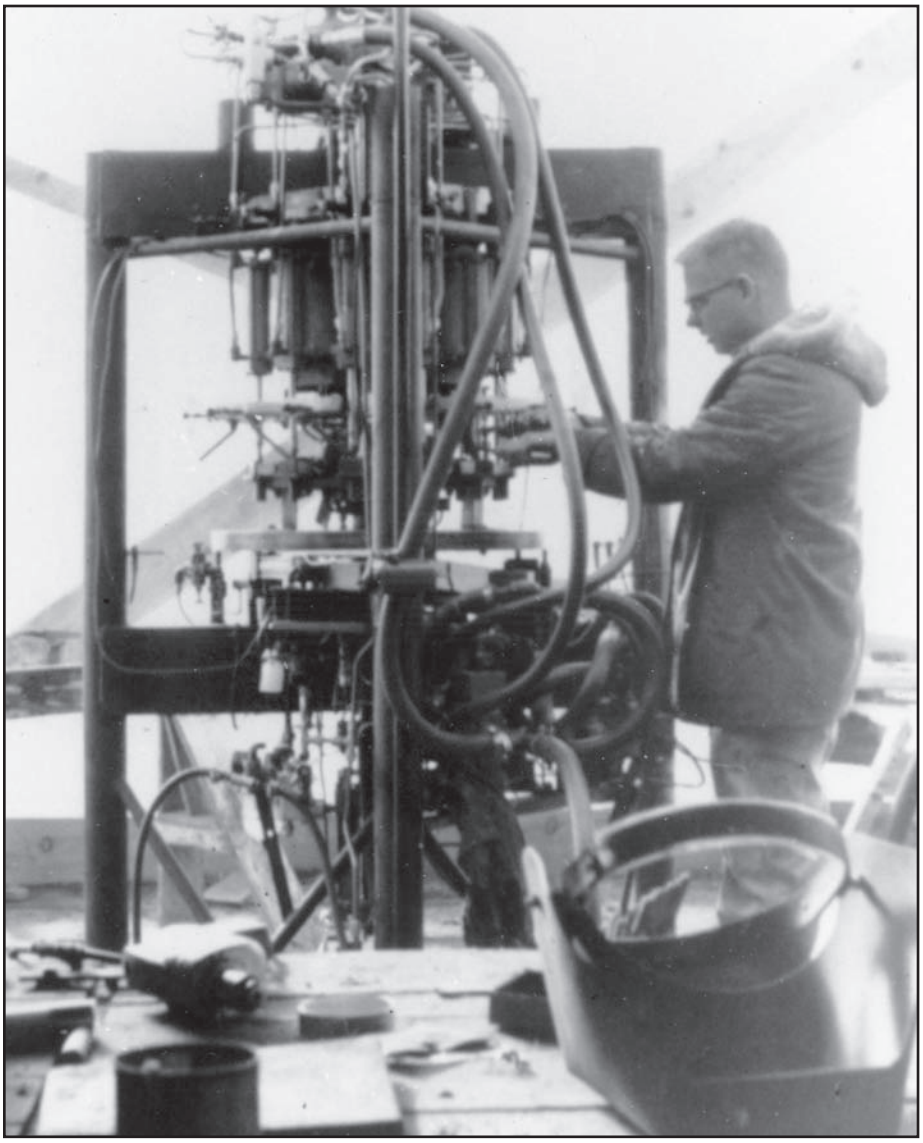


Vern Estes working to complete Mabel in late 1958. The plastic tent that Vern built to house Mabel when he started construction in July proved woefully inadequate against cold winter weather, but it was the best shelter available. Vern continued work on Mabel and Gleda even operated it for short periods while it was still in the plastic tent.

An Interview with Vern and Gleda Estes

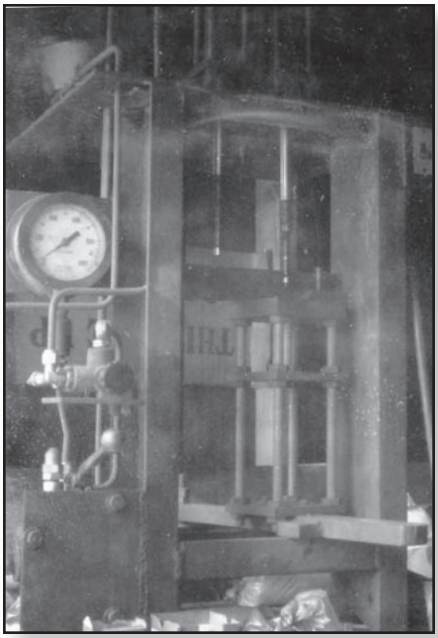
All About Mabel

Editor's note: This is a continuation of the interview from the previous issue of Sport Rocketry. This installment focuses on "Mabel," the rocket motor manufacturing machine that Vern built in 1958.

SR: Can you give us details about building your first motor making machine?

Gleda: During the time Vern was preparing to build the machine, later known as Mabel, he was looking for help on how it might be accomplished. His first effort was to contact an Engineering Consulting firm in Denver. An engineer came out, went over Vern's preliminary thoughts and ideas, and then said, "It can't be done!" That seemed like a "red flag to a bull" as Vern simply could not resist the challenge or give up on his project. He told me "I think he's wrong and I believe I *can* do it and make it work" and he was right. During Mabel's construction I frequently woke up in the middle of the night to find Vern gone. He would have come up with another way of doing something and would have to go to the workshop *right now* and try it out. It seemed like all of his thoughts and energy were directed toward just this one thing. Everything else had to wait.

Vern: I am an inventor at heart. I have always enjoyed making things, especially



making them with very little to work from. I'd as soon work from some old pieces of scrap iron as a piece of shiny new metal. So the fact that I had little resources to work with did not seem like a major problem. First I began thinking about what it would take. I knew I would be working with explosives so the first consideration was to not use electricity on the machine itself. Yet compressing loose black powder into a solid mass required a lot of force. Hydraulic pressure could easily do the job and the motors to run the pumps could be in a separate room with hoses run through the wall to the machine. Good enough—so with little to work with, how could this be accomplished?

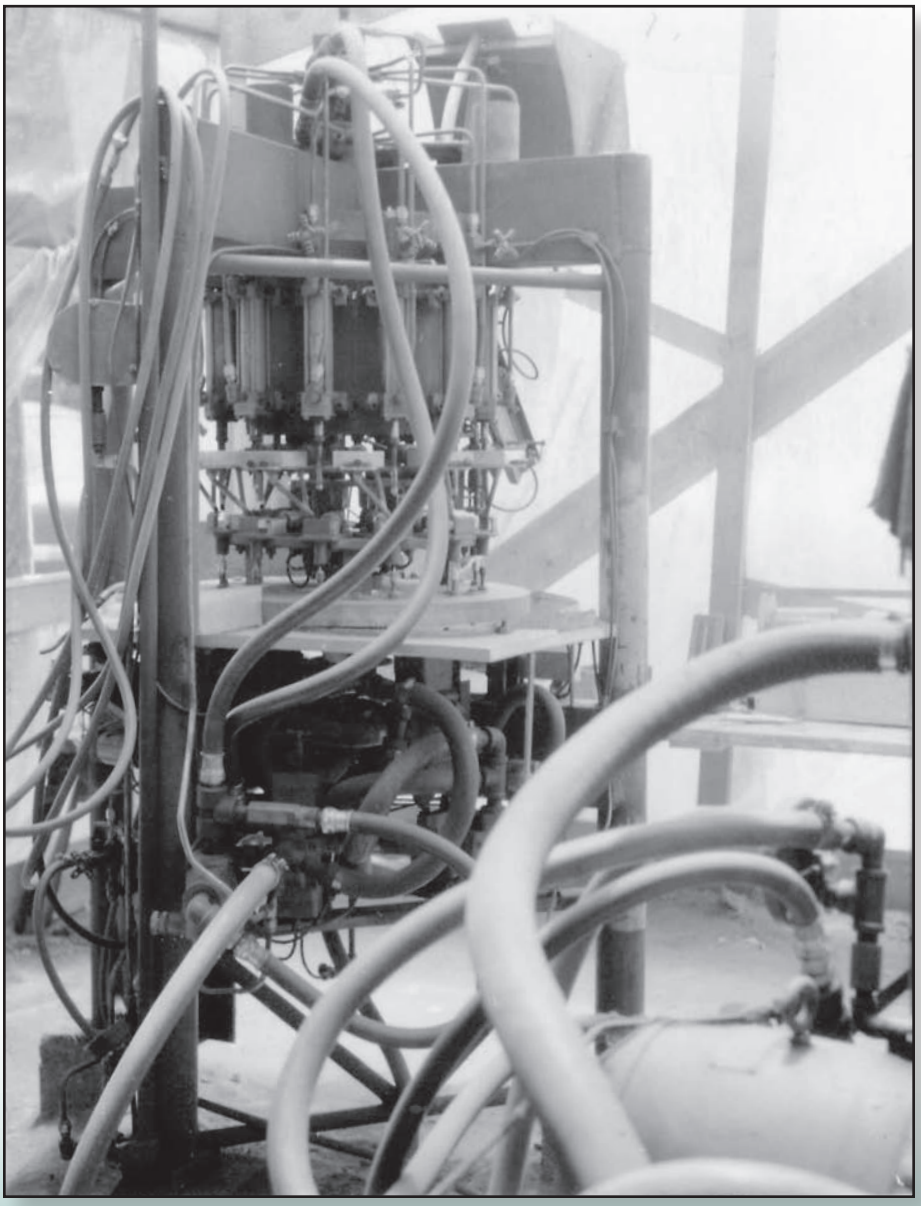
Vern built this test press in 1958 to determine how much compression pressure, what type and grain size of black powder, and what type of the engine tubes were needed to make successful rocket motors. These preliminary experiments were an important part of the development process that led to Mabel.

Realizing that I did not have enough specific information to proceed, I first built a small test press. This enabled me to determine such things as how much powder could be pressed at a time and how much pressure it would take, the best grain size for the propellant, the type of material to use to press the ceramic nozzle and the strength and type of tubes needed for the casings. Armed with this test information I had confidence it could be done and was ready to move ahead.

I began looking around. I visited a surplus store in south Denver and found a couple of used electric motors. I knew that for most of the cylinder travel time very little hydraulic pressure would be required. But, when the actual compression took place a lot of pressure would be needed. I began to think about a dual volume/pressure system. All I needed for such a system was two motors, two hydraulic pumps, and an appropriate valve setup for control so each system could do its specific job.

I had already spotted some suitable motors but not the hydraulic pumps. New pumps were expensive and not my first choice. So off to the junkyard I went. This time it was to an automobile salvage yard. I found just what I was looking for: two power steering pumps from wrecked Buicks. I got both of the pumps I needed for almost nothing.

I decided the best configuration for the machine was to use a circular table with multiple stations. My idea was for tubes to be fed onto the table at the first station, and then as the table advanced various components would be added until each motor



Mabel I nearing completion in December 1958, still inside the plastic tent. The hydraulic pumps can be seen in the lower right with hoses running to Mabel. Because the pumps were powered by electric motors, this was not a satisfactory situation. When Mabel was moved into its special building in back of the Estes home in Denver, the air compressor and hydraulic systems were housed in a separated part of the building, which had its own outside entrance.

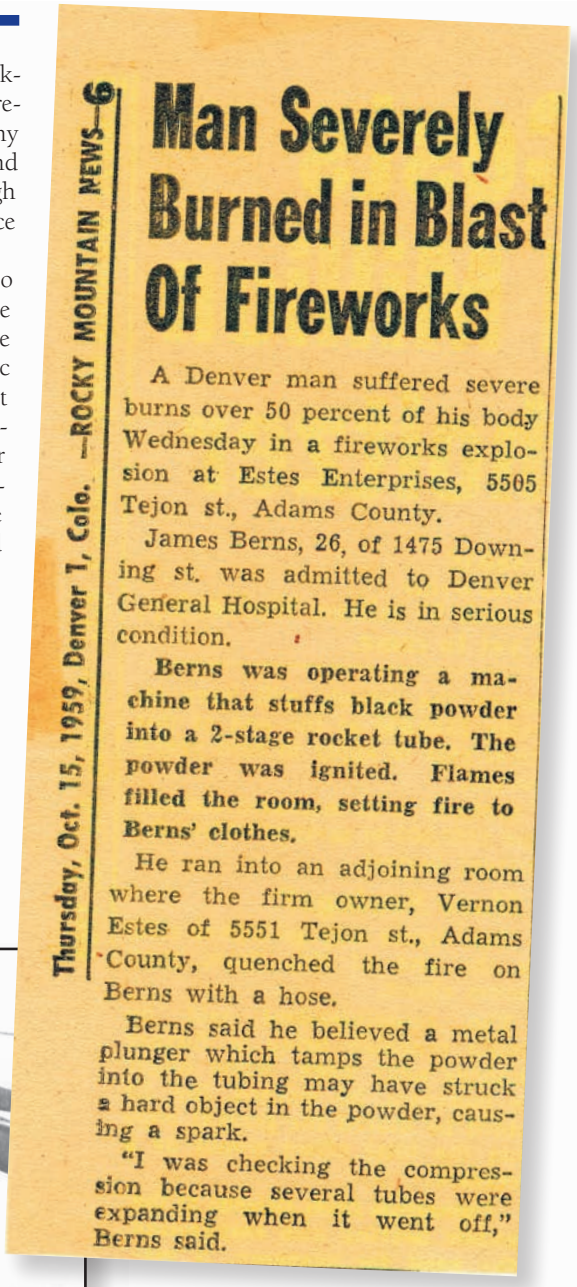
was completed. Then, at the final station, the completed motor would be ejected from the table. As it was ejected, the motor would drop into a printer for labeling.

I began to look around for a suitable circular table. There was a big scrap yard on South Santa Fe Drive that I had visited a couple of times in the past. Climbing through the mounds of scrap material I came upon a 2" thick by 24" round piece of steel that had been torch-cut from a larger sheet. I have no idea what someone was making when they carved out this little gem for me, but there it was and available at scrap metal prices. Although a bit heavy it was available, it would stand the pressure exerted by the hydraulic cylinders, and I just knew I could make it work.

Now a big piece of round heavy metal is not a rotating table. I needed to find a way to make it rotate. A friend of mine had torn apart the rear end of a truck that had the bearings and hub intact. He gave it to me and this served as the pivot mechanism for the table. I then rigged up a way for an air cylinder to engage the table to move it forward, then retract ready to repeat the operation after each compression cycle.

It took a lot of time and my other work suffered. I'd lay awake at night thinking about my project. Then, frequently an idea would pop into my head and I'd jump out of bed and head for the shop. It was as though I was driven by some strange force to make this project work.

So on and on it went. With no electricity on the machine, all the logic to make it run had to be done with compressed air (pneumatic logic). In simple terms this meant that as each operation was completed a small air valve would trigger signaling the start of the next operation. When all operations were completed the sequence would start again and continue to repeat until the operator pressed the stop button (or Mabel detected a problem and shut itself off). Much of the information on how to hook things up and make them go came from reading catalogs and other publications from suppliers. Day after day I learned new things and it all began to come together. From start of construction to first production the proj-



Thursday, Oct. 15, 1959, Denver 1, Colo. —ROCKY MOUNTAIN NEWS— 6

Man Severely Burned in Blast Of Fireworks

A Denver man suffered severe burns over 50 percent of his body Wednesday in a fireworks explosion at Estes Enterprises, 5505 Tejon st., Adams County.

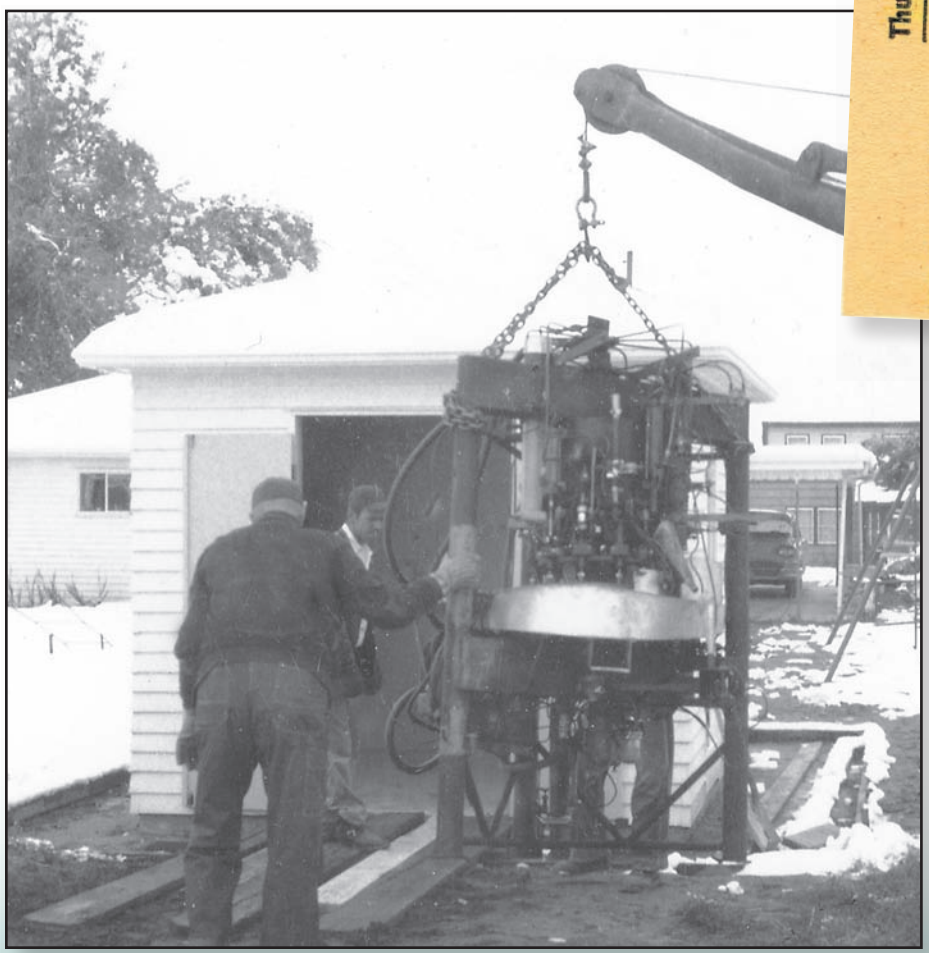
James Berns, 26, of 1475 Downing st. was admitted to Denver General Hospital. He is in serious condition.

Berns was operating a machine that stuffs black powder into a 2-stage rocket tube. The powder was ignited. Flames filled the room, setting fire to Berns' clothes.

He ran into an adjoining room where the firm owner, Vernon Estes of 5551 Tejon st., Adams County, quenched the fire on Berns with a hose.

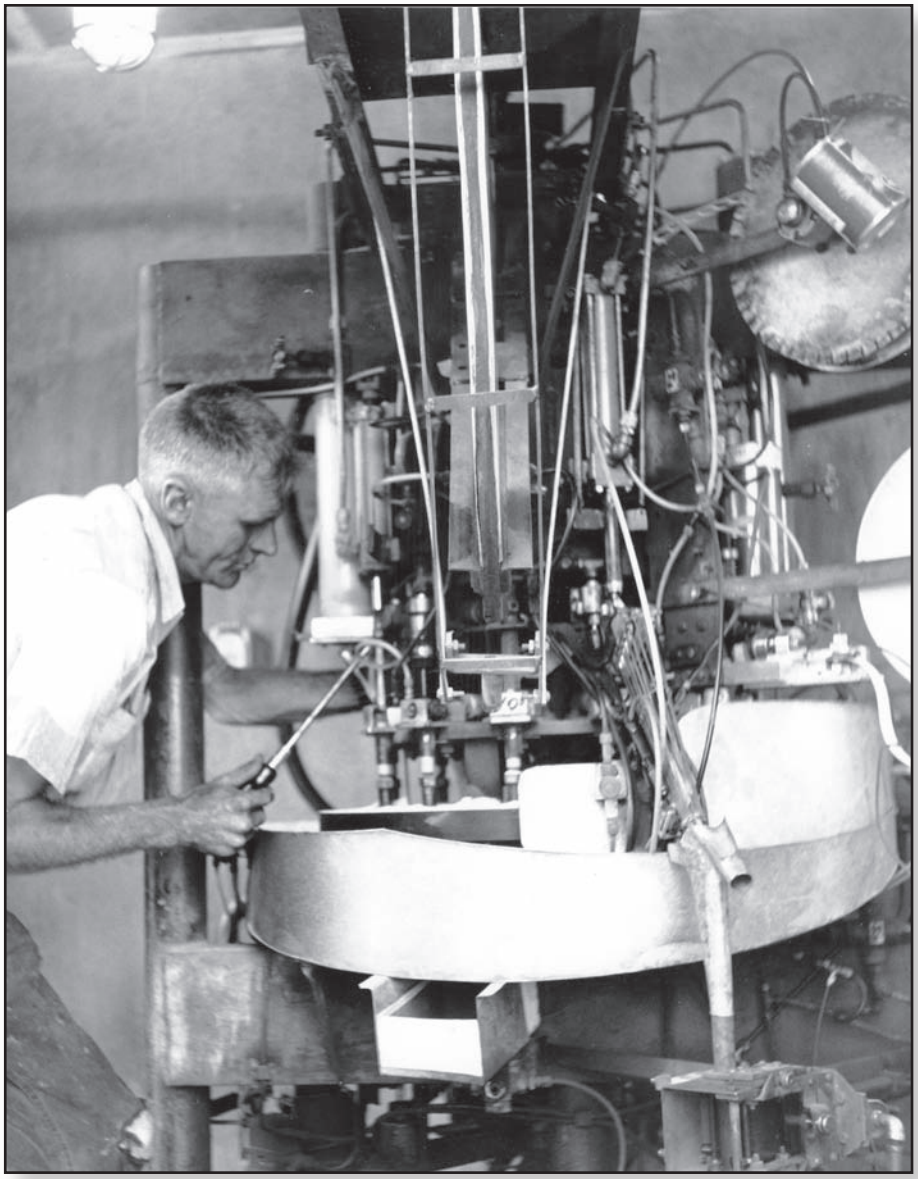
Berns said he believed a metal plunger which tamps the powder into the tubing may have struck a hard object in the powder, causing a spark.

"I was checking the compression because several tubes were expanding when it went off," Berns said.



Above: Newspaper clipping from October 1959 describing the first Mabel accident that seriously injured the operator and nearly led to Vern abandoning the model rocket business.

Left: A special building to house Mabel was constructed behind the Estes home in Denver. Mabel was moved into her new home on September 30, 1959, with the help of Rudy Strong (a neighbor and part-time employee) and Andy Gunderson.



ect took about six or seven months.

No plans were ever made of the machine that later became known as Mabel—just sketches of various parts and pieces as they were made, assembled and tested. Although Mabel was rather crude by comparison to today's machines at Estes she helped launch a hobby that is still enjoyed by millions.

SR: Were the later motor making machines something very different, or basically refinements of the first Mabel?

Vern: Later Mabels operated on the same basic principles as Mabel I. With experience behind us, a new method of loading and unloading the motor casings and completed motors was devised. The label printing was removed from this operation and the motors casings were printed before being loaded. New electric motors, hydraulic pumps, and rotating tables were now economically possible. In the original Mabel the motor casings were not mechanically supported, so sometimes they were deformed from the extreme pressure of compressing the propellant. Later Mabels

Below: John Schutz at outside controls operating Mabel in Denver in 1961. These controls outside the building were an attempt to improve safety. But in practice it was not always practical to "follow the rules." On a very windy day, John took refuge inside when another ignition incident occurred and he suffered moderate injuries.

Above: This photo taken by G. Harry Stine in 1960 appeared in his first edition of the *Handbook of Model Rocketry.* Vern expressed concern that it might provide too much information to competitors, so it was left out of future editions. John Schutz is making adjustments to one of the powder measures.

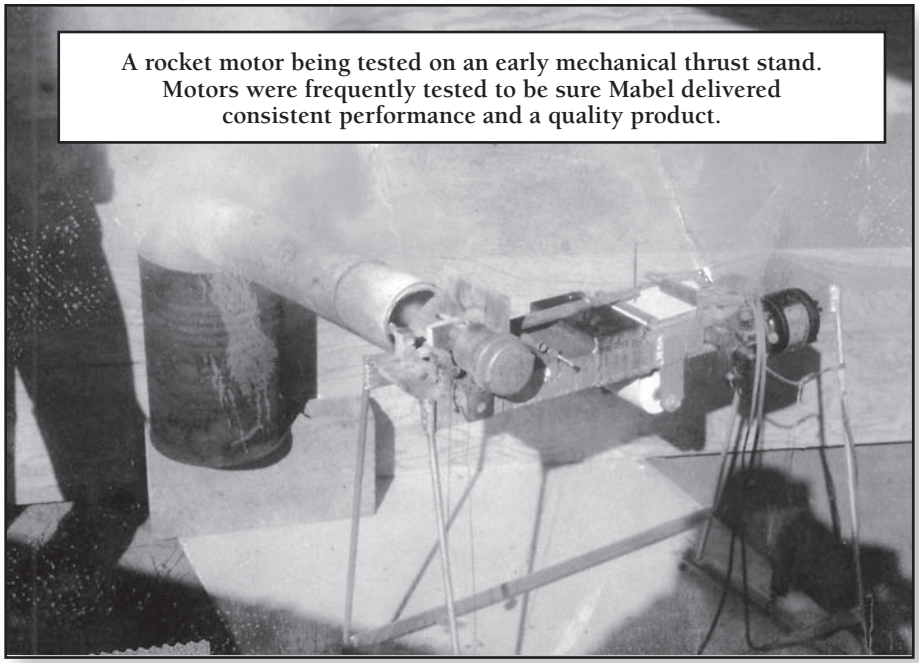
At the top of the photo is the motor tube hopper (black). The mechanism at lower right prints the markings onto the completed motors.

At upper right are the feed-out and take-up reels for the paper tape from which the paper ejection charge retaining end-caps were cut.

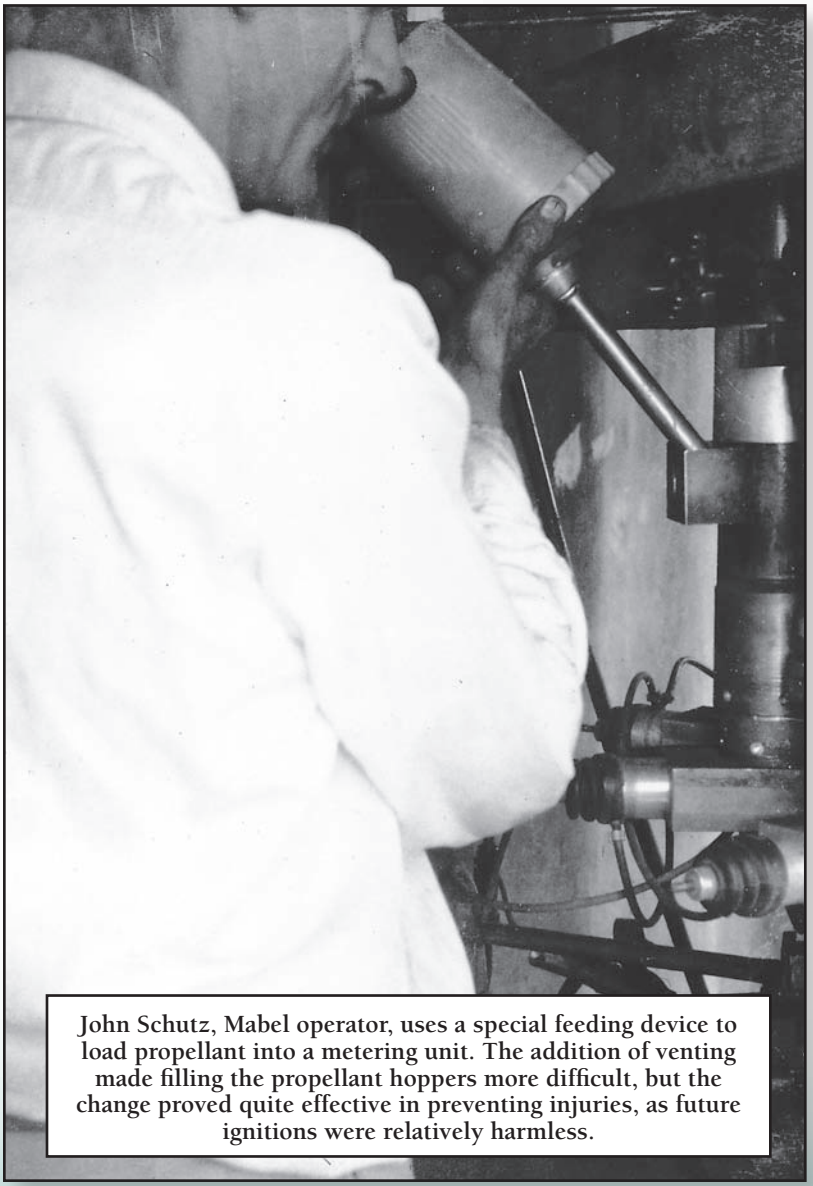
corrected this problem. One of the most important changes was a safety enhancement involving the way the propellant was stored and fed onto the machine. Some later Mabels cut production time to less than half of the original.

SR: How long did it take the first Mabel to go through all the steps needed to make an engine?

Vern: The original Mabel was capable of producing a completed motor every 5½ seconds. There were several fixed stations positioned above the rotating table. At the first station empty casings, picked up from a hopper, were loaded onto the table, then the table rotated and at the next station the nozzle material was loaded and pressed. This was followed by multiple positions where a small amount of propellant was compressed, then the delay would be loaded and compressed. Next was a station that dropped in a small amount of ejection powder and also provided for cutting, forming, and placing the paper end cap. At the final station the motor was ejected and sent through the printer and then dropped into a box below. If Mabel's inspection of the motor indicated a defect, a small air cylinder activated to divert that motor into a separate reject box. A counter kept track of the number of good motors produced.



A rocket motor being tested on an early mechanical thrust stand. Motors were frequently tested to be sure Mabel delivered consistent performance and a quality product.



John Schutz, Mabel operator, uses a special feeding device to load propellant into a metering unit. The addition of venting made filling the propellant hoppers more difficult, but the change proved quite effective in preventing injuries, as future ignitions were relatively harmless.

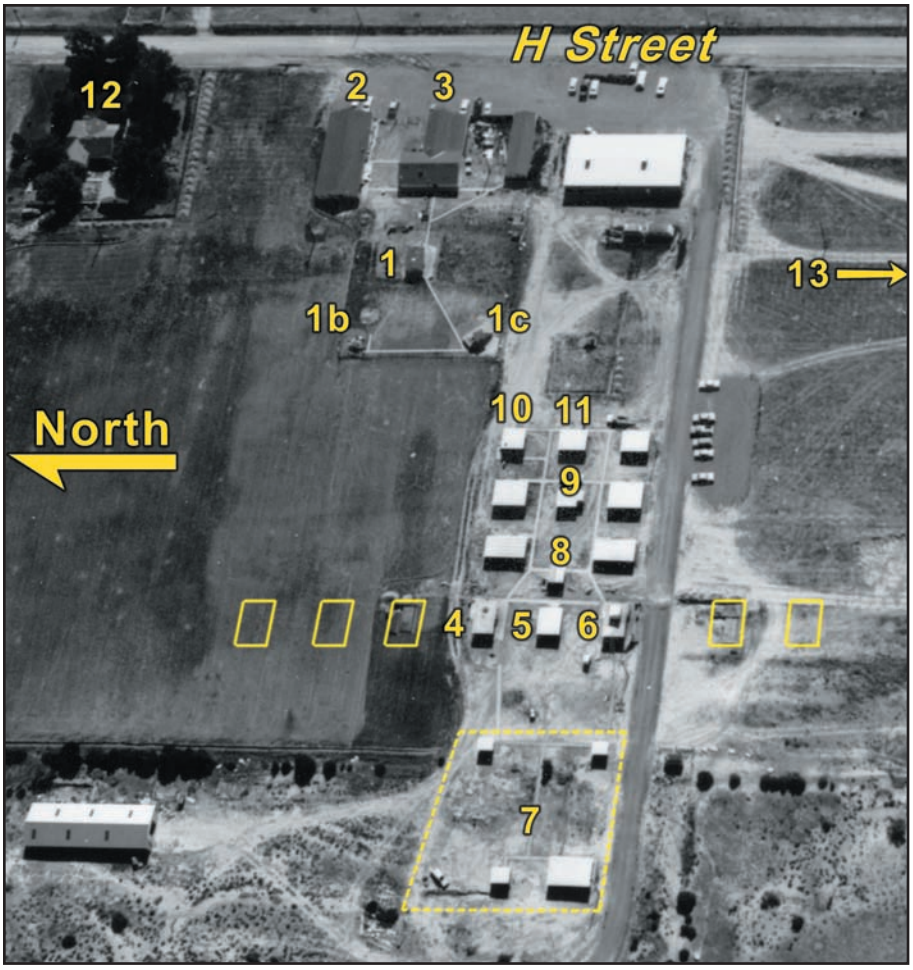
Mabel made her own distinctive sounds. The hum of the hydraulic system changed as it went from high pressure to low pressure then silenced as the fluid was bypassed during the rotating table advance. Bangs from the pick up device for the tubes was ever present as it moved up and down. Exhaust from the air valves and cylinders added to the variety of sounds—hisses, snaps, and pops. In Denver, Mabel's home was in our back yard and the sounds were ever present—real music to my ears.

SR: Why "Mabel" for the name of the rocket motor making machine?

Vern: For a short time a fellow by the name of Rudy Strong operated her. Mabel was designed to shut down if any part of the operation was not as it should be. On some occasions you would press the start button and nothing would happen. Then again, just when you thought you could turn your back on her and walk away she would turn off again. Rudy started calling her Mabel with the comment that he knew a lady by that name who was stubborn and acted exactly like that. Others operators agreed and the name stuck.

SR: What did Gleda think about you making a rocket motor machine...and the possible dangers involved? And about taking time away from your other job to pursue this new scheme?

Gleda: It was not the *first* time he had branched out from the construction business. However, I felt that the potential and the rewards of being able to help a young



Aerial view of the Estes engine manufacturing area in 1968. When moved to Penrose, Mabel I was first located in the small building (1) behind the woodshop (2) and machine shop (3). The small structures (1b & 1c) near Mabel's building were for powder storage and prep. Later, Mabel I was moved to a building (4) in the new engine manufacturing area, next to the compressor building (5) and Mabel II (6). Yellow rectangles mark the sites of later Mabels (construction can be seen at the sites for Mabels III and IV to the north and south). Propellant and smoke delay powders were mixed and stored in the buildings in the area (7) to the west. The static test stand (8) is located near the building where engine markings were printed (9). Series II (core burner) and Series III (short) engines received further processing in a building (10) located next to the office/lunch room (11). The other buildings in the cluster were for storage of completed engines. The Estes family residence (12) is visible, and the new main office building is off to the south (13).

generation of would-be rocketeers survive to become citizens was worth the financial risks. Also, I felt Vern was safety conscious and would not put himself at great risk. But, it wasn't easy. Vern's endless pursuit to build Mabel interfered with the time he could spend at his construction business. I was out of money to run the household and we even put our TV set up for sale. Vern tried to borrow money on the machine he was building and the banks wouldn't consider it. Eventually, we sold the construction business and that, along with the few mail orders that had begun to trickle in, gave us enough money to keep going and later make our move to Penrose.

Vern: I will let her speak for her feelings about it all. However, she was the first operator of Mabel and made the first rocket motors sold to Model Missiles. I would not have let her do this if I had been aware of the degree of danger she was subjected to. Mabel was just completed, still being debugged, and housed in a temporary plastic shelter that housed both Mabel and the electric motors to run her. It was a dangerous setup. A couple of accidents later I became agonizingly aware of just how dangerous this rocket motor making business could be.

SR: Was the operator of Mabel in the same room with the machine? I had the impression that the machines were operated automatically by remote control.

Vern: At first the operator was in the same room, which also included a few pounds of exposed propellant. When we had our first accident this propellant ignited causing severe burns to the operator. It was a very serious situation. Jim Berns, the operator, lay in the hospital in severe pain and near death. This accident almost ended my career in rocketry. *(When this happened I thought I should just shut things down and concentrate on my construction business. I am reasonably certain that my quitting would have changed the development of the hobby, or perhaps even killed it. Certainly others would have followed a different course with emphasis on issues other than those we chose to pursue.)* Then, just as Jim began to improve, an article appeared in the Denver Post describing in detail how a young boy was killed when a rocket he was making exploded. It seemed like I couldn't let go—I began to think about how Mabel might be redesigned to make the operation safer.

As part of this redesign Mabel's on-off controls were placed outside the building. The operating procedure was to not enter the building when Mabel was operating. On one very windy day this rule was not followed. An ignition occurred injuring the operator, but a lot less severely than with the earlier incident. Subsequent safety improvements were incorporated into the operation to make it safe for the operator to stand right beside the machine when it was running. The final improvements involved complete elimination of unprocessed propellant in the pressing room. In this case the propellant is fed from above with a concrete ceiling as the barrier between the unprocessed propellant and the room with operating personnel. The propellant hopper is housed in a structure with Styrofoam walls held in place by a steel framed structure. If an ignition occurs while a motor is being pressed, it will not necessarily transmit to the propellant hopper. If it does transmit to the hopper, the explosion that occurs will blow the Styrofoam walls to bits. Other than that, little damage occurs. No personnel are permitted in propellant storage areas when the machines are in operation. The lesson learned: Try to eliminate accidental ignitions of propellant during the operation, but just as important, make it safe to be there when all goes wrong. These final improvements have proved very successful.

Top: B.8-4 motor from 1959. Bottom: 1/2A.8-2 SM motor from late 1960 or early 1961. Both motors were produced in Denver. The "SM" stands for "smoke" —Estes had just changed the delay formulation to add smoke at that time.

SR: Were you always able to figure out the causes of the accidents?

Vern: Figuring out the exact trigger of an accident is virtually impossible in a situation like we had. Ramming black powder into paper casings can be extremely dangerous and we finally decided that we could not prevent an occasional ignition. Thus, our final solution to the problem was to have "zero" loose propellant in the room where the operations take place and installing a strong concrete barrier separating Mabel and her operator from a ***limited*** quantity of black powder. I learned the hard way and I hope no one else ever goes through the same thing.

One of the worst accidents in the manufacture of model rocket motors occurred in the 1960's in California. Cox (the model airplane manufacturer) decided to get into the model rocket hobby. Six workers were killed in a single accident. This accident caused them to give up on making motors. Today Estes owns Cox, but that has no relationship to this past incident.

I cannot overemphasize how dangerous the handling of explosive materials like black powder can be. I still have newspaper clippings relating to many, many accidents where individuals were injured or killed in attempts to make their own rocket motors. I will always urge individuals to "let the experts take the risk" and concentrate their efforts on other aspects of rocketry.

SR: I remember well the literature from Estes about the dangers of "basement bombers." Did you realize right away the danger that the basement bomber kids were putting themselves in, or was this point only apparent from your experiences making motors?

Vern: The Denver papers had frequent articles about kids getting injured or killed attempting to build their own rockets. I do not remember having associated the dangers they faced with what we were doing. I suppose it is human nature to think that you can escape those dangers just by being prudent and careful. I must confess I did not realize until we were well into the operation just how dangerous making rocket motors could be. I expect that gaining that knowledge first hand played a role in the extreme emphasis we placed on having our customers avoid this type of hazard.

SR: Did you have patents on certain aspects of Mabel that other motor manufacturers had to license? I recall a story that AVI had to quit making motors because Estes Industries revoked their license on some critical machine part.

Vern: I think that story is pure nonsense. We had no patents and did not have any specifics as to how other companies were making motors. I suspect they found their way of doing business was ineffective against the competition so closed up shop.

SR: How did you test the engines you were making?

Vern: MMI had been using a small postal scale to measure thrust, but that didn't give enough information. So I built a mechanical test stand that produced a thrust-time curve and let us measure peak thrust, total impulse, and time delay. The test stand used a roll of wide adding machine paper that was pulled under the writing stylus (a ball point pen) by a small gear motor at the rate of 1.0 inch per second. A pivot arm had a motor mount on one end and the ballpoint pen was on the other. The system had a damping mechanism, which consisted of a vane that "swished" through a built-in tank containing automotive antifreeze. A spring attached to the pivot arm had an adjusting screw to provide calibration. To read the data, the operator used a clear plastic layover sheet having grid markings of 0.1" x 0.1" and counted the squares. It was several years later, when my brother Earl left his engineering job at Hughes Aircraft to come to work for us in Penrose, that we went to electronic test systems.

SR: Did you ship engines in the "blue tubes" from the beginning, or did these come along later?

Vern: The blue tubes were the third generation of shipping containers. For a very short while we used a small rectangular box just large enough for three engines. We next shipped in red/brown tubes, which were identical to the blue tubes except for color. At the time only 3 rocket engines could be mailed in a single package, but there was no limit on the number of packages. The mailing tubes were very economical for us to obtain and package, so were ideal for our operation. We used the same tube to package our first kit, the Astron Scout.

SR: Do you have examples of the earliest engines Estes made (I'm wondering what the markings looked like)?

Vern: I have a Polaroid photo of engines taken as we were just starting to go mail order. I also have at least two actual engines (labeled as 'Rocket Motors') with the 5505 Tejon, Denver, Colorado, address that are from an early production run on Mabel. These engines, now nearly 50 years old, would probably work just as well as when made. But they are very rare and I plan to keep them in their present condition and not test them just to satisfy my curiosity. They will probably end up in the Smithsonian or other National museum with other early artifacts of model rocketry.

SR: Why did you decide to use the term "engine" instead of "motor" for Estes model rocket engines?

Vern: "Rocket Motor" was the designation used in our early production. We changed to calling them "Rocket Engines" following a discussion I had with G. Harry Stine about the proper nomenclature.

Above: Early B16 and 1/2A motors with the term "rocket motor" and the Denver address on the casings (circa late 1960 or early 1961). The B16 was the first Series II (core burner) motor, later redesignated "B3" when better thrust stand data should that its average thrust was 3 pounds, not 16 pounds (these are pre-metric motors).

Years later Harry and I were discussing the old days and he asked why I had used the term engine instead of motor. I responded that I had changed to engine because he had told me that was proper (I have always considered Harry an expert on such matters). Harry then set the record straight, saying that "motor" is the correct nomenclature, and that was what he had told me in our original discussion. I apparently had misunderstood Harry. As I understand it today, motor is probably the more accurate term, although not everyone agrees on this. As you can see in this article I use the terms interchangeably. However, I expect the "engine" designation will continue to be used when referring to propellant devices manufactured and sold by Estes Industries (and perhaps others). As one rocketeer put it, "Who cares what you call it. It is still that thing you put in the end of your rocket to make it scream skyward."

SR: Where did the idea of making booster engines come from?

Vern: The development of the multi-stage rocket was a joint effort between Bill Simon and myself. It is covered by Patent #3,292,302, for which the application was filed in September 1964 and issued in December of 1966. Through experimentation we had learned that it was possible to ignite an adjoining stage by "blow through" and making a lower stage engine simply meant setting Mabel to leave out the delay, ejection charge, and end cap.

Early B16 and 1/2A motors. Note the thicker casings used in these old motors, and the larger nozzle diameter of the core-burning B16.

One of the few disagreements we had with Centuri related to multi-staging. So far as we could determine, the technique they employed with their multi-staged rockets was in direct violation of our patent. We had requested that they cease and desist their infringement but Centuri continued its violation. At the time Damon acquired Centuri we were preparing for action through the courts. Of course the acquisition brought a halt to any such plans. I don't know who would have won that battle but I was glad it ended that way.

SR: Estes actually produced motors for Centuri. How did this come about and how long did it last?

Vern: Shortly after we moved to Penrose, Lee Piester came to visit following NARAM held in Colorado. Lee was starting a model rocket company and proposed our selling them rocket engines. At the time Mabel was running well and capable of making far more rocket engines than we were selling. Our fledging company could certainly use the extra cash so we shook on a deal.

Our business continued to grow at a rapid rate and so did Centuri. In spite of running Mabel on a 24/7 schedule the day came when she could no longer keep up. It was a painful situation. We had obligations to serve our mail order customers and a conflicting obligation to provide rocket engines to Centuri. We did our best to balance the situation but it caused difficulty for both companies. Mabel II was under construction but for several months we shared the limited engine supply with our #1 competitor.

We were still selling motors to Centuri at the time we sold Estes to Damon. However, Centuri had been developing motor manufacturing equipment and facilities at their Chandler location. I believe they had just started producing on their own at the time Damon acquired Centuri. The motor equipment built by Centuri was moved to Penrose. It was not compatible with the methods and facilities we were using so it was never put into service.

SR: What became of the original Mabel I machine?

Vern: Mabel I, and the Centuri motor making machines mentioned above, were sold to a local salvage yard sometime in the mid to late 1970's. This was done while I was out of town and was unaware of the sale until it was too late. I believe this equipment, especially Mabel, had a place in history that should have been preserved. If she were still around, she would soon be celebrating her 50th birthday.