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Chapter 1

French Rocketry 1739-1872*

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Few would dispute that rocketry is an epitome of modern technology. Yet, the thunderous vehicle which allowed man to leave the Earth and to walk on the Moon has origins much older than such otherwise mundane realizations as the car or the airplane. So ancient actually that nobody knows, and probably never will, the first rocket or its inventor. Which, some would perfidiously add, should prevent any controversy or undue claim of precedence—witness the Ader/ Wright polemic!

Rocket Beginnings (1st to 17th Century)

Fire was one of the Ancients' four Elements, and as such an early link is established with the rocket. Five centuries BC, the use by Byzantium of Grecian Fire, based on Marcus Groecus' powder, probably led to the invention of the self-propelled incendiary rocket during the first century of modern times: by the Chinese Han dynasty against ships, and by the Romans against the Tartar Cavalry.[1] Very imprecise, the rocket was then nothing more than a reed or a bamboo tube filled up with black powder.

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The first improvement can be credited to the Chinese who added a lateral stick, thus providing good stability to the weapon. It proved fairly popular during the Middle Ages, first in the Orient:

- in 1098 in Antioch (now Turkey) against the First Crusaders,
- in Damiette (now Egypt) in 1218 and in 1249, against King St-Louis,
- in 1232 in Kaifeng, capital of the Chinese Kin, against the Mongols,
- in 1399 by Tamerlane to seize Delhi,
- in 1453 by Mehmet II for the capture of Constantinople.

The "blazing arrow" had in the meantime appeared in Europe, reportedly introduced by Marco Polo in 1295:

- during the 1378-81 war between Genoa and Venice,
- in 1428 by Joan of Arc in Orléans,
- in 1436 during the siege of Chavency,
- in 1449 by Charles VII for the liberation of Pont-Audemer (Normandy),
- in 1451 for the siege of Bordeaux,
- in 1453 for the attack on Ghent by the Duke of Burgundy,
- in 1465 during the siege of Corbeil.[2]

Still used during the 16th century, notably by Charles V (1500-58), the rocket however slowly faded away because of artillery progress, a presage of events to come as rocketry fortunes until this century were going to depend upon those of the cannon. During the 17th century many wrote about the weapon, but only Hülst is recorded testing 50 and 100 pound rockets in Berlin in 1668. The so-called "barbaric nations" (!), less able to use up-to-date hardware, however kept using the weapon as it was: Algerians against the fleet of de Tourville, Turks against Moscovians and Hindis against the British.

The Rocket is Reborn—The Ruggieri's (1739-79)

Ruggerieri is the first name that can be be truly associated with the rocket, and what a grand name it is! This family is well known today for its fireworks business, a highly successful perpetuation of their pioneering work of the 18th century, and a vivid testimony to the closeness of both activities at the time.

The three brothers, Gaetano (1719-76), Petrone (1726-94) and François (1728-70) left Bologna for France in 1739, where Louis XV (1710-74) was reigning. In 1760, Gaetano and François tested rockets in Frankfurt, headquarters of Field Marshal de Broglie during the Seven Years War. At about the same

time other individuals, such as Montjory, had their rockets tested by the Artillery in Besançon and Dunkerque.

The Rocket is Used in Anger—Colonel Prevot (1780-88)

It probably can be said that the presence of saltpeter, the main constituent of black powder, in a natural state in India, sparked off the reappearance in force of the rocket in the 18th century.

There, Hayder Ali, the Sultan of Mysore, together with his French allies was fighting the British East India Company. For this purpose he had a dedicated corps of 1,200 "rocketeers," the first recorded in history. When a single rocket detonated four ammunition containers in Pollilur in September of 1780, leading to the routing of 4,000 men, news of this disaster sent ripples back to England.[3]

At Hayder's death in 1782, his son Tipu Sultan succeeded him; he brought the strength of the rocket corps to an impressive 5,000 men. All this, for sure, was not lost on the the French, who must have been given information or even rockets by their allies. There is thus a probable link with the work of Colonel Prevot.

He had devised incendiary rockets fitted with hooks attached to a wire, no doubt to ensure a grip in the boat sails. Then in the service of Russia, Prevot used his weapons in 1788 against the Ottoman fleet massed near Otchekow in the Black Sea. For the satisfaction of the Prince of Nassau, havoc was wreaked among the vessels, their sails being set ablaze.

The Revolution—Testing Flurry (1792-1803)

The infamous Comité de Salut Public (Comittee of Public Safety) created on 6 April 1793, encouraged rocket trials. As a consequence many proposals of rather varied quality, were made:

- General Julienne de Belair, fresh from witnessing the many firings made by Tipu during the Battle of Srirangapatna in 1792,
- Captain Jean-Ambroise Baston de Lariboisière (1759-1812),
- Marescot, from the corps of engineering,
- Monniotte, from Parliament who was later executed under the charge of conspiracy,
- Chevalier, a Jacobin (Robespierre disciple), who experimented in 1796-8, and who was later executed as guilty of plotting,

- an architect from Piedmont,
- a convicted painter,
- soldiers and various opportunists!

Claude-Fortuné Ruggieri (1777-1841), the son of Petrone, also experimented much in cooperation with Belair starting in 1794. In 1800 he published "Eléments de Pyrotechnie" [Elements of Pyrotechnology]. Time was ripe indeed for such activity, as the sciences of physics and chemistry were making good strides.

Alas, since 1764, First Inspector of the Artillery Gribeauval (1715-1789) had improved the cannon. Then in 1788, a further blow was dealt by the death of Prevot in Sevastopol. In 1800, again bombarded the previous year by rockets in Srirangapatna, the British decided to react by manufacturing weapons derived from the Indian ones. The lead acquired by France was soon to be lost, however. Congreve stepped in.

English Pressure Upon Napoléon (1804-09)

With his father at the head of the Woolwich Arsenal (which received captured Indian rockets) and an impressively creative mind, all conditions were set for William Congreve to become the grand name of rocketry in the beginning of the 19th century. He began experimenting in 1804, even proposing to use rockets the following year against Napoléon's fleet. Peace negotiations in Paris delayed the operation.

In 1804, General Eblé, too, was succeeding in launching rockets with an angle as low as 15 degrees. However France felt so strong, that no consideration was ever given to these results.

Then, on 8 October 1806, during the night, eight launches took position 2,400 m away from Boulougne. The 200 rockets of 76 mm fired by the British had mixed results, as only a few boats and three houses were damaged. The surprise was, however, considerable, and Congreve set forth on a brilliant career, building and exporting thousands of rockets of up to 135 kg and 20 cm diameter. The sinking of one of the launches with its precious cargo in the harbor allowed its recovery and study by the chemist Vauquelin.

But the most terrible event had yet to come. September 1807 saw the massive use of 3,000 Congreve rockets during the siege of Copenhagen. Two thousand dead and six hundred houses destroyed sent a wave of horror and disgust over Europe, not only because of ravages created by the new "non ethical" weapon, but also because of an attack on a city which was neutral.

While Denmark (with Von Schumacher), as well as Austria (with Mager), lost no time in starting work on the rocket, France remained reluctant. General Gassendi of the War Ministry even described the weapon in the Artillery Manual as one "which could do much harm if used for any other operation than war, and is of no use for the latter."

Yet, when 1,200 Congreve rockets were launched during the battle of Aix Island, only 2 boats of the Rochefort Flotilla managed to escape. Emotion began to spread across the French Empire. Somewhat in line with Congreve detractors in England who feared retaliation, the French press issued warnings about the "diabolical" weapon. Again, some of the rockets were recovered for analysis by chemists d'Arcet and Gay-Lussac and a secret report written.

French Reaction (1809-10)

When, in August, 30 rocketeers obtained the surrender of Veer and Flessingue on the Island of Walcheren, the government, even in the absence of the Emperor, reacted at last. The Navy consulted André Garnerin, brother of the first parachutist. The War Ministry asked Ruggieri to send 300 of his rockets to Anvers, where Colonel Brunau and Captain Jean-Nicolas Bigot (1768-?) also built some. None, however, reached more than a pitiable 600 m, compared to the 3 km of the Congreve ones. Back at St-Cyr, where he was an instructor, Bigot was allowed to continue his research.

Farther away, following the capture of Vienna, General Lariboisière, Chief of the Artillery, recovered the models of Mager and directed Captain Claude-Gabriel Jacquier (1766-1855) to work on this basis. In spite of his pyrotechnics background, he could not obtain distances of more than 1,500 m.

Research was obviously in need of rationalization. More interested than some, Napoléon decided on 8 February 1810, upon the creation of a commission of scientists and artillerymen to develop incendiary rockets of 2,800 m range for the upcoming Spanish campaign. Its scientists were the president, Monge, and the chemists Berthollet and Guyton-Morveau (who created military ballooning). The two administrators of Powder & Saltpeter Service, Lariboisière, Eblé (Minister of King Jerôme), Captain Pierre-Frédéric Bourée (1778-1845) from the Navy and Captain Charles-Alexandre-Henri Moreton de Chabrillan (1782-1845) from Ecole Polytechnique [Politechnical School] completed it.

Work began in Vincennes where Jacquier was in charge, and at St-Cyr as well. The first rockets were tested in the Plain of Alfort on March 19th, with Jacquier and Bigot present. The Emperor himself came on August 6th to witness some launches, whereupon satisfied, he awarded the Légion d'Honneur [Legion of Honor] to Bigot.

By the end of the year, the rocket gap with England was already closed. Four calibers were selected, the smallest ones reaching 1,300 and 1,700 m, the largest 2,500 and 3,000 m. His objectives fulfilled for 25,000 F, Napoléon released 30,000 F for the full development of these "preseries" models, as well as for the instruction of qualified personnel for each artillery regiment and naval base, including Italy and Naples. On December 15th, an official instruction of the commission was released in the whole Empire as a conclusion to its work.

The Rocket Everywhere (1810-14)

At the end of 1810, Napoléon sent Jacquier (Moreton replaced him in Vincennes) and Captain. Baudart to Seville to manufacture their rockets using the high quality Spanish powder. Reaching an impressive range of 4 km, the rockets were used in Cadiz in 1811, as a reply to their Congreve counterpart: it may have been the first time both sides used the weapon. With the help of Bourée, Moreton also manufactured 2,000 76 mm rockets for the same use in Toulon, a town selected for its dry weather which was favorable for powder manufacturing.

The Navy, which had become very active, decentralized research. In Boulogne, Bourée and Captain Goard adapted the rocket to marine artillery with the help of Liège siderurgy, and they devised a special launch for this use. Omnipresent, Bourée also created workshops in Brest, Cherbourg and Rochefort.

Still active, the commission, over the signature of Lariboisière, summarized in 1812 the excellent results achieved: 3,000 m range with 76 mm and 4,200 m with 89 mm ones. But Congreve had not stayed inactive either. Among others, he managed to convince the Prince of Wales to authorize the creation of a Rocket Brigade in Bagshot in September 1811. British rockets would then be seen everywhere: in India and America in 1812, in Goehrde, Wittenberg, Leipzig, Pomerania and Spain in 1813, in Frederiksort, Bayonne, Toulouse, Catalonia and America in 1814, and at Waterloo in 1815.

Still under the shock of Copenhagen's gutting, Denmark was also making remarkable progress. Working in utmost secrecy in Frederiksvaert, Schumacher innovated in 1811 by manufacturing rockets incorporating for the first time various explosive heads. Naturally allied to Denmark since 1807, France had been following these tests: an observer sent by Field Marshall Davout, commander of the Army in Germany, witnessed flights of 4 km range. Very long negotiations by Captain Augustin-Joseph Brussel de Brulard (1786-1856) of the Ecole Polytechnique, led in 1813 to an agreement with Schumacher, on the condition of keeping the secret. Back in Hamburg with five rockets, Brulard immediately started the manufacture of a modified version: instead of being simply laid atop

the cartridge, the head was now mechanically fastened to it. Davout was able to witness the launch of three of them on 10 January 1814. Convinced, he gave the go-ahead for quick production using Danish saltpeter and sheet metal. Soon a daily output of 30 rockets was achieved, with 12 or 16 cm shells, grenades or bullets. In February, mobile batteries were being deployed around Hamburg.

Yet another workshop is known to have been created in Danzig in 1813, by Dominique-Nicolas Munier (1790-1838), from the Ecole Polytechnique.

But the abdication of the Emperor on 6 April 1814, four days before a last battle in Toulouse which saw Wellington use the Congreve weapon, signified a slackening of rocket activities in France.[4] Thus Brulard had to destroy his production facility, before going to La Rochelle with one example of each of his different models, as well as four of the Danish rockets.

The Hundred Days (1815)

As soon as he was back, in March 1815, Napoléon asked Davout, now War Minister, to push the rocket. Brulard opened a new workshop in Vincennes with the help of Bourée, ballistics specialist Grobert and the Englishman Williamson, who pretended to be the true inventor of the Congreve rocket. Brulard made good use of the work of chemist Proust, saltpeter manufactured according to the new Champy process, as well as sheet metal made from Swedish iron by a Liège industrialist located near Paris. He was given additional money on June 18th by Davout, who wanted rockets in great quantity. Cautious, Brulard preferred to continue perfecting the weapon, although he was well aware of criticism from the Artillery. However, on this very day, Napoléon was defeated at Waterloo.

The Eclipse of the Rocket in France (1818-23)

The reign of Louis XVIII then marked a stagnation of rocket activities in France. The remaining rocketeers were concentrated in Bourges in 1817 under Jacquier, only to shift to Toulouse at the beginning of 1818. There, they were given the task of the yearly production of . . . 20 rockets! Of 51 and 76 mm diameter, they used the Hamburg technology and reached 2,000 and 4,000 m respectively. Built for instructional purposes, they were used in Cadiz in 1823, however with meagre results.[5] Incidentally, the Brulard rockets were brought back from La Rochelle, only to be "burnt in some insignificant experiment." In 1821 Jacquier was replaced by Munier.

Meanwhile, the rest of Europe was researching very actively. This made Navy Captain De Montgéry, who had worked on the project, very sad: "Only Turkey, Spain, and France stay completely indifferent to the rocket." At this time, a significant innovation was introduced by Congreve in 1819, when he managed to shift the stick to a central position, thus improving the balance of the rocket.

Ecole de Pyrotechnie de Metz [School of Pyrotechnology of Metz] is Created (1824-40)

With the coming to power of Charles X, the fortunes of rocketry improved again. An important and decisive step was the creation in 1824 of the Ecole Centrale de Pyrotechnie in Metz, into which the rocketeers of Bourges were merged. Led by Commander Cailly-Duchesne, with Munier as his second, it however had neither money nor tools for any rocket activity.

On the other side of the Channel, things suddenly went awry for Congreve too, when he was convicted of fraud in 1826. It probably explains why one of his collaborators, Robert Bedford, after having unsuccessfully proposed his services to Russia, reached a conditional agreement with France in December. Fifty of his rockets were tested in Vincennes. Although not all the stipulated goals were fulfilled, a deal was struck on 11 May 1827, for Bedford-Morvat (as he was also called) to work in Metz. The many competent French specialists with their excellent—if not superior—results were baffled and preferred to stay away. Such was the Copenhagen effect and the prestige of Congreve.

Doubts were quickly confirmed when the tests of 1827, which Bedford said were as good as for any British rocket, did not show any progress: with a diameter of 81 to 108 mm, the lateral stick weapons had a range of 2,900 to 3,400 m.[6] An attempt was then made to improve the powder composition—to no avail. At least the various activities performed provided some results, allowing Cailly-Duchesne to announce in the summer of 1828 that regular behavior now justified military use of the weapon under moderate wind conditions. Probably now equipped with a central stick, the rocket showed a penetration of 4.63 m inside a mound at 1 km range in the Polygone of Metz.

On the previous 15th of May (1828), Congreve, forced to leave his country, had by a strange coincidence, died in Toulouse.

Now ready, a few rocket containers were sent in 1828 to Patras in Greece. Just when a good occasion to use them presented itself, everybody tried to locate the only rocketeer available . . . only to find him dead drunk!

Probably as a result of the above, and to prepare for the impending Algerian campaign [in the French plan to conquer that territory], Bourée came to work in Metz in 1828/9. Accordingly, the Ecole de Metz sent to Toulon 200 rockets of 51 mm diameter, and 200 of 64 mm, to be loaded with the expedition corps. Assigned to use them, the 10th Battery of the 9th Regiment under Captain Robert had not even been specially trained. The conflict however was quick. During the Battle of Staoueli, Robert routed the cavalry trying to encircle the French troops. Several rockets were also launched against the Emperor Fort during the bombarding of Algiers with unknown results.

All that did not alleviate the controversy, and a Committee was created in Metz to rule on the rocket. By 1831, it was recording the following results.

- the 51 mm rocket, weighing 3 kg, with 15 bullets, reached 1,650 m at a 19 degree angle, (Figure 1),
- the 64 mm rocket, weighing 6 kg, with 25 bullets, was available,
- the 89 mm rocket, weighing 15 kg, reached 2,380 m at an angle of 45 degrees. (Figure 2).

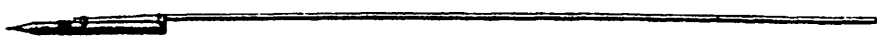

Figure 1 51 mm diameter rocket (Toulouse).

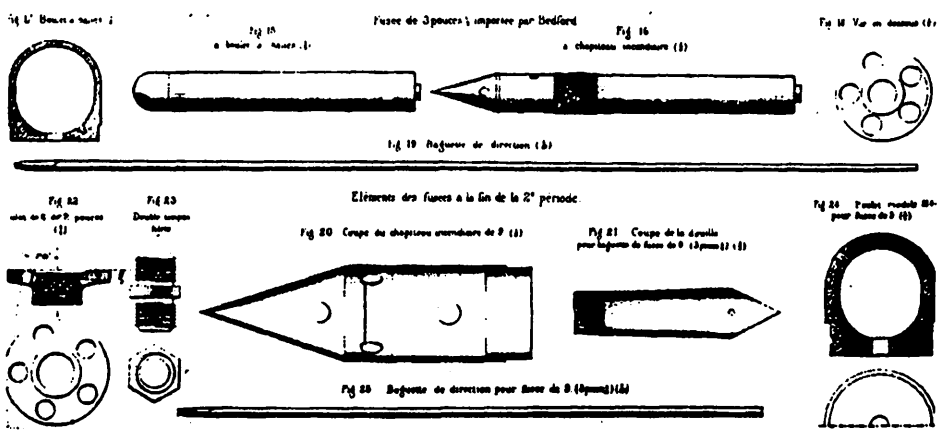

Figure 2 Bedford rockets (top), 9 cm rocket (bottom).

Although these distances were rather low, the Committee seemed convinced since it had a battery of cannons modified in 1831, in a rather stupid way

however, as rockets directly replaced the barrels without changing or simplifying the associated hardware. The higher mobility afforded by the rocket was thus negated.

Another opportunity was lost in December 1832, when no fewer than 1,000 rockets were sent to Antwerp [in the French action against the Dutch following the latter's invasion of the newly independent Belgium], only to arrive the day following the city's surrender. Only 11 were launched on the 23rd against the Dutch fleet, 1,400 m away, but without any hit being recorded.

This did not deter the Committee from staying active. In 1833 it proposed the shifting of two Metz officers who opposed Bedford, the latter being—not surprisingly—more and more controversial. When Wade, the former associate of Congreve, who thought that the bad reputation of rockets in France was due to manufacturing difficulties, proposed selling the "true secret," the Committee was charged by the Government to organize comparative tests in 1834 in La Fère. Any doubts were quickly dispelled. Equivalent in precision, the Metz rockets were clearly more powerful than the British ones. Another action of the Committee was to ask for the distribution in all artillery schools and arsenals of Captain Larchey's journal about rockets.

During the expedition against [the walled Algerian city of] Constantine, 51 mm rockets were used, although they were not efficient against stone houses. So, some were employed to send signals during the retreat of 1836, while Captain Coteau with the 4th Battery of the 10th Regiment launched a few during the night of 9 to 10 October 1837, without good effect.

Nearly all military units sent to Algeria between 1837 and 1844 actually had rockets with them, but nobody knew how to use them! It could not be otherwise, if one had read the report that Captain Piobert of Ecole de Metz wrote in June 1837, comparing the cannon and the rocket:

- because of wind, the rocket is not precise enough,
- the rocket is not powerful enough,
- as a consequence the cannon is superior, except where its weight prevents its use (even Bedford agreed).

However, the worst was over.

Creation of the Battery (1841-45)

An irresistable rise of the military rocket in France started in 1841, when the decision was made to create a dedicated battery due to the pressure of many, including General Schouler, who now commanded in Metz. There, the 6th Bat-

tery of the 5th Regiment was incorporated under the command of Captain Rougé.

In 1841, Schouler had started testing large caliber rockets with excellent results, although loading imperfections led to several accidents, notably during exercises held in 1844 to simulate the siege of Metz. Toulon was also still working on the weapon. Bedford reported its secret use in 1844 by the Navy under the command of Prince d'Joinville against Mogador (the government did not want the press to reveal French progress to other nations).

A general reorganization of the Artillery in 1845 planned the transfer of the Ecole to Vincennes. It did not happen, but Bedford did go, no doubt a welcome departure. Even more important, the same year highly respected Field-Marshal Marmont of the artillery wrote a very favorable opinion about the rocket in "De l'Espirit des Institutions Militaires" [The Spirit of Military Institutions]: "in short, this invention, as it is, and with the improvement it still portends, can do everything, under all circumstances, with all combinations, and should take immense ascendancy over the world's destiny." Rather than having a dedicated corps of rocketeers, Marmont would have liked to see them in all regiments. Such an extraordinary prediction impressed many at the time and caused much controversy. We can realize today how far-fetched it was.

1845 also saw the battery fire its first shots during a short expedition to Algeria. Twenty-five rocketeers easily dislodged Arabs from high cliffs with only a few shots.

That year, too, saw a promising invention by Englishman Hale, who tested a rotating rocket with the hope of improving precision.

France, the First Military Rocket Power (1846-51)

It may be a coincidence, but as soon as Bedford left, an exhaustive research program was launched in Metz in 1846, addressing many aspects:

- powder composition,
- shape and dimensions of the core,
- shape and dimensions of the vent,
- guidance means,
- powder loading method (hammer or press),
- manufacturing methods.

The objective of Rougé was to start building better rockets as soon as the program was completed. Improvements also concerned testing methods: thrust now was measured with a blade dynamometer, no longer indirectly by recording the

range of an actual launch. Sadly, Rougé was killed during a test in 1848, confirming the risky aspect of propulsion activities. Captain Gerbaut took command of the Battery with Captain Nores his second in command.

Progress must have been satisfactory since the Army decided to adopt in succession:

- the field rocket of 5 cm in 1849 (54 mm internal diameter of the cartridge),
- the field rocket of 7 cm in 1850 (68 mm internal diameter),
- the rocket of 9 cm (98 mm internal diameter), mentioned in the Artillery manual. (Figure 3).

This accelerated schedule could also be explained by the needs of the Alps Army, for which a fairly high number of rockets of 5 cm were prepared. They were not completed because tensions abated.

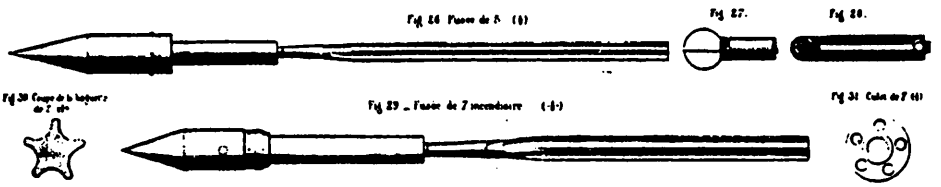

Figure 3.

France also experimented with rotary rockets. Lieutenant Colonel Goupil proposed ejecting gases through holes drilled in a ring made of zinc. The stick, thought to be the cause of lack of precision, could be removed. Starting around 1850, the Artillery School of La Fère tested this type thoroughly until 1855, but any hopes of better accuracy were dashed.

Susane Pioneering Work (1852-54)

The arrival of Commander Susane (1810-?) in Metz accelerated the momentum of rocket activities there. Research was immediately boosted.

A major achievement concerned the location of the center of gravity (CG), until then arranged at the level of the exhaust, which was thought to be the point of thrust application. When the latter was actually found to be within the propellant core, the CG was moved up accordingly by reducing the stick length and increasing the warhead weight.[7]

Another significant improvement was the use of a press for propellant loading. The drop hammer then in force was a fairly rough affair, introducing

cracks at the origin of local detonations: combustion was not uniform—if not explosive. The press not only allowed smooth loading of the powder, but also packing more of it in the casing. Two such presses were in service in 1854.

In the same vein, it was confirmed that no "secret" had to be unravelled about black powder composition, which had for long been established. Materials for the structure were analyzed as well. Cardboard, wood or leather were light, but they had several drawbacks: insufficient protection against shocks and atmospheric conditions, and incompatability with high energy powder use. Bronze and iron alleviated some of these, but at the expense of weight; they were also considered to be dangerous in case of explosion. So the availability of the roll-forming process for sheet metal, with its small thickness and good homogeneity, made it an obvious choice.

Manufacturing was also the subject of much attention: by relying less on hand work, dispersion was reduced, notably at the level of the duct (axis and diameter) stick and CG (position). Trajectories could thus be more regular.

As for the doctrine, Susane had rightly understood that, to be compatible with artillery, the rocket had to have at least a similar range. He thus decided that the smallest rocket had to have the range increased to 2,500 m with a 3 kg head, and that it had to be compatible with a man-portable tripod.

While this work was going on, half the battery was deployed in April 1852 in [the Department of] Algier at the request of the Governor General of Algeria. It took along the 5 cm rockets planned for the Alps together with their tripods. Then, in 1854, in the frame of the new reorganization of the Artillery, the battery was renumbered the 4th and attached to the 12th regiment.

Susane's remarkable work was, however, soon to be put to the test. With the Crimean War looming on the horizon, Napoléon III asked for 5 km range rockets. Ten weeks later testing produced the following impressive results:

- more than 7 km range for the 9 cm rocket (with 15 cm shell),
- 6.5 km range for the 12 cm rocket (with 16 cm shell).

New buildings were erected in Metz to house the 22 presses needed for mass production of 50 rockets per day—20,000 annually.

The Crimean War—The Rocket Comes of Age (1854-55)

The Crimean War is of historical nature, since it seems to have seen the first regular use of the military rocket, that is, planned in advance and effective during the whole campaign, both by the French Army and Navy.

The Navy opened with the first shots on 26 April 1854, in Odessa: the steam-powered frigates *Mogador, Descartes* and *Vauban* and the corvette *Caton* successfully set on fire several Russian and Greek vessels, as well as several stores.

The half battery, which had left Algier with 81 men, 10 horses and 45 mules, arrived in Galipoli where 15 men and 15 mules were added. It left on June 16th with 300 rockets of the 1849 model and 6 tripods. Its operational debut came in August, as part of the Dobrudja expedition. Its intervention was not necessary, but Nores who died of cholera was lost and was replaced by Captain Harel (Captain Mauger also replaced Gerbaut in 1854). The battery was not required during the Old Fort landing of September, and lacking transportation, missed the Battle of Alma as well. Carrying the equipment for the whole day had been in vain.

With the start of the Sevastopol siege, some 9 cm rockets brought from Toulon were fired on October 18th from light ships toward several forts. Two days later, the battery at last entered the action by launching 5 cm rockets from tripods in two locations against the Bastion du Mal (Evil's Bastion) 1 km away. Constantly shifting between the 32nd and 47th Batteries' positions, the 4th was so active that, by the turn of the year, only 58 rockets remained of its original consignment. Having in the meantime received its first long range 9 cm rockets of the 1854 model, it launched two of them with incendiary heads on November 21st; they fell into the harbor. Once these models were in sufficient supply, a battery of siege tripods was built at the end of January 1855 in the Bay of Streletzka.

Launches became systematic, with good results:

- 4 on January 26th, one hitting a house used by officers for their meetings, killing and wounding several of them,
- 6 on January 28th,
- 10 on February 22nd,
- 5 on February 23rd,
- 50 on February 26th,
- 35 on February 27th, by which time the civil population, helping the garrison concentrated in Oucht-Kouerkou, had to leave completely,
- 30 on March 3rd,
- 22 on March 7th (half of them incendiary, the rest explosive), were successfully used against a 2,000 vehicle park 6 km away, compelling the Russians to hurriedly try to disperse the vehicles,
- 40 on March 11th, starting many fires in Sevastopol,

- 90 on March 22nd, setting huge fires to a wood store, as well as the apartment of the commander in Sevastopol, General Osten-Sacken.

In spite of several in-flight bursts of these 9 cm rockets, their behavior was considered sufficiently good for a huge order to Metz: 24,000 rockets, including 16,000 long-range ones (half explosive, half incendiary), and 4,000 short range explosive ones. The order was not completely fulfilled because all toolings were not yet available.

Launches continued unabated, the most notable being:

- 112 from Streletzka on April 10th,
- on April 19th only 50 rockets allowed Captain Hurel to rout 1;500 Russian horsemen on reconnaissance under the command of Omar Pasha,
- 150 9 cm and 12 cm long range rockets (incendiary and explosive) launched during the night of June 6 to 7 lit several fires in the town,
- on June 18th a single rocket, launched amidst intense firing to help a wavering offensive, detonated a building holding thousands of bombs and grenades, in turn destroying another building and its artillery material, killing many in the process.

More launching stations were being created as well:

- near St-Wladimir Church on July 27th,
- on a station formerly used by the 21st Battery, at the end of July,
- in the Eperon for the Navy rocketeers, at the end of July,
- in the Canrobert Fort, with 3 high caliber rocket tripods, on August 13th.

Any weapon has its own limitations: this was shown in August when rockets could not prevent the Russians from building a bridge in the bay, although several hits were recorded. The final phase of the conflict was, however, to see widespread and successful use of the rocket. On August 16th it created havoc among horsemen and artillery during the Battle of Tratkir. On September 7th and 8th 1,000 rockets were launched from St-Wladimir and the 26th Battery station as a preparation to the assault on Malkoff, in addition to many Navy firings. Utter disaster was then barely avoided when only prompt reaction prevented the detonation of 32 tons of ammunition in the main fort following the fall of a rocket just at the entrance. However, another rocket killed many as it hit a launch unloading 3 tons of powder on Grosski quay.

After the fall of the town, the Army took position in Fort Nicolas, and the Navy in front of Inkermann, to shell the northern part of the bay with long-range

7 cm rockets from September 12th through October 26th. One of 400 such rockets severely injured Lieutenant Kargaloff, the commander of the Volchff tower, on September 18th. When, during the winter, Russian patrols on foot spied on vessels blocked by ice, the Navy had to launch a few rockets at them.

Complete with 4 officers, 154 soldiers, 34 horses and 72 mules, the 4th Battery participated in the victory parade on 17 April 1856. On May 24th it left for Algier.

As a postscript, Table 1 summarizes rocket use during the Crimean War:

User	Army (Metz)			Navy (Toulon)
Caliber	5 cm	7 cm	9&12 cm	9.5 cm
Delivered			10,116*	
Launched	3 to 400	400	3,500	1,300

In-flight burst: 4.37 % (Army)
Accident to personnel: none "

* 6,600 sent back after arriving too late

In the official history of artillery at Sevastopol, General Auger wrote that the rocket, while not replacing the cannon, was a useful tool, and that unfortunately it was not always available in sufficient numbers. He only levelled criticism at the new 7 cm field rocket: transporting their heads separately made them useless in the heat of battle, negating one of the advantages of the rocket—its simplicity of use. The artillery seemed at last convinced by the "new" weapon.

Many of the above results were only known later, when the other side wrote about them, as did respected General Konstantinoff. Incidentally, that "side" is recorded as having only launched about 20 2-in. rockets during the night of 5 to 6 September 1855. Some were seized in the town and analyzed in Metz, where they showed a somewhat average performance.

So, when one takes into account the fact that Sevastopol did not have much ammunition nor much wood inside its confines, it can safely be said that the French rockets truly made a significant contribution to the war effort.

A Baltic Interlude (1855)

At the request of British Admiral Napier—now an ally—long-range rockets had been ordered from France in May/June 1855, for use at Sevastopol as a test for the forthcoming bombardment of Cronstadt: shallow waters would keep

the fleet 5 km away. In Congreve's country such a request must have raised a few eyebrows.

A high gear experiment seems to have been planned. The corvettes *Saône* and *Marne* left Le Havre on August 2nd and 18th, respectively, with 4,816 12 cm rockets and 25 tripods on board. Half of them had 2.5 kg incendiary heads, while the rest had either explosive heads of 3 to 9 kg or 16 cm shells. No less than 100 specialists from Metz, under the command of Captain Mancourant, with Captain Martin as his second in command, had the specific mission of setting up plans, taking into consideration local conditions for a foreseen 4 hour bombardment.

No sooner had the *Saône* arrived on August 22nd, than Martin had to make test launches for the French staff and in full view of the British flotilla. Two days later, the British light vessels went back home for whatever reason. On the 29th, the *Marne* and Mancourant arrived, with a secret letter for Napier. Much agitation ensued, upon which the French commander left for Paris via Danzig, while Mancourant repeated a demonstration in front of both staffs by launching 4 rockets.

The Russians, who had witnessed the tests, and who actually had no more than a dozen rockets, had some delivered from St. Petersburg. Four of these were fired on the 28th and four on the 30th, to entice the allies into believing they were fully equipped with these rockets.

Then, on September 9th, a cable arrived from Paris, whereupon the whole French armada departed. In the absence of details regarding the results of the launches, one can only conjecture about the reasons for this volte face. Were they technical? Political?

The Rocket System is Adopted (1856)

Nominated Lieutenant Colonel in 1854, Susane achieved his goal when in 1856 the Army adopted a complete rocket system, which was made of:

- a field and mountain 6 cm rocket, weighing 7 kg with a 3 kg head, (Figure 4)
- siege and place rockets of 9 and 12 cm,
- a 16 kg tripod with two perpendicular hinge lines. (Figure 5 of an 1857 model).

Thus in 1856, as Jacquot replaced Mauger at the head of the battery, the military rocket had come of age as an operational weapon. Susane had given France the only true rocket system in the world.

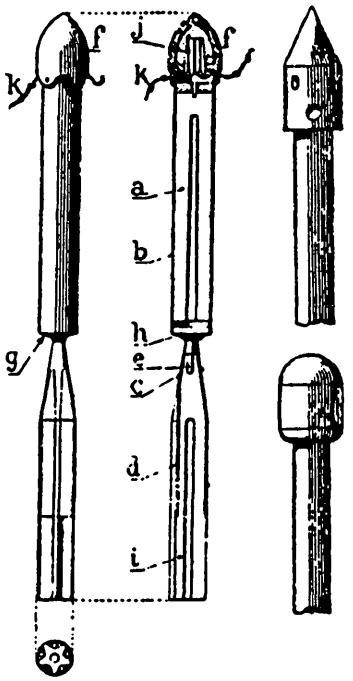

Figure 4 6 cm rocket with shell, Right: incendiary head (top), balls head (bottom).

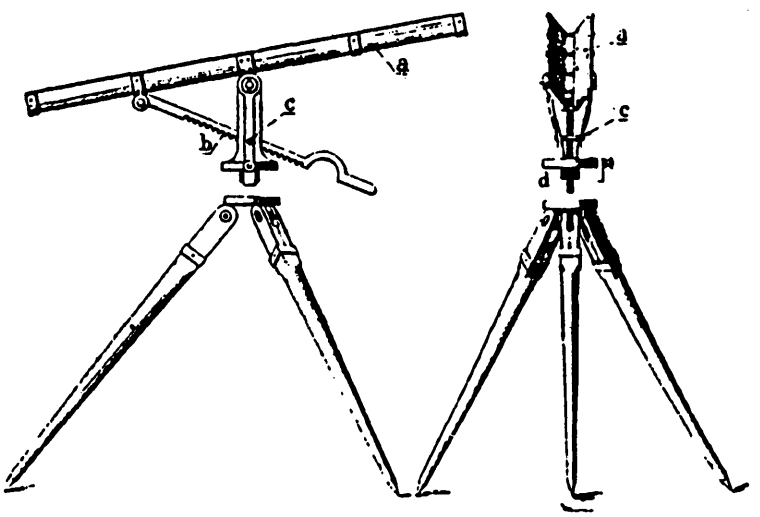

Figure 5

The Kabylie Campaign (1857)

The operational debut of the new system took place during the Grand Kabylie campaign of 1857. The battery, still based in Algier, was split into 3 sections corresponding to the divisions of General Renault (the Governor General of Algeria), of MacMahon and of Yusuf. Jacquot was attached to the first division, but we happen to have details only for the section working with MacMahon. Its initial complement was made up of 2 officers, 50 men, 10 horses, 23 mules (later 25), 4 tripods, and 148 6 cm rockets (92 shell ones, 38 balls and 18 incendiary). Later, its number of rockets was brought up to 165.

In hilly terrain the rocket played a primary and decisive role when 85 shell, 24 ball and 12 incendiary rockets secured the surrender of the villages of Tacheraich, Bollias, Afensou and Imaiseren on May 24th, as well as the submission of the Beni Raten tribe. On June 26th only 96 rockets sufficed to take Icheriden which was in a very difficult area. The following day about 60 rockets were used to impress the Beni Yenni, as well as to help the Renault and Yusuf troops on the other wing of the attack. Twenty-five rockets were launched on the 28th to capture Taourirt el Hedjadi. The mobility of rocketeers enabled the takeover of Aguemoun-Isen on the 30th. Finally on July 10th, with the rocketeers climbing steep slopes, the rockets played a decisive role in the surrender of M'Zien.

A total of 540 rockets was launched in Kabylie, at the orders of now-convinced and even laudatory military commanders. The Artillery Chief of Staff in Kabylie wrote that "they were launched with great success . . . they rendered the greatest services . . . they could go everywhere and be positioned in locations even mountain artillery could not reach, thanks to the man-carrying of ammunitions and launchers." The general at the head of the African Army Artillery said that "their launches had been generally good, mainly at high angles. They tend to replace light artillery in mountain artillery, on the side of grooved cannons." Renault wrote to Susane: "The mobility of the tripods allowed me to constantly place the rockets in line with the tirailleurs, all the movements of which they could follow. The experiment is conclusive. I know how much you worked to improve rocket launching. I am happy to tell you that, during the campaign, I did not have the slightest accident, and that all hits were well adjusted."

The Military Rocket at its Pinnacle (1858-63)

No doubt thanks to the influence of Marmont, France had an operational rocket system as a result of Susane's pioneering work. Susane went on to a

brilliant career, Colonel in 1857, Chief of the Artillery and Brigadier General in 1864, then Major General.

The Battery of Metz, as well as its naval counterpart, would see many horizons in the world during their 17-year life span. On 19 May 1859 the battery left Algier for Toulon, where it received 2,000 field rockets. Although quickly transported to Italy, its 4 sections with 4 officers, 220 men and 152 horses and mules arrived too late, on the day after the Battle of Solferino. It went back on August 15th.

On October 4th the third section was on the road again, this time to Morocco. On the 27th and 28th a few shell and ball rockets were instrumental in dislodging the Beni Snassen from the Aïn Tafouralt pass.

At the same time the Navy was active in Senegal, successfully using 6 cm rockets several times, notably during the Battle of Guemou on October 25th. Alas, as much brilliant success as had been achieved, downfall was to be abrupt. A new weapon appeared around 1858, the grooved cannon.

Reorganization—Far East Campaign (1860-63)

A severe blow was dealt to military rocketry when yet another artillery reorganization took place in 1860. A decree of April 1st disbanded the rocketry battery and renamed it a regular 9th of the 12th regiment. From now on rocket detachments would be created only according to needs. Without a constant stream of specialists, the rocket's future was doomed.

Two sections were still to participate in two campaigns, however. The third section was attached to General Desvaux for the Oriental Kabylie expedition. There, shell and ball rockets allowed columns to cross the Fedj Ménazel pass on 14 June 1860. On the following day, shell rockets routed the Kabyls at Beni Khettod Mountain. Involved in all reconnaissance, the section was back in Algier by August 24th.

Then on October 6th, together with another section, it was sent to Besançon, where their rocket status fell into oblivion. The only active rocket corps of the Army was now a section fortunate enough to have left France before the "upheaval:" it had left Algier on 1 December 1859, for a long trek to China under Captain Delaroze. Personnel were on a big sailing ship, *Reine des Clippers*, while rockets (1,000 of 6 cm, 800 of 7 cm, 144 of 9 cm and 54 of 12 cm) were loaded onto another vessel. After the clipper burned near Macao, the section eventually reached Sin-Ko on 12 August 1860, where it contributed significantly to the takeover of the fortifications. Two days later, the rockets' precise hits allowed the capture of the Tang Ho camp. On the 21st their bombing so demoralized the Chinese, that they abandoned Ta Kou, Si Kon and the forts on

the Pei Ho River. On September 21st the rockets routed the Tartar cavalry, which led to the seizing of Oua Koua Ye and of the Pa Li Kiao camp. Until October 13th, when the Chinese surrendered to the French and the British, the section was constantly at the fore, but it never had to be put into action.

At the end of January 1861, a small detachment of 5 rocketeers was sent to Annam with 9 cm weapons, joining the Navy and its 12 cm rockets. The rest of the section was sent back to Besançon, thus marking the effective end of the battery per se.

Many rocket salvos took place between February 23rd and 25th against the Annamese camp. On April 9th, during the Mytho campaign, a big camp was quickly set on fire. Using only one tripod, the detachment managed to capture the Forts of Go Den and Long Phu by itself between the 8th and 14th of January 1863!

A Fast Winding Down (1863-72)

In accordance with the new policy, a mixed detachment including some rockets was sent to Mexico in September 1862. It barely managed to launch a grand total of 8 rockets: 2 at Ventilla on 12 January 1863 against horsemen, 3 at the siege of Puebla, and 3 during the battle of Guadalajara on 28 February 1864. The French Army had fired its last rocket, a sad conclusion to one century of effort from Ruggieri to Susane.

This was not, however, the end, since the Navy rocketeers were still active in Annam: on 22 February 1865, with a single launcher and 9 cm rockets, they burned down the fort of Suai Gia Cao, sending the enemy into retreat. This marked the end of the use of military rockets in France (and in the world?) for a long time, as a final campaign in June 1867 against Vinh-Long did not employ the weapon.

Low-key activity persisted a few years in the homeland. A shell rocket was tested in 1863 in Vincennes to try to overcome the problems found with the rotating rockets: after the shell was fired from a grooved cannon, a slow burning fuse, ignited at launch, lit a powder block at the back of the shell, thus giving a further impulse to the combination. The results are not known.

It then only remained to transfer the Ecole de Pyrotechnie from Metz to Bourges* in the beginning of 1870, in order to protect it from German hands. Toolings were not even used and upon Committee advice, on 27 July 1872, the

*One century later, Aerospatiale is manufacturing hundreds of thousands of its famous anti-tank missiles there for armies all over the world.

War Minister decided to remove the rocket from its arsenal, and to destroy the remaining ones.

Grooving and breech loading had won the day for the cannon. How could a system proven and praised during the Crimean War and Kabylie campaign of 1854 to 1857 be put aside barely 3 years later, in spite of demonstrated superior hitting power and ease of use? Was it just the victim of the latest Artillery reform, that of 1860? Or, as had happened several times previously, had the new technical gains of conventional artillery been decisive: better precision, possibly increased range, too? Probably the nature of a rocket, inherently more complex than a shell, made it more difficult to be perfectly symmetric, thus making it less precise—at least with 19th century technology.

And so the rocket disappeared from the world scene for many years, and with it the pioneering work of Metz started in 1824 and the research initiated there in 1846, with the definite influence of Susane in 1852.

The French lead was not totally lost, since the rocket made a timid but conspicuous return during the Great War, with the efficient Le Prieur weapons fired from Allied fighters against the Drachens, to become the first roquettes.

Then it was up to the modern rocket, as promoted by the great pioneers, Esnault-Pelterie (1881-1957), Tsiolkowski (1857-1935), Goddard (1882-1945) and Oberth (1894-1989).

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