The Rocket Pioneers

by Frank J. Malina

The late Frank J. Malina inaugurated the jet age 50 years ago with the construction and test-firing of the first liquid-fueled rocket motor in the Arroyo Seco. In this article, adapted from one he wrote for E&S *in 1968, he describes those exciting early days of rocketry at Caltech.*

MY INTEREST IN SPACE EXPLORATION was first aroused when I read Jules Verne's *De la Terre a la Lune* in the Czech language as a boy of 12 in Czechoslovakia, where my family lived from 1920 to 1925. On our return to Texas I followed reports on rocket work which appeared from time to time in popular magazines.

In 1934 I received a scholarship to study mechanical engineering at Caltech. Before the end of my first year there I began part-time work as a member of the crew of the GALCIT (Guggenheim Aeronautical Laboratory, California Institute of Technology) 10-foot wind tunnel. This led to my appointment in 1935 as a graduate assistant in GALCIT.

The Guggenheim laboratory at this time, a few years after its founding, was recognized as one of the world centers of aeronautical instruction and research. Under the leadership of Theodore von Kármán, GALCIT specialized in aerodynamics, fluid mechanics, and structures. Von Kármán's senior staff included Clark B. Millikan, Ernest E. Sechler, and Arthur L. Klein. The laboratory was already carrying out studies on the problems of high-speed flight, and the limits of the propeller-engine propulsion system for aircraft were beginning to be clearly recognized.

In 1935-36 William W. Jenney and I conducted experiments with model propellers in the wind tunnel for our master's theses. My mind turned more and more to the possibilities of rocket propulsion while we analyzed the characteristics of propellers.

In March 1935 at one of the weekly GALCIT seminars, William Bollay, then a graduate assistant under von Kármán, reviewed the possibilities of a rocket-powered aircraft based upon a paper published in December 1934 by Eugen Sänger, who was then working in Vienna. The following October Bollay gave a lecture on the subject before the Institute of the Aeronautical Sciences in Los Angeles.

Local newspapers reported on Bollay's lecture, which resulted in attracting to GALCIT two rocket enthusiasts — John W. Parsons and Edward S. Forman. Parsons was a self-trained chemist who, although he lacked the discipline of a formal higher education, had an uninhibited and fruitful imagination. He loved poetry and the exotic aspects of life. Forman, a skilled mechanic, had been working for some time with Parsons on powder rockets. They wanted to build a liquid-propellant rocket motor but found that they lacked adequate technical and financial resources for the task. They hoped to find help at Caltech. They were sent to me, and that was the beginning of the story which led to the establishment of the Jet Propulsion Laboratory.

We reviewed the literature published by the first generation of space flight pioneers — Ziolkowsky, Goddard, Esnault-Pelterie, and

Oberth. In scientific circles this literature was generally regarded as science fiction, primarily because the gap between the experimental demonstration of rocket-engine capabilities and the actual requirements of rocket propulsion for space flight was so fantastically great. This negative attitude extended to rocket propulsion itself, in spite of the fact that Goddard realistically faced the situation by deciding to apply this type of propulsion to a vehicle for carrying instruments to altitudes in excess of those that can be reached by balloons — an application for an engine of much more modest performance.

We concluded from our review of the existing information on rocket-engine design that it was not possible to design an engine to meet specified performance requirements for a sounding rocket to surpass the altitudes attainable by balloons. After much argument, we decided that until someone could design a workable engine with a reasonable specific impulse there was no point in devoting effort to the design of the rocket shell, propellant supply, stabilizer, launching method, and payload parachute.

We therefore set as our initial program the following: (a) theoretical studies of the thermodynamical problems of the reaction principle and of the flight performance requirements of a sounding rocket; and (b) elementary experiments of liquid- and solid-propellant rocket engines to determine the problems to be met in making accurate statistical tests. This approach was in the spirit of von Kármán's teaching. He always stressed the importance of getting as clear an understanding as possible of the fundamental physical principles of a problem before initiating experiments in a purely empirical manner, which can be very expensive in both time and money.

Parsons and Forman were not too pleased with an austere program that did not include at least the launching of model rockets. They could not resist the temptation of firing some models with black powder motors during the next three years. Their attitude is symptomatic of the anxiety of pioneers of new technological developments. In order to obtain support for their dreams, they are under pressure to demonstrate them before

This photo, taken in the Arroyo Seco in 1936, shows the first liquid-fueled rocket motor and the men who built it. The man at the left is unidentified. The others are, left to right, Apollo M.O. Smith, Frank J. Malina, Edward S. Forman, and John W. Parsons.

they can be technically accomplished. Thus there were during this period attempts to make rocket flights which were doomed to be disappointing and which made support even more difficult to obtain.

The undertaking we had set for ourselves required, at a minimum, informal permission from Caltech and from the Guggenheim laboratory before we could begin. In March I proposed to Clark Millikan that my thesis be devoted to studies of the problems of rocket propulsion and of sounding rocket flight performance. He was, however, dubious about the future of rocket propulsion and suggested I should, instead, take one of the many engineering positions available in the aircraft industry at that time. His advice was no doubt also influenced by the fact that GALCIT was not then carrying out any research on aircraft power plants. Later he supported our work.

I knew that my hopes rested finally with von Kármán. He was at this time studying the aerodynamics of aircraft at high speeds and was well aware of the need for a propulsion system which would surmount the limitations of the engine-propeller combination. After considering my proposals for a few days, von Kármán agreed to them and gave permission for Parsons and Forman to work with me, even though they were neither students nor on the staff at Caltech. This decision was typical of his unorthodox attitude within the academic world. He pointed out, however, that he could not find funds.

During the next three years we received no pay for our work, and during the first year we bought equipment — some secondhand — with whatever money we could pool together. Most of our work was done on weekends or at night.

We began our experiments with the construction of an uncooled rocket motor similar in design to one that had been previously tried by the American Rocket Society. For propellants we chose gaseous oxygen and methyl alcohol.

Our work in the spring of 1936 attracted two GALCIT graduate students, A.M.O. Smith and Hsue Shen Tsien. Smith was working on his master's degree in aeronautics; Tsien, who became one of the outstanding pupils of von Kármán, was working on his doctorate. Smith and I began a theoretical analysis of flight performance of a sounding rocket, while Tsien and I began studies of the thermodynamic problems of the rocket motor.

The group heard with excitement that Robert H. Goddard would come to Caltech in August to visit Robert Millikan. Millikan arranged for me to have a short discussion with Goddard on August 28, during which I told him of our hopes and research plans. I also arranged to visit him at Roswell, New Mexico, the next month, when I was going for a holiday to my parents' home in Brenham, Texas.

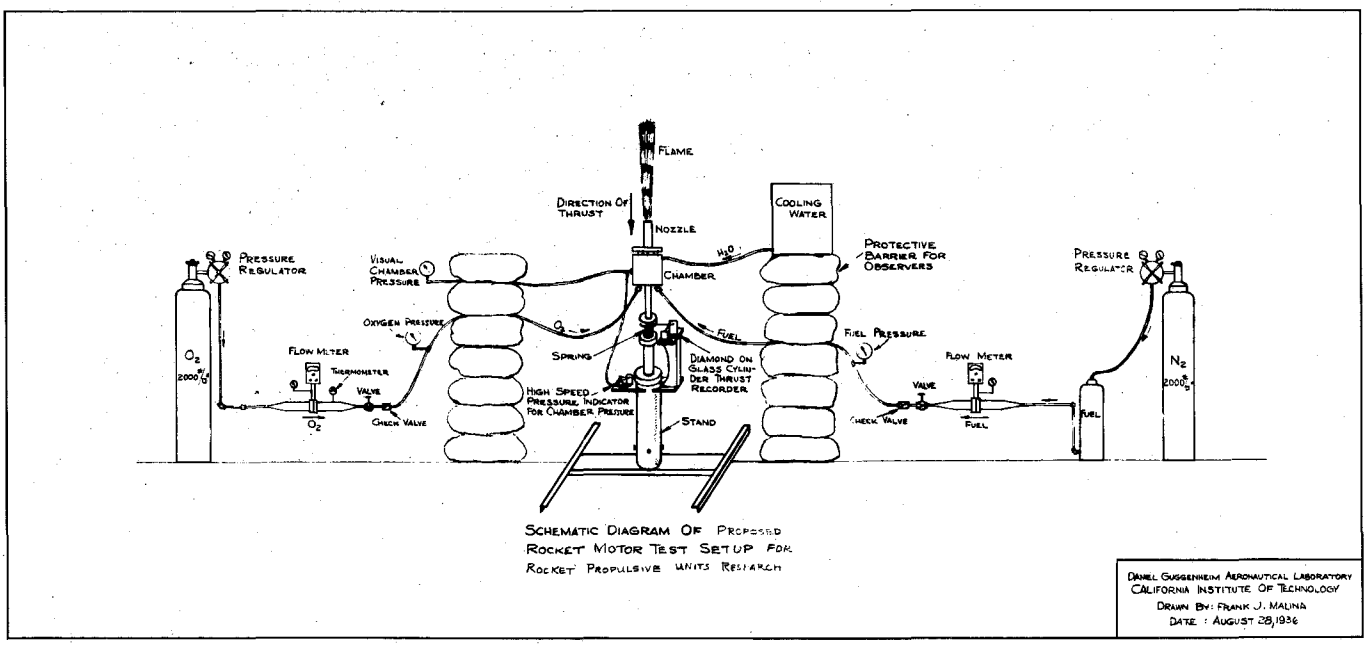
Both Dr. and Mrs. Goddard received me cordially. My day with him consisted of a tour of his shop (where I was *not* shown any components of his sounding rocket), a drive to his launching range to see his launching tower and 2,000-lb.-thrust static test stand, and a general discussion during and after lunch. He did not wish to give any technical details of his current work beyond that which he had published in his 1936 Smithsonian Institution report, with which I was already familiar. This report was of a very general nature and of limited usefulness to serious students.

The impression I obtained was that Goddard felt that rockets were his private preserve, so that any others working on them took on the aspect of intruders. He did not appear to realize that in other countries there were men who had arrived, independently of him, at the same basic ideas for rocket propulsion, as so frequently happens in technology.

Von Kármán in his autobiography, *The Wind and Beyond*, writes:

> I believe Goddard became bitter in his later years because he had no real success with rockets, while Aerojet-General Corporation and other organizations were making an industry out of them. There is no direct line from Goddard to present-day rocketry. He is on a branch that died. He was an inventive man and had a good scientific foundation, but he was not a creator of science, and he took himself too seriously. If he had taken others into his confidence, I think he would have developed workable high-altitude rockets and his achievements would have been greater than they were. But not listening to, or communicating with, other qualified people hindered his accomplishments.

On October 29, 1936, the first try of the portable test equipment was made for the gaseous oxygen-methyl alcohol rocket motor



in the area of the Arroyo Seco back of Devil's Gate Dam on the western edge of Pasadena — a stone's throw from the present-day Jet Propulsion Laboratory. I learned several years later from Clarence N. Hickman that he and Goddard had conducted smokeless-powder armament rocket experiments at this same location during World War I. On October 31 we tested the rocket motor itself. The next day I wrote home as follows:

> This has been a very busy week. We made our first test on the rocket motor yesterday. It is almost inconceivable how much there is to be done and thought of to make as simple a test as we made. We have been thinking about it for about six months now, although we had to get all the equipment together in two days, not by choice, but because there are classes, and hours in the wind tunnel to be spent. Friday we drove back and forth to Los Angeles picking up pressure tanks, fittings, and instruments. Saturday morning at 3:30 a.m. we felt the setup was along far enough to go home and snatch three hours of sleep. At 9 a.m. an Institute truck took our heaviest parts to the Arroyo, about three miles above the Rose Bowl, where we found an ideal location. Besides Parsons and me, there were two students working in the N.Y.A. working for us. It was 1 p.m. before all our holes were dug, sandbags filled, and equipment checked. By then Carlos Wood and Rockefeller had arrived with two of the box type movie cameras for recording the action of the motor. Bill Bollay and his wife also came to watch from behind the dump.
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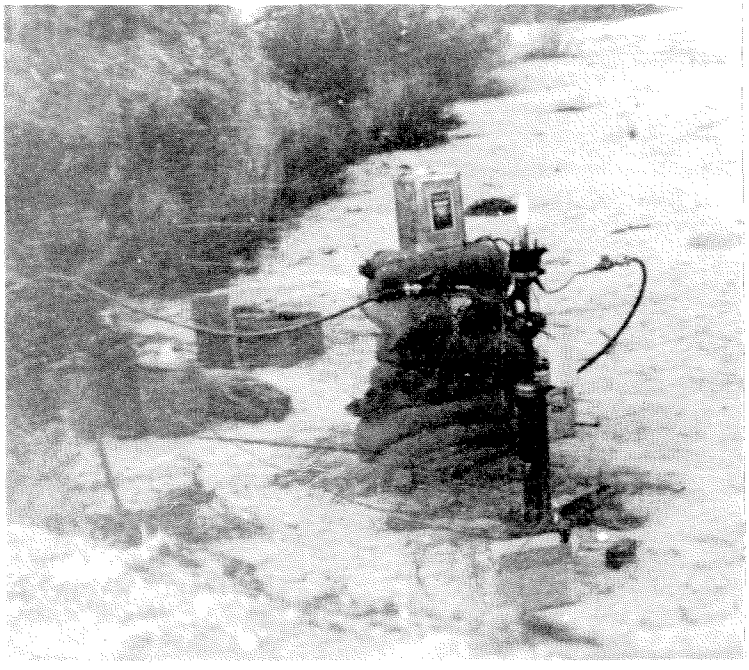
> Very many things happened that will teach us what to do next time. The most excitement took place on the last "shot" when the oxygen hose for some reason ignited and swung around on the ground, 40 feet from us. We all tore out across the country wondering if our check valves would work. Unfortunately, Carlos and Rocky had to leave just before this "shot" so that we have no record on



The rocket motor fires.

film of what happened. As a whole the test was successful.

We made a number of tests with this transportable setup, the last one on January 16, 1937, when the motor ran for 44 seconds at a chamber pressure of 75 lbs. per square inch.

In March 1937 Smith and I completed our analysis of the flight performance of a constant-thrust sounding rocket. The results were so encouraging that our project obtained from von Kármán the continued moral support of GALCIT. We were authorized to conduct small-scale rocket motor tests in the laboratory. This permitted us to reduce the time we wasted putting up and down the transportable equipment we had used in the Arroyo Seco. Von Kármán also asked me to give a report on the results of our first year's work at the GALCIT seminar at the end of April.

The unexpected result of the seminar was the offer of the first financial support for our project. Weld Arnold, then an assistant in the astrophysical laboratory at Caltech, came to me and said that in return for being permitted to work with our group as a photographer he would make a contribution of $1,000. His offer was accepted with alacrity, for our project was destitute.

Arnold, who commuted the five miles betweeen Glendale and Caltech by bicycle, brought the first $100 for our project in one-dollar and five-dollar bills in a bundle wrapped in newspaper. We never learned how he had accumulated them. When I placed the bundle on Clark Millikan's desk with the question, "How do we open a fund at Caltech for our project?" he was flabbergasted.

In 1942 the Jet Propulsion laboratory consisted of just a few buildings in the Arroyo Seco, close to the site of the original rocket-motor firing. This location is at the eastern edge of the grounds of today's JPL.

When von Kármán gave the group permission to make small-scale experiments of rocket motors at GALCIT, we decided to mount a motor and propellant supply on a bob of a 50-foot ballistic pendulum, using the deflection of the pendulum to measure thrust. The pendulum was suspended from the third floor of the laboratory with the bob in the basement. We planned to make tests with various oxidizer-fuel combinations.

We selected the combination of methyl alcohol and nitrogen dioxide for our initial try. Our first mishap occurred when Smith and I were trying to get a quantity of the nitrogen dioxide from a cylinder we had placed on the lawn in front of Gates Chemistry Laboratory. The valve on the cylinder jammed, causing a fountain of the corrosive liquid to erupt all over the lawn. This left a brown patch there for several weeks, to the irritation of the gardener.

When we finally tried an experiment with the motor on the pendulum, there was a misfire. The result was that a cloud of nitrogen dioxide-alcohol mixture permeated most of GALCIT, leaving behind a thin layer of rust on much of the permanent equipment of the laboratory. We were thrown out of the building the next day, of course.

Then we built what we called the gas apparatus on the outside of Guggenheim. It must have been about 1939 when that blew up. It's quite possible that I might have been done in by that explosion, but von Kármán had called his secretary and asked if I would bring him a typewriter at home. I hopped in my Model A Ford, put the typewriter in it and drove to his house. When I came back I saw many people standing around. As I came closer and closer to the end of the building, I began to see pieces of the apparatus on the ground, and I realized something terrible had happened. Fortunately, neither Parsons nor Forman was hurt; they were shaken up a bit. But where I had been sitting before I left, a piece of a pressure gauge had blown right across where my head would have been and buried itself in a piece of wood. It was at this time that we began to be known on the campus as the "suicide squad."

From the beginning the work of the group on rocket research at GALCIT attracted the attention of newspapers and popular scientific

journals. Since our work was not then classified as "secret," we were not averse to discussing with journalists our plans and results. There were times that we were abashed by the sensational interpretations given of our work, for we tended to be, if anything, too conservative in our estimates of its implications.

The fact that our work was having a real impact in America came from two sources. In May 1938 von Kármán had received an inkling that the U.S. Army Air Corps was getting interested in rocket propulsion.

Then, in August 1938, Ruben Fleet, the president of the Consolidated Aircraft Co. of San Diego, approached GALCIT for information on the possibility of using rockets for assisting the takeoff of large aircraft, especially flying boats. I went to San Diego to discuss the matter and prepared a report entitled "The Rocket Motor and its Application as an Auxiliary to the Power Plants of Conventional Aircraft." I concluded that the rocket engine was particularly adaptable for assisting the takeoff of aircraft, ascending to operating altitude, and reaching high speeds. The Consolidated Aircraft Co. appears to have been the first American commercial organization to recognize the potential importance of rocket-assisted aircraft takeoff. But in October 1938 a senior officer of the U.S. Army Ordnance Division paid a visit to Caltech and informed our group that on the basis of the Army's experience with rockets he thought there was little possibility of using them for military purposes! It was not until 1943 that liquid-propellant rocket engines, constructed at Aerojet-General Corporation, were tested in a Consolidated Aircraft flying boat on San Diego Bay.

In December 1938 I was informed by von Kármán, Robert Millikan, and Max Mason that I was to go to Washington, D.C., to give expert information to the National Academy of Sciences Committee on Army Air Corps Research.

One of the subjects on which General H.A. Arnold, then Commanding General of the Army Air Corps, asked the Academy to give advice was the possible use of rockets for the assisted takeoff of heavily loaded aircraft. I prepared a report which contained the following parts: (1) Fundamental concepts, (2) Classification of types of jet propulsors, (3) Possible applications of jet propulsion in connection with heavier-than-air craft, (4) Present state of development of jet propulsion, and (5) Research program for developing jet propulsion.

The word "rocket" was still in such bad repute in "serious" scientific circles at this time that it was felt advisable by von Kármán and myself to follow the precedent of the Army Air Corps of dropping the use of the word. It did not return to our vocabulary until several years later, by which time the word "jet" had become part of the name of our Laboratory (JPL) and of the Aerojet-General Corporation.

I presented my report to the committee on December 28, 1938, and shortly thereafter the Academy accepted von Kármán's offer to study with our GALCIT rocket research group the problem of the assisted takeoff of aircraft on the basis of available information, and to prepare a proposal for a research program. A sum of $1,000 was provided for this work.

Parsons and Forman were delighted when I returned from Washington with the news that the work we had done during the past three years was to be rewarded by government financial support and that von Kármán would join us as director of the program. We could even expect to be paid for doing our rocket research!

Thus in 1939 the GALCIT Rocket Research Project became the Air Corps Jet Propulsion Research Project. In 1944 I prepared a proposal for the creation of a section of jet propulsion within the division of engineering at Caltech. It was decided that it would be premature to do so. Instead, von Kármán and I founded JPL. □

The first practical application of Malina's rocket work came sometime between August 6 and 23, 1941 with the first jet-assisted takeoff of an airplane. Malina is the man furthest to the right.