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Chapter 2

NINETEENTH CENTURY ROCKETRY IN FRANCE*

Frederick I. Ordway, III† and Hervé Moulin‡

Frontispiece General Louis August Susane, head of the 19th century French rocket establishment (National Air and Space Museum).

The development of rockets in France during the 19th century did not assume the importance it did in Great Britain, Russia and Austria. Although there were exceptions, only moderate interest existed among most leading artillery officers and

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ordnance planners. This was due in part to the fact that no great innovator like Britain's William Congreve, Russia's Konstantin Ivanovitch Konstantinov, or Austria's Vincenz Augustin appeared to "sell" rocketry to the military; in part because of the swiftly changing military and political climate; and in part because of the nature of the wars conducted by French troops. Nevertheless, France accomplished a considerable amount of research and development on rockets, propellants, warheads and launchers from roughly 1810 to the early 1880s.

It was not that the nation lacked a strong pyrotechnic base on which to build. Quite the contrary: it was the country of Amédée François Frézier, Pérrinet d'Orval, A. M. Th. Morel and especially Claude Fortuné Ruggieri, latest of the famed Ruggieri family. Morel, in his *Traité pratique des feux d'artifice pour le spectacle et pour la guerre* published in 1800, describes all sorts of pyrotechnic devices, including "fusées volantes," or firework rockets of seven different calibers ranging from 6 *lignes* (a ligne is equivalent to 1/12th of an inch) to 36 *lignes*, or 3 inches. The title page of the book is reproduced in Figure 1, while Table 1 lists the principal measurements of these flying rockets. Figure 2 reproduces a plate whose numbers are keyed to descriptions in the book's text.

TRAITÉ PRATIQUE

DES

FEUX D'ARTIFICE,

POUR LE SPECTACLE

ET POUR LA GUERRE,

Avec les petits Feux de table, et l'Artifice à l'usage des Théâtres.

PAR A. M. TH. MOREL.

A PARIS,

Chez FIRMIN DIDOT, libraire pour les Mathématiques, la Marine et l'Architecture, rue de Thionville, n.os 116 et 1850.

AN IX. — 1800.

Figure 1 Title page, Traité pratique des feux d'artifice by A. M. Th. Morel (1800) (Ordway Collection, Space and Rocket Center).

Table 1
ROCKETS AVAILABLE IN 1800 ACCORDING TO MOREL

Name	Diameter in Lignes*		Length in Inches & Lignes*
	Exterior	Interior	
Petit Partement	6	4	3 - 0
Partement	9	6	4 - 6
Marquise	12	8	6 - 6
Double Marquise	15	10	7 - 9
Trois Douzaines	18	12	10 - 2
Fusée d'Honneur	24	16	10 - 4
Republicaine	36	24	13 - 6

* 1 ligne = 1/12 inch

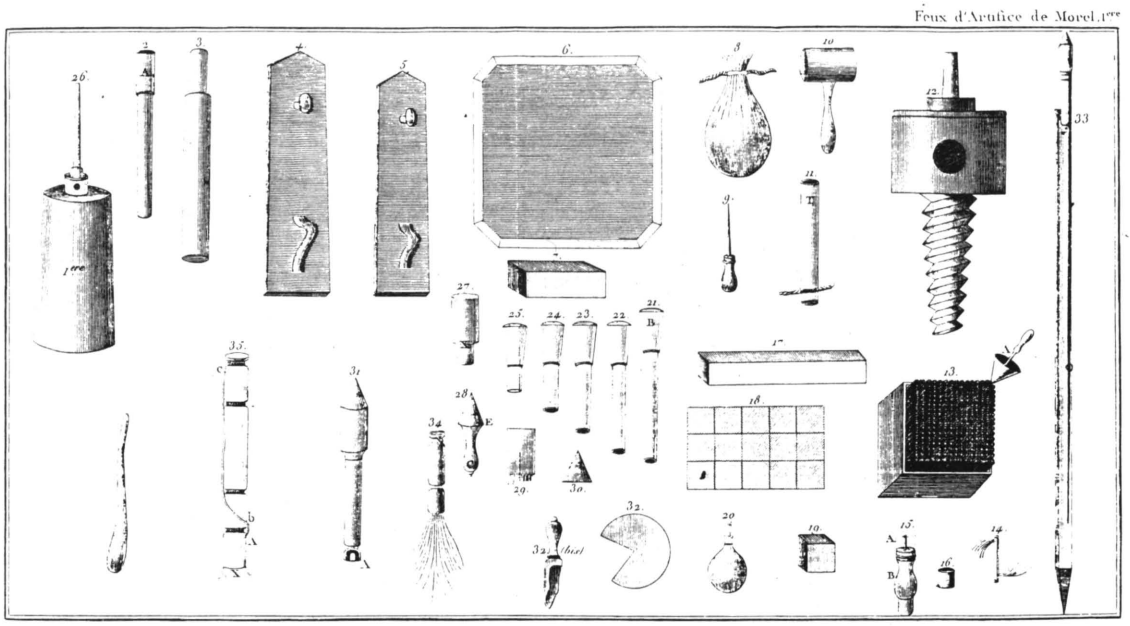


Figure 2 Plate from Morel (Ordway Collection, Space and Rocket Center).

Morel's description of rockets at the turn of the century makes charming but technically inaccurate reading: "The cases of flying rockets are charged on a peg with pierced rods. This peg is of conical shape and leaves an empty space in the body of the rocket; it is this space that, presenting a large surface for the fire, burns in a lively manner, and pushes a column of fire that strikes against a column of air opposing its passage, and makes the body of the rocket act against itself which, being directed vertically by a tail that serves as a counterweight, forces the rocket to

ascend in a straight line, without which it would move to and fro, with the risk of burning or hurting someone." [1]

Ruggieri, in his 400-plus page *Élémens de pyrotechnie* (1802) spends barely more than a page on incendiary and war rockets, and states: "It was after the tests that I made on these rockets (3 years ago) at the instigation of a privateer, that I am certain of the effect that I am announcing." Ruggieri made them in practically the same manner as his firework rockets. Figure 3 is the frontispiece of the book and Figure 4 a reproduction of plate 18 (whose Fig. 3 depicts three rockets assembled to ignite one after another in flight).

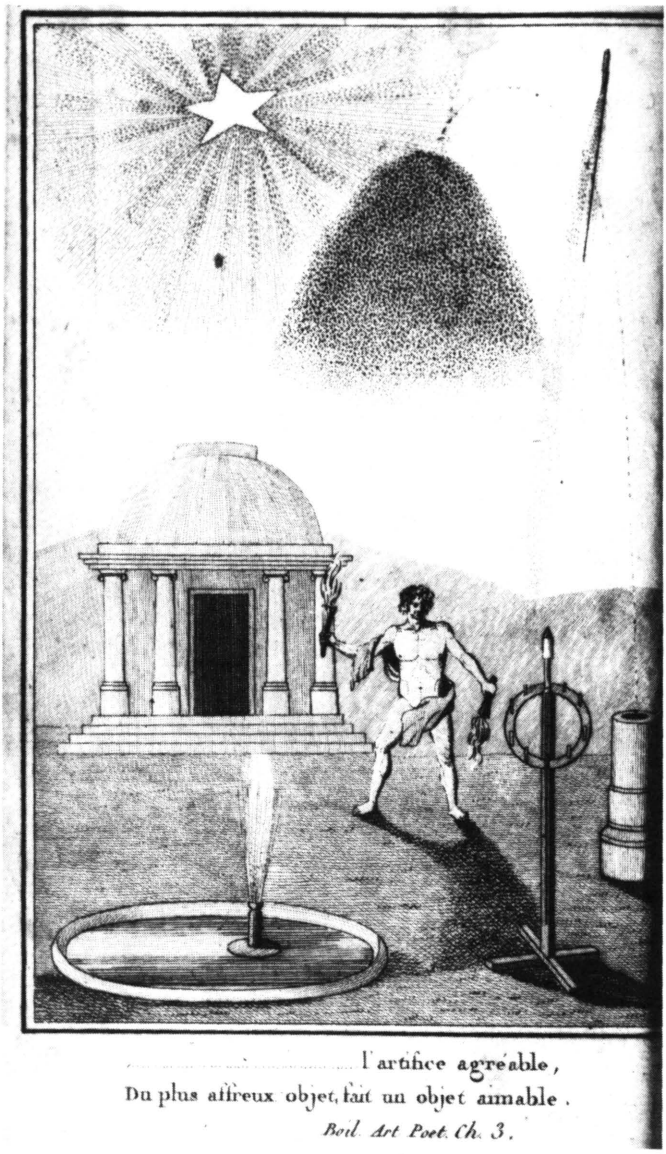


Figure 3 Frontispiece of Claude Fortune Ruggieri's Élémens de pyrotechnie (1802) (Ordway Collection, Space and Rocket Center).

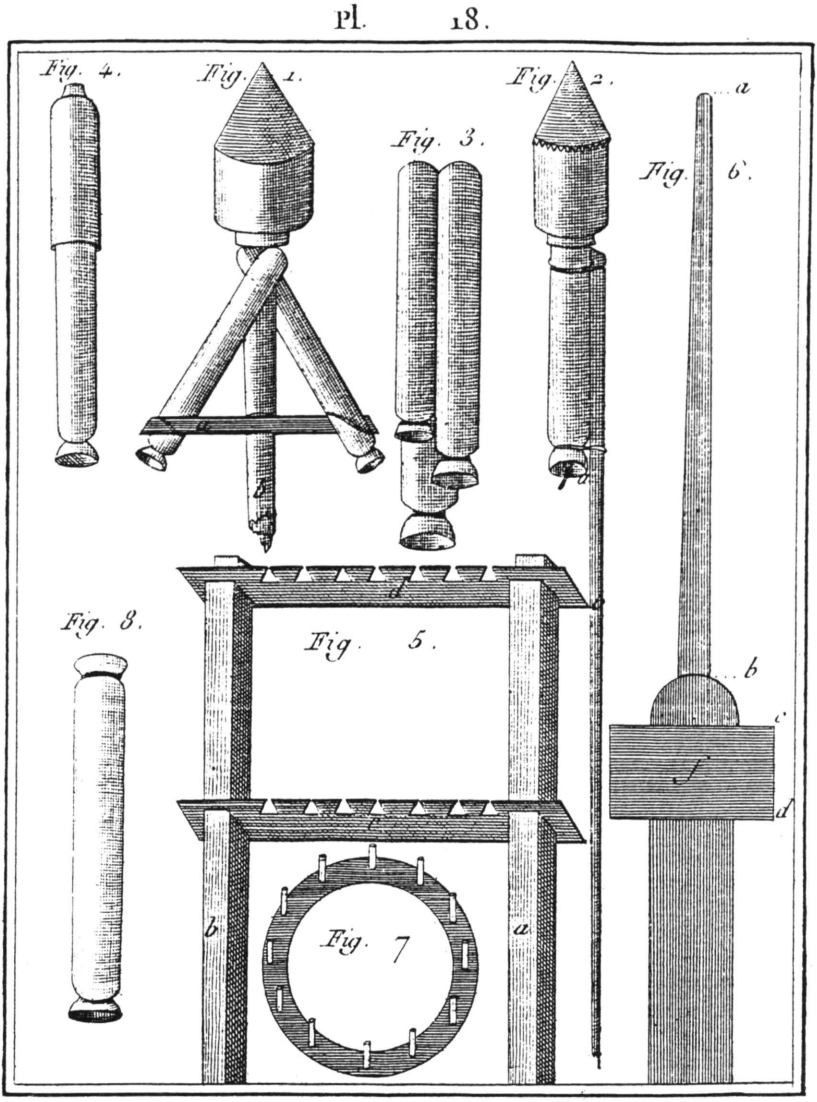


Figure 4 Plate 18 from Ruggieri's Élémens. The upper center Fig. 3 illustrates as assembled rocket cluster whose stages are designed to ignite one after another in flight (Ordway Collection, Space and Rocket Center).

Ten years later, after the Congreve rocket had become known to him, Ruggieri dismissed the device in *Pyrotechnie militaire* . . . [2] as an unimportant innovation, saying that: "This Congreve rocket is nothing more than that which I described in my *Élémens de pyrotechnie* 10 years ago. Figure 5 is the title page of the book signed by the author and Figure 6 reproduces Plate VIII, which illustrates a stick-guided rocket (designated Fig. 4).

Yet, Ruggieri's statement was hardly accurate, for despite his work, French interest in military rocketry was practically nil. Like many nations, France—from the end of the first decade of the century—was to learn about rockets from the work of William Congreve [3].

PYROTECHNIE
MILITAIRE,
OU
TRAITÉ COMPLET
DES FEUX DE GUERRE
ET DES BOUCHES A FEU,

Contenant l'origine de la Pyrotechnie militaire, les principes chimiques et mécaniques pour composer, préparer et lancer les machines incendiaires à l'usage des arsenaux de terre et de mer; un Précis des bouches a feu; un Abrégé de la fortification, de la défense, de l'attaque, etc.; suivi d'un Vocabulaire.

Bella manu lethumque gero.
VIRG., *Æn.*, lib. 7.

PAR CLAUDE-FNÉ. RUGGIERI.

A PARIS,

Chez { L'AUTEUR, rue de Clichy, n° 3;
MAGIMEL, rue de Thionville, n° 9;
PATRIS et Cie, quai des Augustins, n° 37;
BARBA, Palais-Royal, galerie des Français, n° 51.

DE L'IMPRIMERIE DE C.-F. PATRIS, RUE DE LA COLOMBE, N° 4.

1812.

Figure 5 Title page of Ruggieri's Pyrotechnie militaire . . . (1812), signed by author (Ordway Collection, Space and Rocket Center).

During the opening years of the 19th century, while Congreve was experimenting at Woolwich, Napoleon was enlarging and consolidating his power in Europe. Despite the Treaty of Luneville and the Peace of Amiens in 1801 and 1802, conflicts broke out in 1803 and continued almost without interruption for 11 years—until the fall of the Empire. During these years, one occasionally reads of rockets being used against the Grande Armée by coalition forces, but not of French rockets being fired back. They were not used, as far as we know, in any of Napoleon's early campaigns in Portugal and Spain, nor against the Austrians at Wagram in July 1809. Up until that time, the French simply had not seriously considered introducing rockets into their armed forces.

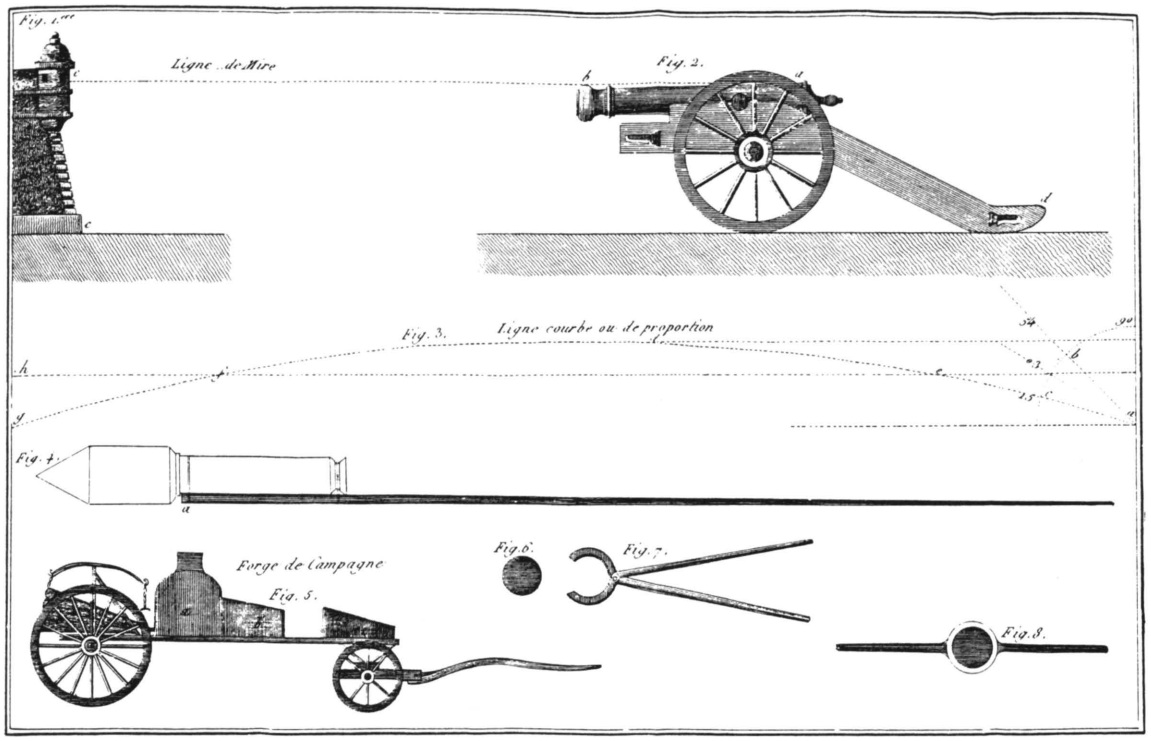


Figure 6 Plate VIII from Ruggieri's Pyrotechnie. The included Fig. 4 illustrates a stick-guided rocket (Ordway Collection, Space and Rocket Center).

A curious use of a sounding rocket, however, took place in Marseille in 1806. Claude Ruggieri sent a small sheep up to a distance of 200 meters and returned it by parachute.

FRENCH LEARN OF CONGREVE ROCKETS

The English had fired rockets against Boulogne as early as 1805, and especially in 1806, but the French military paid little heed to the new weapons. Yet, they did recover and study a few duds. Moreover, they were quite impressed by the results, as Colonel (later General) Louis Auguste Susane (occasionally spelled Suzanne) testified: " . . . the general impression produced in France by the attempt [the Congreve rocket bombardment] on Boulogne was so striking that it has endured until today."

Three years afterwards, in 1809, the French began to take a second look at what the British were unleashing against them. During the nights of 11-12 April, rockets were used during British Admiral Gambier's attack on the French fleet assembled in the Aix Roads. According to the famed historian and statesman François Pierre Guillaume Guizot (*Histoire de la civilisation en France, 1830*), the attack was: " . . . conducted by several divisions, composed of frigates and brigs; thirty large fire-ships were suddenly launched against our vessels, exploding in all directions, breaking the wooden bars by the weight of their burning masses, adher-

ing to the sides of the ships and compelling even those that they did not set on fire to go aside to avoid dangers that were more to be dreaded."

In August, the French again learned about the rocket—at their expense. Just how many the English fired during the bombardment of Flushing, following their landing of a 40,000-man army and much artillery on Walcheren Island, is not known. French chroniclers attribute the destruction of the town hall and 70 houses to rockets along with considerable other damage.

Once Congreve's work became known to the French, their activities in rocketry commenced. It is convenient to divide the growth of 19th century rocketry in France into five periods.

The first extends from approximately 1810 until the arrival of the Englishman Robert Bedford in 1826, and covers early French developments based on their analyses of captured Congreve rockets. The second runs from 1826 to 1846, during which time the French under Bedford's technical direction attempted to perfect English rocket technology and integrate it into the armed forces.

The third period lasted some 8 years to the beginning of the Crimean war, and the fourth began and ended with the war itself, at which time long-range, hydraulic-press loaded rockets came into operational use. The final period commenced when the war was over and lasted until 1872—the year when war rockets went out of fashion in France, as was happening in other European nations.

THE STUDIES OF d'ARCET

Dud rockets from both Aix and Flushing were duly collected by French ordnance experts. An Engineer Colonel Récicourt is known to have sent to the Société d'Encouragement pour l'Industrie Nationale in Paris some incendiary rockets found on board an English fireship that ran aground off Aix. Almost immediately, at Vincennes, Jean Pierre Joseph d'Arcet conducted a thorough analysis of their construction and composition, reporting on his findings in the Society's *Bulletin*. Following his studies, a special commission of artillery officers was formed at Napoleon's orders to investigate means of manufacturing rockets based on the type examined at Vincennes by d'Arcet.

In 1812, the commission reported the results of its findings and preliminary work under the signature of General Lariboissière. Both 3 and 3-1/2-inch rockets had been built and fired successfully at ranges of 3 and 4.2 kilometers, respectively. Indeed, in Toulon, 2,000 of the 3-inchers had already been made and sent to Cadiz, along with some manufactured in Seville. We know little about their employment in the bombardment of the Spanish city, except that they were ineffective compared to the mortars. For one thing, their range was too short. And they were expensive: a contemporary *Aide-Mémoire* says they cost 30,258 francs, 86 centimes.

During this early period of development of war rockets, accidents occurred during testing, both on the ground and in flight. Although they became progressively rarer with the passing of years, accidents were bothersome, and many steps had to be taken to reduce their severity. Most resulted from explosions caused by inter-

nal gas pressure exceeding the structural strength of the rocket casing, explosions that might occur either in the launcher or while the rocket was in the air. The cause for the pressure rise might lie with uneven settling of the propellant or cracking resulting from shock; or perhaps from an accidental obstruction of one or more vent holes by residue fragments resulting from the manufacturing process.

Naval Captain Mérignon de Montgéry, in his *Traité des fusées de guerre* (1813), recounts a typical accident in flight that occurred in 1811 at Vincennes: " . . . a rocket, after having hit the ground, encountered an obstacle that made it return in the opposite direction to its original flight. It entered one of the supports of a launcher in the paddock. For a moment there were fears that the rocket would endanger the rest of the paddock, but only the launcher was damaged." Figure 7 reproduces Plate 5 from the book.

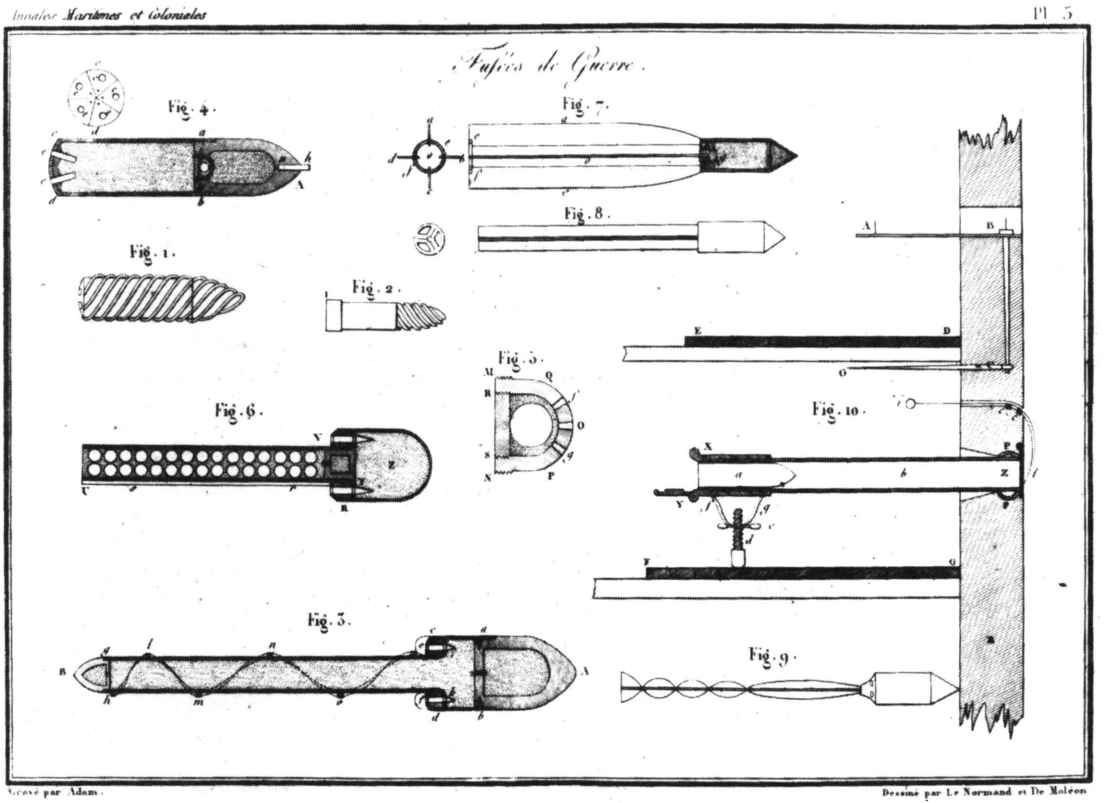


Figure 7 Plate 5 from Montgéry's fusées de guerre (1813)

As the artillery service was beginning to show some interest in the rocket as a weapon of war, Napoleon's ill-fated campaign against Russia was unleashed. Along the route to Moscow, he lost 150,000 of his 600,000 invaders from disease and desertion, before even engaging in major combat with the enemy. When the two armies finally met at the Moscow River on 7 September 1812, another 30,000 were lost. Though the French were the victors and went on to occupy Moscow, the end was in sight. Finding a burned city and Czar Alexander unwilling to sue for peace, Napoleon had no recourse but to retreat across the bitter cold lands he had tem-

porarily conquered. Along the route westward, he was constantly harassed by Cossacks. Of the 600,000 men who started out, only 100,000 returned; the Grande Armée was finished. Within 2 years France itself would be invaded by the Prussians, its hegemony over Europe ended.

EXPERIMENTS IN HAMBURG

Despite the catastrophe in Russia and elsewhere during the final 2 years of Napoleonic power, some work was accomplished of interest to rocketry. This was particularly the case in the city of Hamburg, which was still an integral part of the French Empire. Marshall Davout, realizing that a French retreat behind the Rhine was becoming inevitable, sent artillery Captain Brusselle de Brulard to Copenhagen to learn from rocket expert Andreas Anton Frederik Schumacher of the Danish Corps of Engineers the techniques he had developed.

Drawing on this experience, and work conducted at Vincennes during 1811 and 1812, and with the help of Captains Bourrée and Morton, Brulard set up a shop in Hamburg's demilune of Teerhoff—an outwork resembling a bastion with a crescent-shaped gorge. On 10 January 1814, he demonstrated his first three rockets in the presence of Marshall Davout, who was so impressed that he instructed Brulard to proceed immediately to commence manufacture.

Events overtook the marshall and the captain, however. The French were beaten by the Prussians and Austrians at La Rothière on 1 February; and, although Napoleon held them off, and actually won several later battles, in the end the invaders triumphed. Paris itself capitulated on 31 March and the Emperor abdicated.

THE RESTORATION PERIOD

Rocketry languished in France during the period of the restoration of the Bourbons (from 1815 to 1830). In fact, one authority called it the "height of military scandal" that France should lag behind the British, Russians and Austrians in this exciting military field. The lack of French interest in the rocket probably resulted in part from early neglect, in part from the decline of French power and in part from the kind of wars the nation had been waging.

In the case of the Russians, light, mobile firepower was always welcome during campaigns in such remote places as the Caucasas and Siberia. Austria found them useful in rugged, mountainous territories in its wars in Croatia, Hungary, and especially Italy. Britain, for its part, liked to move rockets all over the world in support of colonial and maritime enterprises, such as ship-to-shore bombardments. France, primarily a continental power up to 1830, leaned heavily towards conventional artillery.

After the loss of Hamburg in 1814, Brulard brought back to France models of the four rockets he had developed based on Schumacher designs. In 1815, these rockets found their way to La Rochelle and thence to Toulouse, where they were fired in experiments termed "insignificant" by Susane. A couple of years later, a small rocket group composed of pyrotechnicians formerly attached to the Grande Armée was set up in Bourges only to be transferred in 1818 to Toulouse. For

several years, Toulouse produced some 20 experimental rockets similar to the ones Brulard had made in Hamburg, but with slight modifications stemming from the latest English and Austrian developments. Two-inch rockets attained 2,000 meter range, while the larger 3-1/2-inchers could reach some 4,000 meters or even more.

According to H. J. Paixhans [4], in the year 1815 rockets were being manufactured at Vincennes under the supervision of an Englishman named "W . . . . ." This turned out to be one Thomas Williamson, who claimed—in a letter to U.S. President James Madison—to be the true inventor of the Congreve rocket. The next year, he offered his services to the United States military, but nothing came of it. Henry Jackson, secretary to the American Legation in Paris, described Williamson as a "man of talents and mechanical inventions," adding that he was highly thought of by French military engineers. Unfortunately, his influence on French rocketry is unknown; he is ignored by most contemporary writers on rocketry and pyrotechnics.

The rockets in use during this period are recorded in the *Aide mémoire a l'usage des officiers d'artillerie de France, attachés au service de terre*. This work was published in 1819 in two volumes running to nearly 1,300 pages. "The Congreve-type rockets [according to the *Aide memoire*] resemble signal rockets. They have larger dimensions, and their casing is made of sheet metal instead of cardboard. They are made in France in 2-inch, 2-1/2-inch, 3-inch, 3-1/2-inch and 4-inch sizes; and they weigh from 24 to 26 up to 40 pounds. They are fired at angles of 45, 55 and 60 degrees. The 2-inchers have had some success, but the 4 inchers are sluggish and more uncertain in their effect."

In 1824, an École de Pyrotechnie was founded in Metz; but, without adequate money, support, equipment or personnel, it could do nothing of significance. Montgéry complained in 1826 that only three major countries remained completely indifferent to the rocket: Spain, Turkey and France.

THE ACCORD WITH BEDFORD

As Montgéry was expressing his pessimism, events were under way that would signal a change in attitude. Robert Bedford, who earlier been unsuccessful in interesting the Russians in his talents, proposed, in December 1826, that the French utilize his services in building up military rocket production and deployment. At that time, Baron Charles Dupin had just come from Britain, where he had made a study of military and naval progress, and he helped to persuade his government to accept Bedford's overtures. It did so on 11 May 1827. Bedford subsequently moved to the École de Pyrotechnie at Metz. There he remained until 1845, a period of 18 years.

Why France did not take advantage of Brulard and others while readily accepting the advice and services of the foreigner, can only be explained by the fame of the Congreve rocket. Whether it deserved it or not, the English rocket had a strong hold on the French military, who could not forget the many instances it had been used against the forces of Napoleon.

Whether the French were better off having Bedford is open to question. While not doubting the Englishman's sincerity, Susane felt that the "secrets" of Congreve

were either not adopted effectively by the group in Metz, or never existed in the first place. The Metz group " . . . groped and fumbled in the preparation of the compositions [of the rockets] as if they had not bought the secret from England . . . . Once placed on the slippery ground of empiricism, the problem could only become complicated, then incomprehensible, and produce for some discouragement and for others the feeling of doubt."

French rocketry had a long way to go.

The fault was certainly not all Bedford's; he oversaw the construction of rockets he claimed were identical to the best in Britain. Yet French artillerymen were unsatisfied: not only did they harbor inaccurate ideas of what a rocket could and could not do, but they over-estimated the Congreve device—real or copied.

THE ROCKETS AT METZ

Following the installation of Bedford at Metz, the French developed four basic field rockets and two incendiary types. According to Master Pyrotechnician Dereaux in an unpublished *Mémoire sur l'armement et l'equipment de la fusée de guerre* prepared in September 1834 and officially submitted to the director of the École de Pyrotechnie in September of the following year, these rockets possessed the characteristics noted in Table 2.

Table 2
FRENCH FIELD AND INCENDIARY ROCKETS

Caliber *inches*	Field Rockets *length in meters*	Incendiary Rockets *length in meters*
2	0.995	--
2-1/2	1.310	--
3	1.535	1.535
3-1/2	1.545	1.545

In his report, he cites a series of tests conducted on 15 October 1832; describes the composition, construction and range of military rockets; and tabulates data on several so called "communication rockets" used for signaling.

NAVAL ROCKETS

The Navy as well as the Army developed an interest in rocketry in France during the second quarter of the 19th century, and both war and signal models were kept in fleet inventory. J. Lafay's *Mémoire d'artillerie navale* of 1850 lists the following types:

a. 95 mm incendiary, of 1830 manufacture

b. 95 mm, projectile type, of 1830 manufacture, 1832 stick manufacture

c. 68 mm, powder-charge warhead, of 1846 manufacture

d. 68 mm with hemi-ellipsoidal warhead from the Department de la Guerre

e. 68 mm with grenade head and short, cylindrical tail, tested in 1848

f. 54 mm with hemi-ellipsoidal head from the Department de la Guerre

The 95mm rockets would be 3-1/2 inchers; the 68 mm types, 2-1/2 inchers; and the 54 mm, 2 inchers.

FRENCH ROCKETS IN ACTION

While rockets never were fully accepted by the French artillery establishment, they were employed in a number of engagements. The action, or rather the intended action, in the Peloponnesus in 1828 hardly started events off on the right foot. When an opportunity presented itself near Petras, the pyrotechnist could not be found anywhere. And no one else knew how to fire the deceitful weapons. Finally, after it was too late, the rocket specialist (who had accompanied his rockets all the way from France) was found asleep—and drunk—on the threshold of the temple of Bacchus! No wonder Bedford had troubles back in Metz.

The North African Campaigns

Rockets saw sporadic service during the campaigns that brought Algeria into the French colonial empire. In 1830, when the campaign began, the École de Pyrotechnie in Metz dispatched to the Mediterranean port of Toulon a couple of hundred 2-inch and about the same quantity of 2-1/2-inch rockets. There, they were turned over to a Captain Robert of the 10th Battery, 9th Regiment, together with detailed instructions as to their use. Because of their relative insignificance amid large quantities of conventional arms, the effects caused by these rockets cannot be accurately determined. Nevertheless, during the action at Staoueli, they provided effective support to the artillery line during an attack on the plateau. According to Pralon, "Their intervention was not without results, for their projectiles were observed, by their hissing sound much more than by their lethal effect, to throw the whirling masses of the enemy cavalry into complete disarray." His *Fusées de guerre* (1883) contains many illustrations covering the various periods of French rocketry; see Figures 8, 9, 10, 11 and 12.

Rockets were used more or less successfully elsewhere in North Africa, including the action against the Tunisian city of Constantine in October 1837. There, Captain Coteau was in charge of the rocketeers attached to the 4th Battery, 10th Regiment. Back at Metz, a ministerial decision of 28 March 1842, had placed the 6th Battery of the 5th Regiment under the École de Pyrotechnie, so that it could undergo intensive training in war rocketry. This battery became the elite rocket organization in France, being provided with the latest equipment and accompanied by highly trained specialists. One section of it, under Captain Rouge, was transferred to Algeria in 1845, only to return to France after engaging in a single minor action. Later, Marshall Randon, the governor of Algeria, ordered the section permanently stationed in the country. Led now by a Captain Nores, the group of 46 rocketeers left for North Africa in early May 1852 and, although never entering into any major engagements, were present on several small expeditions.

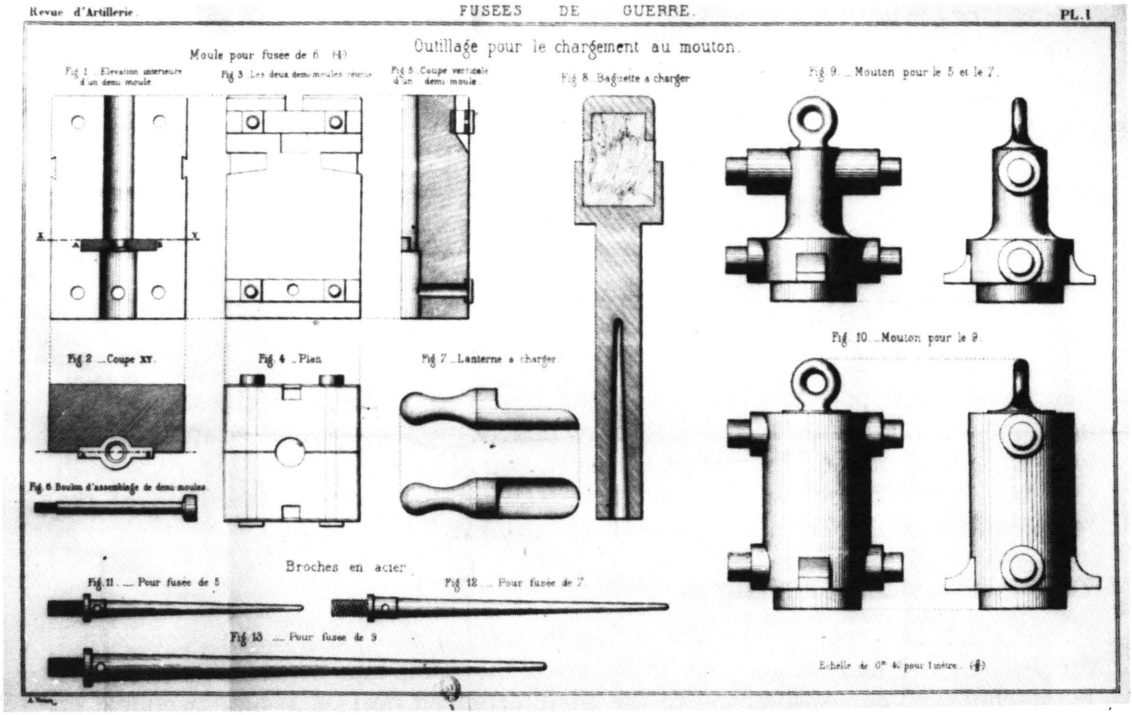


Figure 8 Plate I from A. Pralon's Fusées de guerre (1883) illustrating tools for the making of rockets in 19th-century France (National Air and Space Museum).

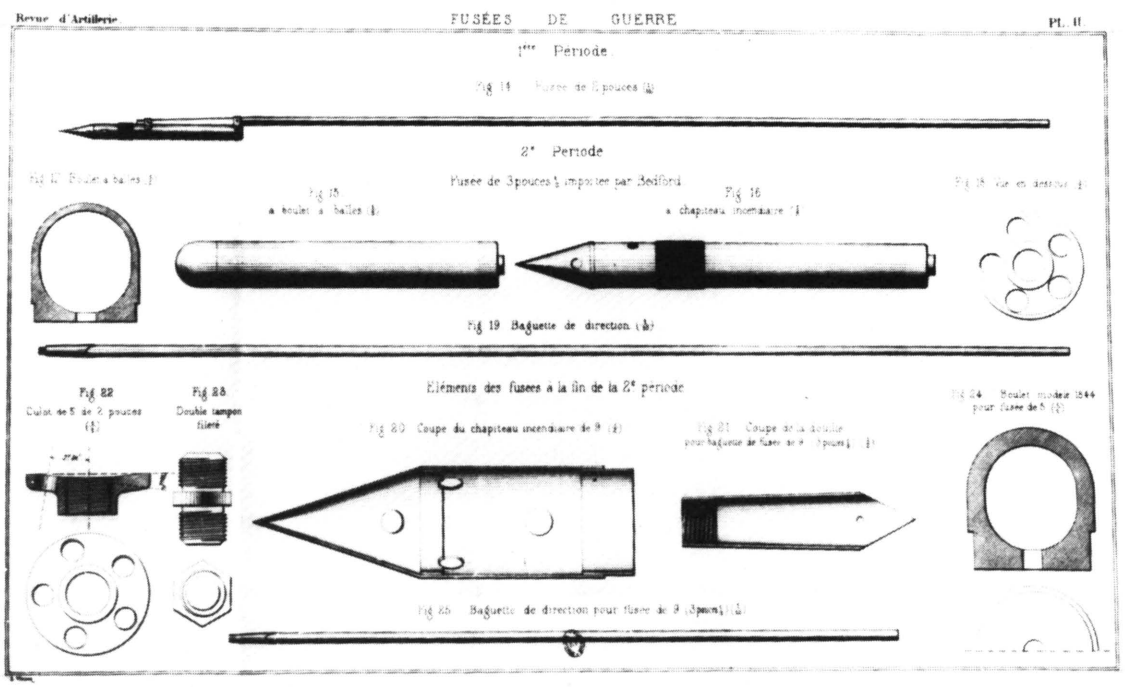


Figure 9 Plate II from Pralon depicting rockets from period 1810 to 1826 and from latter year to 1846, his first and second periods of rocket development (National Air and Space Museum).

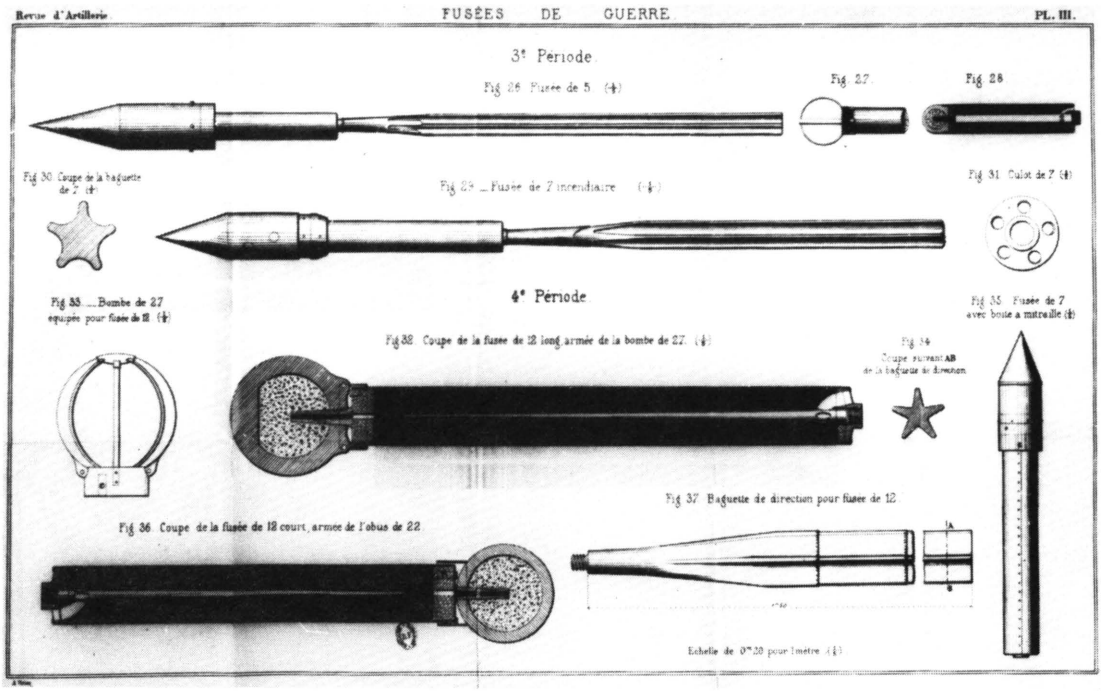


Figure 10 Plate III from Pralon covering period 1846 to 1854 (third period) and the Crimean War (fourth) (National Air and Space Museum).

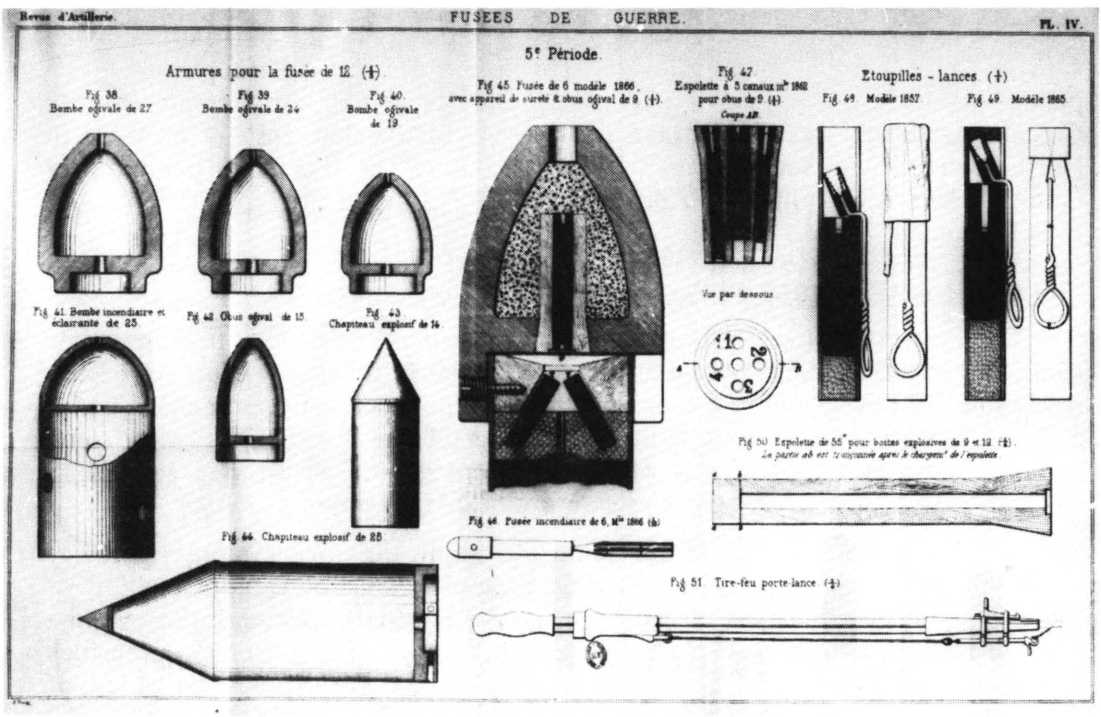


Figure 11 Plate IV from Pralon showing French rockets from the fifth period, 1856-1872. Espolette is a fuze delay element, étoupilles-lances are igniters, and tire-feu a mechanical device for lighting rockets (National Air and Space Museum).

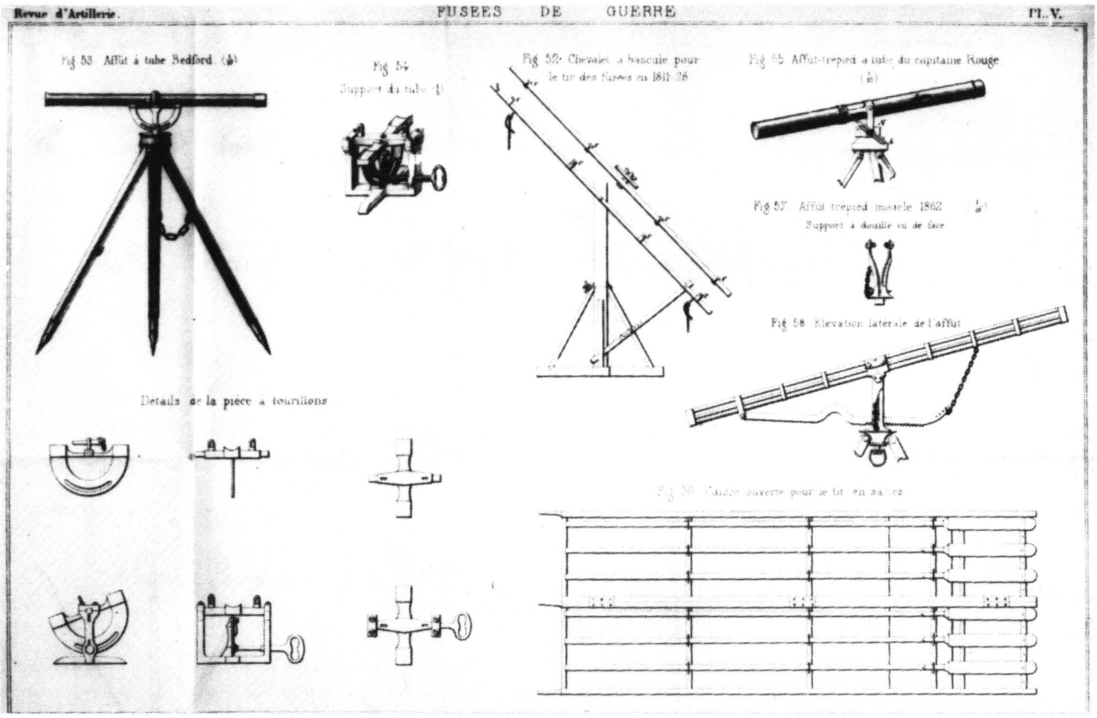


Figure 12 Plate V from Pralon illustrating rocket launchers from 1811 to 1862 (National Air and Space Museum).

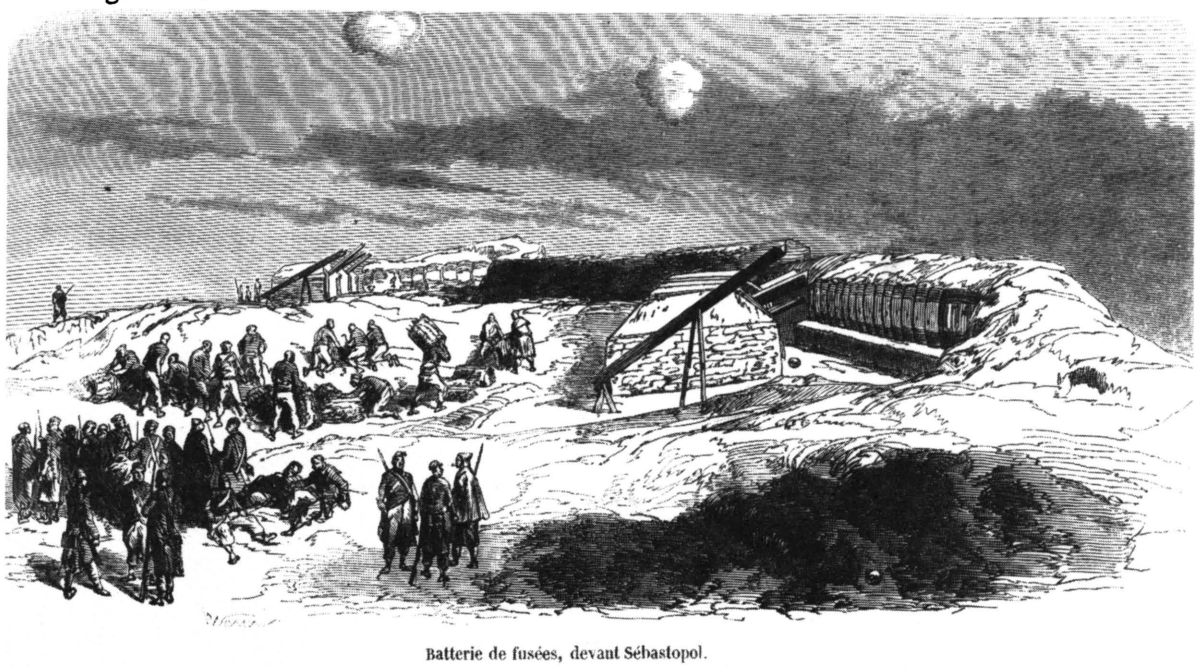
The remaining two sections at Metz were replaced by the 5th Battery of the 11th Regiment under Captain Gironde. Rocket production and troop training expanded rapidly, and by 1854 a new battery, the 4th of the 12th Regiment under Captain Arrachart, was created and made ready for combat. Instead of going to North Africa, it was sent to a new scene of conflict, the Black Sea peninsula of Crimea, where it was joined, in April 1854, by the North African section then under First Lieutenant Harel.

The Crimean War, 1853-1856

The French employed rockets on a far greater scale in Crimea than in earlier conflicts. Nevertheless, many contemporary observers felt that they could have been used more effectively and in greater quantities. Reports show that somewhat under 5,000 rockets were fired by army units during an 11-month-long siege, plus "some hundreds" launched by the navy. However, in the general artillery reserve of 15 November 1855, over 13,000 war rockets were listed in inventory.

Various reasons are given for failing to apply the rocket more rigorously against the Russians: logistics, the great distance of production centers, inability of Metz to satisfy the demands placed on it, confused orders governing the employment of rockets, and lack of strong interest on the part of the military authorities responsible for the war. To the rockets launched by the French must be added, of course, those brought in by their allies, the British.

Probably the most complete account of the French rocket operations in the Crimean peninsula is found in C. Auger's *Siège du Sébastopol*, published in two volumes in Paris in 1859. Auger was not only a general, but was chief of staff of artillery on the Armée d'Orient, or Middle East Army, and thus most well-informed on the subject of the Sebastopol siege, on the use of artillery there, and on the application of rockets. His work runs some 1,400 pages, evidence of the completeness of his coverage. A battery of rockets used in the campaign is illustrated in Figure 13.



Batterie de fusées, devant Sébastopol.

Figure 13 Rocket battery before Sebastopol, from l'Illustration (Paris), 19 May 1855 (National Air and Space Museum).

Early in the first volume he lists the artillery reserve as being composed of " . . . 3 mounted or mixed batteries, 3 horse-drawn batteries, 2 mountain batteries, and 1 section of rocketeers."

The latter debarked at Old-Fort, 5 leagues from the mouth of the Alma on the 11th of September. "In order to flank the landing [Auger wrote], long boats with their artillery and Congreve rockets, light frigates and dispatch boats were sent on the flanks, with the mission of sweeping the beach with fire, should the enemy appear . . . The French artillery that landed consisted of 12 field batteries, including the rocket section with their equipment, which could be carried by the men in their arms . . ."

Their rockets were fired from a total of six tripod launchers of a type modified by Captain Rouge, and filled with a light tube 1 meter long.

Auger writes not only of conventional war rockets, but also of signal rockets: "In order to improve trench services in case of an alert, on the 21st of January 1855,

a rocket signaling system was organized to indicate the positions against which enemy attacks were being mounted, thus:

Attack against the right	Star-bursting rockets
Attack against the center	Rocket fireworks 'a marrons' (rockets with cylindrical granulated powder that explodes at altitude)
Attack against the left	'Fusées à serpenteau,' (little rockets that meander in the air and then explode)

"They were placed, in accordance with the instructions from the general commanding the siege, in convenient places, under the surveillance and responsibility of battery commanders. At the beginning, the stations were established in batteries number 25, 20 and 3."

As far as can be determined, no French rockets were used during the preliminary battle at Alma, which opened the route to Sebastopol. But they were fired rather steadily during the siege itself, at first small caliber models and later one of larger caliber. Pralon summarized what was expected of the French rocketeers in a series of articles in the *Révue d artillerie* (December 1882 - April 1883).

"All the hopes of the rocketeers rested on the long-range rockets. Their reputation had preceded them in the Near East, however vague and mysterious all that is new and comes from afar might be. Marvels were expected. Those who up to then had shown themselves to be the most skeptical, were not far from having to apologize. The 9-cm rockets arrived first, and then . . . the 12-cm types (which had been loaded with propellant by the new hydraulic presses in Metz)." [5]

The 12-cm rockets, with a range of some 7,500 meters, carried both explosive and incendiary warheads. They were directed mainly against the north side of the town. As they were falling, the British opened up with their 6-inch rockets, further adding to the havoc. Their combined effect was particularly devastating among a group of refugees from conventional artillery fire, who had sought shelter in that part of town.

Near the Bay of Streletzka, Captain Harel set up a firing post and launched his rockets primarily at night to annoy enemy communications and generally cause confusion. A Russian eye-witness, according to Konstantin Ivanovitch Konstantinov (generally spelled by the French, Konstantinoff) in his *Mémoire sur les fusées de guerre*, made note (in April 1855) that: "The rockets fired by the enemy [in this case, the French] against Sebastopol produce an astonishing effect. Launched at a distance of about [5,500 meters], they land each time at about the same location, close to the desired place." Plate XIII from his later (1861) *Dessins pour l'intelligence des lectures sur les fusées de guerre* is reproduced as Figure 14.

Many individual actions are recounted: on 6 March 1855, 48 rockets put into disorder a convoy of 2,000 vehicles and during the night of the 22-23, 50 rockets destroyed a wooden redoubt, and one " . . . penetrated the window of the apartment of General Osten-Sacken, chief of the Sebastopol garrison." Auger reports that on the same night, " . . . the firing of the artillery batteries was also supported by large

war rockets which, crossing their fire with rockets launched by the attacks on the left and by the English, caused many fires in the town and greatly annoyed the enemy's communications, his transport and his logistics."

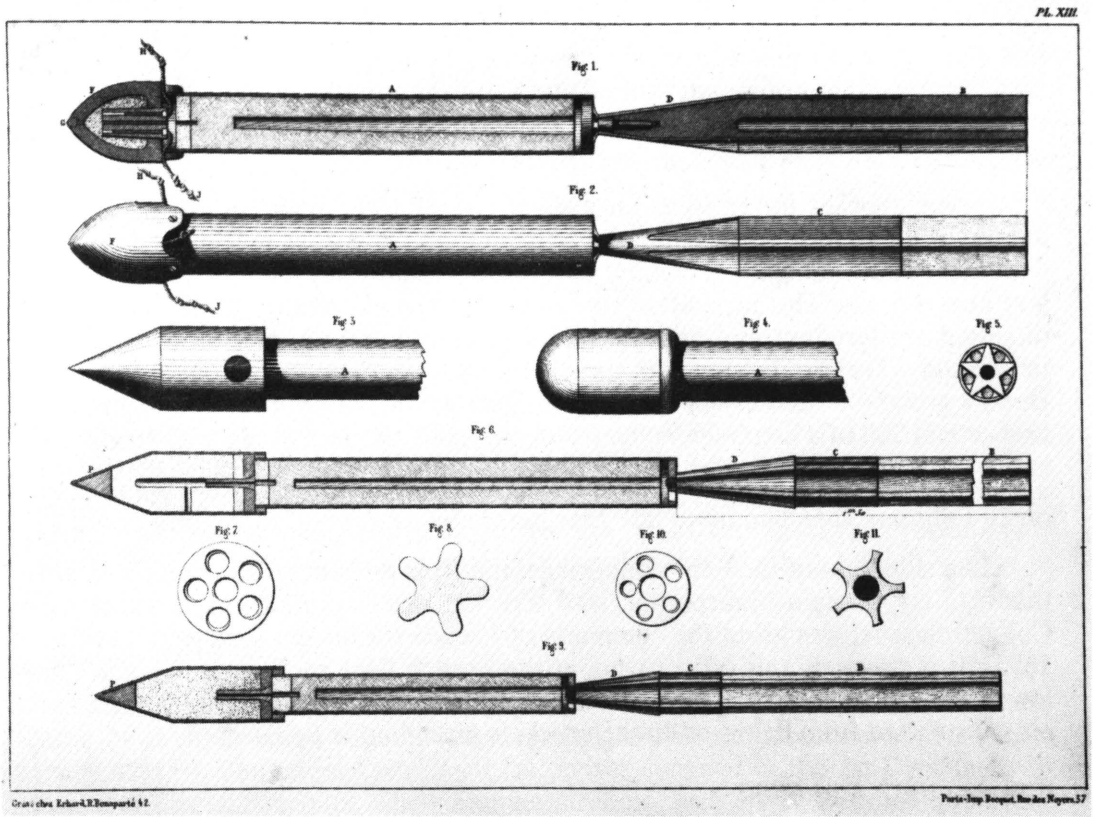


Figure 14 Plate XIII from Konstantinov's Dessins pour l'intelligence des lectures sur les fusées de guerre (1861), showing a variety of rockets (National Air and Space Museum).

The month of June saw the rockets in use at many points, against Malakoff on the 6th and 7th, where "many fires were lit"; by some of the 150 or so 9- and 12-centimeter projectiles; on the 16th, when about 40 rockets caused the evacuation of a camp established at the North-Fort; and on the 18th, when a rocket blew up an artillery storage magazine. During the final bombardments in September, another rocket landed on an ammunition ship next to the dock at Grafskoi. Reported a witness named Poestich: "The explosion was terrible; the dock at the port of Grafskoi was literally destroyed. Cannons of 36-centimeter caliber on the dock were thrown onto the third embankment, and some were broken into three parts. The loss of life caused by this explosion was considerable. Ships and several long-boats scattered about the bay carried troops and military workers, some of whom were killed and some wounded, including naval Captain Kekuatov, a prince . . . "

Also in September, on the evening of the final assault, a rocket glanced off a wall in a Russian position and reversed its course into the door of a powder magazine, which it penetrated easily. Despite attempts to put out the fire from its

incendiary head, 32,000 kilograms of powder detonated, and with it a good portion of Fort Saint Nicolas.

A Russian observer of the effect of the French and British rocket fire said that the only reason damage and destruction by them were not greater, was that most of the buildings had sturdy, thick stone walls, and that much of the wooden material had already been removed for other purposes. Among the psychological effects of these rockets, that apparently caused the Russians trouble, was the fact that many of the skilled artisans in the town, upon which the army depended, retreated precipitously with the arrival of the first rockets.

French rocket forces were engaged in places other than Sebastopol. For example, in the Sea of Azov campaign at Kertch on 22 May, a rocket section armed with 600 rockets landed nearby and covered the main army while it set up its artillery near the city. This expedition consisted of a French infantry division with three mounted artillery batteries and the rocket section, a British division with two batteries, and a Turkish division with three field batteries. The "section de fuséens" was Harel's group, 4th Battery of the 12th Regiment, with 400 rockets of 5-centimeter caliber and 200 of 9 centimeters, half with explosive heads and half with incendiary.

The 4th Battery of the 12th Regiment remained in action beyond the armistice on 29 February 1856 and on to late May before being shipped to Algeria.

In a side-light of the Sebastopol siege, the Russian general Konstantinov wrote that artillery Captain Maucourant, who directed rocket production at Metz under Colonel Susane, was given the command of French rocketeers sent to the Baltic in 1855. "It is precisely this officer who, at the French fleet anchorage at Narget, followed the experiments that we [the Russians] made at Reval in trying out the rockets constructed from damaged French rockets picked up at Sebastopol."

Kabyle, 1857 And 1860

From 1830 through 1835, France had been able to subjugate the principal port cities of Algeria, including Algiers, Oran, Bougie and Bône. By 1840, they had pushed inland, and by 1847 had consolidated a solid band from Morocco to Tunisia, with the exception of the important coastal area of Kabyle between Algiers and Bougie. No sooner had the rocketeers returned to Algeria and gotten used to new equipment and rockets issued, than they were called into action.

Under the command of Captain Jacquot, the battery moved into the Kabyle in May 1857 and distinguished itself to such an extent, that General Runault wrote to Colonel Susane, director of the École de Pyrotechnie at Metz, the following: "The rocketeers gave an excellent account of themselves during attacks on positions I had to take and villages I had to occupy. The mobility of the mounts permitted me constantly to place the rocketeers in the skimisher's lines, where they followed all our movements . . . "

General Konstantinov thought highly of Susane also, writing that it was " . . . he to whom French artillery owes the solution of long-range rocketry."

During the course of the campaign, the rocketeers, called *fusées* by the French, moved through extremely difficult country, much of it inaccessible to mountain artillery. Carrying their own equipment in the height of the African summer, they fired nearly 600 rockets of 6-centimeter caliber (less than 2-1/2 inches). In his report to the Minister of War of 25 July 1857, the commander of Algerian artillery forces wrote of the rocketeers: "No grave accidents were experienced, and, in spite of some abnormal deviations, their aim was generally good, especially at high angles."

Several years later, in eastern Kabyle, the rocketeers again went into action under Lieutenant Dulon's command. From early May to late August 1860, they saw almost continuous service against the Arabs, including the Outlet-Amar and the Beni-Mimoun. They were very effective in dispersing massed Kabyles and in protecting the movements of the main French army.

Solferino, 1859

In May 1859, the rocket battery was moved out of Algeria and over to Genoa, Italy, to prepare for action in a new war. Napoleon III had decided to intervene in Italy on the side of the Kingdom of Piedmont-Sardinia, and it was felt that the mobile rocket corps could be put to good use. Events moved too rapidly, however, and the complement of 234 men, 24 horses, 114 mules and 2,000 field rockets only joined the main army forces the day *after* the decisive 25 June French victory at Solferino.

Morocco, 1859

Later in the year the battery, now divided into four sections or corps, made ready for the Moroccan expeditionary campaign. The third section of the rocket battery with 94 men under Lieutenant Dulon was assigned to the 1st Division artillery under Captain Jacquot. Their first action took place on 27 October when they helped take the Col d'Ain-Taffouralt. Many members of the unit were cited for their prowess in battle.

China, 1858-1860

The political aspirations of the Second Empire were particularly strong in China and Indo-China, leading Napoleon III to intervene on numerous occasions from 1859 to 1867. Between 1858 and 1860, the French and English sent two expeditions to the Peking region to enforce agreements on extraterritoriality and other concessions accorded Europeans. As in other wars, the French decided to call upon *les fusées*.

While Dulon's corps were moving into Morocco, the 1st section under Captain Delaroze, with 2 officers and 47 men, sailed for Toulon, France, on December 1 and thence, in January 1860, aboard the *Reine-des-Clippers*, for the Far East. Near Macao in June, the ship caught fire, but the rocket group was saved. Fortunately, their munitions were on another ship, but all their other equipment was lost and had to be replaced.

The rocket corps moved into action in mid-August at Sin-Ko and Tong-Ko with nearly 2,000 rockets of several types, ranging from 6 to 12-centimeter caliber. Because of the scarcity of artillery and the nature of the war, the rocketeers were heavily relied upon in the engagements against the Chinese. They distinguished themselves at Oua-Kaua-ye on 21 September, when they were instrumental in turning back hordes of poorly disciplined, yelling Chinese horsemen. Later, the French took the key bridge of Pa-li-kao.

THE DECLINE OF THE FRENCH WAR ROCKET

The Chinese and Kabyle campaigns marked the end of the use of the rocket as a major French weapon. Only a relatively few rockets were fired between 1861 and 1865 in actions against the Annamese along the east coast of Indo-China (modern Viet Nam). Operations back at Metz declined, and officers were no longer trained in pyrotechnics to serve with the rocket corps. The batteries that pulled out of Algeria on 8 September 1862, to be transferred to Mexico, were understaffed and undertrained. From the time they reached Vera Cruz on 2 November to their departure 4 years later, barely a dozen rockets were launched. In the Puebla campaign the rocketeers fired a few, and three more on 23 February 1864. The last known French rockets were fired against the citadel Vinh-Long in Indo-China by Admiral La Grandiere's marine rocketeers in June 1867.

And that was the end. French war rocketry passed into oblivion. The *Dictionaire militaire: Encyclopédie des sciences militaires* (Tome 1; Paris: Berger-Levrault, 1898) could report at the beginning of its entry on rockets: "After having enjoyed, during more than half of this century, a reputation that at times was exaggerated, the war rocket today is practically abandoned. It is nonetheless important to devote a few columns to the subject here, both for historic interest and for the hopes, not yet given up by all, of the future of a device that is distinguished by its simplicity and ease of use."

THE LIFESAVING ROCKET

It seems probable that the idea, if not the realization, of the lifesaving rocket must go to the French. Claude Fortune Ruggieri, a querulous individual with a particular antipathy toward British rockets, especially those of William Congreve, wrote in his *Élémens de pyrotechnie* that his father, Petroni Ruggieri, had conceived the idea for the lifesaving rocket. The elder Ruggieri, he said, proposed using the rocket in the ship-to-shore mode to carry a line ashore in regions where there were no established lifesaving stations, which in the 18th century included all the known shores.

The rocket proposed by Ruggieri was to be of 2-inch diameter and carry 1,980 feet of 1/3-inch diameter hemp line attached to the end of the stabilizer stick. As an afterthought, Ruggieri, the son, adds that the rocket could also be used from shore to effect the rescue of the shipwrecked.

Whether this proposal was or was not the product of Petroni Ruggieri is a moot point. Since the idea was published in 1802, well before the first English developments in this area of applied rocketry, to Ruggieri must go considerable credit.

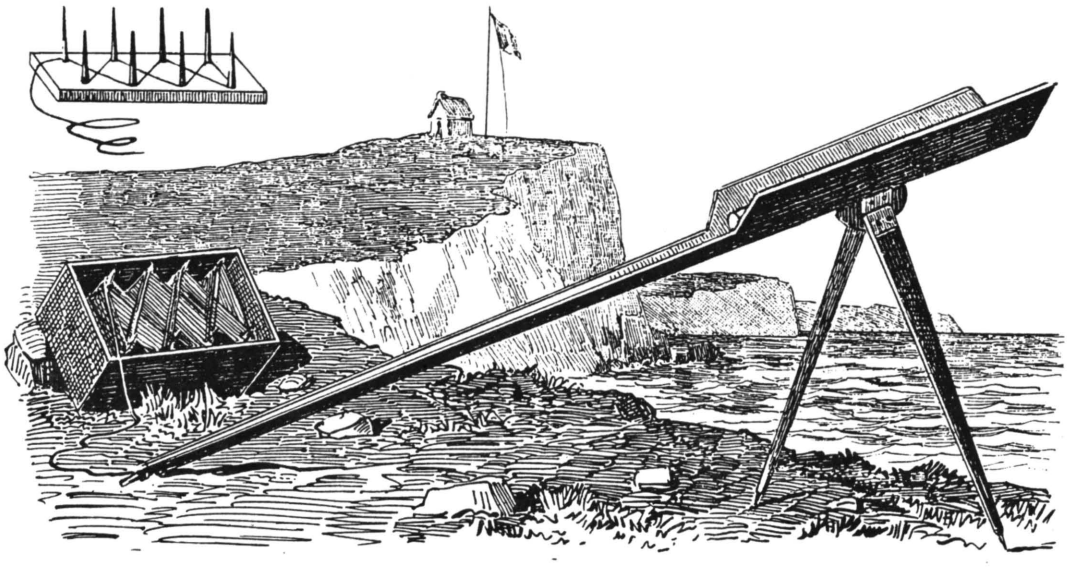


Figure 15 Launch stand for life-saving rockets illustrated in Amédée Denisse's Traité pratique complet des feux d'artifice (1882) (Ordway Collection, Space and Rocket Center).

Despite this promising start, the French showed little enthusiasm for developing a lifesaving rocket. The French Society for Saving the Shipwrecked was not formed until 1865, and it turned its efforts to the lifeboat as an instrument of such salvation. Jean Tremblay, a Frenchman of this period, seems to have developed and demonstrated a lifesaving rocket with a barbed head, which could be used in the ship-to-shore mode to carry a lifeline. Amédée Denisse, in his *Traité pratique complet des feux d'artifice* (1882) describes lifesaving rockets (Figure 15), winged rockets (Figure 16) and other devices. Despite these and other French studies of lifesaving rockets, little seems to have come of them, and for the most part France preferred to turn to the British Boxer rocket for use in its lifesaving stations.

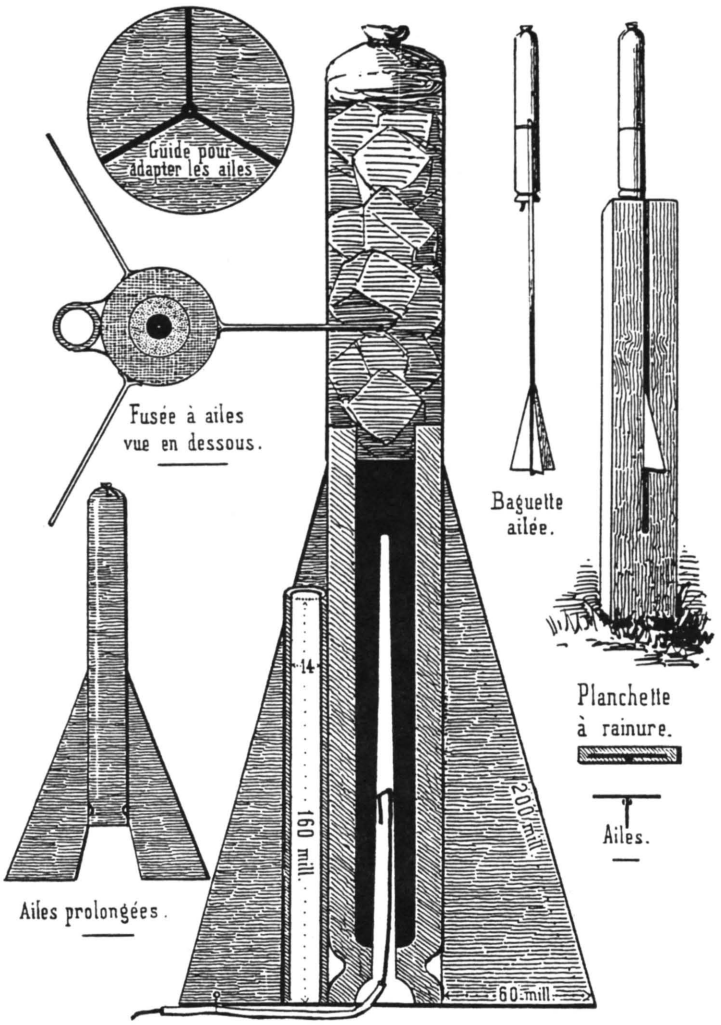


Figure 16 Winged rockets illustrated in Denisse. The figures indicate, in millimeters, the dimensions of a winged rocket whose interior diameter is 28 millimeters (Ordway Collection, Space and Rocket Center).

REFERENCE NOTES

1. Most of the book concerns the means of making rockets, propellant composition, types of firework displays, and the use of fireworks in theater. Only in the final chapter does the author consider land and naval pyrotechnics. In a section on "Des dards enflammés" or flaming darts, he briefly covers 1-inch rockets to which an incendiary composition is added that ignites at the end of the trajectory. Morel recommended them especially for use in coastal forts from where they could be launched against attacking ships, setting fires to their sails.

2. From Article XIX, Chapter 11, *Pyrotechnie militaire, ou traité des feux de guerre et des bouches à feu*, Paris, 1812.

3. Ruggieri's attitude about Congreve was strange, and may have been motivated by his failure to interest French authorities in his own rockets, or perhaps by a feeling that the Englishman was getting credit that he, Ruggieri, deserved. Whatever the case, he complained that " . . . it is wrong to regard it [the war rocket] as an English invention; rather, it was invented by [an unnamed] privateer from Bordeaux." In a letter published in the *Journal de Paris* of 8 September 1809, Ruggieri termed the English use of war rockets as both "ridiculous" and "criminal," and argued that the Congreve weapons could not possibly enjoy any "marked advantage." Elsewhere, he talked of the inaccuracy of rockets and their high cost when compared to conventional artillery. Ruggieri, a world-famous rocket and pyrotechnic expert, clearly was not promoting war rockets in 1812.

4. Paixhans, H. J., *Nouvelle force maritime et application de cette force à quelques parties du service de l'Armée de Terre*, Paris, 1822.

5. The 12-centimeter rocket could be fitted with a variety of armament, including an ogival 27-centimeter warhead weighing 60 kilograms; a 24-centimeter, 40-kilogram warhead; and a 19-centimeter, 20-kilogram ogival head. All had delayed fuses.

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