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Chapter 13

Jean-Jacques Barré, French Pioneer of Rockets and Astronautics*

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Introduction

Little known abroad, or even in France, Jean-Jacques Barré was one of the French pioneers of rockets and astronautics. A follower of Robert Esnault-Pelterie, he started work on rockets as early as 1927, and he was the first in France to fly a liquid propellant rocket on March 15, 1945. Although his effort was directed, throughout his life, mostly to rocket development, he was also a theoretician in this area. Thus, his studies related to nucleothermal or ion propulsion as well as to chemical propulsion. He also took an interest in astronomy and in the applications of nuclear energy. In spite of the difficulties he had to face in a particularly disturbed period marked by the Second World War, he managed to show great persistency in carrying out his ideas.

In the 1920s, a major interest was shown in Europe, in the Soviet Union and in the United States, in interplanetary travel and rockets. There were Oberth and the *Verein für Raumschiffahrt* in Germany, Goddard in the United States, the Gas Dynamics Laboratory (GDL) in the Soviet Union, Esnault-Pelterie in

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France, and others. Working first in the shadow of Esnault-Pelterie, then on his own, Jean-Jacques Barré was the follower of these pioneers. He was one of those who started to turn their dreams into reality.

A Man Whose Passion for Astronomy and Astronautics was Awakened Early

While he was a student at the Ecole Polytechnique (Polytechnical Institute), Jean-Jacques Barré became interested in astronomy. He published, at that time, in the review *Astronomie* an article concerning the construction of parabolic mirrors. This was in 1923. He was 22 years of age.

After graduating from the Ecole Polytechnique, he chose a career in arms. He was then assigned, on October 1, 1924, to the Fontainebleau Artillery Engineering School, where he continued to study, out of personal interest, astronomical subjects, such as solar radiation. Thus, from 1923 to 1934, he was to publish seven articles in the field of astronomy.

When he became an artillery lieutenant, he attended, on June 8, 1927, a conference given by Robert Esnault-Pelterie to the General Assembly of the Astronomical Society of France; the theme was the "Possibility of Interplanetary Travel." At this time, Robert Esnault-Pelterie, engineer and airplane constructor, was primarily known for having invented the "joy stick" and the radial-type engine; he had not yet acquired a reputation in astronautics. It is true that this science was then very new in France. Alone, Esnault-Pelterie had been working on it out of personal interest starting in 1908 and, in 1927, apparently only one conference on this subject had been done by him in 1912, in Saint Petersbourg, under the title "Reflections on the Results of Indefinite Lightening of Motors."

The June 8th, 1927, conference was not only of great interest to Barré, but seems to have been at the origin of his future vocation for the study of rockets. In the days immediately following this conference, Barré wrote Esnault-Pelterie and told him of his thoughts on an electromagnetic propulsion system for a space ship, which he called the "integrated propulsion unit." On the 12th of June, Esnault-Pelterie wrote him back, and there began a correspondence between the two men, which was to last more than six years. They exchanged more than 300 letters, including 102 in the 1929 alone. This correspondence dealt with theoretical aspects of rocket-engines: the problem of combustion, ejection speed, propellant flow-rate, pump dimensioning, and so forth.

On the 11th of July 1927, when he was at Fort de Vincennes, Barré began to put down in writing an interplanetary navigation project by designing an inhabited vessel capable of escaping the Earth's magnetic field. He called this vessel an "ether-ship" (étheronef), and he imagined equipping it with an "integrated propulsion unit." Deeply religious, he annotated the first page of his study in the following way: "If I am allowed to build one day, and for the greater glory of God, the 'étheronef' that I have described here, I vow to christen it 'Marie Stella.'" Nonetheless, somewhat later he was to qualify his project as utopian. But in spite of this, his initial study was to give way to others which would lead to concrete results.

From 1927 to 1931, Jean-Jacques Barré was to provide invaluable assistance to Robert Esnault-Pelterie in his theoretical studies; the latter was, moreover to say, how much he appreciated this help and the often original ideas coming from Barré.

Aside from these studies linked to problems specific to rockets, he also gave a great deal of thought to the General Relativity Theory. In this same year, he learned of the work that Hermann Oberth was carrying out in astronautics, and he supplied several commentaries. The following year, his research led him to become interested in methane combustion. Although the relations between Robert Esnault-Pelterie and Jean-Jacques Barré were sometimes difficult, it is nonetheless true that these two men respected each other and complemented each other perfectly. Esnault-Pelterie asked Barré not only to help him to solve theoretical problems, but also to correct texts for conferences that he was to give. In this way, Barré was, in particular, to contribute to the Esnault-Pelterie study entitled "l'Astronautique," published in 1930. The collaboration was sufficiently profitable, so that in November 1930, Esnault-Pelterie, who was working under contract with the Ministry of War, asked for Barré to be assigned to his service in order to work on the realization of an aerological rocket designed to reach an altitude of 100 kilometers. This assignment did not take place before the 25th of September, 1931.

Hardly three weeks after his arrival in the Esnault-Pelterie laboratory, located in Boulogne-sur-Seine, Jean-Jacques Barré witnessed an explosion resulting from a test of a kerosene and tetranitromethane mixture, which blew off the ends of four fingers on Esnault-Pelterie's left hand. It may be noted that this accident was the direct origin of the choice of liquid oxygen, judged less dangerous for missile and rocket tests which were to take place over the next fifteen years. Within Esnault-Pelterie's small team, Barré continued theoretical studies and began to develop motor components.

A year later, in September 1932, Barré's assignment was over. He then told Esnault-Pelterie that General Weygand was ready to double, or even triple the subsidies granted to his work, with the reservation that he obtain tangible results within three years.

In 1933, Barré, who was now a captain and assigned to the Gunpowder Commission in Versailles, spent little time in rocket studies; nonetheless, "he shall be authorized to undertake, outside his present duties, tests on nitrogen peroxide-based propellants." Moreover, in December 1935, he published a report on combustion studies for liquid and solid propellants. Then, from mid-1937 to 1939, he was to try to develop a rocket, using nitrogen peroxide and benzotoluene without, nevertheless, coming to conclusive results. He was then to go back to the idea of the liquid oxygen-petroleum-ether combination which had been satisfactorily used by Esnault-Pelterie.

In 1937 and in 1939, he was to receive two bonuses from the Ministry of War for 6,000 and 2,000 francs respectively, for the quality of the research that he had carried out.

Jean-Jacques Barré, the Father of the First French Liquid Propulsion Rocket

There followed the year 1939 and the Second World War. Then, in June 1940, the defeat. The northern area of France was occupied by German troops. On November 16, 1940, Jean-Jacques Barré was assigned to the Central Markets and Supplies Supervision Service in Lyon. Behind this name was hidden the Technical Artillery Section, reformed clandestinely by General Arnaud, Colonel Gentil of the Artillery Service Sub-Division, and by the Colonel Dubouloz, who was to be its director. The latter then asked Barré to undertake the study of a rocket with a 100 kilometer range. He was assisted by two officers, Captain Derrier and Captain Calas, and a draftsman, Mr. Gautier. On the 15th of January 1941, Barré submitted a study for self-propelled projectiles called, at that time, rocket-shells. He then imagined the possibility of realizing:

- Very long-range rocket-shells (1,000 kilometers and more);
- Armor-piercing rocket-shells which could reach around 2,000 m/s;
- Anti-aircraft defense rocket-shells (allowing the time to be cut in half).

For aerial bombardments:

- Armor-piercing rocket-bombs;
- Super-accelerated rocket-bombs.

For very-long-range rockets, he imagined thrusters using gasoline and liquid oxygen. In case of a shortage of gasoline, he foresaw the use of hydrogen or methane, liquids which were produced in France, but he also recommended nitrogen peroxide coupled with benzene. Finally, he imagined the stabilization of such rockets through stabilizers with, possibly, rudders controlled by a gyroscopic device.

In conclusion, he judged that the scope of possibilities of self-propelled projectiles was vast.

He thus proposed to carry out, at one and the same time, the development of different types of self-propelled weapons that he evoked, by remarking that the self-propulsion units could be used for strictly scientific or utilitarian purposes. It seemed, he said, that their design could be undertaken without contravening any armistice clauses.

In the annex to this memo, he evoked the case of aerothermal propulsion projectiles, in which the oxidizer comes from the surrounding air. He, thus, reflected on the design of the ramjet engine by showing the sizable gain in specific impulse in relation to the self-propulsion rockets. He emphasized the fact that, in order for the ramjet engine to operate, it needed to impart an initial speed on the order of 800 m/s, which could be transferred to it through a self-propulsion unit, which would thus constitute 2 stages. But he considered that the ramjet engine would be sensitive to atmospheric pressure and hygrometry variations. On the other hand, this principle offered considerable ranges with relatively insignificant mass ratios: 1.5 to 2 for a speed of 4,000 m/s at the end of combustion.

Following this general study, Jean-Jacques Barré, starting at the beginning of the month of March 1941, elaborated a preliminary study of a thruster for a sounding rocket. Then, on July 4, 1941, the project was sufficiently well-defined so that in a note classified "Top Secret," the Secretary of State for War asked the Director of the Central Markets and Supplies Supervision Service "to order the realization of 22 gas generating apparatuses," conforming to the plans which were furnished to his Central Administration by Barré on the 23rd of June, 1941. The memo indicates, additionally, that a provision of 300,000 francs was allocated for this purchase. To be noted here is all the ingenuity used by the responsible parties to conceal this work on rockets, which in no way was to be revealed to the Germans.* To distract the attention of the latter, these rocket-thrusters were called "gas generators." It should be remembered that, at that time, automobiles were run on the principle of the famous "gas producers" which were, in a way, "gas generators."

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* During the summer of 1944, Colonel Dubouloz was arrested and interned in Fresnes. Interrogated on his team's activities, he managed, most cleverly, to convince the indiscreet individual that this study was completely hair-brained.

In a few months, the first prototypes for the first French liquid rocket, which was called EA 1941, were realized and, on the 15th of November 1941, at the Camp du Larzac, an initial bench-test of a complete missile was carried out.

Starting with the tests on March 17-18, 1942, which followed that of November 1941, Barré was to use a slightly modified version: the EA 1941 B. At the same time, more precisely the 17th of March, 1942, an additional stipend of 200,000 francs was granted to continue the work. The failures of the last two tests carried out at the Camp du Larzac (those of March 17-18) were put down to the very organization of the test-bench. It was then decided to carry out further tests at a new static test facility located at the Vancia structure, in the Lyon suburbs, which was more open, thus allowing the propulsive jet to lessen the heat in the missile structure.

After the seven bench tests shown below and, more particularly after the last test, which had succeeded very well, it was decided to carry out flight tests which, for obvious reasons of discretion, could not take place in metropolitan France. The choice fell on Algeria, where France had vast amounts of territory. A mission was thus carried out by Barré to Beni-Ounif in southern Oran, from the 3rd to the 16th of October 1942, but as he himself tells us below, unforeseen difficulties were to forbid flight tests.

CHARACTERISTICS AND PERFORMANCE OF THE EA 1941 ROCKET

PERFORMANCE SPECIFICATIONS

- Range : 100 kilometers
- Maximum speed : 1000 m/s
- Thrust : around 1 ton
- Maximum accelaration : 10 g

CHARACTERISTICS

- Total weight : approximately 100 kilograms
- Payload : approximately 25 kilograms
- Weight of petroleum ether : approximately 17 kilograms
- Weight of liquid oxygen : approximately 35 kilograms
- Weight empty : approximately 48 kilograms
- Length : 3.13 meters
- Diameter : 0.26 meters
- Combustion pressure : 5 bars
- Ratio of expansion : 10
- Cooling of the ejector with pre-cooled petroleum ether
- Nozzle in Alpax gamma
- Injection of liquids through flushing under nitrogen pressure
- Launching on adjustable ramp 16 meters long
- Stabilization through fins

SUMMARY OF THE 7 STATIC TESTS FOR THE EA 1941 ROCKETS				
TEST DATE	PLACE OF TEST	DURATION COMBUSTION	THRUST OF MOTOR	RESULT
15 November 1941	Camp du Larzac	42 s	?	Success, but explosion after 42 seconds of combustion for 18 planned
17 March 1942	Camp du Larzac	5 s	719 kgf	Explosion after 5 seconds of combustion
18 March 1942	Camp du Larzac	4 s	650 kgf	Explosion after 4 seconds of combustion
6 July 1942	Ouvrage de Vancia	0.6 s	608 kgf	
23 July 1942	Ouvrage de Vancia	non - meaningful test		
12 August 1942	Ouvrage de Vancia	2.8 s	860 kgf	
24 September 1942	Ouvrage de Vancia	10.9 s	654,5 kgf	Complete success

As soon as the mission was over, we prepared the equipment for shipping from Lyon to Algeria and, on the 2nd of November 1942, the Bônoise escort left with around a third of the equipment aboard. On the 8th of November, the rest of the equipment was on the quays of Marseille, ready to be loaded, when news broke out of the allied landing in North Africa. Mr. Mechin immediately went to the ship and managed to camouflage everything in a nearby castle, in Mimet, thanks to the very courageous cooperation of its owner, Mrs. C. Perrier.

In hopes of being able to resume the tests at the static test stand of Vancia, half of the equipment stored in the castle of Mimet was transferred to Lyon onto property belonging to the (Captain Barré's) family.

Circumstances did not allow theoretical studies to be continued, and it was necessary to wait until the end of the occupation to resume the flight tests; several pilot pressure-reducer tests were, nonetheless, carried out, and the manufacture of ballistic tooling for self-propelled missiles was undertaken.

Barré then again resumed the theoretical studies. Thus, on January 17, 1943, he finalized a study on the use of nuclear energy for propulsion. He then examined the nucleo-thermal thrusters using hydrogen as a propulsive jet, as well as the nucleo-electric thrusters (ion motors). For the latter, he specified, "When the time comes for astronautics, they will be used as sustainer engines."

March 15, 1945: First Flight of a French Liquid-Fuel Rocket

While the liberation of France, begun in 1944, continued its course, the flight tests of the EA 1941 rocket were again envisaged, as Jean-Jacques Barré notes:

After the liberation, the equipment was rapidly gathered together, including the Oran part which had been found intact: it was decided that the initial firings would take place in La Renardière, in the Saint-Mandrier peninsula which closes off the natural harbor of Toulon.

The launching ramp was quickly assembled and reconnaissance was carried out in Toulon to coordinate efforts with the Marine forces and organize the first firings.

After numerous incidents, the first firing took place the 15th of March. The Marine forces had made a considerable effort to mark out the firing line: two hydroplanes, two escort destroyers, and 8 fighters and patrol boats. The missile shot across the ramp quickly, but rapidly began to 'precess,' and exploded after a five-second flight; a Marine patrol boat picked up several fragments floating in the sea, including the bottle of nitrogen.

The cause of the explosion was never fully determined: it may be attributed to the precession, which may have been caused by the possible loss of a stabilizer aileron.

Two missiles were to be fired the following day, but only one was set off. For unknown reasons, the remote-control valve did not open and the combustion took place without pressure. The missile, remaining at the bottom of the ramp, exploded after around 10 seconds, rendering the guide rails unusable for the firing of the second missile. Again, circumstances delayed the operations; "money material" was rare and delivered drop by drop, various assignments partially broke up the team, and the assembly of the remaining missiles was confided to the Société pour l'Application Générale de l'Electricité et de la Mécanique [(Company for the General Application of Electricity and Machinery (S.A.G.E.M.)] in Argenteuil. Mr. Pinard, the welder/blacksmith, had moreover been assigned to this company.

Finally, the next launch did not take place until the 6th of July 1945, again at la Renardière, the launching ramp having been put back into proper condition. The Toulon Marine supplied the experimenters with: a hydroplane, an escort and two port patrol boats. Three missiles were fired that day. The first, lacking sufficient speed to get off the ramp, through obvious lack of pressure, was blown over by a gust of wind and fell into the sea, combustion finished, at ten to twelve kilometers from la Renardière. The second, on the other hand, fired at excessive speed, exploded 1.2 seconds after having left the ramp.

Because of the delays accumulated during the previous firings, the third missile was not fired until 7:45 p.m., when the observation flotilla was already on the way back. After a very good start, the combustion ended after 7.5 seconds, instead of the 13 planned for, which seemed due to excess pressure; the missile was followed to the horizon (some 34 kilometers from the launching ramp), and certain observers affirm having seen it disappear behind the horizon. A study of the films later allowed the speed of the missile to be evaluated at 1,400 m/s at the end of combustion; its ballistic coefficient being badly determined, one was only able to evaluate roughly the range, which would have been on the order of 60 kilometers.

The months which followed, were devoted especially to studies on a pilot pressure reducer and various consumption regulation devices; these studies were carried out at S.A.G.E.M., a contract having been signed with this company by the Armament Design and Manufacturing Department, upon request from the Army Technical Section.

A small zenithal static test facility was also set up in Satory, on the spot of the former Robert Esnault-Pelterie static test facility, which had been dismantled during the occupation.

It proved to be very difficult to coordinate the arrival of the two liquids in the chamber, which was flooded by the one which arrived first.

In his laboratory, Professor Roccard studied a "Mesny" transmitter, which was to serve for bi-static localization of the missile; this led to the study of an ogive in two electrically isolated parts. A final firing of two rockets took place in Toulon, the 18th July, 1946; this proved to be a complete failure, both missiles having burned at the bottom of the ramp with neither pressure nor thrust. The ramp having been damaged, a third missile could not be fired; tested some time later at the Mont-Valérien static test facility, it functioned perfectly. The cause of these incidents was not discovered until a year later: during a workshop test, a scale came off the inside wall of the light alloy bottle, having almost completely blocked up the output orifice located at the bottom of the bottle, the "hissing" and "meowing," analogous to noises heard in Toulon, were clearly perceived; an endoscopic examination of the bottles showed, moreover, that the inside walls of most of them were strewn with scale, ready to fall off.

This failure had deplorable psychological consequences at a time when one was not yet used to the high percentage of incidents for this type of missile.

A modification test for the EA-41 led to the "O.N.M." missile project: after several tests at the Mont-Valérien static test facility, disappointing tests although rich in lessons, this project was abandoned, efforts having been concentrated on the "EOLE" missile for several months already.

In April 1946, Jean-Jacques Barré was to receive a bonus of 200,000 francs to realize the first rocket launched in France.

SUMMARY OF THE SEVEN IN-FLIGHT TESTS OF THE EA 1941 ROCKET
(at the Renardiere Test Range in St Mandrier near Toulon)

March 15, 1945: 1st flight of a French liquid propulsion rocket. Partial success. The missile began to "precess" and exploded after 5 seconds of flight.
March 16, 1945: Failure. Explosion on the launch ramp after around 10 seconds of combustion.
July 6, 1945: Partial success. Combustion finished. Fell back at around 10 kilometers from the launching site.
July 6, 1945: Failure. Explosion after 1.2 seconds of combustion.
July 6, 1945 (19:45): Partial success. Combustion stopped after 7.5 seconds instead of the 13 seconds planned. Speed at the end of combustion: 1,400 m/s. Range: around 60 kilometers.
July 18, 1946: Total failure. Combustion without pressure on ramp.
July 18, 1946: Total failure. Combustion without pressure on ramp.

Barré discovers the German work

In 1945, the Allies learned of the extent of the German work on rockets and Major Barré then took part in two missions inside Germany. From the 9th to the 17th of May 1945, he visited the Ober-Raderach V-2 experimental inspection and acceptance station near Friedrichshafen. On June 7th, he discovered the Lehesten "Basalt" factory near Dora, responsible for calibrating the V-2 nozzles, as well as the "Mittlewerk" factory in Dora, where the manufacture of the V-2s had taken place, and at which numerous deported persons had lost their lives. This was, in particular, the case of Colonel Louis Gentil, who had died in this camp the 8th of April 1945, and who, it is to be remembered, had been one of the promoters, at the end of 1940, of the work on the EA-1941 rocket.

EOLE Succeeds the EA 1941

On the 22nd of August, 1945, a contract was signed with the S.A.G.E.M. company to realize a prototype of a missile more powerful than the EA 1941, which was to be able to carry a load of 300 kilograms over a distance of between 500 and 1,000 kilometers. This missile, first called EA 1946, soon received the name EOLE (Engin fonctionnant a l'Oxygène Liquide et à l'Ether de pétrole (Engine Operating With Liquid Oxygen and Petroleum Ether) and was, in fact, a large-scale replica of the EA 1941.

CHARACTERISTICS AND PERFORMANCES OF THE EOLE 1946 A ROCKET
<u>CHARACTERISTICS</u> Length : 11 meters Diameter : 0.8 meter Total weight at firing : 3.4 tons Payload : 300 kilograms Weight empty : 0.7 tons Propellant : Liquid oxygen petroleum ether <u>PERFORMANCE SPECIFICATIONS</u> Range : 500 to 1000 kilometers Thrust : approximately 10 tons

The nozzle of this new engine had to be cooled through circulation, between its walls of chilled petroleum ether, itself at a temperature near that of liquid oxygen; feeding of the engine with propellant occurred through pressurizing the nitrogen tanks as in the EA 1941; EOLE 1946 A was to be un-guided.

The realization of the EOLE 1946 A began on the 15th of October, 1946. But the first bench test did not take place before February 4, 1949, in the Aerodynamics and Ballistics Research Laboratory (LRBA) in Vernon—which also participated in the study—the test bench not being completed before this date. This test, which lasted 13.5 seconds, was successful.

The second test, which took place January 6, 1950, was not so successful. After 20 seconds of normal combustion, three small detonations, followed by a pulsating combustion, appeared, and at the 34th second, a violent detonation occurred. An intense light lit up the countryside and was visible even 40 kilometers away from Vernon. The missile was completely destroyed and the test bench seriously damaged. The explosion had also slightly injured three people. After analysis, it became clear that the origin of the explosion, as, moreover, that of the two EA 1941's tested in 1945, was due to the hypergolic property of gasoline and liquid oxygen.

It was then decided to abandon petroleum ether in favor of ethyl alcohol, more or less hydrated, which had given satisfactory results with the V-2, and to proceed to various other modifications. A second version of the EOLE was then constructed during the year 1950. It received the name EOLE 1951 (Engin utilisant Oxygène Liquide et alcool Ethylique (Engine Utilizing Liquid Oxygen and Ethyl Alcohol), and on December 19, 1950, an initial test with motor ignition was realized. Six other tests were carried out up to the 25th of September

1951. Then, three bench tests with complete missiles took place on the 27th of March, the 3rd of April and the 31st of October 1952. A maximum thrust of 9.45 tons was reached on September 25, 1951, as well as a gas-ejection speed of 2,110 meters per second.

CHARACTERISTICS AND INDUSTRIAL RESPONSABILITIES OF THE REDUCED CAPACITY EOLE 1951 ROCKET

CHARACTERISTICS

Length : 7.455 meters
Diameter : 0.90 m
Total weight : 1 788 kilograms (3 tons for the normal capacity)
Weight empty : 698 kilograms
Payload : 200 kilograms
Weight propellant : 1 090 kilograms including
liquid oxygen : 642 kg.
ethyl alcohol : 448 kg.

INDUSTRIAL RESPONSABILITIES

SAGEM : missile design
LRBA : stabilizer and bench-tests
SFENA : ogive localization device
Atelier de Puteaux (APX) : ejectable ogive and parachute remote measuring of the ogive design and realization of the launching ramp
Versailles Technical Experiment Establishment : ejectable ogive and parachute

BENCH-TESTS OF THE EOLE 1946 A ROCKET

TEST DATE	COMBUSTION DURATION	RESULTS	PLACE OF TEST
February 4, 1949	13.5 s	Success - Stopped due to lack of oxygen - 18 seconds planned	LRBA
January 6, 1950	34 s	Explosion of EOLE	LRBA

In 1951 and 1952, while the bench-tests were taking place in LRBA, flight tests were being prepared, which were to take place in Hammaguir in the Sahara, a completely new firing range, from which the Véronique sounding rockets were beginning to be launched.

EOLE, not being a guided rocket, was to be launched from a ramp whose length was set at approximately 21 meters, but which remained insufficient. In fact, with an end-of-ramp speed of 25 m/s, the rocket remained very sensitive to possible gusts of wind. It was then envisaged to increase the speed of the missile to 50 m/s through means of an auxiliary solid propellant booster. Nonetheless, at the end of the year 1952, when the inflight tests were going to begin, this booster had not yet been developed. It was then decided to carry out the initial EOLE launchings without the latter, but with lighter rockets with a capacity equal to two fifths of their normal capacity, that is, with a propellant mass similar to that used during the bench tests.

BENCH-TESTS FOR THE EOLE 1951 ROCKET

TEST DATE	THRUST	GAS EJECTION SPEED	RESULTS	TEST PLACE
December 19, 1950	-	-	Failure	LRBA
December 23, 1950	0	-	Failure	LRBA
February 15, 1951	2.3 to 2.5 tons	542 m/s	Success	LRBA
March 1, 1951	4.3 to 3.5 tons	492 m/s	Success	LRBA
April 26, 1951	5.9 to 4.2 tons	700 à 500 m/s	Success	LRBA
May 10, 1951	-	-	Explosion	LRBA
September 25, 1951	9.5 to 8.7 tons	2,110 m/s	Success	LRBA
March 27, 1952	0	0	Complete rocket n°1 Success	LRBA
April 3, 1952	7.4 tons	2,010 m/s	Complete rocket n°2 Success	LRBA
October 31, 1952	-	-	Complete rocket n°3 Fusion at the chamber bottom after 7 s of operation	LRBA

At the end of October and the beginning of November 1952, the equipment necessary for the flight tests was transported to Hammaguir. Undeniably, it was the use of liquid oxygen which caused most of the problems, as Jean-Jacques Barré himself describes it:

> A liquid oxygen production group from the Oberraderach test station in Bavaria had been taken back up to Bidon II, near Colomb-Béchar. The factory had two 32,000-liter German tank-cars, also from Oberraderach.
>
> The instructions were to fill a tank and to send it to Abadla, provisional terminus of the Mediterranean-Niger. Once there, the liquid was to be transferred into the 3,000-liter road tank normally used in Vernon; there remained around forty kilometers of rugged dirt track before reaching the launching base.
>
> Unfortunately, this tank, which had given complete satisfaction on the roads in France, was of light construction, the tank itself being made of old V-2 reservoirs in which had been riveted tranquilizing partitions.

To top off this misfortune, a subordinate took the disastrous initiative to load the road tank in Bidon II and to send it directly by road to Hammaguir, some 120 kilometers away by dirt roads.

At 35 kilometers from the factory, the transporter noticed a sizable leak and he had the tank emptied on the spot; then he sent it on to Hammaguir for examination and repair; it would certainly have been more expedient to take it back to the factory, near the Inter-army Experimentation Center for Special Missiles (C.I.E.E.S.), which disposed of significant means and manpower.

Whatever the case, it was necessary to wait two days for the remainder of the tank to evaporate, the purge siphon not being long enough to reach the low point of the tank.

During this time, the tank-car, which had finally managed to get to Abadla, was badly heat-insulated and had to be sent back to Bidon II for reloading; at this juncture, the factory transformer burned out; fortunately, it was quickly put back into working order.

Moreover, the principal military engineer, Corbeau, took the happy initiative of having two stainless steel nitric acid tanks converted into tanks for liquid oxygen.

At the same time, the Vernon tank was put back into condition by withdrawing the transquilizing partition and by blocking the rivet holes, and Colonel Michaud, Commandant of the Inter-Army Experimentation Center for Special Missiles, offered to air-transport one of the tanks transformed by Corbeau.

Finally, two days later, the transfer was carried out in Abadla into the repaired Vernon tank which, after a threat from the Guir floods, was able to reach its filling station, this time without incident.

On the 22nd of November, at 11:30, the order to fill having been given, a horrible crack was heard and the tank was enveloped by steam. The engineer responsible for the design understood right away that it involved an incident analogous to what had previously happened during a test in Vernon: rupture of the upper siphon elbow. The repair carried out at that time had indeed given way.

After modification and repair, the tank filled up and the rocket took off at 4:30 p.m.; 7 seconds later, there was a rain of debris and the crippled rocket, with neither head nor tail, fell, twirling end over end, at 2 kilometers from the ramp, where its alcohol residue continued to burn for a good part of the night.

The nozzle showed no trace of blistering, and its shining surface could be discerned through the flames. The scattered debris from the stabilizer was strewn out along the firing line.

This deterioration of the stabilizer could be blamed on the heat given off by the tracers, which had been attached at the end of the wings in order to evaluate the rolling of the missile and to allow the latter to be traced after the end of combustion. It was then decided to fire the second missile without tracers.

The firing of this second rocket took place two days later, on the 24th of November, 1952. This rocket included neither remote-measuring, nor S.F.E.N.A., nor releasable ogive but was equipped with an S.F.I.M. recorder. The filling-up operations were carried out without incident.

At the firing, the rocket had difficulty starting up, the combustion irregular, showed a lack of pressure, and because of this, it was released at a very low speed of 18 m/s, whereas the previous one had reached 30.5 m/s, a value lower than had been foreseen, namely: 46 m/s. Straightened upright by an opportune gust of wind, the missile followed its flight willy-nilly, and now it too lost its stabilizer 25 seconds after the firing: after having reached an altitude of 2,950 meters, it fell back to Earth 4,000 meters from the ramp.

A scrutiny of the recording theodolite films revealed that the two rockets had lost their stabilizers at very similar speeds: 335 and 315 m/s; the reason was thus not the tracers, but . . . the sound barrier.

These incidents, occurring after the adventures of the liquid oxygen tank, caused a very negative impression on those taking part, who, for the most part, were doubtless unaware that the first two successful launchings of the V-2 had been followed by thirteen successive failures.

Whatever the case may be, on the 1st of December 1952, the study was suspended "sine die."

With this date, thus stopped the experiments concerning the Jean-Jacques Barré rockets. It is true that, at that time, no ballistic missile program was being studied. Alone, the tactical missiles and, in particular, the ground-air systems were subject to a great deal of research, but the use of liquid oxygen was incompatible with the flexibility of use and rapid departure capacity required by these systems. Moreover, another, more satisfactory, path from this point of view, that of nitric acid, was pursued by the LRBA teams for several months with the Véronique sounding rockets and also by the SEPR (Society for the Study of Jet Propulsion). If, for the time being, the stopping of the French studies concerning liquid oxygen was very disappointing for Jean-Jacques Barré, and left him somewhat bitter, the future was not long in proving him right. From the end of the 1950s, the Americans and Soviets were to put ballistic missiles into service, as well as space launchers, using liquid oxygen, and, at the beginning of the 1960s, the French studies on liquid oxygen propulsion were to be taken up again for an improved Diamant launcher, and they were to lead directly to the realization of the third stage of the European Ariane launcher. The ideas of Esnault-Pelterie and Jean-Jacques Barré had thus been validated.

IN-FLIGHT TESTS FOR THE 1951 EOLE ROCKET IN HAMMAGUIR

TEST DATE	RESULT
November 22, 1952 (16:30)	Failure - Deterioration of a stabilizer after 7 seconds at 335 m/s
November 24, 1952	Failure - Loss of a stabilizer at 25 s at the speed of 315 m/s. Irregular combustion, altitude reached 2,950 meters. Fall of the missile at 4 kilometers

Propulsion, Rockets, and a Good Many Other Fields of Interest

The fields of interest of Jean-Jacques Barré were numerous. Rocket propulsion, and the rockets themselves, constituted his major research areas. As far as propulsion alone is concerned, before the war he also became interested in ramjet engines and in nuclear propulsion. In 1949, while he was giving courses on "self-propelled missiles" at the National Engineering School of Armaments, he resumed his theoretical work on ramjet engines and, from 1956 to 1958, work on nuclear propulsion. Several years earlier, when he had just been integrated into the military corps of engineers and assigned to the Armaments Design and Manufacturing Division, he had become interested in nuclear studies as a source of energy, and, in December 1947, he went so far as to propose a "new type of nuclear bomb." It should also be remembered that, from 1920 to 1930, his curiosity had led him to become interested in astronomy and relativity.

In 1958, he received the General Muteau Prize from the Academy of Science for the entirety of his work concerning astronautics and rockets, and he was to share, in 1963, the Galabert Prize, awarded by the French Astronautical Society, with the Soviet cosmonaut, Yuri Gagarin.

Starting in 1960, he was to put his knowledge and experience as a consulting engineer at the service of the Society for the Design and Realization of

Ballistic Missiles (SEREB) of SNECMA and AFITAE. (Association Française des Ingénieurs et Techniciens de l'Aéronautique et de l'Espace [French Association of Aeronautical and Space Engineers and Technicians]).

In 1978, after a long illness, the General Engineer, Jean-Jacques Barré, died at the age of 77. The man who was the first in France to have flown a liquid propellant rocket, disappeared. With him disappeared a pioneer and a determined researcher who, with Robert Esnault-Pelterie, whose disciple he had been, laid down the bases for French astronautics. Initially their work was so closely connected, that one may say the success and difficulties of the one were also those of the other. Nonetheless, it is without a doubt to be regretted that history speaks so little of Barré, but here the responsibility doubtless lies with historians.