocket took off very slowly and then gradually built up to the breakneck speed of about 30 miles per hour. At peak, which was clearly visible from the bunkers since the rocket only flew up to several hundred feet, there was a conspicuous lack of parachute function. The rocket augured in a few hundred feet from the launch tower and was severely altered in its physical appearance by the experience. The electronics survived fairly well and some data was recovered from the flight. But this was not the end of BERT.

In an amazing feat of ingenuity and "McGyver-esk" on the spot engineering and overhaul, the UCLA gang hacksawed off various damaged and unnecessary rocket appendages and rebuilt a smaller, sleeker, and much higher performing rocket out of the original. Much like the mythological Phoenix, this rocket rose out of the ashes to fly again (and to a much higher altitude) later in the day.

The sixth flight of the day was Tom Mueller's "micro rocket". Designated the HLR-25 (Hypergolic Liquid Rocket), it produced 25 pounds of thrust burning 98% nitric acid and furfuryl alcohol. An engineering marvel for its excellent design and beautifully made miniaturized components, the rocket was 44 inches long, 1.5 inches in diameter and weighed 3.1 pounds fully loaded with propellants. Prior to the launch of the UCLA rocket, the HLR was charged with nitrogen to 1000 psi and the fuel tank was filled with 85 cc of furfuryl alcohol. The rocket was installed in a short rack constructed from EMT tubing just for this vehicle. When the time came to launch, the rocket and rack were carried out to the launch area and set at an 85 degree launch angle. As a final preparation, 125 cc of nitric acid was loaded into the rocket and the squib valve leads were connected.

The rocket left the rack with a rude sound that was uncharacteristically loud for such a small vehicle. One spectator in the bunkers described the sound as "flatulence". The rocket burned for about 4 seconds, but was difficult to follow due to its high acceleration , small size, and speed. Impact was recorded 49 seconds later, and the rocket was found 1500 feet down range not too far off the road. The peak altitude calculated from impact time was 8,500 feet, significantly less than the 10,000 feet predicted. Some propellant was still in the tanks after the rocket landed leading to the conclusion that the rocket spun up during the flight centrifuging the propellant to the sides of the tanks and starving the engine of the full propellant load. In a rocket this size every drop counts! The flight was a complete success and was the third liquid rocket launch from the MTA. The rocket was recovered and was undamaged from aft of the fire valve. A more detailed account of this test will be provided by Tom in the next newsletter.

The seventh flight of the day was Keith Batt's standard zinc/sulfur Beta. The flight was excellent, but the rocket had the dubious honor of being the only one not recovered. Several

Tom Mueller and the HLR-25. This photo gives a good indication of the small scale of this rocket.

people helped Keith scour the desert for it without luck. As these things usually do, it will probably turn up the next time there is a crowd of searchers looking for someone else's rocket. Flights eight through eleven were conducted with black powder Congreve type rockets built by Pat Mullens and Steve Majdali. Constructed of heavy cardboard tubing with rammed clay nozzles and a pressed hand mixed black powder propellant charge, the rockets put out about 100 pounds of thrust for 3 seconds. Stabilized in flight with an 8 foot long wooden stick tail, they were fired from a pipe launcher. Of the four rockets flown, three exploded in the air and one flew well. While not demonstrating a sterling reliability record, they provided great entertainment for the crowd in the bunkers.

Flight twelve was Bill Colburn's zinc/sulfur rocket. The flight was good but the nozzle was ejected during the burn. The rocket was recovered.

Tests 13, 14, 15, and 16 were static tests of small hybrid motors producing 25 pounds of thrust for 2 seconds on nitrous oxide and acrylic. All four tests were conducted with very similar hardware; two by Keith Batt and two by Bill Colburn. Keith was also testing a pyrotechnically actuated burst diaphragm assembly which did not function as designed. During one of Bill's tests, the engine broke loose from its improvised mount to give us in the blockhouse a moment of excitement as it flew around on the end of the line connecting it to the nitrous bottle. Some new rules were established on the spot for acceptable types of engine mounts - even for the static testing of very small 25 pound thrust motors.

Close-up of the HLR-25

The four recovered composite rockets and the HLR-125 post-flight.

Test seventeen was the reflight of the modified BERT rocket. Much shorter now, equiped with a bigger engine, and devoid of all that weighty electronics, the rocket flew at much higher speeds and to several thousand feet. The nose separated sometime after peak, but there was no parachute in the rocket on this flight. Nonetheless, the fuselage was so short and squat without the nose that it tumbled very slowly to the ground and sustained no damage on landing. As a matter of fact, the only damage resulting from the landing was to Tom Mueller's truck. The nose fell out of the sky like a rock and dropped right into Tom's truck bed denting the wheel well. Some of the UCLA group were later observed painting a small silhouette of Tom's truck on the door panels of their own vehicles.

Test eighteen was the first of two 4.5 inch diameter composite motors built by Korey Kline. This one was a "D" grain configuration designed to put out 100 pounds of thrust for 15 seconds. Ignition was smooth, but after a few seconds the wall of the aluminum motor case melted through destroying the test article. The second motor (test 19) was of the same size but with a circular grain port. This one burned well for the planned duration without mishap.

Tests twenty and twenty one were two more black powder Congreve rockets that had been assembled, between other tests during the day, by Pat and Steve. Carefully incorporating the lessons learned from the previous four rockets, these two faired much better climbing as much as another 100 feet in altitude before detonating. As before, they were great entertainment for the crowd.

The last three flights of the day (tests 22, 23, & 24) were the very well done WISP rockets built by Matt Bell. All three flew well and were recovered. Fired just before sun down, these little rockets were very impressive leaping out of the small launch rack built just for this purpose.

In all from Friday night to Saturday at sundown, there had been 18 flight tests and 7 static test. The flights had included liquid propellants, composite solids, and zinc/sulfur rockets. Static testing had included hybrids and composite solids. A tremendous amount of work had gone into the event itself as well as into the designing and construction of all the hardware tested. The only thing lacking from this firing is the completion of the documentation. All those who participated are urged, for the benefit of all the members of the Society, to complete, as a bare minimum, the standard record forms submitted before the firing. More complete information, in the form of articles for the RRS News would be greatly appreciated by the membership.

It takes the effort of many people to set up for and conduct a successful firing; from hauling equipment, setting up generators, mixing propellant, completing the required paperwork to the fire marshal and FAA, to picking up trash and digging trenches. Many members who did not even have rockets to test pitched in their time

REACTION RESEARCH SOCIETY

Facility Upgrade Plans

by
David E. Crisalli

The Reaction Research Society has, for many years, conducted prolific and sophisticated amateur experimental rocket testing at its 40 acre Mojave Test Area. The property was originally purchased in 1955 and has been in continuous use ever since. In recent years, however, the Society has undertaken more and more technically oriented projects in both the solid and liquid propellant propulsion areas while maintaining the capacity to support traditional micrograin rocket flight and static testing. New composite solid propellant motors and liquid engines producing up to 15,000 pounds of thrust have already been built. At the same time, the membership numbers have been growing steadily with more and more people attending each firing event.

As a consequence, several members of the Society have been formulating plans to upgrade existing facilities and build new ones to support this ongoing work and to make the Mojave Test Area one of the most advanced amateur rocket test facilities in the world.

To be specific about these proposed improvements, the following list of the major items is submitted. Some of these tasks may be accomplished by RRS members alone. Others may involve having the work done by contractors. Obviously, the contract work would be much more expensive, but can be accomplished in a much shorter time frame. However, if the Society cannot raise the required funds to have major work done by contractors, we should be prepared to do the construction ourselves as time and funding permit.

1. <u>New Underground Blockhouse:</u> The growing sophistication and size of both the solid and liquid engines being built and tested (up to 15,000 pounds of thrust) require new and stronger blockhouse protection for the test crew and observers. Designs and engineered architectural drawings have been completed. The new blockhouse is almost four times the size of the older one being used now. Instead of being entirely above ground, this structure is to be constructed almost five feet below ground level. Built of concrete block and cast concrete, it has a 10 x 10 control room, a 10 x 10 data collection room, and a 10 x 20 observation room. It will be located at the test site in an area to the south of the old compound fence line selected so that it can be used for all the existing flight towers and test stands including the new 10,000 pound thrust test structure. Bids are being solicited now from local contractors, but have not yet been returned. The enclosed drawings show some of the details of the new blockhouse design.

2. <u>New Observation Bunkers:</u> The old bunkers still in use today at the MTA were built over 30 years ago from donated telephone poles and railroad ties. Refurbished many times over the years, the bunkers have been repeatedly vandalized and the materials carted off. As a consequence, the usable portion of the bunkers has grown shorter and shorter as the damaged sections were cannibalized to keep the remaining part in usable repair. At the same time, the Society has been growing steadily with more and more members attending hot fire events. A new design and architectural drawings have been completed for cast concrete and block replacement bunkers. The design divides the bunker into 20 foot long segments which can be built end to end. The goal is to build at least five of these units for 100 feet of new bunker and, possibly to build one or two more at the excavation started north of the compound. As with the blockhouse, the drawings are now out for bids. Some of the details are shown in the attached drawings.

3. <u>New Assembly and Processing Building:</u> For over 40 years, the only building of any size at the MTA has been the World War II surplus Quonset hut set up in the south east corner of the compound area. A favorite target for recreational shooters over the years, the Quonset hut has been repaired with wads of

chewing gum so many times it is now constructed mostly of "Juicy Fruit". At night, when illuminated internally with a Coleman lantern and viewed from outside, it closely resembles an inverted sieve. This is also distinctly apparent to any occupants of the structure during the occasional rain shower in the desert. It is still used extensively for sleeping quarters, a field kitchen, and rocket assembly. This worked well enough when only a few people attended any given firing, but it is now becoming exceedingly difficult to conduct both living, cooking, gear stowage, and rocket assembly activities out of this small structure.

Almost two years ago, the RRS acquired and transported the structural steel to erect a new 20 x 40 foot building. Footings have been dug in the north east corner of the compound in preparation for pouring the foundation and slab. The RRS intends to complete the concrete work and assemble the steel itself. If funds are available, it may contract for the concrete block walls to be built in an effort to expedite construction. This building will vastly improve the on site capability for test skid and flight vehicle final assembly and check out, and will be greatly appreciated by those who live at the MTA during firing events.

4. New Vertical Test Stand: In 1990 several RRS members began extensive work in the field of liquid propulsion. In support of these activities, they constructed a simple static test structure out of industrial steel shelving and anchored it on the concrete pad of the old "I" beam static test stand. It was very inexpensive to build and has been used successfully many dozen times over the last few years for engines up to the 2,000 pound thrust class. However, it can only provide for either horizontal testing (not particularly desirable for liquid engines) or firing at a 30 degree down angle from the horizontal. The latter, while better from an operational standpoint for liquid motors, allows the engines to generate huge clouds of dust while the test is in progress. This often completely obscures the view from both the blockhouse and observation bunkers. The current plan is to relocate this stand to an area in the compound where the view from the new blockhouse would be better, and modify the structure to allow vertical down testing of solid or liquid engines up to 5,000 pounds of thrust. The design would also allow the static testing of completely assembled flight vehicles in preparation for flight test. This would involve increasing the height of the structure, putting in a new concrete pad, and building a below grade fire brick lined flame bucket to direct the exhaust away from the stand. This construction would be conducted entirely by RRS personnel and a diagram of the structure is included here.

5. New High Thrust Test Pad Extension: The 10k pad poured over a year ago was only part of the required test structure for the recently completed 10,000 pound thrust liquid engine. An extension pad 12 feet by 20 feet is required to support the propellant tankage skid. This effort would be completed with RRS labor.

6. Old Static Test Stand Repair: The old "I" beam static test structure is very useful for vertical up solid motor testing and where a versatile structure may be required. However, the concrete slab around this structure has been severely heat damaged and cracked over the years. The current plan is to pour a new larger slab around this structure. This task will again be accomplished with RRS labor.

7. New 35 Foot Launch Tower and Pad: In the fall of 1991, Mark Grant successfully launched the first bipropellant amateur liquid rocket launched in the state of California. As part of his project, he built a 35 foot tall launch tower designed to be attached to the industrial shelving static test stand. After the flight, the tower was lowered to allow the static test stand to be used for other projects. The tower could be used for a variety of other launches if it were permanently erected on a dedicated pad. Plans have been drawn up to pour a 12 x 20 foot launch pad west of the old "I" beam static test stand and outside the old compound fence line. The tower will be refurbished, fitted with some additional support structure, and permanently erected. It will be used for larger vehicles that cannot be launched from the existing 12 foot adjustable towers. This task will be completed with RRS labor.

8. New Fueling and Assembly Area: In the fueling area of the compound there is a tamping pit for loading zinc / sulfur rockets, two small barricades and an exposed work bench. The size and complexity of the rockets currently being built and flown have outgrown this simple facility. An improved fueling area, to more adequately support composite propellant work, will be built having four bays constructed of block and cast concrete on a 20 x 20 foot pad. The bays will be provided with

permanently installed, grounded metal work benches and will have provisions for either an open shed roof or, at least, provisions for a tarp awning to provide shade. This task will be completed by RRS labor.

9. Miscellaneous: Several miscellaneous items will also be included as part of the general facility improvements. These will include;

- New chain link compound fencing
- Four 30 foot light poles
- Several cast concrete benches located in the compound area
- A generator pad and bay behind the new building
- Installed underground 115 VAC and communications wiring
- Storage shed installation (on site)
- Storage shed installation (off site)
- RRS monument
- Flag pole
- Complete slab next to Quonset hut
- New and improved outhouse

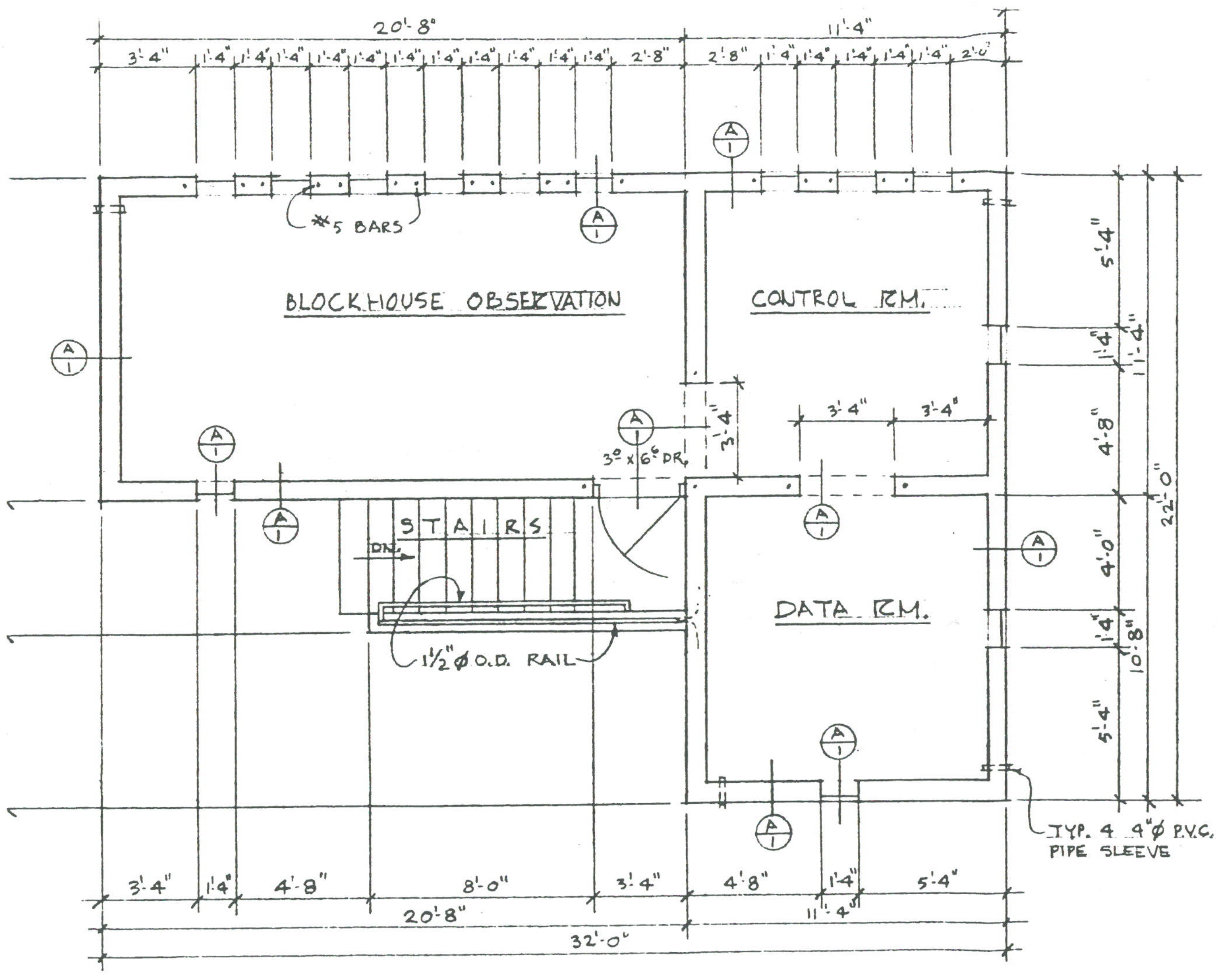
This is a very aggressive list of improvements requiring a considerable amount of money, time, and effort. Nonetheless, it has been determined by the executive council that the Society prioritize these tasks and begin to complete them as funds and labor become available. As a start, $3000 has been authorized to be expended to complete some of the preliminary concrete work required. This will be accomplished during a work party tentatively scheduled for March. The tasks selected for this first effort of 1995 will be of benefit to as many interest areas of the Society as possible. They include;

- Old static test stand slab repair
- New solid propellant mixing and handling bay slab
- New 35 foot launch tower pad
- High thrust (10k) test pad extension slab
- New cast concrete RRS entry sign

In addition, several concrete benches and the pad next to the Quonset hut will be finished.

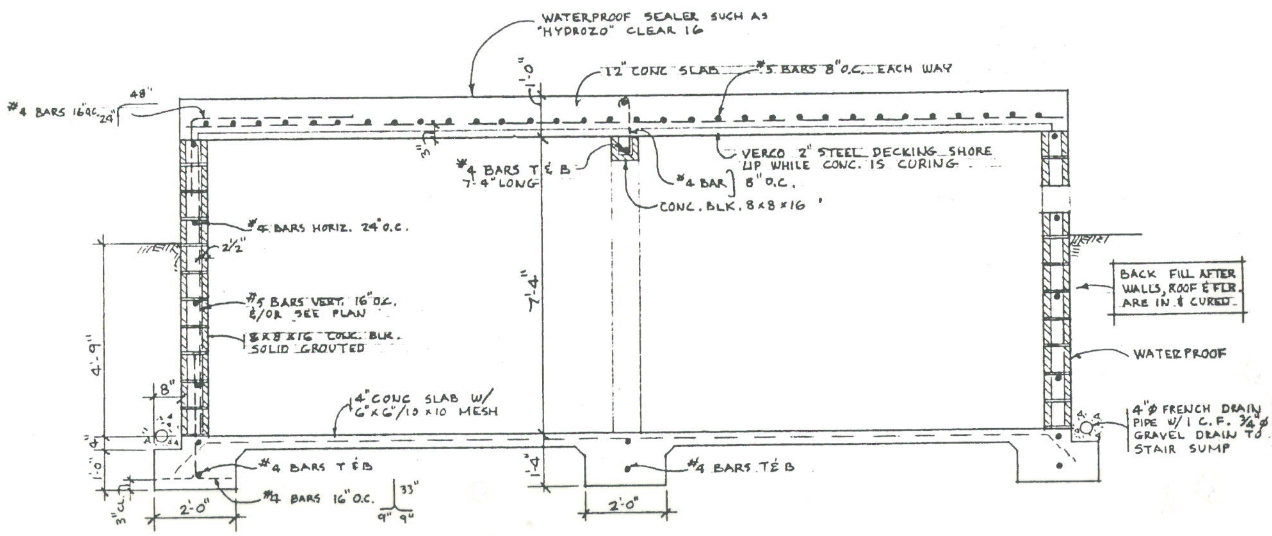
Although we are now, and have been, operating under very primitive conditions over the years, the Society has accomplished some very sophisticated work. Even small and incremental improvements to the test facilities will enhance our efforts and will allow the Society to provide a safe testing area and expanded opportunities to a growing membership of amateur rocket designers.

NEW BLOCKHOUSE FLOOR PLAN

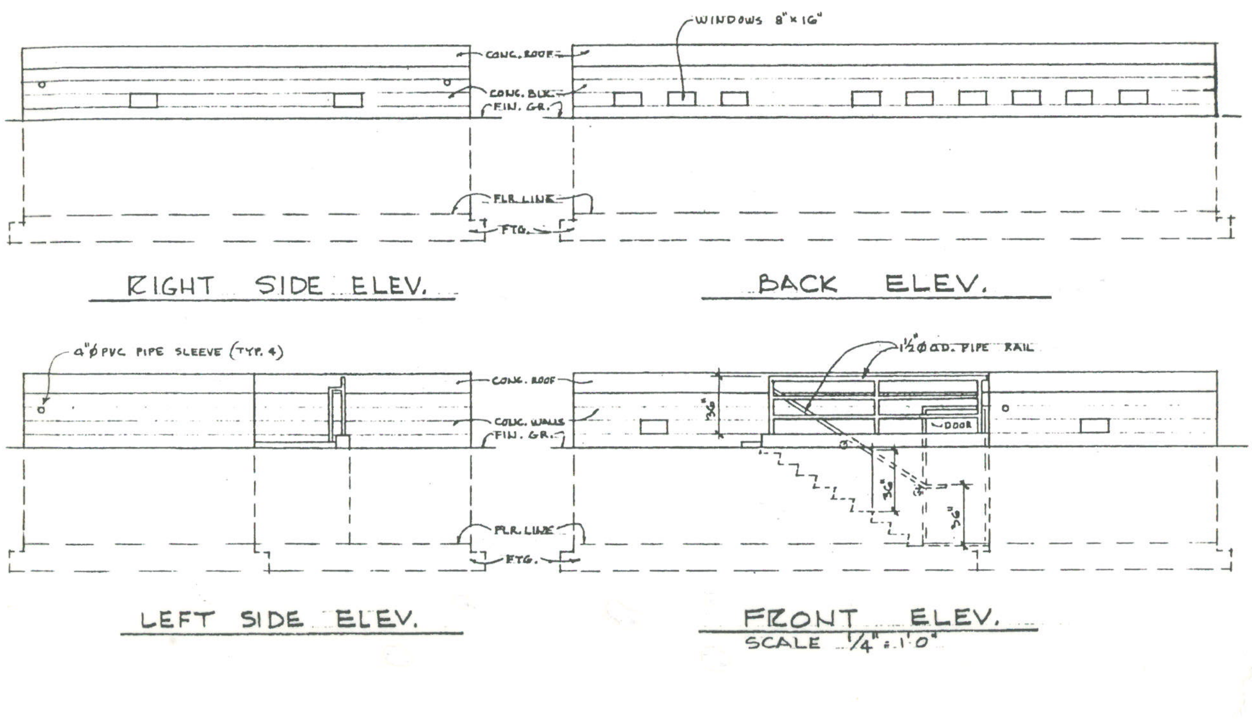


FLOOR PLAN
SCALE 1/4" = 1'-0"

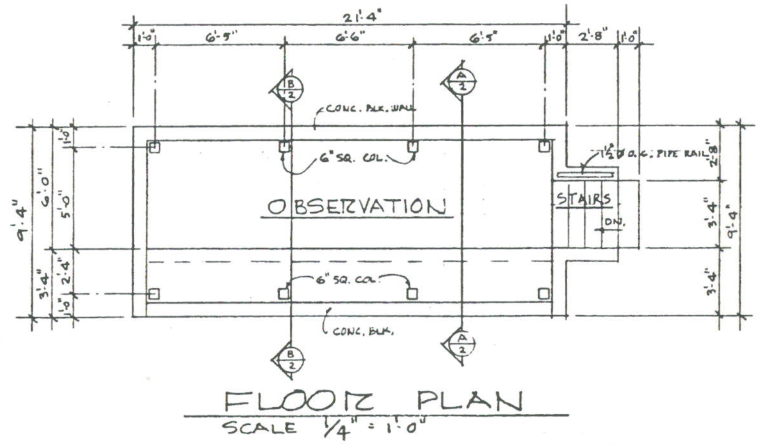
NEW BLOCKHOUSE CROSS SECTION



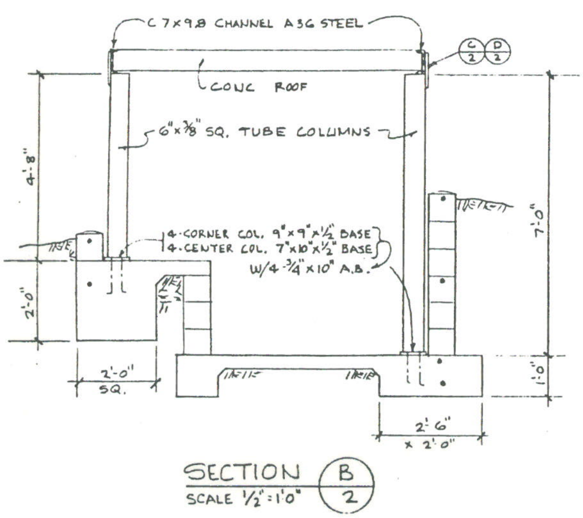
NEW BLOCKHOUSE ELEVATIONS

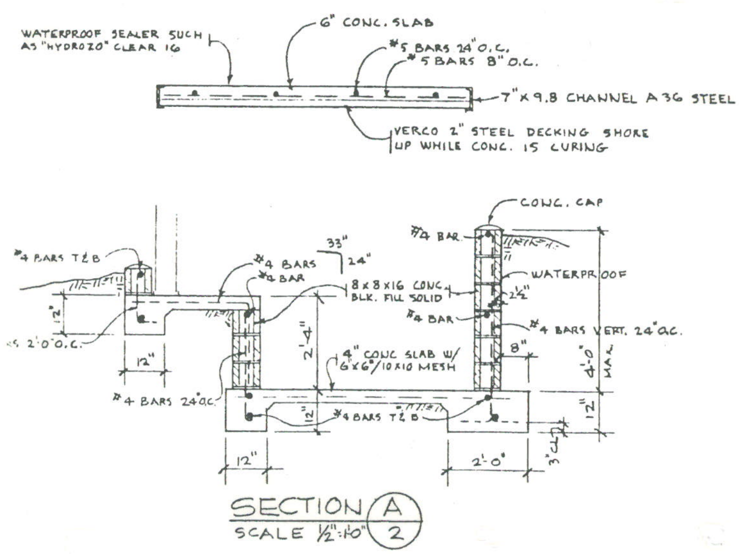


NEW OBSERVATION BUNKER
FLOOR PLAN



NEW OBSERVATION BUNKER
CROSS SECTION





Liquid Rocket Components: Pyrotechnic Valves

by
Tom Mueller

For an amateur rocketeer seeking to build a liquid rocket, one of the most difficult components to obtain or build are remotely operated valves. A liquid rocket will require at least one valve to start the flow of propellants to the combustion chamber. In the two small liquid rockets I have flown in the last year or so, both used a pyrotechnic fire valve located between the pressurant tank and the propellant tanks. The propellants were held in the tanks by burst disks (or equivalent) in the propellant run lines. When the fire valve was actuated, the sudden pressure rise in the propellant tanks blew the burst disks, allowing propellant to flow to the injector. This method of controlling the flow to the rocket allows the use of only one valve, and eliminates liquid valves. In the case of the first rocket, the XLR-50 which flew in October 1993, elimination of the liquid valve was important because the oxidizer was liquid oxygen, and a small cryogenic compatible valve is very difficult to construct. For the second rocket, which flew in October 1994, the small size prevented the use of liquid valves. In fact, the single pyro valve I used was barely able to fit in the 1.5 inch rocket diameter. In this article I will describe the design of the valves that were used on these two vehicles, and variations of them that have been used in other rocket applications.

Figure 1 shows the fire valve I used in the XLR-50 rocket. This valve supplied helium to the propellant tanks, with an initial helium tank pressure of 800 psia. The design consists of an aluminum piston with three O-rings used to seal between ports. In the pre-fire position, as shown in Figure 1a, two of the O-rings seal the inlet, while both tanks are vented to atmosphere. To actuate the fire valve, a black powder charge is ignited by application of 12 volts to a thin nichrome wire in contact with the charge. The rapid expansion of the gases from the charge push the piston over against a stop, as shown in Figure 1b. In this position, the helium tank is now connected to both propellant tanks, allowing them to quickly pressurize. The tank vents are closed, with the fuel tank vent

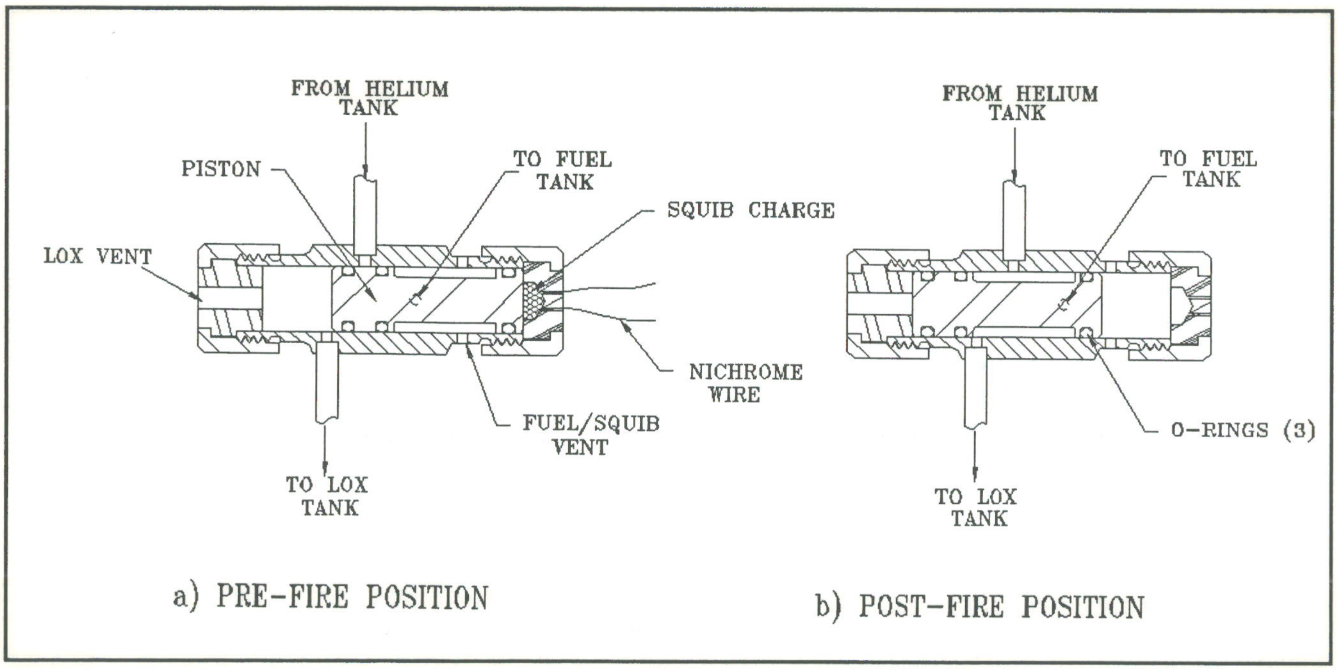


Figure 1 - XLR-50 Rocket Helium Fire Valve

now allowing the excess squib charge gases to vent.

The valve shown in Figure 1 consisted of a stainless steel body with a 0.375 inch diameter piston. The O-rings were viton and the squib charge was contained in a Delrin plastic cap. The Delrin was used to prevent shorting of the nichrome wire, and also to provide a frangible fuse in case the squib charge proved to be a little too energetic. In practice I've never had the Delrin cap fracture. The inlet and outlet lines to the tanks were silver brazed to the valve body. The valve was tested many times at inlet pressures of up to 1000 psi without any problems, other than the O-rings would need replaced after several firings due to minor nicks from the ports. To help alleviate this problem, the edges of the ports were rounded to help prevent the O-ring from getting pinched as the piston translates. This was accomplished using a small strip of emery cloth that was secured in a loop in one end of a short length of 0.020 stainless wire. The other end of the wire was clamped in a pin vise which in turn was chucked in a hand drill. As the wire was rotated by the drill, the emery was pulled snugly into the port, where it deformed into the shape of the inlet, and rounded the sharp edge. I used WD-40 as a lubricant for this operation, allowing the emery to wear out until it would finally pull through the port. I repeated this process a few times for each port until the piston would slide through the bore without the O-rings snagging the ports. Another requirement is to lubricate the O-rings with a little Krytox grease. This helps the piston move freely and greatly reduces the problem of nicked O-rings.

The pyro valve I used in the 25 lbf thrust micro rocket that was launched in October of 1994 is shown in Figure 2. This valve was identical in operation to the XLR-50 valve, with the major difference being its integration into the vehicle body. The valve body was a 1.5 inch diameter aluminum bulkhead that separated the nitrogen pressurant tank and the oxidizer tank. Because of the very small diameter of the rocket, the clearances between ports and O-rings were minimized, just allowing the valve to fit. The fuel outlet port was located at the vehicle center, providing pressure to the fuel tank by the central stand pipe that passed axially down the oxidizer tank. The piston stop was a piece of heat treated alloy steel that was attached to the valve body by a screw. This stop was originally aluminum, but was bent by the impact of the piston in initial tests of the valve. The black powder charge in the Delrin cap was reduced and the black powder was changed from FFFg to a courser FFg powder, but the problem persisted. The stop was re-made from oil hardening steel and the problem was solved. In this application, the port diameters were only 1/16 inch so only a small amount of rounding was required to prevent the O-rings from getting pinched in the ports. The valve operated with a nitrogen lock-up pressure of 1000 psi.

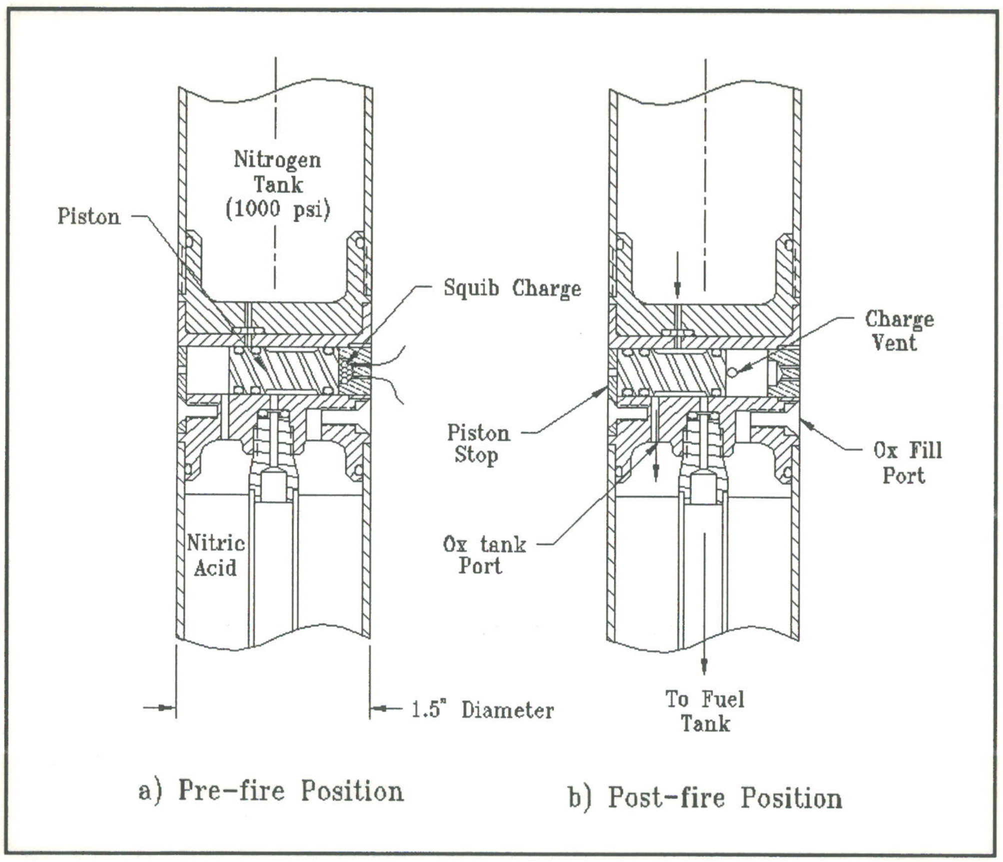


Figure 2 - Fire Valve For Micro Rocket

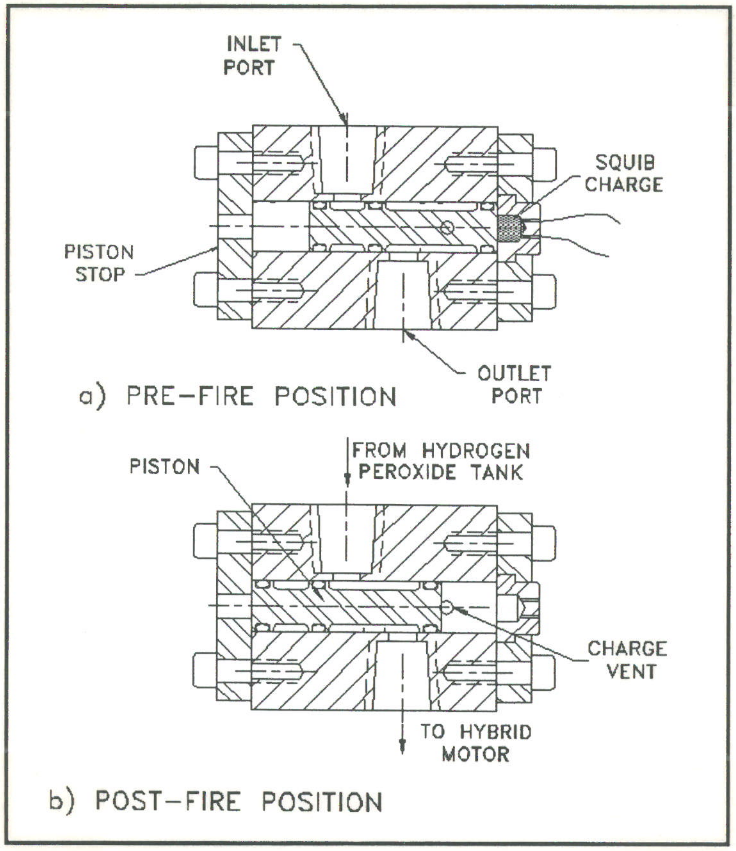


Figure 3 - Fire Valve for Mark Ventura's Hydrogen Peroxide Hybrid Rocket

A more challenging application of the same basic valve design was used for the fire valve of Mark Ventura's peroxide hybrid, as shown in Figure 3. This was the first application of this valve where liquid was the fluid being controlled, rather than gas. In this case the liquid was 85% hydrogen peroxide. The second difficulty was the fact that the ports were required to be 0.20 inch in diameter in order to handle the required flow rate. The valve was somewhat simpler than the previous valves in that only a single inlet and outlet were required. The valve body was made from a piece of 1.5 inch diameter 6061 aluminum, in which a 1/2 inch piston bore was drilled. The piston was also 6061 with viton O-rings, which are peroxide compatible. The ports were 1/4 inch pipe threads tapped into the aluminum body. The excess material on the sides of the valve was milled off, so that the valve was only about 3/4 of an inch thick, and weighed only 4 ounces. Even though the piston size was 1/2 inch, the same charge volume used in the 3/8 inch valves was sufficient to actuate the piston.

In testing the valve with water at a lock-up pressure of 800 psi, I was pleased to find that even with the large ports, O-ring pinching was not a problem. One saving factor was that the larger size of the ports made it easier to round the entrances on the bore side. The valve was tested with water several times successfully before giving it to Mark for the static test of his hybrid.

The only problem that occurred during the static test of hybrid rocket was that the leads to the nichrome wire kept shorting against the valve body, Three attempts were made before the squib was finally ignited and the engine ran beautifully. I have since been able to solve this problem by soldering insulated 32 gauge copper wire to the nichrome wire leads inside the Delrin cap. In this way I can provide long leads to the valve with reliable ignition.

My next liquid rocket is a 650 lbf design that burns LOX and propane at 500 psia. This engine uses a Condor ablative chamber obtained from a surplus yard. For this reason I call it the Condor rocket. This rocket uses a scuba tank with 3000 psi helium for the pressurant. I decided to build a high pressure version of my valve as the helium isolation valve for this rocket. When firing this rocket, just prior to the 10 second count, this valve will be fired, pressurizing the propellant tanks to 600 psi. I assumed going in to this design that the O-rings slipping past a port simply wasn't going to work at 3000 psi. At these pressures, the O-ring would extrude into the port. In order to get around this problem I came up with the design shown in Figure 4. For this valve, the O-ring groves were moved from the piston to the cylinder bore of the valve body, so the O-rings do not move relative to the ports. The piston is made from stainless steel with a smooth surface finish and generous radii on all of the corners. The clearance between the piston and the bore was kept very small to prevent extrusion of the O-rings. The valve operation is similar to the one shown in Figure 3, and the valve body is made in the same way except female AN ports were used rather than NPT ports. When the valve is fired, the piston travels from the position shown in Figure 4a to that shown in 4b. During this travel, the inlet pressure on the second O-ring will cause it to "blow out" as the

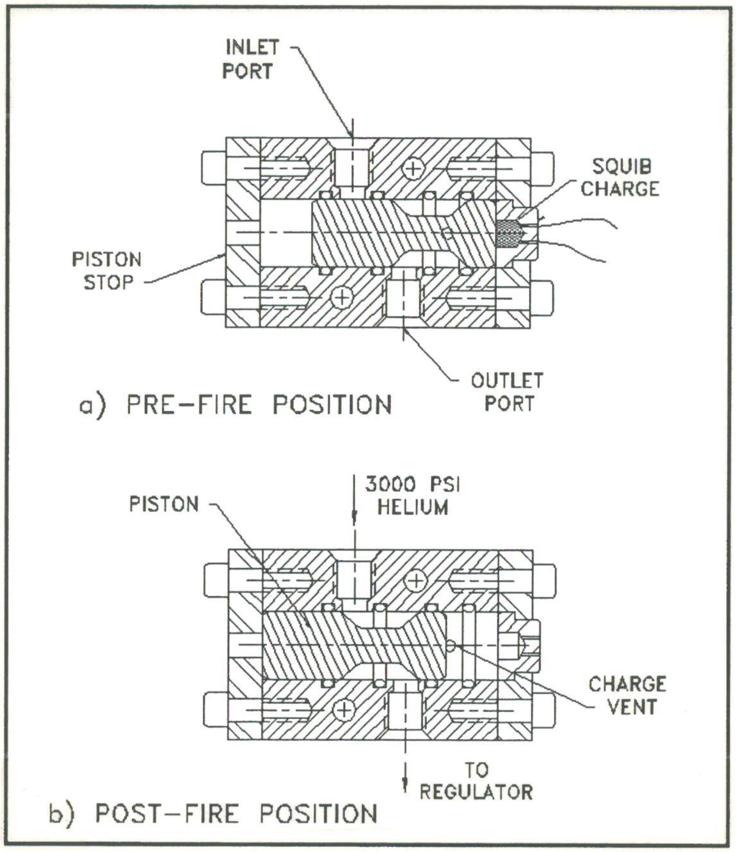


Figure 4 - High Pressure Helium Fire Valve for Condor Liquid Rocket

piston major diameter translates past the O-ring groove. The O-ring is retained around the piston, causing no obstruction or other problems. This valve has been tested at 2400 psi inlet pressure with helium and works fine. It will be tested at 3000 psi prior to the first hot fire tests of the condor rocket next spring.

As a side note, essentially an identical valve design as the one used on the Condor and Mark's valve is shown in NASA SP-8080, "Liquid Rocket Pressure Regulators, Relief Valves, Check Valves, Burst Disks and Explosive Valves".

A second pyro valve is used on the condor system as shown in Figure 5. This valve is used to vent the LOX tank in the event of a failure to open the fire valve to the engine. When the propellant tanks are pressurized by the helium pyro valve, the LOX tank auto vent valve (shown in Figure 6) closes. If the engine is not fired after a reasonable amount of time, the LOX will warm up, building pressure until something gives (probably the LOX tank). The pyro valve shown in Figure 5 is used as the emergency tank vent if the engine cannot be fired. The valve body is stainless steel with a stainless tube stub welded on for connection to the LOX tank. This valve has been tested to 800 psi with helium and works fine. In this case, some "nicking" of the O-rings can be tolerated because the O-rings are not required to seal after the valve is fired. The ports in the bore are still rounded, however, to prevent the O-rings from getting nicked or pinched during assembly of the valve.

Even though it is not a pyro valve, I have shown the LOX auto-vent valve in Figure 6 because this design has proven to be very useful for venting cryogenic propellant tanks without requiring a separately actuated valve or control circuit. The valve uses a Teflon slider that is kept in the vent position as shown in Figure 6a. This allows the tank to vent to the atmosphere, keeping the propellant at its

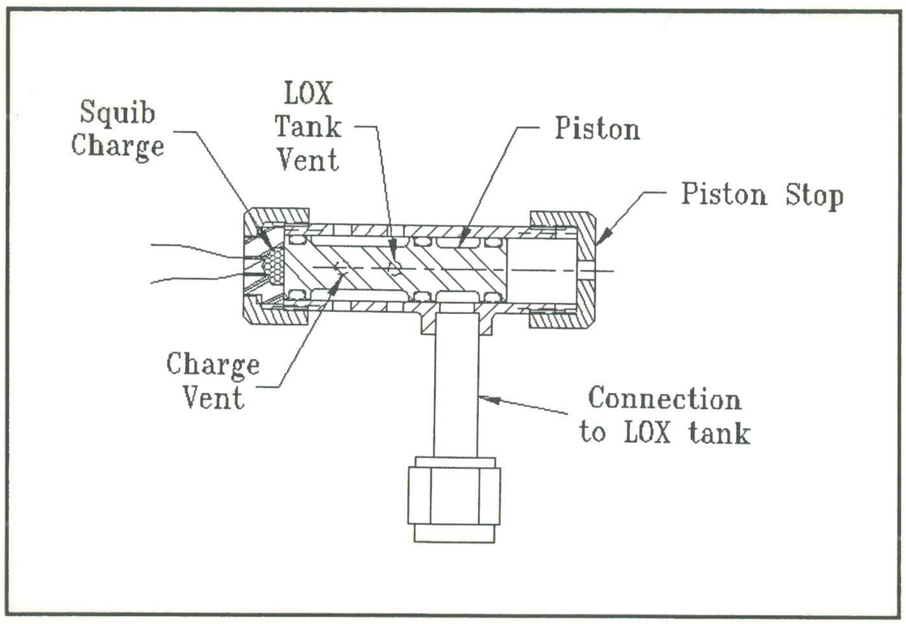


Figure 5 - LOX Tank Emergency Vent for the Condor Rocket

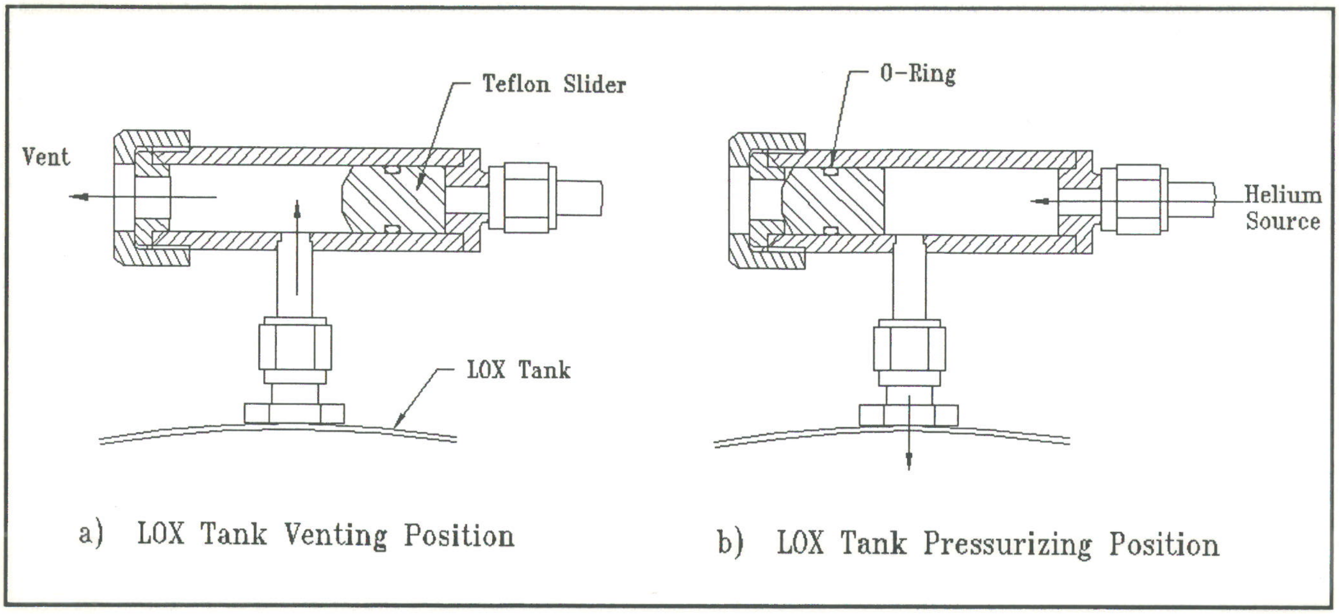


Figure 6 - Automatic LOX Tank Vent Valve

normal boiling point. When the helium system is activated, the pressurant pushes the slider closed against the vent port, sealing off the LOX tank, as shown in Figure 6b. An O-ring is used around the slider to give it a friction fit so the aspiration of the LOX tank does not "suck" the slider to the closed position. This problem happened to David Crisalli when he scaled this design up for use on his 1000 lbf rocket system. I have used this design on the LOX tank of my XLR-50 rocket, which used a 1/4 inch diameter slider, and on the condor LOX tank, which uses a 1/2 inch slider. In both cases the vent valve worked perfectly.

The main fire valve on the Condor rocket is a pair of ball valves that are chained together to a single lever so that both the fuel and oxidizer can be actuated simultaneously for smooth engine startup. For static testing of the rocket I will use a double acting air cylinder to actuate the valves. For flight, however, I plan to use a pin that is removed by an explosive squib to hold the valve in the closed position. When the squib is ignited, the pin is pulled by the action of the charge on a piston, allowing the valves to be pulled to the open position by a spring. This method may not be very elegant, but it is simple, light, and packages well on the vehicle. David Crisalli has successfully employed this technique on his large rocket.

That covers the extent of the pyro valves I have built or plan to build so far. In the next newsletter I will present the design and flight of the small hypergolic propellant rocket that used the valve shown in Figure 2.

Bits and Pieces

Back Issues of High Power Rocketry: Articles about the RRS, experimental Rocketry, and what goes on at the MTA are still being published in *High Power Rocketry* magazine. The editor, Mr. Bruce Kelly, is interested in all aspects of the rocketry field and has done us a great service by providing a forum for reporting activities in the experimental amateur rocket arena. Articles submitted to him about the RRS and our work have been published in full color in several recent issues. Back issues circled here contain articles about RRS activities and can be ordered per the instructions on the enclosed ad. Although geared specifically toward the high power model builders, the magazine contains much information of interest and utility to RRS members. "How to" instructions for composite material construction, flight instrumentation, electronic components and equipment, recovery system designs, and active guidance information are just a few of the areas covered. You do not have to be a Tripoli member to subscribe to the magazine, and I would enthusiastically recommend a subscription to anyone interested in any type of rocketry. The current subscription rate, I believe, is still $25 per year and arrangements can be made through Mr. Kelly.

Membership Forms: Several people have recently asked for copies of the RRS membership form to hand off to others interested in joining the Society. A copy has been included in this issue to help speed up the process of signing up new members. Photo copies can be

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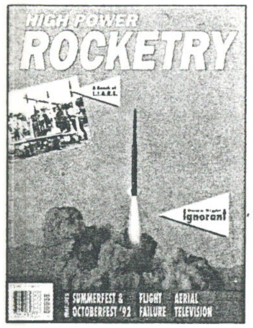


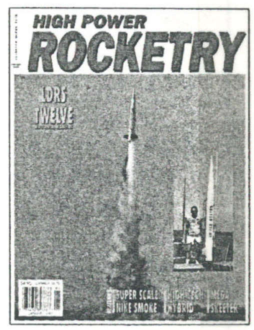
JAN/FEB 1993

MAR/APR 1993

MAY/JUN 1993

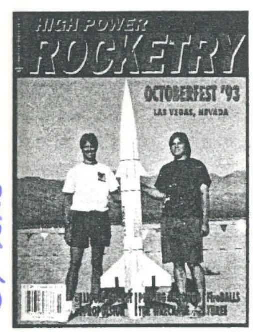
JUL/AUG 1993

SEP/OCT 1993



NOV/DEC 1993

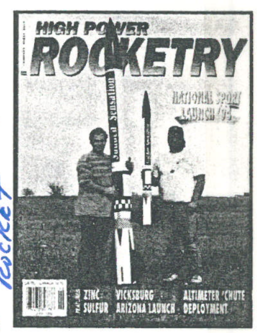
LIQUID ROCKET WORK BY RRS



FEBRUARY 1994

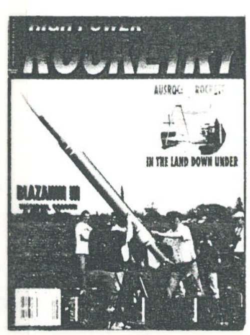
APRIL 1994

LARGE ZINC/SULFUR ROCKET



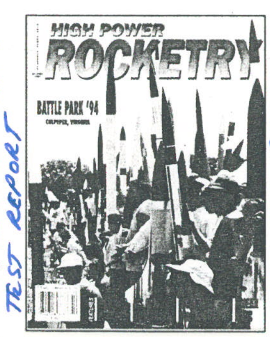
JUNE 1994

1950 HYDROGEN PEROXIDE ROCKET



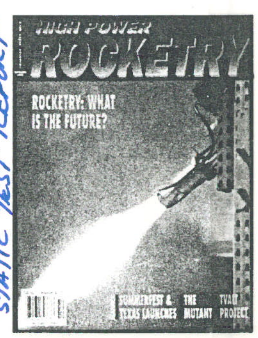
AUGUST 1994

LOX/ALCOHOL STATIC TEST REPORT



OCTOBER 1994

APRIL 94 RRS STATIC TEST REPORT



DECEMBER 1994

REACTION RESEARCH SOCIETY

P.O. BOX 90306 WORLD WAY POSTAL CENTER
LOS ANGELES, CALIFORNIA 90009

MEMBERSHIP APPLICATION

Corresponding Membership is for those interested individuals who live outside the immediate area and/or cannot attend meetings and firings. Corresponding members receive the Newsletter and have all privileges of Associate members except firing privileges (unless he/she is sponsored by a Honorary/Administrative/Associate member). $20.00 annual dues

Associate Members are "active" members who have all the privileges of Administrative members except that of serving as a project or testing chief or in any other manner being in charge of a Society's technical or scientific research activity. They are not eligible to vote at meetings of the membership or for officers of the Society or hold office themselves. Associate membership is an initial active membership and can lead to an Administrative membership with approval of the Executive Council after certain Society requirements are met. $25.00 annual dues.

Trial Membership has all the privileges of Corresponding Membership for a duration of 30 days. Non-members attending launches are required to become Trial Members except for children. The nominal fee will be credited to a full membership if the individual upgrades within 30 days. $3.00

Type of Membership (Please check one)

Corresponding ___ Fill out complete form **Associate** ___ Fill out complete form **Trial** ___ Fill out Gray portion only

First Name	Middle Initial	Last Name
Street Address		
City	State	Zip Code
Home Phone	Occupation	
List of Special Skills		
Membership in Professional or Scientific Societies		
Phase of Rocketry Most Interested In		

Disclaimer: I, the undersigned, by my action in joining the Reaction Research Society, agree to indemnify and hold harmless the Reaction Research Society, its appointed pyrotechnic operators, each of its members, officers, and agents from and against all claims, damages, or injuries direct or consequential arising out of any participation in activities associated with rocket test operations. I understand the potential hazards involved with rocket launch and static test activities. I also recognize that violations or non-compliance with the directions (pertaining to safety) of the Pyrotechnic Operator in charge of any particular event, may result in suspension of my participation in firing events.

Signature Date

OFFICIAL USE ONLY

PAID **CARD SENT** **REC'D**

made from the original in this issue or the RRS secretary can be contacted if you prefer doing things the old fashion way.

Membership Roster: Just a reminder again - please check the information on the enclosed membership roster and verify it. If anything is incorrect or has changed, please contact Mr. George Dosa with any corrections by telephone or mail. He is on the list and we made sure his name, address, and phone number were OK.

RRS Symposium: The Society is planning to conduct another amateur experimental rocketry symposium in the fall (September). Frank Miuccio is heading up the organizational effort and he needs volunteers to help out in various areas. Please volunteer for something and contact Frank to let him know you are willing to help.

RRS News Articles: I'll make this short and sweet. **ALL MEMBERS ARE HIGHLY ENCOURAGED TO WRITE SOMETHING ABOUT WHAT THEY ARE DOING (ROCKET RELATED) AND SEND IT IN TO THE BELEAGURED ASSISTANT EDITOR. HELP.** Sincerely, D. Crisalli. P.S. - Send photos and drawings too.

Back Issues of the RRS News: For those members who may be interested, copies of the last three RRS Newsletter issues are now available for $5.00 each. This offer includes

• Volume 51, No. 3, July 1994 (LOX/alcohol rocket, venturi design part I, 30 April 94 firing report and color photos)

• Volume 51, No. 4, Oct. 1994 (10,000 lb thrust liquid engine, 1950 hydrogen peroxide rocket, zinc/sulfur performance, venturi design part II)

• Volume 52, No. 1, Feb. 1995 (this issue)

Contact D. Crisalli if you need back issues and make the check payable to the RRS.

Photo Contest: As it seems to be so difficult to get copies of any photographs people take out at firings (with some notable exceptions - thanks to those few of you who have sent things to me), I've decided to hold my own photo contest. Send in 4 x 5 copies of your best photographs of RRS activities by June 1995. Put your name and telephone number on the back as well as the date the photo was taken and what the subject is. (DO NOT STACK THE PHOTOS FRONT TO BACK AFTER WRITING ON THEM - I WILL GET GREAT PICTURES WITH YOUR NAME AND ADDRESS TRANSFERED BACKWARDS ON THE BEST LAUNCH PHOTO EVER TAKEN !!! Stack them front to front or back to back and make sure the darn ink is dry before you stack them at all.)

There is no limit to the number of entries you can send in and the photos can be new or old. So if you have some great shots from 20 years ago, send them along. I will do the judging in July. First prize is a year's paid membership. Second prize is five rolls of your favorite 35mm film. Third prize is some cheesy little gift I haven't thought up yet. The only person disqualified from participating is me. So send your entries to D. Crisalli, 3439 Hamlin Ave., Simi Valley, CA 93063.