RRS NEWS

FOR THE ADVANCEMENT OF
ROCKETRY AND ASTRONAUTICS

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THE REACTION RESEARCH SOCIETY

NEWS

A magazine of comment on the amateur field today.

RRS NEWS NO. 100 FALL, 1965

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MANAGING EDITOR
Don Girard

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FROM THE EDITOR

On November 22, Thomas G. Fisher retired from twenty-five years of active service as Special Enforcement Officer of California. He held a unique position, working directly under the State Fire Marshal, and in this capacity he served his community well.

Mr. Fisher has been of particular importance to the amateur rocket interests in California, as he was responsible not only for the enforcement of the laws regulating rocketry but was instrumental in creating them. His aid was invaluable, his advice inexhaustable, his guidance incalculable.

The Reaction Research Society has worked with Mr. Fisher through many years, and has always appreciated his efforts to distinguish the true amateur experimenter from the basement bomber.

The Society has found this to be true in the careful wording of the present legislation (note that the restrictions are aimed towards the safety of the experimenters and the public), in his assistance in breaking the insurance barrier (finally accomplished in 1963), and in his dealings with the California Committee on Educational Rocketry (CCER) (considered a villain by some, nonetheless he brought model rocketry into the state as a somewhat restricted enterprise, to protect the safety of the individual).

At his retirement dinner, a great number of people saluted the Special Enforcement Officer; he was honored by a message from Governor Pat Brown, by the presence of the State Fire Marshal Glenn Vance; he was awarded a scroll and medallions from the County Fire Department, from the Chinese community, and from the motion picture industry (in the form of a special Oscar).

We can add little to the praise already given to Mr. Fisher by his associates, superiors, and friends; but for what small amount of pleasure it might give him, we congratulate Thomas Fisher on his retirement and thank him for his friendship.

POST FIRING REPORT

AUGUST 15, 1965

By Maryann Butterfield,
Reaction Research Society

On August 15, 1965, the Reaction Research Society fired two experimental rockets at its Mojave Test Area. Weather conditions were ideal for the firing; the slight breeze blew high scattered clouds overhead which kept the temperature below 95°F. Because blistering temperatures were expected, however, only seven people were on hand to witness the firing, leaving our crew a little short handed. As one member said, "I've got a bit of a problem. I need a hand to run this mike, I need a hand to run the stopwatch, and I need a hand to run the camera. How 'bout that?"

The solid propellant star grain rocket was static fired at 8:45 Sunday morning. This rocket was 16 inches long with an outside diameter of four inches and a wall of 0.065 inches. It used potassium perchlorate as an oxidizer and polyester resin as fuel. The igniter was composed of ten grams of smokeless powder and two electric matches connected in parallel. The rocket was mounted in a vertical position with the nozzle directed upward.

Upon ignition, the rocket exploded. The explosion could have been caused by the igniter alone, or more likely, the igniter may have set up a shock wave which detonated a portion of the propellant grain. The force of the explosion was generally outward with very little upward force. The rocket tube was blasted into five pieces which ripped away from the nozzle by the tearing of the metal from around the nozzle mounting bolts. Only three of the eight Allen bolts used to mount the nozzle were sheared by the violent explosion.

The nozzle was blasted approximately 20 feet into the air. During the brief time the pieces were in motion, the largest fragment (about 15 inches by 5 inches) collided with a smaller fragment (about 10 inches by 5 inches) leaving in the smaller piece a 2-3/4 inch gash. The smaller piece then penetrated a ¼-inch plywood sheet about two feet from the firing site, finally landing 10 feet from its original position. Pieces of propellant (none of which showed any signs of combustion) were blasted into an area bounded by an almost perfect circle with a radius of about 200 feet. Of the 10 pounds of propellant cast into the grain, only 7 pounds were recovered.

The second rocket fired was similar to the Fort Sill Beta (see Brinley's Rocket Manual For Amateurs) with the micrograin (75% Zn + 25% S) packed into it by means of a five-ton hydropress. This packing method effectively formed the 9-pounds, 7-ounces of micrograin into a solid cylindrical grain, giving the rocket a mass ratio of 1.80. The igniter, composed of two electric squibs and one gram of smokeless powder, was inserted above a two-inch diameter burst diaphragm made of a $\frac{1}{4}$-inch plaster disc and a 1/16-inch formica disc mounted above the nozzle.

When fired, the force of the igniter sheared the four nozzle bolts, blasted the nozzle out of the rocket, and lifted the vehicle two feet up in the rack, but failed to ignite the hard-packed propellant.

As there was no way to re-attach the nozzle, it was not replaced for the second attempt to fire the rocket. The lower ends of the fins were wired into place. A new igniter, made of two electric matches and a gram of smokeless powder, was placed into loose micrograin now occupying the area previously held by the nozzle. The micrograin and igniter were kept in place by a new burst diaphragm. This burst disc had been fashioned from a 1/16-inch piece of formica, two inches in diameter, and was held in place by two crossed bolts running through the nozzle attachment holes in the lower end of the rocket.

Upon ignition, the rocket sat in the launching rack and burned for 30 seconds, then exploded. During the combustion period, it was noted that the burning of the propellant was uneven. At 21 seconds a popping sound was heard. Accompanying this pop was an increase in the volume of fire coming from the back of the rocket. At 30 seconds the rocket exploded, sending the upper 15 inches of the tube a distance of 500 feet downrange, and damaging the lower portion of the launching rack.

A possible explanation of the failure of the rocket might have been the manner of fueling. The pressure put upon the casing during the fueling operation may have weakened the wall of the rocket. Another possibility is that the propellant grain may have developed a series of hairline cracks (possibly at the time of the "pop" mentioned earlier), thereby increasing the burning surface. The increased burning surface would allow a greater amount of propellant to burn in a given amount of time causing a rapid increase in pressure and subsequent overpressurization of the rocket tube.

It was noted, upon examination of the recovered rocket parts, that there was no sign of heat failure. The prolonged burning time apparently did not soften the wall of the rocket prior to the explosion.

Because the rocket was fired without its nozzle, we have no way of comparing its performance with rockets loaded in various other ways. We can, however, compare the densities of propellant obtained by the different packing methods:

1) Hand packed	0.0826 pounds per cubic inch
2) Hydropressed	0.0886 pounds per cubic inch
3) Mechanically compressed	0.0905 pounds per cubic inch
4) Theoretical density	0.1249 pounds per cubic inch.

It should be noted here that the figure for mechanically compressed micrograin density was erroneously reported as 0.1162 pounds per cubic inch in RRS NEWS 99.

The information contained in this report concerning the actual firings was taken from tape recordings of the firing, and from two sets of 16mm motion picture film. One camera was hand operated, the other was operated electrically from the blockhouse and was located approximately 30 feet from the launching rack.

PROJECT X-1A:
PHASE TWO

By Richard Butterfield, Secretary
Reaction Research Society

The core pattern and motor casing for the X-1A gathered dust for a couple of weeks, the period between completion and the return of Larry Teebken, our vice-president, from his tour of duty in Korea.

Larry had a rocket designed that he wanted to build during his 30-day leave, but when he saw the core pattern and read the preliminary report (RRS NEWS 99), he dropped his own project, and took on the propellant development for the X-1A. As Larry was on leave and I was obliged to work, he had to do most of the material purchasing also.

The first items on his list were two discs, one-half inch thick and approximately five inches in diameter, of mild steel. He did admirably: he got two discs of steel that were almost exactly the right size. The only drawback to his first acquisition was the material--a flame hardened piece of chrome-moly steel--very hard. The rest of the material for the X-1A was closer to specification, though, and we began the fuel development and the machining of the hardware.

While Maryann and I did the machine work on the forward closure and on the mounting fixture, Larry made a few test casts of the propellant. The first was just a fuel cast (that is, no oxidizer was added) to check the cure time and color characteristics of this particular resin. Before the next experiment could be carried out, a suitable mold release process had to be developed.

A can of spray Teflon was bought and a sample piece was coated in the manner recommended on the can. This method seemed to do a fairly good job, but there were a few blisters under the Teflon. A new approach was tried: preheat the material to cure temperature (500°F), spray on the Teflon, then run a full cure cycle. The sample looked very good. A fixture was made to support the mandrel; then the mandrel was heated, coated, and cured. The result was nearly perfect. A sample piece of motor casing was similarly coated with Teflon with the same degree of perfection.

While casting the first grain, a great number of bubbles were observed in the liquid. To reduce the size and number of these bubbles, the liquid resin was placed under a bell-jar and pulled down to a couple of centimeter of mercury pressure. This de-gassing procedure worked quite well.

The second cast was another fuel cast, this time the pour was made around the mandrel and in the sample motor casing. The cast was beautiful but--it broke itself up due to the thermal stresses produced during the cure phase.

The next cast was made using un-dessicated potassium nitrate in a 50-50 mixture. This batch used a very small amount of catalyst in order to prolong the cure time, thereby reducing the cure temperature. This cast was a total loss; the top and bottom of the grain were nicely jelled but the center was not. We tried the experiment again; this time we achieved a perfect cast, about an inch and a half long. We next cast the first live grain, a mixture of 72% potassium perchlorate and 28% resin. This grain too was perfect.

And still Maryann was machining the first disc for the forward closure.

To permit a smoother gas flow into the nozzle, we decided to taper the exit end of the grain. To accomplish this, an inert grain about four inches long was cast and machined to use as a pattern for the live grain end shape. The core in the inert pattern was filed out to compensate for the shrinkage which developed during the cure phase. We re-Teflоned the mandrel, degreased the motor casing so that the propellant would bond to the walls, and assembled the motor onto the casting fixture.

The machine work was progressing quite well, and about the time the propellant process was developed, the hardware was ready. After some three weeks of long tedious work, we were ready for the casting of the live grain.

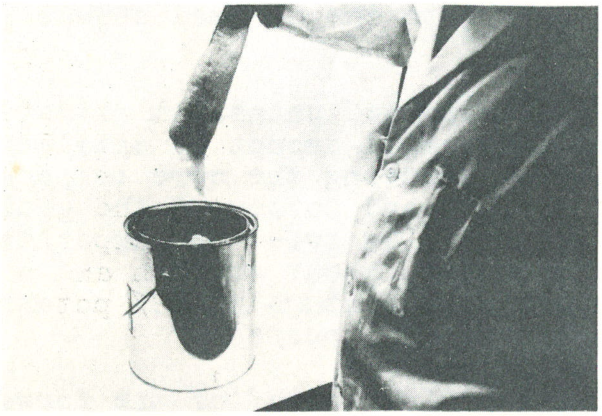
We carefully weighed out the ingredients, and blended the fuel and oxidizer to a homogeneous mixture. A careful examination of the motor tube and fixture was made, the check list was double checked--yes, we were ready!

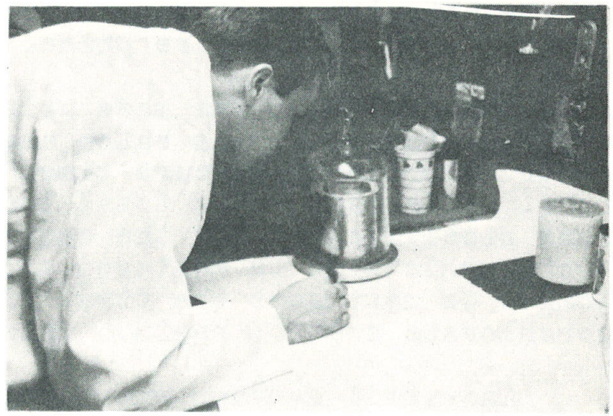
The catalyst was thoroughly blended into the mix; the propellant was evacuated and the cast was made. The volume of this pour was three to four times larger than our largest previous one, resulting in a higher than usual cure temperature. A bucket of cold water was brought in for possible emergency cooling. "Temperature crayon" lines were drawn along the motor casing to indicate the cure temperature. The casing reached a little over 150°F during cure.

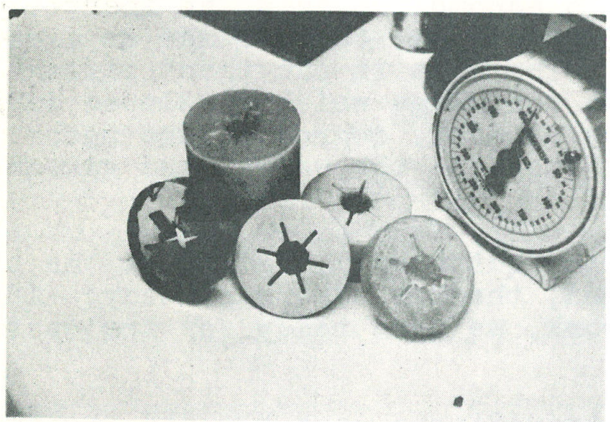
As soon as the grain had set to rubbery consistency the mandrel was pulled out. Air from a blower was ducted through the grain to keep the temperature down. After an hour the grain had cooled down to ambient temperature. Examination showed the grain to be almost

XI-A PREPARATION

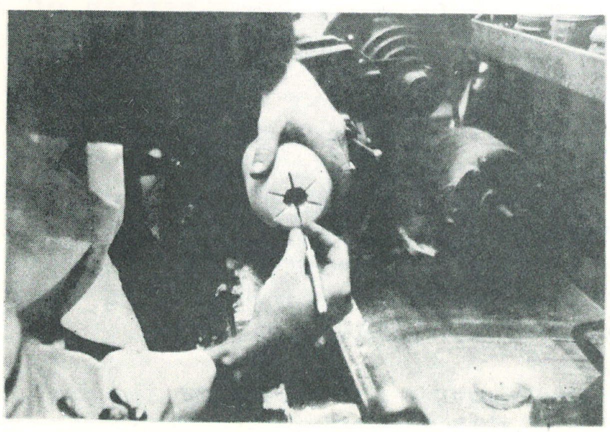
(Right) Larry Teebken is computing the amount of liquid propellant to make the cast. (Below) The ingredients are mixed--note viscosity of the mixture. (Below Right) De-gassing the liquid prior to pouring the grain.

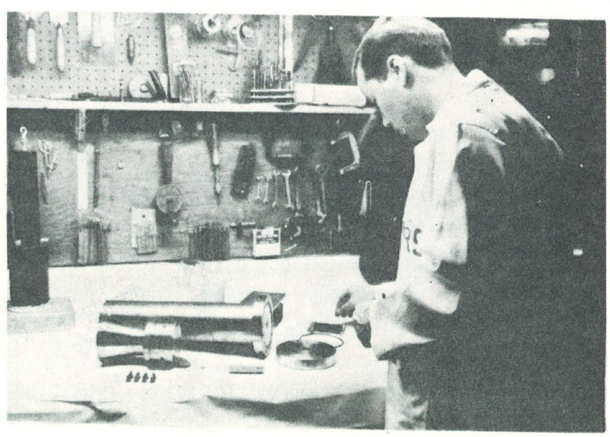


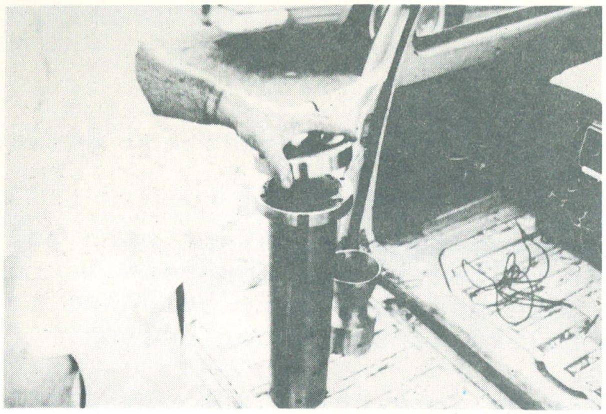


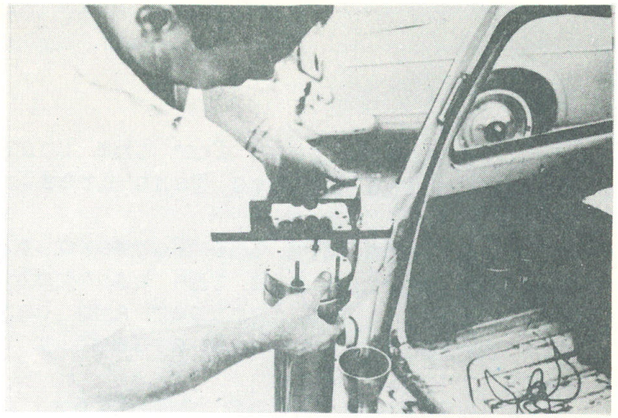


(Left) Several short grains, both fuel only and inert grains. (Below Left) Machining the inert grain form used as the pattern for the live grain cast. (Below) All materials are lined up and ready to go. Note the "O" ring used to prevent gas leakage between the motor and the forward bulkhead.



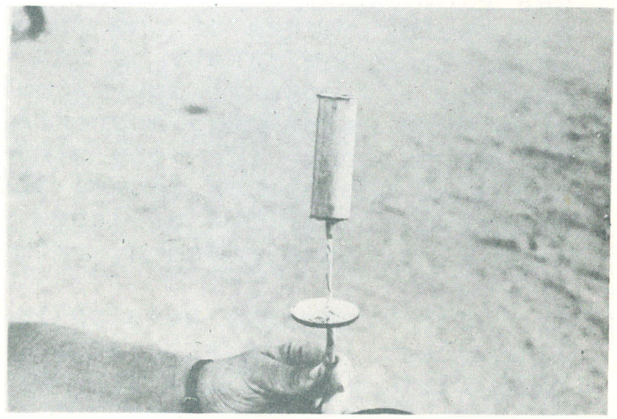


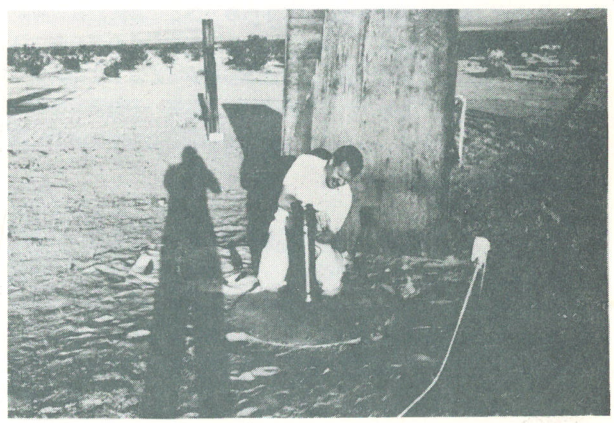


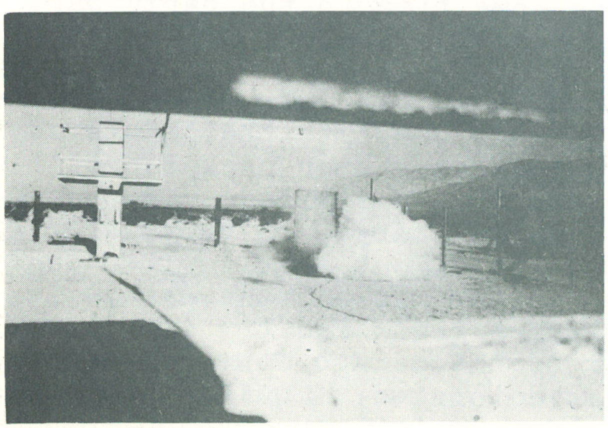


XI-A ASSEMBLY

(Above) The forward bulkhead is being attached. (Above Right) The static pad mounting bracket is being attached to the forward end of the rocket. (Right) The igniter and the burst diaphragm assembly.







(Above Left) Larry Teebken cementing the burst disc in place. (Above) Richard Butterfield bolts the nozzle into place and the rocket is ready to go. (Left) The explosion as seen from the blockhouse. Note the nozzle above and to the left of the smoke cloud.

perfect.

Preparations for the test firing were completed, and we set out for the Mojave Test Area.

At the MTA the forward closure and mounting stand were bolted to the casing and the assembly was bolted to our concrete launching rack pad. The igniter and burst disc assembly were cemented to the nozzle and this assembly was bolted to the motor casing.

After a brief briefing, all hands took cover and the countdown was run. Promptly, (I like prompt rockets) the sonofagun blew up, scattering chunks of the propellant all over four acres. The photo, taken from the safety of the blockhouse, shows the nozzle on its way up. It rose to approximately 20 feet. The chunks of the grain that were recovered, approximately 70% of the total, showed no sign of combustion. (The one benefit of this explosion--the broken surfaces of the pieces showed the internal structure of the grain. It appeared to be free of large bubbles and, with the exception of some minor edge effects, rather homogeneous in composition.)

The fragments were policed up and sorted. After weighing, the propellant (along with some surplus micrograin) was burned in an open fire. The flame was very intense and produced a minimum of smoke. There was almost no residue left from the X-1A propellant, indicating a good mix.

With regard to Girard's hydropressed micrograin rocket (which used the same type of igniter as the X-1A and which also blew up) and to the lack of evidence of burning on the grain fragments, we think that the motor failure was due to an over energetic igniter. It must be noted that the smokeless powder used was several years old. The age of the powder might have caused it to explode rather than burn.*

Plans are being laid for several investigations before the X-1B is fired. A reliable igniter and ignition system must be developed. A cooler method of curing these resin grains should be worked out. A method to make a secure bond between the grain and the casing should be developed. Perhaps polyester resin should be abandoned in favor of a more flexible fuel, thiokol, for instance.

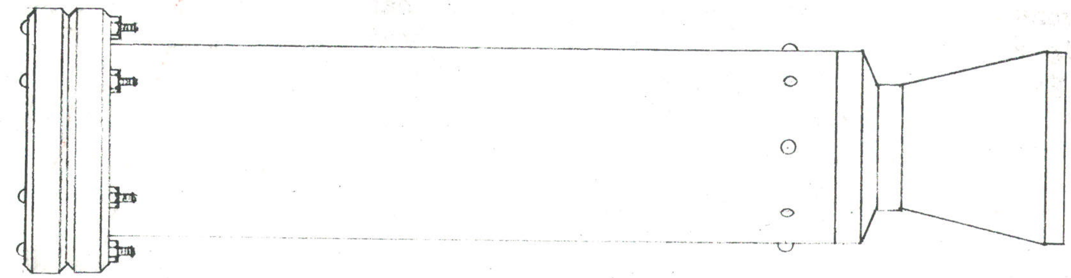
The X-1B will be forthcoming some time in the early part of 1966--this time we hope with more obvious success and fewer pieces.

---

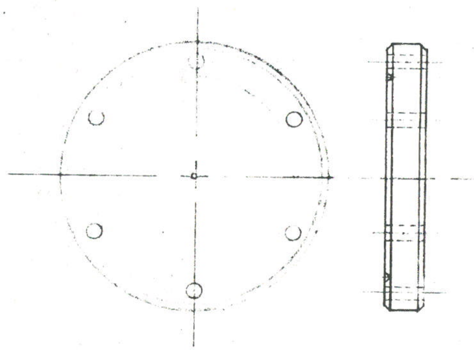
*Larry Teebken, now on duty in Chicago, reports that his study of the current literature available indicates "our rocket probably blew up because the smokeless powder was finely divided. It should be in the form of either pellets, or a solid charge, or very large grains."

And in another letter he writes: "About that igniter business. The only way to find out if the igniter did all the damage is to construct another motor with an inert grain and try it all over again. However, from the extent of the damage done, my guess is that a fraction of the propellant detonated. ¿Quien sabe? One thing is for sure: we need an extensive igniter development program."

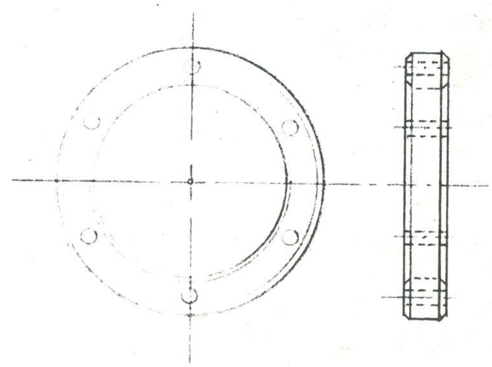
X1-A



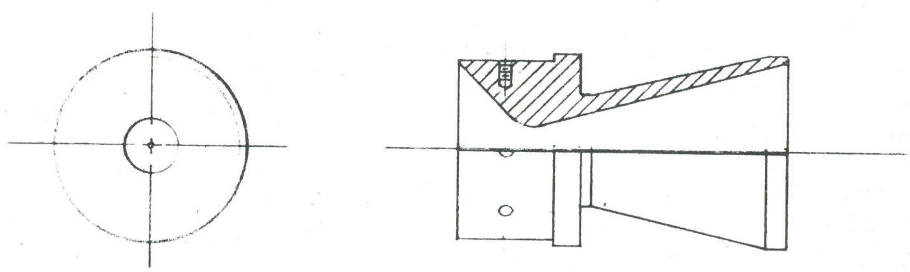
X-1A ASSEMBLY



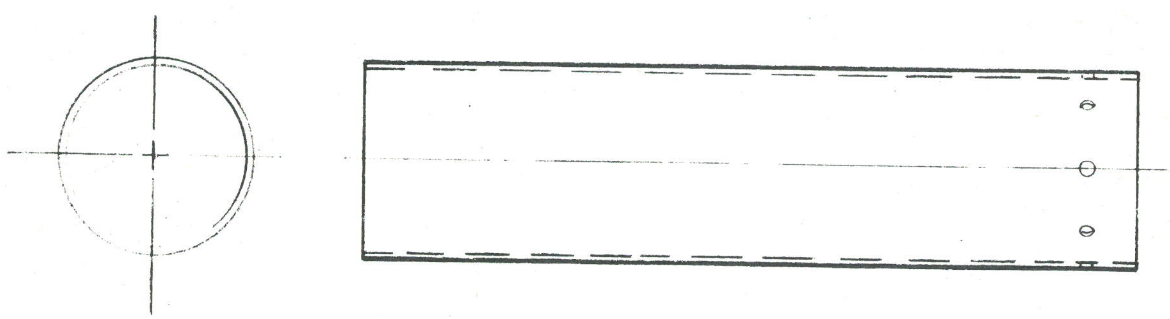
BULKHEAD



FLANGE



NOZZLE



CASING

BUTTERFIELD

PRELIMINARY TEMPERATURE TESTS

During a recent firing a two-inch RRS vehicle was treated with temperature sensing crayons (Thermochrom by Air Reduction Co.) in an attempt to establish some range of external skin temperatures encountered in a typical firing.

Four individual longitudinal stripes of markings were applied to the outside of the rocket. These markings, of individual colors, undergo a color change when the temperature for which they are designed is reached or exceeded. The four temperatures tried were: green (1240°F), blue (1110°F), brown (930°F), and pink (840°F).

When the temperatures listed are reached the green and the blue change to white. When the brown and pink reach rated temperature the change is to black. These changes are permanent and do not return to their original color.

The post firing examination of the treated rocket revealed that the green and the blue had not changed color and the other two stripes had turned black. This indicated that the outer skin had reached a temperature between 930°F and 1110°F.

ZAMBODIA PLANS VENTURE TO MOON

LUSAKA, Zambia (AP) — You have no idea what problems you run into when you're trying to put the first African on the moon.

The finances are slow, the would-be astronauts are balky, and there's a matter of biology, too.

Zambia is a small country in the heart of Africa. Its minister of space research, as he describes himself, is Edward Mukuka Nkoloso.

"We are delaying our plans to plant the Zambian flag on the moon," Nkoloso says.

"But this is only a temporary setback. A reply to my request to the United Nations for a loan of $19.6 million and a further $1.0 billion from private foreign sources hasn't yet been received."

The toothless little space enthusiast flutters around in a faded, torn, red and green cloak. His 16-man team of astronauts has revolted against his tortuous space training program.

"After the worldwide television showing and press publicity of our astronauts in training I received thousands of letters from foreign countries," he said. "But my spacemen thought they were film stars."

"They demanded payment and refused to continue with our program of rolling down hills in oil drums and my special tree-swinging method of simulating space weightlessness."

Zambia's No. 1 space girl, Matha Mwamba, completed the full course of 50 hill rolls and tree swings, but now she is pregnant. She has returned to her parents who have, according to Nkoloso, talked her out of continuing her space training.

"Two of my best men went on a drinking spree a month ago and haven't been seen since," he said. "Another of my astronauts has joined a local tribal song and dance group. He says he makes more money swinging from the top of a 40-foot pole."

Dejected though he is, Nkoloso has not yet entirely abandoned his ideas to get the first African on the moon. Government sources say, however, that President Kenneth Kaunda of Zambia has asked him to curb his enthusiasm.

Despite his setbacks, Nkoloso maintains he could have the Zambian flag on the moon in a couple of years if the money were forthcoming. He has plans for a new rocket to replace one "recently sabotaged by foreign elements." He wouldn't elaborate on that.

"Perhaps the Americans would like to join me in my space program," he said. "I'd be most happy. But let's get one thing straight--I step on the moon and hoist the Zambian flag first."

RADIO TELEMETRY

By D. J. Shusterman
Reaction Research Society

Today's highly sophisticated aerospace experiments would have little significance were it not for radio telemetry. A combination of the sciences of instrumentation and communications, radio telemetry enables us to measure factors of a rocket's performance and environment from tracking stations on the ground. Although telemetry has not been widely used by the amateur rocketeer, it could add a new dimension of productivity and sophistication to amateur experimentation.

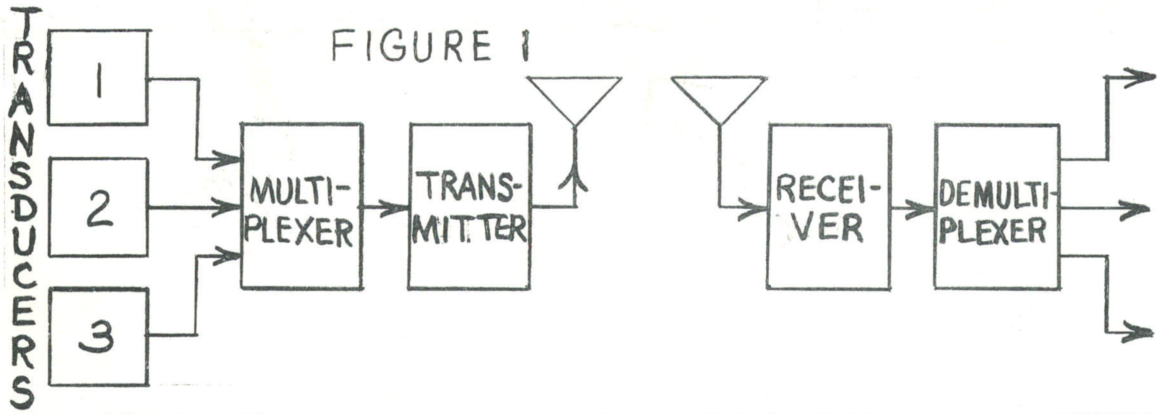
Let us construct a simplified model telemetry system. First, the physical information that we wish to measure must be sensed and translated into electrical variations. This is accomplished by transducers. The information could be fed directly into the transmitter, for reception and display on the ground. However, in most cases we wish to telemeter more than one channel of information, and it is impractical to have a separate transmission link for each.

Consequently, techniques known as multiplexing have been developed, whereby many channels of information can be transmitted on a single radio-frequency carrier. In order to combine information channels while keeping them distinguishable, we must separate them either in frequency or in time. In the first case, each channel occupies only a small portion of the available frequency spectrum. In the second, the channels are sampled, each one being connected to the transmitter for only a small fraction of the time. These techniques are known as frequency-division and time-division multiplexing.

From what we known so far, we can construct the simplified block diagram of a multichannel telemetry system shown in Fig. 1. The various subsystems are discussed in greater detail in the following paragraphs.

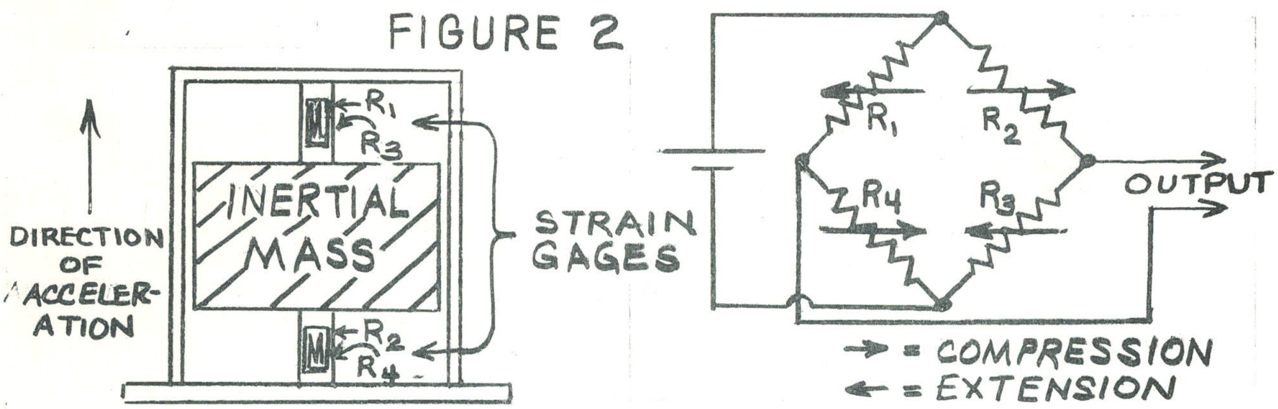
TRANSDUCERS. The information we wish to measure may be in the form of temperature, pressure, acceleration, strain, or radiation, among others. Typical transducers for these measurements would include the thermocouple, thermistor, strain gage, Geiger-Mueller tube, plus various electro-mechanical devices incorporating piezoelectric or piezoresistive elements, potentiometers, strain gages, or variable inductance or capacitance pickups. A possible configuration for an accelerometer is shown in Fig. 2.

FIGURE 1



FREQUENCY-DIVISION MULTIPLEXING. In a frequency-division multiplexing system, the output of each transducer is used to control the frequency of a subcarrier. This is accomplished with frequency-modulated subcarrier oscillators. The frequency ranges of the subcarrier are carefully controlled, and there are guard bands between them to prevent interference. Under IRIG (Inter-Range Instrumentation Group) standards, there are eighteen subcarrier channels, the center frequencies of which lie between 400 CPS and 70,000 CPS. In most cases, the frequency of each subcarrier is varied up to ± 7.5% of the center frequency. (The top five bands are sometimes used with ± 15% deviation.) The deviation ratio (maximum subcarrier deviation divided by maximum data frequency) is set at 5, to minimize distortion and interference.

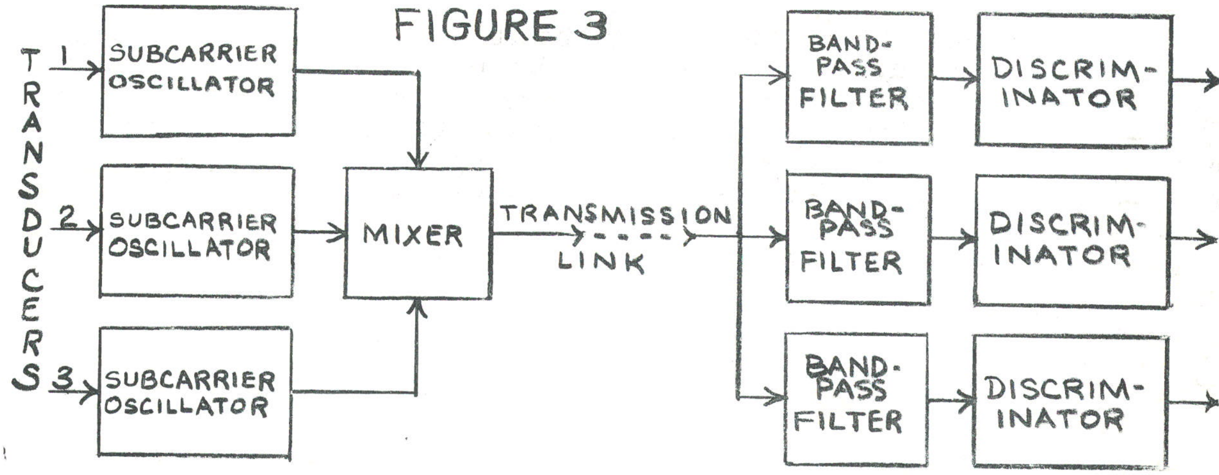
FIGURE 2



Subcarrier channel No. 1, for example, has a center frequency of 400 CPS, a maximum deviation of ±30 CPS, and a maximum data frequency of 6 CPS. While the response of this channel would perhaps be too slow for an accelerometer, it would certainly be fast enough for a thermocouple measuring nozzle temperature.

The outputs of the subcarrier oscillators are fed together in a mixing network to form a composite signal. At the receiving end, the subcarriers are separated by bandpass filters and fed into frequency-sensitive discriminators. Each discriminator recovers the original data by producing voltages proportional to the frequency within the subcarrier band. These voltages, in turn, are fed into readout or recording devices. A typical system is shown in Fig. 3

FIGURE 3



TIME-DIVISION MULTIPLEXING. In time-division multiplexing, the information channels are sampled in regular order by a commutator, simply a type of switch. Since none of the channels are continuously monitored, the sampling rate must be sufficiently high to preserve details in the information. Normally a sampling rate of five times the maximum information frequency is sufficient to retain details. The output from the commutator is a series of pulses, the heights of which represent the instantaneous amplitudes of the sampled information channels. This is known as pulse-amplitude modulation (PAM).

On the ground the PAM signal is fed into a decommutator, another switch which operates in step with the airborne commutator. The decommutator has separate outputs for the various information channels. The output pulse trains are usually filtered to form a smooth reproduction of the original information. In this system, it is essential that the commutator and decommutator are in synchronization, or else information will be fed out through the wrong display channels.

While all time-division multiplexing techniques use the shared-time principle, not all of them use pulse amplitude to carry information. In a pulse-duration modulated (PDM) system, information is fed through a keyer to produce pulses of uniform height and varying duration. Since the information is carried by pulse duration rather than amplitude, random noise is less apt to degrade the accuracy of the system.

Still more accurate is the pulse-code modulated (PCM) system. Here the instantaneous information level is represented by a series of pulses and spaces arranged in a binary code. Since all the pulses are the same shape, it is necessary only to detect their presence or absence, making the system less sensitive to noise. Also, binary codes can be fed directly into digital computers, thus simplifying data processing.

A comparison of the various pulse-modulated methods of data representation, as well as frequency modulation, is shown in Fig. 4.

THE RF LINK. The composite output of the subcarrier oscillators or commutators is used to modulate the radio-frequency carrier. Although various amplitude and pulse modulation techniques are possible here, frequency and phase modulation are most often used. The output of the transmitter is fed into a multi-directional transmitting antenna. Frequencies of transmission for government telemetry are 216 - 260 MC, 1435 - 1535 MC, and 2200 - 2300 MC. The current trend is toward the higher bands.

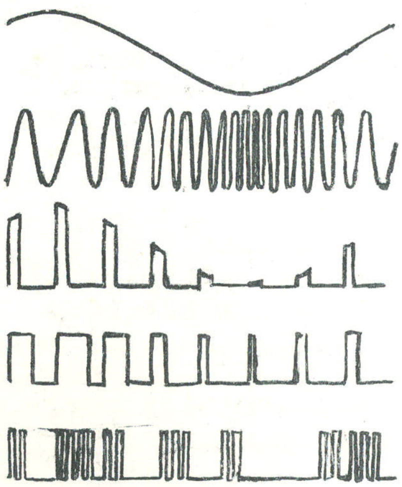


FIGURE 4

SINE WAVE (FROM TRANSDUCER)

OUTPUT : F.M. SUBCARRIER OSCILLATOR

: P.A.M. COMMUTATOR

: P.D.M. KEYER

: P.C.M. ENCODER

On the ground, the signals are picked up with a directional antenna. The circularly-polarized parabolic and helical antennas are best suited for this application, because wave propogation and changing flight angle produce randomly polarized waves. Both of these antennas are of the high-gain variety, requiring a minimum of transmitted power from the telemetry package to sustain solid communications.

The signal is frequently amplified at the antenna before going to the receiver. The receiver itself is quite sensitive, and has an output frequency response good to far above the audio range. The output is often recorded on magnetic tape, in addition to being directly processed. The composite signal is either discriminated or commutated, depending upon the type of multiplexing. The recovered data is then recorded, either on an oscillograph, for direct analysis, or on magnetic tape, for computer processing.

TELEMETRY FOR THE AMATEUR. Even though telemetry techniques may seem quite difficult, a simple FM-FM system, with one subcarrier, is an immediate and attainable goal. Later systems can be of the multi-channel type. IRIG standards are a good guidepost to telemetry system development (particularly if you hope to test under military auspices). At the same time, the amateur need not place any restrictions on his project, and therefore has limitless possibilities for development of an original radio telemetry system for amateur rockets.

THE NOMOGRAPH: HOW TO PROGRAM YOUR OWN COMPUTER

By Beth Hooper
Reaction Research Society

Tired of devoting hours of concentrated effort to tedious calculations? Then sit back and learn how to solve equations quickly and accurately with your own computer. All you need in order to construct this computer is some paper, a sharp pencil, a good foot-ruler, and the formula you wish to work with. Once you have set up the nomograph appropriate for the formula, you can read solutions simply by constructing a few lines.

The art of nomography was first developed in detail by a Frenchman named d'Ocagne. It combines the ease of multiplication and division claimed by the purveyors of the trusty slide rule with a built-in system of addition and subtraction. Decimal points are nailed down automatically, and the formula itself is incorporated in the diagram, so that no parts are accidentally overlooked or transposed while the solution is developing.

At very little expense, accurate scales of various sizes and types can be combined to produce solutions to problems in elementary calculus, or to swiftly evaluate a formula such as the one below, which may arise when two sighting stations cooperate in following the trajectory of a rocket:

$$h = \frac{B}{\dfrac{\cos \alpha_1}{\tan \beta_1} - \dfrac{\cos \alpha_2}{\tan \beta_2}}$$

Let us now take a look at some very basic nomographs. Suppose you wish to add the numbers a and b. Construct two parallel lines, A and B, and calibrate them uniformly, as shown in Fig. 1. Construct line C equidistant from A and B, and graduate the C scale so that a reading there is twice what it would be on the A or B scale. Now locate the point corresponding to a on the A scale, and the point representing b on the B scale. The line connecting these two points intersects C at a point we can identify with the value a + b, called c. The summation of -3 and -1 (which yields -4) is illustrated in Fig. 1.

You are now able to add together two parts of a formula. Notice that the value a can be determined if c and b are known, and so subtraction is possible here, since c - b = a.

Now let us move onto multiplication. Suppose you want to determine the product of a and b. Once again, construct parallel lines A and B, but this time calibrate them with a logarithmic scale (directions for constructing such a scale follow). Then locate line C equidistant between A and B, and graduate it as shown in Fig 2, using a half-size log scale. All three scales can be extended in

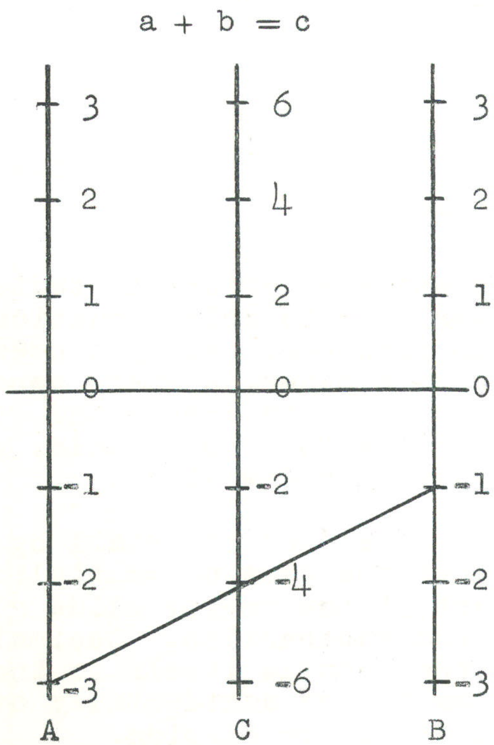


Figure 1

order to include larger numbers.

The product of a and b may now be found by connecting the appropriate points on scale A and scale B, and determining where this connecting line intersects line C. The multiplication of 2 and 5 is illustrated in Fig. 2. Observe that division is also possible here, since c/b = a.

As a final example, let us investigate the relationship $a^n = b$, where a is some number between 1 and 10, and n has a positive value. Construct parallel logarithmic scales A and B so that A runs from 1 to 10 and B runs in the opposite direction, as shown in Fig. 3. The distance between A and B must be the same as the distance between 1 and 10 on the A scale.

Now construct a diagonal from 1 on the A scale to 1 on the B scale. The diagonal will be the n scale. You must calibrate this line yourself by connecting corresponding points on A and B. For example, since $3^2 = 9$, you can set a = 3 and b = 9; the point at which the line connecting 3 and 9 hits the n scale is the one which should represent 2. Note that there are many ways to locate a number on the n scale--the values 6 and 36 would have led to the same position for 2, as shown in Fig. 3.

Recall that $a^1 = a$, and you can easily record 1 on the n scale. To set down fractional values on the n scale, observe that the principle nth root of a can be written as $a^{1/n}$. For example, since the principal second root (square root) of 4 is 2, we can say $4^{\frac{1}{2}} = 2$; let a= 4 and b = 2, then the point $\frac{1}{2}$ is determined. Similarly, $8^{1/3}$ is equal to 2, so that we may find a place on the n scale for 1/3, as shown.

You are now equipped to find the powers and roots of numbers between 1 and 10.

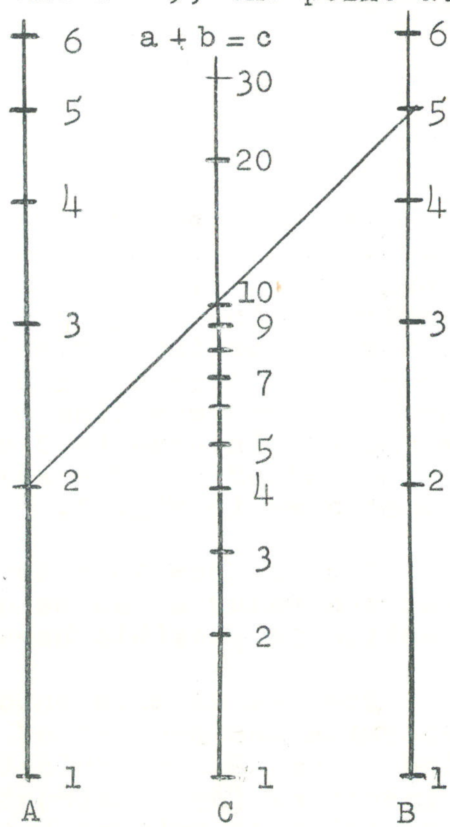


Figure 2

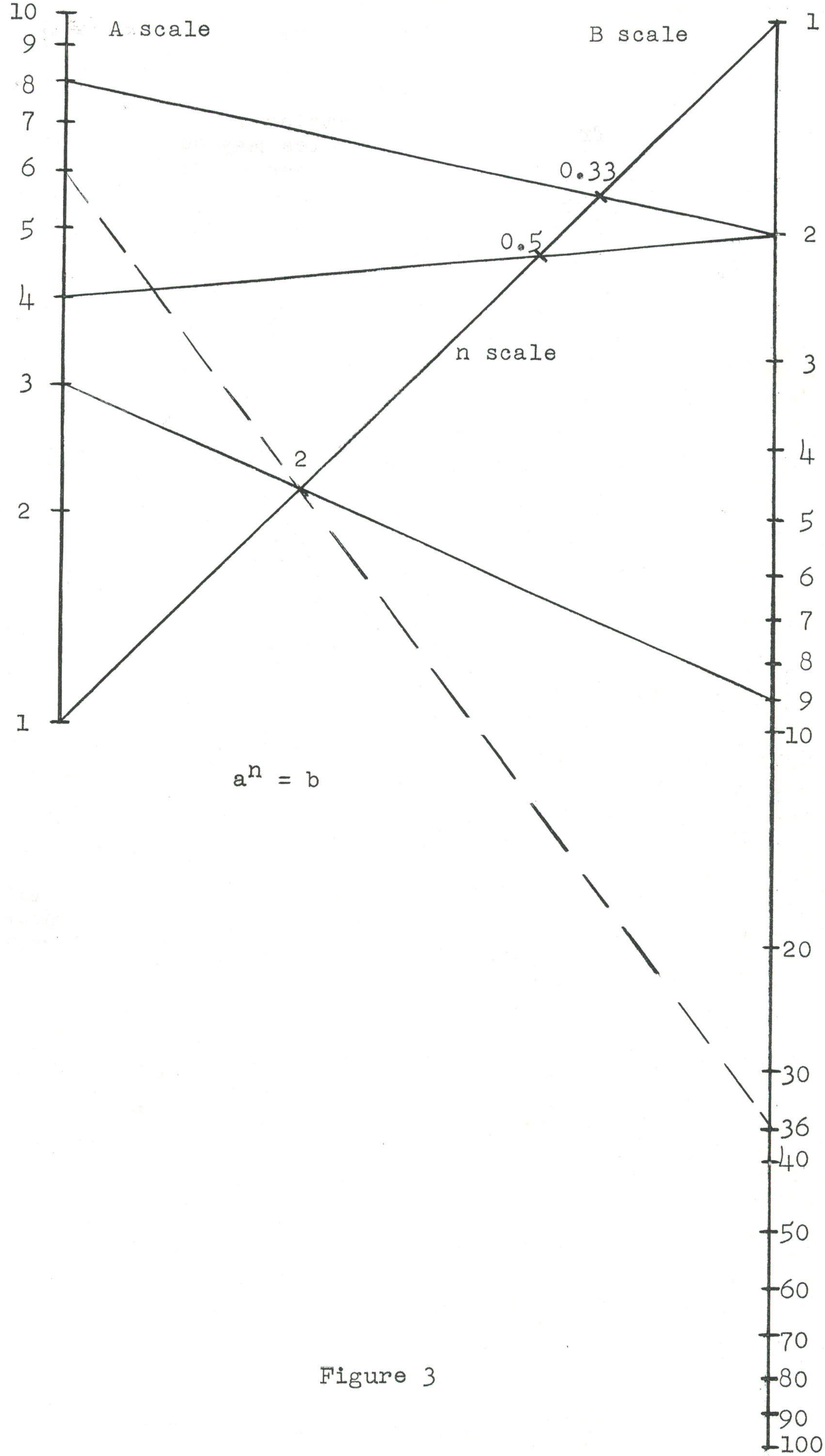

A scale
B scale
n scale
0.33
0.5
2
10
9
8
7
6
5
4
3
2
1
1
2
3
4
5
6
7
8
9
10
20
30
36
40
50
60
70
80
90
100
$a^n = b$

Figure 3

It is clear from the above examples that the nomographer uses many log scales. At times these scales may be copied from a slide rule or a piece of graph paper, but when a problem involves successive operations, one must be able to construct log scales of specified sizes, in order to combine the nomographs corresponding to the given operations in a convenient way.

The following procedure for constructing a log scale was suggested by Jerome S. Meyer in Fun With Mathematics. The basic proportions remain fixed, but the distance between 1 and 10 may be changed to fit the diagram, or perhaps increased for greater accuracy.

Obtain two well-cut strips of paper, a sharp pencil, and a magnifying glass if great accuracy in marking is desired. On adjacent edges of the strips, lay off lengths of 6.25 inches between points marked 1 and 10. Mark 2, 3, and 7 as shown in Fig. 4; the point 1.1 should be placed 0.25 inches to the right of 1, and point 1.3 should appear 0.719 inches (or 23/32 of an inch) to the right of 1.

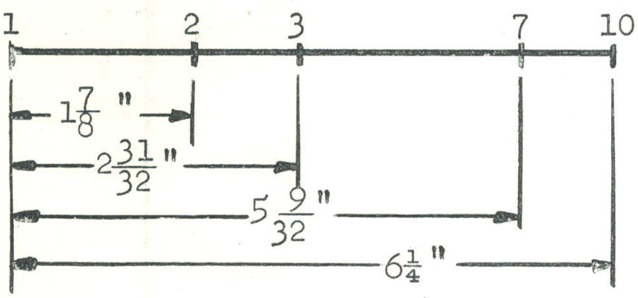


Figure 4

The basic marks should be painstakingly laid off, because the rest of the scale is determined from them. For example, as illustrated in Fig. 5, we can determine the positions of 4 and 6 by setting 1 on the X strip directly below 2 on the Y strip. This follows the basic principle of slide rule multiplication. Similarly, by placing 1 on the X scale below 3 on the Y scale, we can locate 9. And in general if 1 on the X scale is placed y on the Y scale, the product xy appears on the Y scale directly above x on the X scale.

The above information can be combined with additional diagrams in order to set up the solutions of many useful equations. More detailed information about this may be found in a good library or ordered through a bookstore.

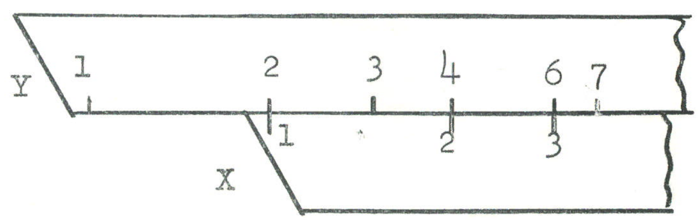
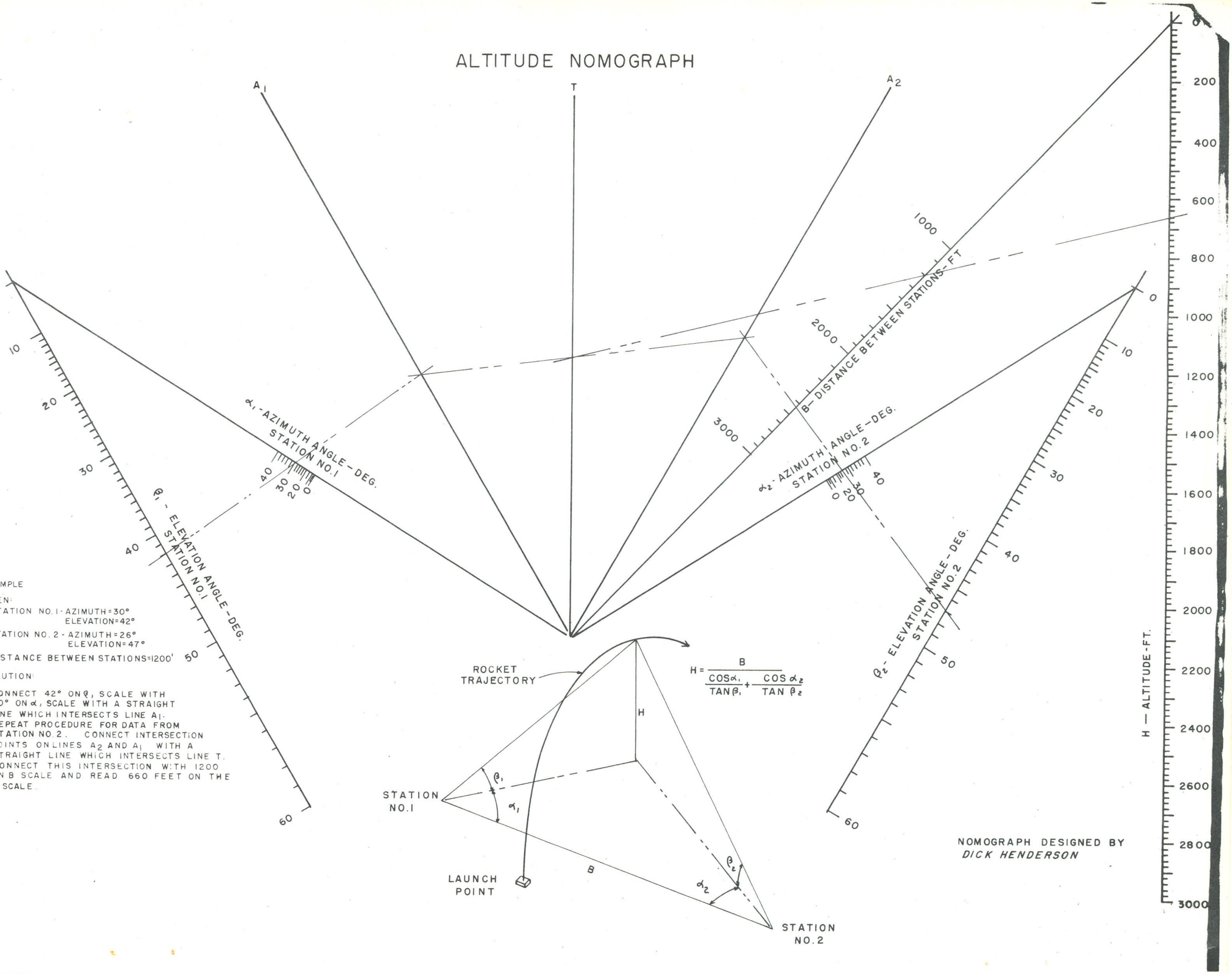


Figure 5

ALTITUDE NOMOGRAPH



$$H = \frac{B}{\frac{\cos\alpha_1}{\tan\beta_1} + \frac{\cos\alpha_2}{\tan\beta_2}}$$

EXAMPLE

GIVEN:

STATION NO. 1 - AZIMUTH = 30°
ELEVATION = 42°

STATION NO. 2 - AZIMUTH = 26°
ELEVATION = 47°

DISTANCE BETWEEN STATIONS = 1200'

SOLUTION:

CONNECT 42° ON β_1 SCALE WITH 30° ON α_1 SCALE WITH A STRAIGHT LINE WHICH INTERSECTS LINE A_1. REPEAT PROCEDURE FOR DATA FROM STATION NO. 2. CONNECT INTERSECTION POINTS ON LINES A_2 AND A_1 WITH A STRAIGHT LINE WHICH INTERSECTS LINE T. CONNECT THIS INTERSECTION WITH 1200 ON B SCALE AND READ 660 FEET ON THE H SCALE.

NOMOGRAPH DESIGNED BY
DICK HENDERSON

FIRST PROGRESS REPORT ON
HYDROGEN PEROXIDE AND
METHYL ALCOHOL ROCKET

By Don Girard,
Reaction Research Society

On May 1, the Executive Council of the Reaction Research Society approved a research contract to design, build, test, and fire a hydrogen peroxide-methyl alcohol rocket of approximately 1000 pounds thrust. An initial appropriation of $30 was given, followed by another $30 in June.

One of the first considerations is proposing a project of this nature is cost, and particularly the cost of the hydrogen peroxide. Following a lead presented in David Elliott's work, we contacted the Buffalo Electro-Chemical Company, and were rewarded with a bonanza of information, from which much of the preliminary survey was drawn up. Becco also distributes 90% H_2O_2, and the purchase of 300 pounds will cost 61.5 cents a pound.

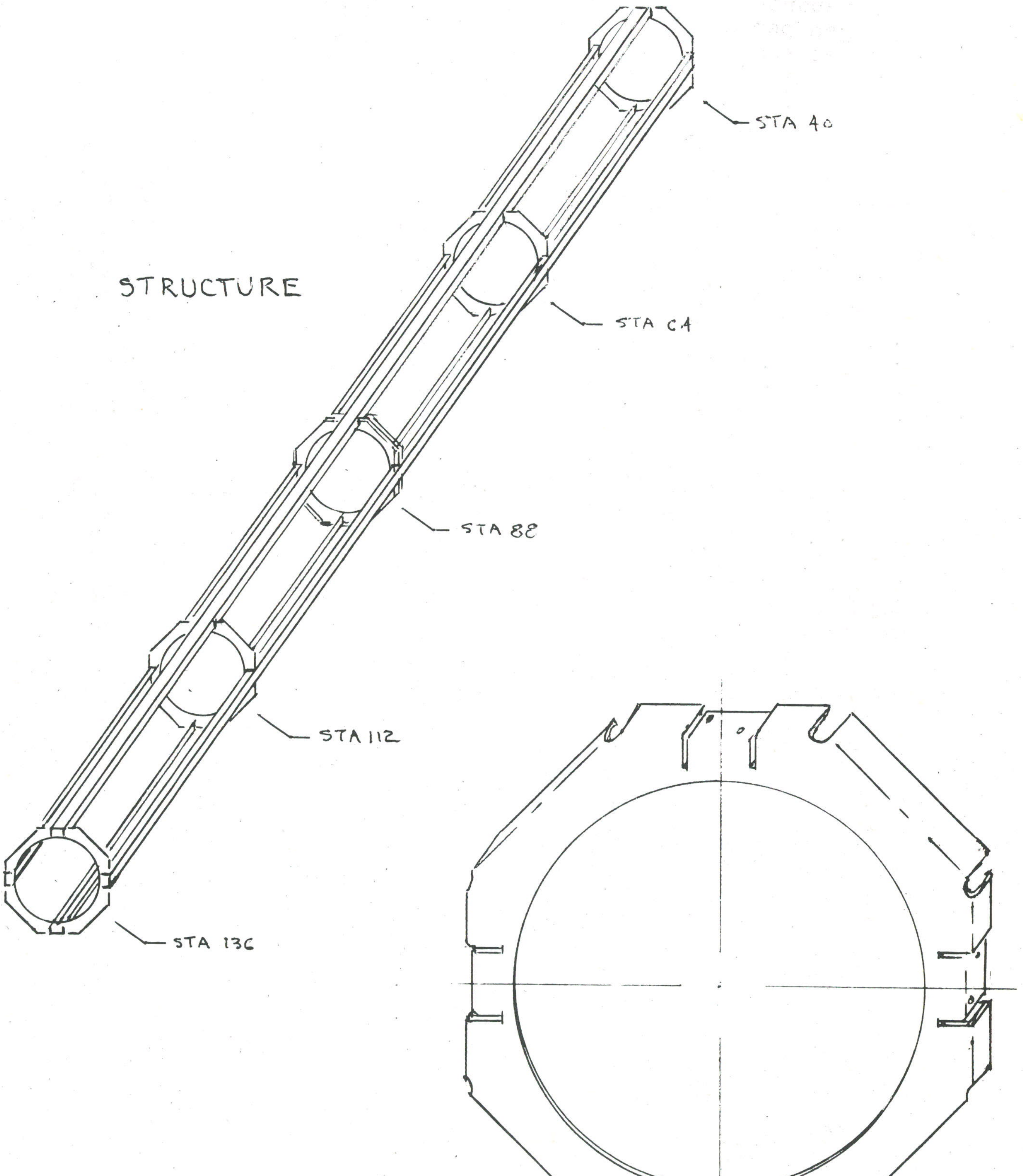
The structure of the rocket, as originally conceived, was to be 10.6 feet in length, and about 7 inches in diameter. Again following a lead from Elliott and Rosenthal, we investigated the purchase of flight tanks, and decided upon the F-2 stainless steel tank for the peroxide, and the D-2 stainless steel tank for the methyl alcohol. The size of these tanks, when considered with the other space requirements, forced us to lengthen the proposed structure to 11.7 feet.

For the basic shape, it was decided to go perhaps a somewhat unusual route. Mr. George Dosa suggested that we consider an octagon body, that is, an eight-sided figure rather than a circular tube. He did so for the seven-inch tube would be both difficult to make and difficult to obtain, which a seven-inch octagon would be easy to make. It would have other advantages too. The transition from octagon to the round nose cone could be done easily in the instrument section, bulkheads would be easy to fabricate, access panels easier to fit, and finally, the corners would permit passage for plumbing.

Working from this shape, then, it was easy enough to decide upon a structural scheme. Four channels of aluminum alloy, each eight feet long, were positioned by a series of bulkheads. See Fig. 1. For an outer skin covering, wall thicknesses of 0.065 inches and 0.040 inches were considered, with the final choice of the smaller size covering made for reasons of weight.

The flight tanks are about five and a half inches in diameter; the peroxide tank has a volume capacity of 1000 cubic inches, the alcohol tank 500 cubic inches.

The system is designed for a chamber pressure of 300 psi, created by a 3000 psi nitrogen pressurization. The methyl alcohol is used in regeneratively cooling the motor. We emphasize at this point that



TYPICAL BULKHEAD

FIG. 1

300 psi chamber pressurization is a design parameter, and calculations as to line loss and amount of regulation must proceed from this figure. For an over-view of the plumbing system, refer to Fig. 2.

As reported in the preliminary survey, the heat of combustion of hydrogen peroxide and methyl alcohol is 4156°F. It becomes apparent that some sort of cooling system will be required. The basic plan is to circulate the fuel in a spiral fashion about the motor, and then introduce it into the combustion chamber. The sketch, Fig. 3A, is from <u>Fundamentals of Rocket Engines</u>, and would serve quite well.

The problems involved in machining such a design proved to be a major headache, and after dealing at some length with designs utilizing divergent and convergent retaining rings, Mr. Dosa abandoned the gradually expanding spiral for a flattened aluminum tubing tightly wrapped in place about the motor with fiberglass mountings, as shown in Fig. 3B.

The injector design is still very preliminary, and is waiting upon a number of water tests to determine spray patterns. The injector itself will be completely removable from the combustion chamber.

The combustion chamber length has been established. The length is a function of the volume, area of the throat, and the characteristic length, L*, where the relation is:

$$L^* = \frac{V_c}{A_t}.$$

Values for L* for hydrogen peroxide-methyl alcohol are unavailable. However, similar fuels range between 30 and 40 inches.

TABLE 1.

CALCULATED VALUES OF CHAMBER LENGTH
(INCHES)

L^*	A_{throat}	$V_{chamber}$	$V_{ent.\ cone}$	V_{tube}	$Area_{tube}$	l_{tube}
30	2.303	69.090	21.294	47.796	16.800	2.845
35	2.303	80.605	21.294	59.311	16.800	3.530
40	2.303	92.120	21.294	70.826	16.800	4.216

On the basis of the above figures, a safe length of five inches was chosen.

For the calculations necessary to design the motor, the fuel flow rate, and injector design, the following parameters are either known or specified:

Fuel - methyl alcohol
Oxidizer - 90% hydrogen peroxide
Thrust - 1000 pounds
Chamber Pressure - 300 psig

PRELIMINARY PLUMBING

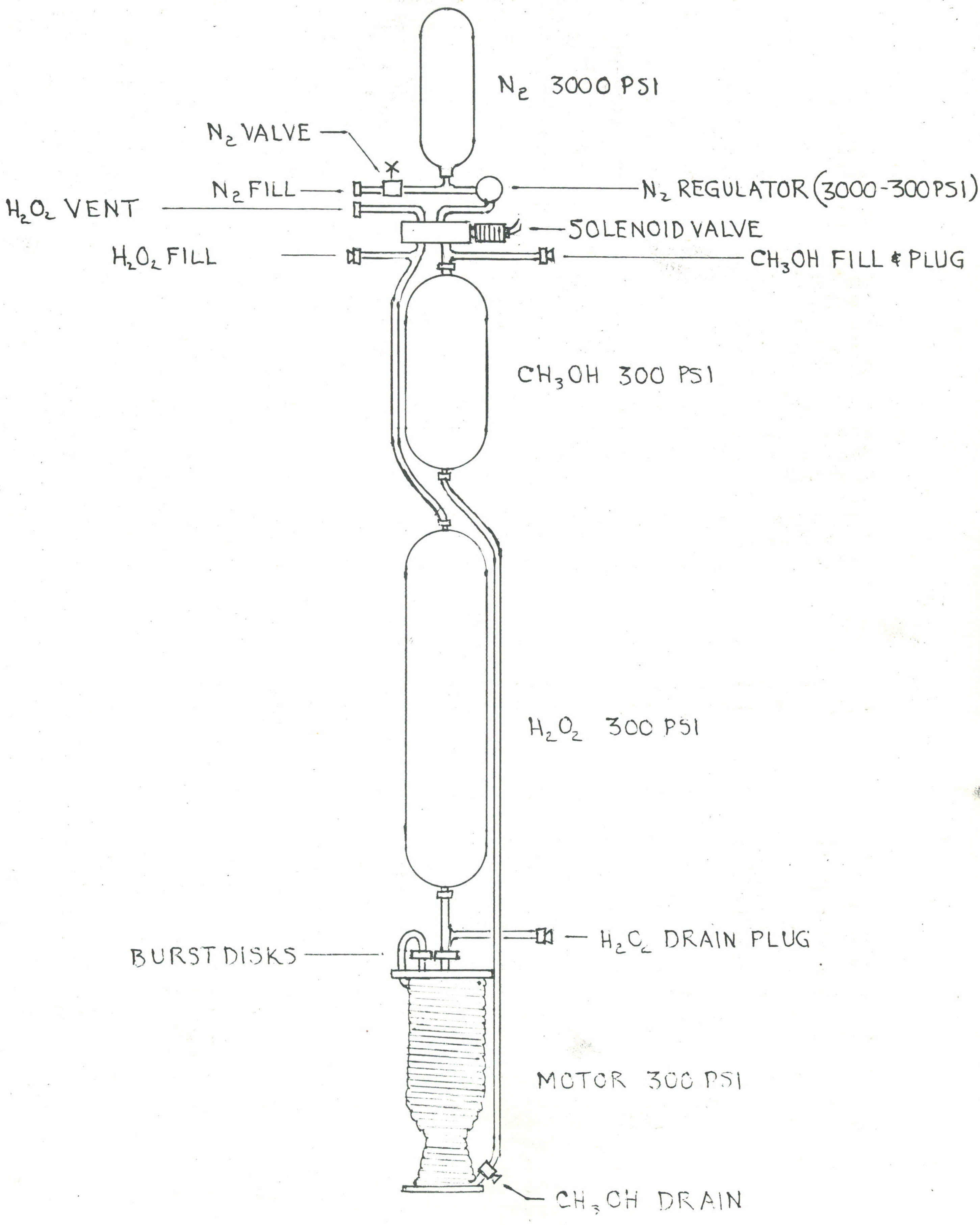


FIG. 2

I_{sp} - 223 seconds
Oxidizer to Fuel Ratio - 4:1
k - 1.25
Density H_2O_2 - 0.050 lbs/in^3 at 68°F
Density CH_3OH - 0.027 lbs/in^3 at 68°F
Motor O.D. - 5 inches
Motor Wall - 0.1881 inches
Motor I.D. - 4-5/8 inches
Volume D-2 tank - 500 cubic inches
Volume F-2 tank - 1000 cubic inches.

Working from this information, we can now determine throat area by using the relationship:

$$F = C_f P_c A_t, \text{ where } F = 1000 \text{ lbs}$$
$$C_f = 1.38$$
$$A_t = 314.7 \text{ psia},$$

and consequently $A_t = 2.30$ square inches; the throat diameter then is 1.71 inches.

Since A_e/A_t is a function of P_c/P_e for different values of k,

$$\frac{P_c}{P_e} = \frac{314.7}{14.7} = 21.4, \text{ where } k = 1.25.$$

From chart (Fig. 4), $A_c/A_t = 3.52$, and hence $A_e = 8.105$ and $D_e = 3.21$.

From this information, using a diverging angle of 15° and a converging angle of 30°, the nozzle dimensions can be calculated from simple trigonometric relations.

Prior to selecting the tanks for use, it was necessary to determine some notion of volume. Since $I_{sp} = F/\dot{W}$, $\dot{W} = 4.48$ pounds per second, divided between the oxidizer and fuel in the ratio of 4:1. It was also decided to provide as long a duration of thrust as possible, and the current choice of tankage allows approximately 14 seconds of powered flight.

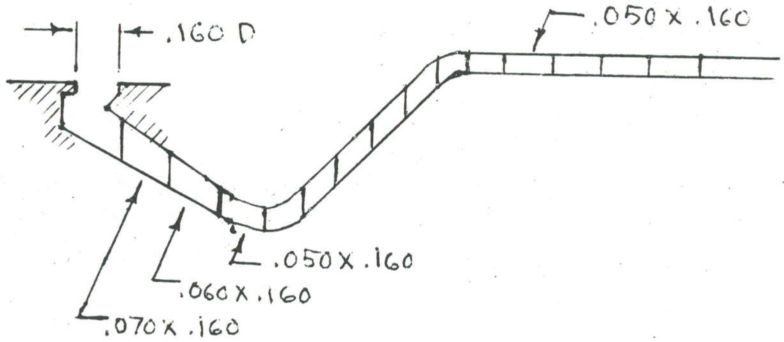
Proceeding further, then, from the relation $Q = AV$, where Q = cubic feet per second, A = area in square feet, and V = fuel flow velocity, the oxidizer flow rate is 8.201 feet per second and the fuel flow rate is 4.10 feet per second.

To determine the pressures necessary to generate such a line flow, we make use of Bernoulli's equation.

$$\frac{W_B^2}{2} + \frac{p_o}{\rho} = 0 + \frac{p_1}{\rho}.$$

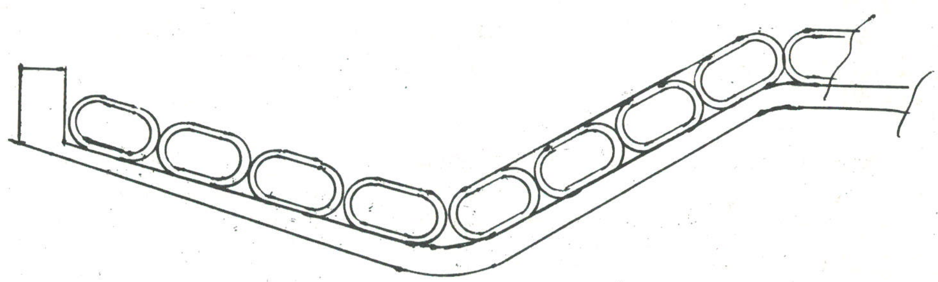
Solution of this equation for the oxidizer yields a value of 331.4 psi; for the fuel, 303.6 psi.

We will stop here with our calculations. Further work must be done in injector design before static testing can begin.



FROM "FUNDAMENTALS OF ROCKET ENGINES"

FIG. 3A



COOLING COIL OF
FLATTENED ALUM ALLOY TUBE

FIG. 3B

The nose cone for this rocket is made from fiberglass and has several interesting features. It is seven inches in diameter at the base and is 28 inches long; it is based on a selected fineness ratio of 8:1. Its shape is a secant ogive, designed for minimum drag at its maximum velocity. The cone is fabricated from shell halves joined along the seams. The shell halves were laid-up in a plaster mold produced by a precision made sweep template. The calculations for this shape are based on the work of the noted aerodynamicist Theodore Von Karman.

The forward nine inches of the cone contain a sealed compartment for the smoke generator to be used for tracking. The rear section, with its locking ring adapter, will house the parachute and 'chute ejection mechanism. The finished assembly weighs just under one pound.

The instrument section is 12 inches long, and is the transition piece from the octagon to the tubular shape. At this stage, instrumentation is entirely open, and dependent on outside assistance. The following table perhaps gives some idea of the possibilities. The items listed under "Type" are those that are immediately available to the society.

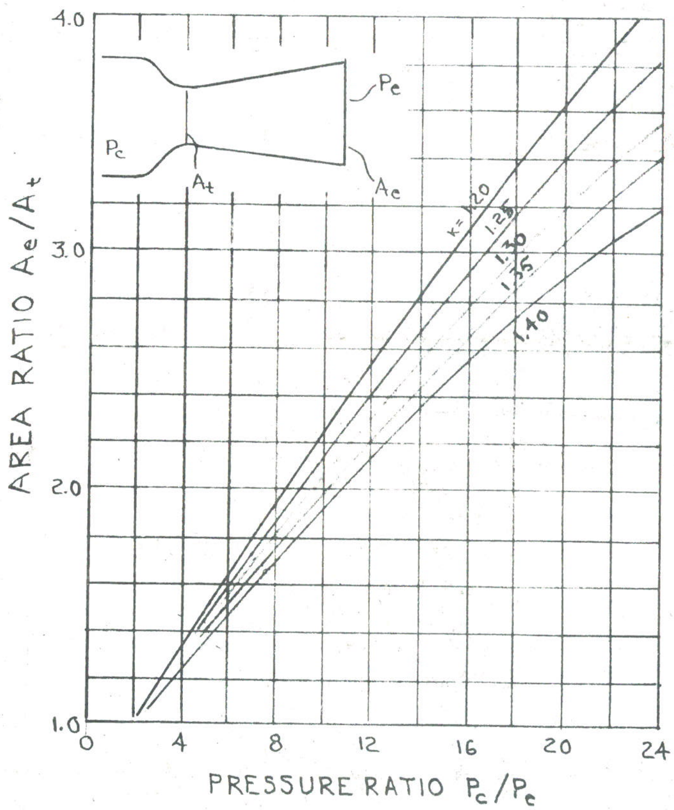
TABLE II

INSTRUMENTATION

PRIMARY DATA		
Data	**Instrument**	**Type**
Acceleration	Accelerometer	
Attitude	Gyroscope	Modified Summers K-7
Pressure	Pressure Transmitter	Giannini 46139
Altitude	Barograph	FAA sealed (?)
Radiation counter	Geiger-Muller	
Homing device	Transmitter	
Time base	Time generator	
Photographs	8mm movie camera	
CONTROL DATA		
Function	**Instrumentation**	**Type**
Primary Parachute ejection		
Ejector back-up	Timer	
Ejection indicator	Microswitch	
POWER SUPPLY		
Function	**Instrumentation**	**Type**
8-10 Channel telemetry	Transistor power supply	
D.C. power	Battery pack	
Ejector squib	Electric squib	Du-Pont S-67
Recorder supply	Gasoline generator	

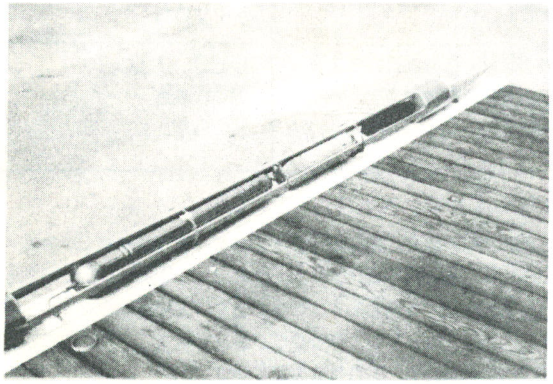
RECEIVER		
Function	Instrumentation	Type
Telemetry Records	Galvonometer (9 channel) Recorder (2 channel) Tape recorder	CEC 118 Brush Sony

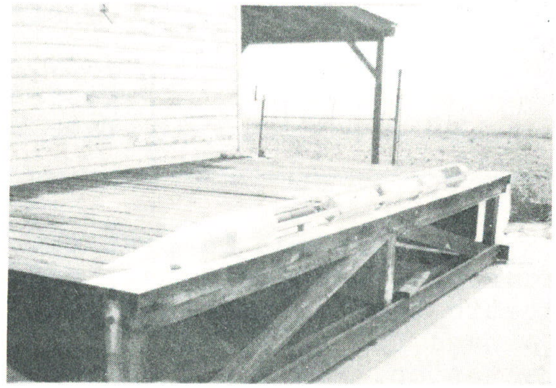
The project is past the large part of the first phase, researching and designing, and well into construction. The first static testing probably won't take place until early summer. There is need for additional help on this project, especially in instrumentation. We would certainly welcome any inquiries.

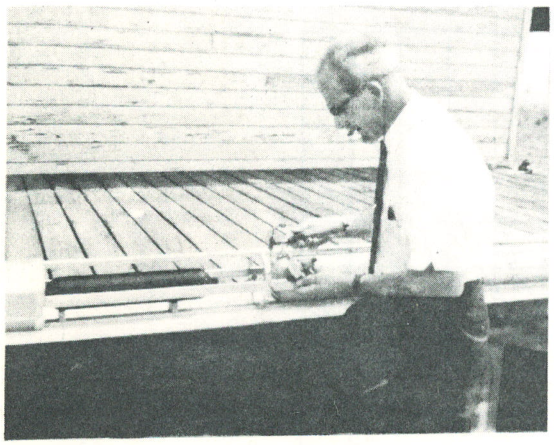


AREA RATIO A_e/A_t FOR AN EXHAUST NOZZLE AS A FUNCTION OF THE PRESSURE RATIO FOR DIFFERENT VALUES OF k

FIG. 4







PEROXIDE STRUCTURE
(Above left) A view of the H_2O_2-CH_3OH rocket showing tank arrangement. (Above) Second view emphasizing the 28-inch hollow fiberglass nosecone. (Left) George Dosa is shown fitting the pressure regulator to the nitrogen tank.

DENNIS SHUSTERMAN and Bob Schreiner replace railroad ties taken from the retaining wall of the trenches by vandals.

DRIFTED SAND is being removed by Maryann Butterfield from the bottom of the trenches to lower the floor to five feet. Note the completed bunkers in the background.

SECTION 8

EDITORIALS

FROM THE EDITOR: II

Somewhere between No. 98 and No. 100, THE RRS NEWS became a big thing. Perhaps because the RRS holds a considerable amount of importance itself.

This issue, a milestone at least in number, should be heralded as the biggest and best ever. But we make no such claim, for this way lies irresponsible journalism. We do present you with a magazine of comment, a magazine that contains information we believe will further your progress in rocketry. We present our post-firing reports, and the articles detailing the experiments attempted; we present our feature articles, a section we believe will become increasingly important as the high school and college student and adult investigate the more obscure (the more professional?) sides of rocketry; we present Section 8, that catch-all phrase for editorials and book reviews and letters and reports on what is happening.

A few notes on this issue: the magazine is printed by use of the multilith process, and allows a better reproduction than mimeograph. And happens to cost more than mimeograph, which means please don't expect this quality of print for every issue.

Secondly, please write.

Thirdly, suggestions for further refinements of our standard experimental rocket are in order.

And finally, your support, moral or financial (whichever is less painful), is deeply appreciated.

MORE ON THE PROPOSED REVISIONS OF CALIFORNIA LAW AFFECTING ROCKETRY

The Pacific Rocket Society of the Los Angeles area has made several suggestions toward formulating a position on amateur rocketry for the California Committee on Educational Rocketry (CCER). Prior to this time, most of the work has been with regard to model rocketry. The PRS feels that formal recognition should be given to the scientific value of amateur rocketry and the potential it has as an educational tool.

The first major point made is that the blanket requirement for public liability insurance be lifted, and be required in only those cases where some significant possibility of hazard to the non-participating public appears to exist. The PRS has suggested that the

CCER endorse the concept of operator licensing and facility permit.

A second major proposal concerns provisions for blanket operating permits, rather than the complex system of pre-firing and post-firing reports made after each testing. Such reporting should be limited to injuries, damage, or violations of law, and a statistical summary at the end of the year.

The third suggestion, one that is currently under study by the Reaction Research Society, is for the immediate provision for flight testing of liquid rockets. A member of the executive council of the RRS, and who is partially responsible for the tenor of the present law, is planning to present further recommendations during the early part of the coming year.

One final point asks that determination of facility adequacy be left to the discretion of the pyrotechnician, and not simply be at the mercy of numerical specifications.

RRS STANDARD EXPERIMENTAL ROCKET

After due consideration, the RRS has adopted the experimental Y-4 as its standard liquid rocket test vehicle.

The preliminary design is shown in the drawing on the opposite page.

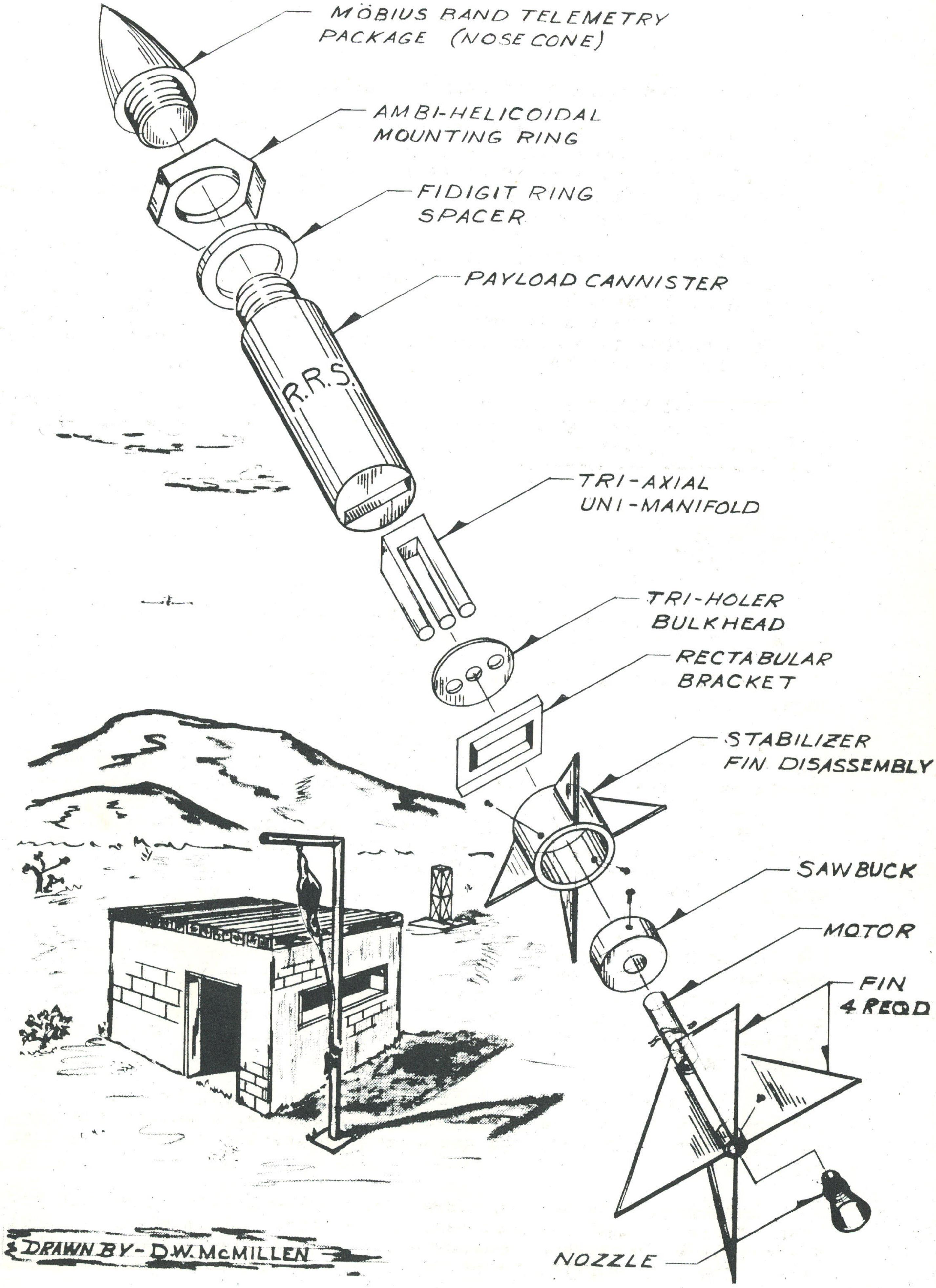
Static tests indicate that a stoichiometric mixture (1:1) of di-hydrogen oxide (oxidizer) and H_2O (fuel) is an ideal, inexpensive propellant for this program. The mixture has a specific impulse.

The nozzle will be of 4130 chrome-moly steel with a wood's metal throat insert. Erosion is expected to be minimal. The nozzle will be held in place with three 15/32-11 ambihelical headless capscrews with counter-clockwise threading.

The motor casing itself will be machined from a billet of a special high-temperature alloy (3115 steel alloyed with $BaNa_2$). The injector will be a new tri-conic design which employs the tri-axial uni-manifold. The manifolds were adapted from surplus U.S.M.C. three-pronged blivets. The manifold is to be mounted on a large ambihelicoidal manifold mounting ring which is then fused to the forward section.

A most interesting feature of this new design is the use of the Möbius band for the radio telemetry system, a sophistication usually found only on large government-supported rockets, such as Vanguard I.

The final fuel and oxidizer tank configurations have not yet been resolved. But several designs for cryogenic stainless steel Klein bottles have been presented for use as the di-hydrogen oxide tank. The only difficulty so far with this phase of the design has



MÖBIUS BAND TELEMETRY PACKAGE (NOSE CONE)
AMBI-HELICOIDAL MOUNTING RING
FIDIGIT RING SPACER
PAYLOAD CANNISTER
R.R.S.
TRI-AXIAL UNI-MANIFOLD
TRI-HOLER BULKHEAD
RECTABULAR BRACKET
STABILIZER FIN DISASSEMBLY
SAWBUCK
MOTOR
FIN 4 REQD
NOZZLE
DRAWN BY - D.W. McMILLEN

been the layout of the pressurization system for the tank. The fuel tank has presented no major design problems, and a prototype is under construction.

The fuel and oxidizer pressurization system is a unique method of gas pressurization achieved by injecting pellets of sodium acetyl salycilate directly into the tanks under a pressure of 1000 millibars. The sodium acetyl salycilate pellets are 1.29 inches in diameter and 0.153 thick. As much as we would like to take credit for this unique system we must admit that it was adapted from the system used on Spuntik I.

Further refinements of the design of the Y-4, and of course all phases of tests, static and dynamic, will be published exclusively in the RRS NEWS as soon as available.

BOOK REVIEWS

Peters, Robert L. Design of Liquid, Solid, and Hybrid Rockets. New York: Hayden Book Co., Inc., 1965

Here is a book which reduces the usual tedious design calculations to useful, nomograph forms. This excellent and rapid method can be used for quick preliminary calculations as well as being suitable for total system design.

Any amateur who dreams of launching a satellite would do well to read the first chapter before making any claim to having the knowledge, skill, or capabilities of putting a satellite into orbit.

Several of the nomographs have been tried and compare very favorably with previous calculations. As in any new book, there are some typographical errors. For example, page 15, step 2, calls for the use of the left index instead of calling it the center index as labelled. On page 41, Figure 5.1 shows a formula, $2(A_t)^{\frac{1}{2}}/\pi$, for a throat radius without any explanation. Undoubtedly, there are more; however the book is still a fabulous design tool and is very highly recommended.

To those who appreciate the value of nomographs, reference is made here to a very excellent article on the subject, elsewhere in this issue of THE RRS NEWS.

Tipper, C. F. H., ed. Oxidation and Combustion Reviews. New York: American Elsevier Publishing Company, 1965

This series of review articles is intended for professionals, and is most useful to those engaged directly in the field of oxidation studies. While the first volume encompasses many aspects of oxidation, only those processes involving molecular oxygen or NO_2 are reviewed.

It is hoped that future volumes include the important class of oxidation reactions involving atomic oxygen in its various electronic states.

The reviews are well written, and give an insight into the problems involved in these studies and the limitations in interpreting the results given.

United States Army Artillery and Missile School. A Guide to Amateur Rocketry. Fort Sill, Oklahoma, 1963

For the high school student, about to take his first ride along the trail of amateur rocketry, the reading material available is dismally short in supply. Up to now he has never heard of a co-efficient of thrust formula, let alone have one in his house, and the game of handing him George Sutton's Rocket Propulsion Elements might well be called Pin the Tail on the Donkey.

But there is one reference tool that is often overlooked. This is a fifty-two page pamphlet put out by the United States Army, prepared to assist the young scientist with his study of low impulse propellants. It is the same information that Captain Bertrand Brinley has based his Rocket Handbook For Amateurs on. The introduction is quite basic (perhaps pedantic?) but moves quickly enough into some of the tools of rocket engineering. It gives a clear definition of specific impulse, a good discussion of thrust and exhaust velocity.

Most of the information presented is intended to be used in solving problems with paper and pencil, while practical construction and ground support are left as details. (Admiral Rickover once suggested the best way to end the German war submarine menace would be to heat the ocean to 212°F, and render the ships immobile. When asked how, he replied that this was merely a detail, and not his job at all.)

We would recommend this Fort Sill home-owner's car manual to any high school group about to attempt amateur rocketry, but we point out that it is not satisfactory for those who might want to undertake any experimental work, or have a desire to learn engineering theory.

Page, Lou Williams, and Page, Thornton. Wanderers in the Sky. New York: Macmillan Company, 1965

Page and Page. Neighbors of the Earth.

This series of books has been compiled from articles published during the last thirty years in The Telescope, The Sky, and the periodical they merged to form, Sky and Telescope. The series is designed to inform the public of the developments in astronomy that have led to space technology, and to show how astronomy has developed from the ideas of a few years past.

The first, Wanderers in the Sky, deals only with the exploration of the solar system, covering some celestial mechanics, and noting some ground-based observations. Each of the articles is reproduced essentially as it originally appeared, with comments by the editors intended for today's reader, and not as a criticism of work of twenty years ago.

The second volume, Neighbors of the Earth, considers the terrestrial planets, and the observational data recorded about the environment and the surface conditions of these other "wanderers."

The series is truly impressive, and well worth the somewhat sizable expenditure to obtain.

Lent, Constantin Paul. Rocket-Jet Flying. New York: Pen-Ink Publishing Company, 1965

Rocket-Jet Flying is published, edited, written, and admired by Constantin P. Lent. It is a quarterly magazine that. . . wait, we'd better let him describe it for fear we might not get the superlatives in the right place:

"The journal has been published without interruption since 1945, and it's obviously the earliest commercial magazine in the field.

"Such magazines as Life, Look, Western Flying, Missiles and Rockets, et cetera, publish technical information on rockets as it becomes released by the various Federal Agencies. By that time it is old stuff. Rocket-Jet Flying is different. The journal is an 'ideas' magazine and predates the work in the field by the Space Agencies by at least two years. It has been responsible since 1945 in predicting of the things to come [sic]. As an 'ideas' magazine it has been and still is subscribed to by many government agencies here and abroad, by laboratories and most of the main libraries.

"The journal is edited by Constantin Paul Lent, an engineer and one of America's early rocket pioneers, and a former Vice-President of the American Rocket Society. He is the author of many books and articles on rockets. His book Rocket Research published in 1944 is considered to be the first book on liquid fueled regenerative rocket motors ever published.

"The journal is published by offset typography and is replete with illustrations, drawings and articles on rockets, space travel and other pertinent material. Subscription is $7.00 yearly."

And our opinion? Sliding over Constantin's ego (which is rather difficult for men of our girth), the magazine is poorly written, excellently illustrated, terribly impractical, and halfway informative. It should prove useful for a true enthusiast about rocketry and outer space, but not particularly helpful for the build 'em and test 'em kind of fanatic.

THE LOCAL SCENE

Excerpts from the minutes of the July 17, 1965, RRS meeting: Vandalism at the desert testing area was reported, with the western half of the south bunkers destroyed, and the water well partially filled with rocks. The repair work must be completed prior to any public launch. . . . The RRS intends to participate in the Shrine Auditorium Hobby Show, in late October. . . . The RRS has entered a bid for heavy machinery including two lathes, a metal brake, a mill, and an arc welder. . . . Dates set for August firing, for release of RRS NEWS 100.

Excerpts from the minutes of the September 7, 1965, RRS meeting: The society has received donation of 200 railroad ties from Southern Pacific. . . . bid for heavy machinery not accepted. . . . committees set up on public firing, on regulations for liquid rockets.

Excerpts from the minutes of the November 8, 1965, RRS meeting: RRS participation on Louis Lomax television interview show appears likely. . . . regular meetings set on second Monday of each month . . . . RRS is considering purchase of multilith printing equipment . . . . current analysis shows project to obtain water at the MTA to be beyond our means. . . . public firing committee report submitted. . . . participation in hobby show continues to be uncertain.

Mr. George Dosa, of the Reaction Research Society, has announced publication of his paper, Data Reduction and Drag. Mr. Dosa has written previous material on fin design, nosecone design, and tracking, and has now turned his attention to the important subject of drag.

As the former president of the National Cash Register Rocket Society, Mr. Dosa was instrumental in the writing of the California Fireworks laws dealing with amateur rocketry. He is concurrently directing the H_2O_2 project and working as a key member of the public relations committee of the RRS.

The paper is a report on data reduction on a standard Mark Series rocket. With certain basic data and photo tracking, it is possible to determine the behavior of the rocket through all phases of the flight. It's possible to arrive at "ball park" figures on thrust, drag, and performance. The final sections of the report introduce the notion of coefficient of drag, and present a graphical analysis of drag effect on performance.

We feel certain that it will hold an important place in the library of the serious student of amateur rocketry.

On October 9 and 10, the RRS sweated. Or rather the members did. They lifted and carried and dug and chopped and drilled and swore. All day and half the night. And a good part of the next day.

The occasion was that most gala of all events: the work party. Dress was casual, simply gloves and levis. Dutch cuisine. Cokes at 6:00, lunch at 12:00. Cokes at 3:00, supper at 7:30.

Some idiot had destroyed half of the south bunker at the Mojave Test Area in order to steal perhaps twenty railroad ties, and the RRS had to rebuild. The Southern Pacific Railroad was kind enough to give us as many ties as we needed, Richard Butterfield provided as many shovels as needed, and the bunkers were rebuilt.

Q.E.D.

The Society extends its thanks to the Associated Press for its kind permission to reprint the Zambia selection, and to Darwin McMillen for the artwork on the Y-4 standard rocket. Thanks also to Miss Roseanne Dymond for the cartoon appearing on the back cover.

We are deeply indebted to Mr. Ray Stagner for the loan of three Type-120 Rheem D.C. differential amplifiers, for use with our oscillograph recording system.

The trustees and president of Clark University are pleased to announce that the university's proposed new library will be named the "Robert Hutchings Goddard Library" to honor Dr. Goddard, father of the space age, distinguished alumnus, and professor of physics at Clark from 1914 to 1942.

Dr. Goddard's priceless personal and professional papers, which constitute the theoretical and technical foundations of modern rocketry, will occupy a prominent place in the Goddard Library at Clark.

These historic documents, along with Goddard memorabilia and other related materials which record the early history of the Space Age, will be permanently reserved in a special Goddard memorial area in the library. When the library is opened in 1968, future generations of historians and scientists and admirers of Dr. Goddard will be able to view and study these remarkable papers which literally have marked a turning point in the history of mankind.

The collection is the world's major source of original information about Dr. Goddard, his ideas, his research and his experiments. It was given to Clark University last fall by Mrs. Robert H. Goddard, the scientist's widow.

Foremost in the collection are Dr. Goddard's 214 patents, which Dr. von Braun has often said are "the essence of rocketry." Other important items include:

Dr. Goddard's diaries from 1898 to 1945, containing over 17,000 daily entries which give insight into the complex nature of the man;

Five green notebooks, running from 1906 to 1915, in which Dr. Goddard carries on a dialogue with himself in search of the theoretical solutions to rocketry and space flight;

Ten red notebooks, dated from 1924 to 1939, which contain notarized memoranda and sketches of his rocket devices;

A 1929 report which summarizes all of Dr. Goddard's work on liquid propellants, carried on at Clark from 1921 to 1929;

Twenty-three volumes of detailed notes which report on his experiments and test flights at Roswell, New Mexico, from 1930 to 1942;

Reports to his sponsors which outline test progress, and ideas and theories for future experiments; and

3600 feet of motion picture film which record test flights in Worcester and at Roswell.

LETTERS

Dear Sir:

We would like very much to receive the RRS NEWS regularly. Would you kindly enter a subscription on our behalf and bill us accordingly?

Thanking you, we remain,

CANADIAN ROCKET SOCIETY
M. Valeriote
President

Dear Sirs:

Yes, thank you, I did get a copy of RRS NEWS #99. It was forwarded to me at my address here. I thought it was very good; at least equal to AR [Amateur Rocketeer]. I plan to send for a subscription to it. In 1961 we launched three rockets which were similar to the Fort Sill Beta. The first tore loose from its static test stand and reached 8,000 feet without a nosecone; the second reached 15,000 feet and the third (carrying a second stage which exploded) reached 6,000 feet. Launches at Camp Pickett, Virginia, of Beta-type rockets have attained 22,500 feet. . . .

Our Beta-type rockets used the 78% Zn, 20% S, and 2% Al mixture, a rubber stopper to temporarily build up chamber pressure, a nichrome wire igniter, and a convergent (30) divergent (15) nozzle of 4130 steel with a 5/8-inch throat. Altitude was determined by tracking with radar provided by the USAF.

I would like very much to here from Larry Teebken. I thought his article was very good. He came to many of the same conclusions about micrograin as I did.

Jim Boland might investigate the effect of hydrides on NH_4ClO_4 decomposition. I have found they are more efficient accelerators.

On Page 17 (RRS NEWS #99) it says that a small percentage of copper chromite powder results in a reduction of the surface temperature without reducing the burning rate of perchlorate-oxidized propellants. My experience has been that the surface temperature (dependent primarily on the combustion temperature, grain, specific heat, and heat transfer properties of the foam, fizz and flame zones) remains relatively constant but the burning rate increases significantly.

Enclosed also are photos of the first two filament wound motors during firing. The propellant used was a rather old (and reliable) mixture of NH_4ClO_4, PBAA, Al, and epoxy resin, with a sea level I_{sp} of less than 300 seconds. A considerably more advanced propellant (not yet flight rated) will be used in the satellite rocket propulsion section. The advanced propellant will undergo tests beginning with the Block II test. Present tests are scheduled with the old propellant to get preliminary data on the required amount of insulation and nozzle deterioration. Initially, RTV-511 Silicone rubber is being used as insulation and has worked satisfactorily so far.

Bill Wood
Hill AFB, Utah

Dear Sirs:

Thank you for the latest copy of your RRS NEWS. I found it very interesting and informative. If at all possible, as suggested in the introductory letter in your latest issue, we (TAEC) would like to make an agreement with you whereby we would send you our own magazine (Theoretical Review) in return for yours. Would this arrangement meet with your approval? We publish eight times per year.

Erich Aggen, Jr.
Liberty, Missouri

Dear Mr. Butterfield:

I'm a sophomore at North Park College in Chicago and will transfer this winter to John Brown University to work toward an electrical engineering degree and towards graduate degrees in radio astronomy at a larger university. My interest in rocket research certainly has not waned, but due to the lack of funds and time in which to design motors and such, I've been set back. I want to continue in the future and would appreciate hearing from your group and about methods you have tried, through your publication.

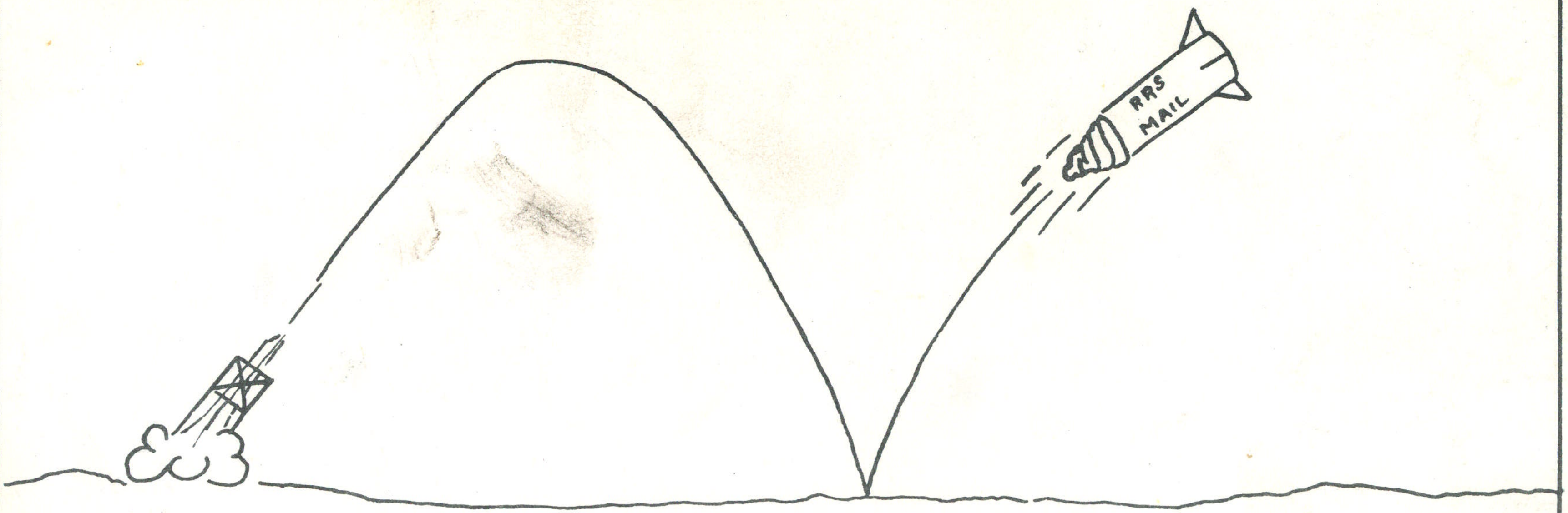
I'm particularly interested in altitude determination on a more reliable basis, workable parachute mechanisms, and the inclusion of radio equipment within the payload to study rotation patterns of the rocket, and perhaps a radio altimeter. As you're aware, the possibilities are limitless, but I'm trying to design a good workhorse which will support my numerous experiments. I'm interested, in view of astronomy, in infra-red and ultra-violet photographs.

Dennis Eckert
Chicago, Illinois

* I sat up all night last night trying to think of a clever advertisement for the NEWS.

* Did you think of one?

* No.



"SEE, GEORGE, I TOLD YOU NOT TO PUT FOAM RUBBER IN THE NOSE CONE"

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