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Chapter 3

Rocketry in Latin America in the 19th Century: A Historical Survey*

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Introduction

By this new millennium, several nations in Latin America have evolved sophisticated space and sounding rocket programs. Yet some of these countries were introduced to rocketry much earlier, during the 19th century, and represent a colorful and complex history that has still been little explored. This article surveys these efforts and includes material found in recently discovered new sources. The authors wish to thank Col. Antonio Burgos of the Brazilian Army Commission, Brazilian Embassy, Washington, D.C., and his staff for their kind help in translations and providing some material. Special thanks are also due to Adler Homero Fonseca de Castro for undertaking investigations on existing specimens of 19th century war rockets in museums in Brazil (See Brazil section of the Addendum.).

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Background

The introduction and uses of the Congreve and Hale rockets of the 19th century in England and their adoption by other countries has been documented, especially in Europe. However many gaps remain, particularly in Latin America, which has been more difficult to document because that region saw numerous revolutions during that period with the consequent disappearance of records or poorly kept military records. Much of the available information is thus fragmentary. Nonetheless, it appears that some eight Latin American nations—Argentina, Brazil, Chile, Cuba, Mexico, Paraguay, Peru, and Uruguay—experienced some rocketry activities and raised rocket troops patterned on those of European countries.

On closer examination, there were several reasons for this. One was a lack of industrial and financial capacity to produce more advanced artillery weapons as in European nations. This was markedly true during the earlier part of the 19th century when Latin Americans underwent their respective fights for independence from either Spain or Portugal and they therefore had no professional armies and much less well-equipped arsenals or industrial bases to fabricate their own rockets and other arms. Thus, the weapons largely had to be acquired from elsewhere—imported—although in several instances, as will be seen, there were early efforts to produce these rockets indigenously. Even in importing the weapons, rockets were favored because they were cheaper to acquire and produce than guns. In addition, they were ideal for use in the many mountainous terrains found in South America where conventional cannons were difficult to convey. They were especially advantageous against cavalry troops of the day since, as on European Napoleonic battlefields, they had an excellent reputation for frightening and stampeding cavalry horses. In various South American river campaigns, rockets were serviceable in providing short-range artillery firepower from and against wooden ships earlier in the century, and were later employed from steam vessels. On the other hand, Congreve and Hale rockets had their drawbacks in being unpredictable, because they were still largely hand-made. It is thus interesting to observe the general history of these types of rockets in another part of the globe and how South Americans acquired and used them, and faced the same problems and successes with them compared with other nations.

The countries covered in this survey are arranged chronologically, as best as can be determined, according to the earliest known activity in rocketry in these countries, whether the rockets involved were indigenous or foreign in origin. With some exceptions, notably the earliest demonstration of Congreve rockets in Latin America, a brief mention and depiction of the British deployment of Congreve rockets in Argentina in 1846, and the American attempt to use Hale rockets in the Paraguay expedition of 1858, the use of Congreve and Hale type rockets *by* European or other

powers against Latin American countries is not treated in this survey. American Congreve and Hale rockets in the Mexican War and French rockets in Mexico in 1862 during the installation of Maximilian, for example, are covered elsewhere. There are still gaps in the knowledge on 19th century Latin American rocketry, but this article contributes more data, clues, and trends, to arrive at a clearer, overall picture of the start of early rocketry in Latin America.¹

Brazil

Perhaps the first appearance of Congreve rockets in South America occurred early in 1809 when Sir William Congreve's friend, Commodore William Sydney Smith—the same man who led the first Congreve rocket expedition against French shipping at Boulogne, France, in 1805—demonstrated these weapons in Rio de Janeiro, Brazil, before King John VI (João VI) of Portugal. João had fled to the large Portuguese colony on Napoleon's invasion of his country. In the demonstration, as João and his whole court were assembled on the balconies of the palace, the rockets misbehaved as they sometimes did in battle because they were still unpredictable in that early state of the art. The rockets veered around, and instead of flying over to Praia Grande, they took off to the opposite direction and “exploded in the great square, almost beneath the windows of the palace.” Smith, who was then the British “admiral on the Brazil station,” was mortified and sent an officer to the king to explain the situation and offer to make another trial. But the king “would not hear of it,” and it is not known if João was able to get the Brazilians to try their own rockets before he returned to Portugal in 1821. (About the same time, in late February 1809, Smith wrote to William Wellesley-Pole, secretary of the (British) Admiralty stating his intention to reinforce Captain James Lucas Yeo “with the *Lightning* and *Pitt* armed brigs, with a portion of the field-pieces and [Congreve] rockets,” for use against French privateers operating in Brazilian waters, but there is no evidence he turned over this material.) But there were undoubtedly Brazilians around before the first half of the century who were acquainted with war rockets firsthand. Most notably, the Brazilian Artillery sent men to Portugal in 1832 to assist in its civil war; Congreve war rockets were employed extensively on both sides. Also, the early French rocketry historian Merigon de Montgéry wrote in 1825 that Congreve rockets had been “provided for in the Empire of Brazil, Colombia, and other new republics of America,” but he did not give specifics in either case. However, elsewhere he wrote: “We are able to presume that they [Congreve rockets] will also be introduced in the Empire of Brazil, Colombia, Mexico, and other new American republics,

which entrusting their industries and armament enterprises on land and sea to English companies, [will] inevitably receive some war rockets."²

According to a Brazilian colonel of engineers and instructor of history, Claudio Moreira Bento, the night of 7 February 1827 may have marked the first wartime employment of the rocket in his country. This was in Bagé, Brazil, at the edge of the Lexiguana River, or rivulet, during the Cisplatine War of 1825–1828 against Argentina, when Pedro I of Brazil annexed the disputed territory of Cisplatine, or Banda Oriental (later Uruguay). The rockets were under General Henrique Braun, then commanding the Southern Army. Braun had recently been in Europe and wished to introduce new European methods of war, including rockets, to the Brazilian forces. (Bento claims Braun was perhaps one of the German colonizers of Brazil's Rio Grande do Sul area, and may have been related to Wernher von Braun, the technical director of the V-2 rocket of World War II, and afterward a leader in the Apollo Saturn V program that first took humans to the Moon.) Nonetheless, with General Braun was another German, Lieutenant Carl Ludwig August Siegener, a veteran of Waterloo, who helped with the rockets. (Siegener had contracted for military service for Brazil, and arrived at Rio in February 1826.) According to an eye-witness, a Captain Seweloh, Siegener did not take precautions and "three rockets exploded near him, the closest right at his feet." As a consequence, he was wounded and was taken by cart to the nearest city, Caçapava do Sul, but died en route. Siegener was thus called by Bento, "the first martyr in the use of military rockets in Brazil." No details are offered by Bento on the origin of the rockets and their description, nor circumstances as to their other possible uses in the Cisplatine campaign which led, in 1828, to the formation of the "buffer" state of Uruguay. During this period, however, Brazil barely had an army and was relying largely on mercenaries, many from Portugal and Germany. It may thus be assumed, as Bento suggests, that the rockets were acquired from Europe. Not until 1839 was Brazil's Army systematically organized.³

Nothing is heard about war rockets again in Brazil until mid-century, when the earliest known British attempt to sell them to this country was undertaken by William Hale Junior, eldest son of the British inventor of the stickless, or Hale rocket. In May 1850, the younger Hale sailed to Rio for this purpose and was successful in persuading the Brazilian government to purchase them. According to de Souza, these were subsequently used in 1852 in Brazil's war against Argentine dictator Juan Manuel de Rosas. This would make the second time Hale rockets were used in battle. The first was by the Americans against the Mexicans during the Mexican War of 1846–1847. Perhaps for this reason, or possibly because William Hale Jr. may have sailed from a U.S. port to Rio in 1850, the Brazilians mistakenly called the projectiles "foguetes Americanos," or "American rockets." However, they also variously called them "foguetes de rotação" ("rotary" or "rotation rockets"),

“foguetes sem cauda” (“rockets without tails”), or “foguetes tangencias” (“tangential rockets”), yet only occasionally were they named “foguetes de Hâle” (“Hale rockets”). It is not known how many Hales the Brazilians purchased, although it was probably not a large number.⁴

It was also during the critical time of the war against Rosas in 1851–1852 that Hale was to have a German competitor named Mr. Wenelt “of Silesia” (Prussia). This man was actually the armorer Rudolf Walckneldt, also given in Brazilian documents as Rodolpho Waehneltdt. By mid-July 1851, Walckneldt or Waehneltdt had approached the Brazilian Ministry of Foreign Affairs to promote the adoption of his improved bomb fuses and grenades in the amount of 1,600 (Prussian) Thalers. The offer was taken, and Waehneltdt was obviously pleased with the remuneration and continued to offer more inventions, which were sent for review by Brazil’s Committee for the Improvement of Army Supplies. By September 1852, his proposal to construct a foundry and house to manufacture the fuses at Campinho was approved, but in June of that year, “Engineer Rodolpho Waehneltdt” had also sent a letter to the Committee in which he had analyzed “the British Congreve rocket sent from Buenos Aires and the corresponding drawing that is attached to the mentioned letter.” Whether this meant he had analyzed a captured Argentinean rocket originally acquired from England is unknown, but, in any case, he designed his own. Meanwhile, Brazil’s critical wartime need for munitions, and the need not to rely on foreign arms purchases prompted the founding of the Laboratório Pyrotecnico do Campinho (Pyrotechnic Laboratory of Campinho). It was established near Rio, and Waehneltdt was placed in charge of it. Waehneltdt’s rockets were begun to be made here too, under contract to the Brazilian government. Apparently, they were of the conventional side-stick types. Requirements for the qualifying tests included a target of 5 paces (5 ft or 1.5 m) in diameter. The firing line was also to be “divided by means of numbered pickets in intervals of 20 braças [fathoms, or 120 ft or 36.5 m] starting where the [launch] stand must be placed. The launcher will allow vertical and horizontal movements, with the proper graduations to determine the elevations.” But the rockets failed abysmally. As Bento puts it, Waehneltdt “sold to the Brazilian government, for an enormous sum of money, the secret of the worst Congreve rockets.” Thus ended the German’s career in Brazil, and he was dismissed on 10 December 1852. Bento offers no details as to the nature of Waehneltdt’s rockets or how they failed, whether it was during the tests or on the field of battle. Waehneltdt’s position was assumed by Engineer Lieutenant Dr. Francisco Carlos da Luz, who in turn contracted the services of another German firearms master, Andre Kolbe (also a German craftsman), but it is not clear if the latter men were involved with the rocket manufacture or the manufacture of the friction matches or both.⁵

Campinho continued to flourish. It had originally started as Fort Campinho in 1822, in Iraja parish, to control the intersection of the Jacarepagua and the Campo Grande roads leading into Rio from the southwest, and there was already a small military pyrotechnical laboratory here, but, with its expansion in 1852 to a full laboratory by Minister of War Felizardo de Souza e Melo, it warranted a name change to Laboratório do Campinho. Among the many pyrotechnical articles that were begun to be manufactured here were friction matches and fuses. This necessitated new buildings and personnel, including the “Officina de Foguetes” (literally, “Rocket Office,” or “Rocket Department”), which initiated war rocket manufacture on “a modest scale,” according to the official *Relatório* or *Report* of the War Department to the Brazilian General Assembly. Rocket batteries were also formed in the Artillery and immediately placed in the field against Rosas’s forces and most notably played a part in the famous battle of Monte Caseros, Argentina, ten miles (16 km) northwest of Buenos Aires, on 3 February 1852, which defeated Rosas. Although de Souza indicated that Hales were used in the war, it is not known whether both Congreve and Hale or only Congreve rockets were those employed at Caseros. Either case is possible because Hale rockets were relatively new during that period, but the term “Congreve rocket” was a well established one that was universally applied to all war rockets. It is also not certain whether Waehneltd’s rockets were at Monte Caseros. For certain, the Congreve rockets that were used by Brazil during this period were side-stick mounted. It is known that a Brazilian rocket battery consisting of four firing tubes, or stands, and 160 men, commanded by Captain Antonio José do Amaral, served in the battle. (This unit was in the Brazilian Division of the “Grand Allied Army of Liberation of South America” under Justo José de Urquiza of Argentina, Rosas’ opponent.) Vasconcellos also says there was a Congreve rocket battery, but under Major Joaquim Gonçalves Fontes and assigned to the 1st Regiment of Artillery in the 3rd, or Light Division. The latter battery similarly had 160 men and may or may not have been the same unit under do Amaral but led by different commanders at different times. Vasconcellos adds that the rockets gave little precision in firing but were effective when sent against large targets like masses of cavalry since they “terrified” the horses.⁶

In 1853, after the Rosas campaign, War Minister de Souza e Melo decided to augment the production of rockets at Campinho in which Lieutenant Carlos da Luz was entrusted to carry out this task. The rockets then cost 130 réis (rs) per pound, while the cast iron metal bases for the rockets were 320 rs per pound. But not until the long and bloody War of the Triple Alliance of 1865–1870 against Paraguay, also known as the Paraguay War, did Brazil again field war rocket troops. Their employment was widespread from the beginning to the end of the conflict. (The first hostile act actually began on 11 November 1864). Evidently both Hale and Con-

greve types were employed, although, as before, some writers may have indiscriminately called all rockets after Congreve. For sure, in a letter of 2 December 1865 by Hale's younger son, Robert, to the American Chief of Ordnance, when Robert was staying in Washington, D.C., he remarked that Hale's rockets "had also given satisfaction in Paraguay." Indeed a Hale rocket from this war is in the Museu Histórico Nacional (National Historical Museum) in Rio de Janeiro. It is of 76.2 mm (3 in.) caliber and has five axial venturis around a central venturi. Unfortunately, the rocket has no markings that might shed further light on its origin.* Despite the existence of these Hale rockets and a small production of Hale rockets (150) at Campinho in 1867, central stick rockets were also introduced in the same year at the laboratory and by far, were the most popular and widely produced and had completely supplanted the old side-stick models. For the new production, "new machines for rocket manufacture" were installed at Campinho. Most likely these were steam-driven hydraulic presses, which had replaced the earlier hand-driven pile-driver type presses consisting of pulley-operated drop weights.⁷

As for the actual use of rockets in this campaign, one can cite numerous instances of use by both the Brazilian Army and Navy. At the beginning, for example, Jourdan mentions the presence of "uma estativa de foguetes á Congrevè" (a Congreve rocket stand or launcher) under the command of Naval 2nd Lieutenant Miguel Antonio Pestana as part of the forces that accompanied Admiral Joaquim, Visconde Tamandaré's attack against the port of Paysandú, facing the Río de la Plata, Uruguay, from December 1864. Tamandaré's other operation along the river during this time, which included rockets, was his attack against the Uruguayan city of Salto. Four firing stands belonging to the Allies (probably meaning Brazil) were in the battle of Yatay on 17 August 1865.⁸

The Paraguayan town of Curupaity, heavily fortified by Lopéz, and a key site in the war, was bombed from 22 September 1866 for several weeks with the assistance of two rocket tubes of the Brazilian fleet. Another source, Fragozo, says there were two rocket batteries at Curupaity, while Best says four Brazilian launchers served in the battle that day; at another point, Fragozo says four stands at Curupaity were under the command of Major Lobo d'Eça of the Horse Artillery. This officer was actually Manoel de Almeida da Gama Lobo Coelho d'Eça, who later became a Marechal de Campo, a Field Marshal, and Baron de Batovi. According to Boiteux, Major (later Field Marshal) Gama d'Eça was indeed with the 1st Regiment of Horse Artillery and, in 1866, commanded the Provisional Battalion of Artillery, which included rockets. Initially his rockets did not fire well, but they did fire well at Curupaity, as he was afterward cited for displaying "bravery, activity, and intelligence,

* See the Brazil section of the Addendum regarding another, recently learned about, second existing Brazilian-made Hale rocket.

furnished with a battery of 12 guns and four Congreve rocket stands, launched at convenient distances from the enemy entrenchments, from 3:30 in the morning to 1:30 in the afternoon and sustained a lively fire against artillery of large caliber.” It can also be seen that the Brazilians integrated both guns and rockets into their rocket batteries. Other engagements in the war in which rockets appeared were: the occupation of the island of Cabrita in March 1866, where a battery of “incendiary rockets” was commanded by Captain Francisco Antonio de Moura; at Tuyuty (notably in the battle of 24 May 1866); and at Yatayty-Corá; and Curuzú, where Frago says the stands were abandoned because of the failure of the rockets. At Tuyuty, according to Argentine Colonel Palleja, as cited by Beverina, at “10’clock in the day, a [Brazilian] Congreve rocket launched from the right of the enemy which fell among the [ship] *Florida*, and was the signal of the attack.” Against the other strong Paraguayan fortress town of Humaitá, in July 1867, there were four Congreve rocket stands (launchers) under Nepomuceno da Costa as part of the Brazilian vanguard of troops commanded by Lt. Gen. Barão do Herval; in the same action there were four Congreve launchers in the 2nd Division of Infantry. (Two more were stationed at Chaco). Almost nothing is known of the Brazilian Navy’s adoption of the rockets, although during this period a naval engineer by the name of Baptista was said to have been making war rockets at a pyrotechnical lab at Ponta da Armação, in the city of Niterói, or Niterói, just opposite Rio. Rockets appeared in the last actions of the war, in December 1869, notably at Pykyskry, or Pikysyri; Ita-Ibaté, or Ità-Yvaté; and at Peribiebuy, or Piribebui. Masterman, who witnessed the fierce action at Ità-Yvaté, on the 25th, remarked: “A tremendous but badly directed fire was poured into the place: shot, shell, and rockets swept the [Paraguayan] lines the whole of that day.” Overall, Vasconcellos observed that by the time of the Paraguay campaign, the Brazilians found war rockets to be “indispensable.”⁹

Because the Paraguayan War was so important and prolonged in Brazilian military history, the official *Relatório* for 1873 includes production figures for Campinho during the key years of the war, from 1867–1870, and continuing to the reporting period of 1872. From this same document, and other sources, it can also be learned about the different calibers of Brazilian rockets during the overall period. Besides the batch of 150 Hales made at the laboratory in 1867, none were made the following year, only 10 were produced in 1869, and none after that. All the other rockets were stick types. Side-mounted stick types were sometimes called “of the Austrian system.” In 1867 there were even rocket stands of the “Prussian system,” which must have also been side-stick types. Center-mounted stick models were referred to as of the “English system” or “French system.” These designations did not reflect the origins of the rockets, which all appear to have made at Campinho, but on their styles, though perhaps there may have been some importations to supplement

supplies or for experimental purposes. The *Relatório* of 1867 reports there were 1,262 “Austrian” (side-stick mounted) rockets made in addition to 110 English (central stick mounted) types. Altogether, the authors count 8,997 rockets of all calibers manufactured at Campinho during the war years of 1865–1870, making Campinho probably the largest war rocket manufactory in Latin America during the 19th century.¹⁰

Fragoso and other sources also provide conventional calibers of Congreve rockets supplied to the Brazilian Army during the 1865–1870 war period. The Brazilians then used the term of “polegadas” (inches). The calibers were 2, 2.5, and 3.5 in., but there were also 18, 24, and 32 calibers that seem to correspond to British Congreve pounder designations, although the Brazilians had their own unique caliber systems described below by do Amaral et al. The year 1866, the height of the war, saw the peak production of rockets of all calibers, especially the 18, of which 1,813 were made; in the same year, 1,060 2.5-in. and 1,218 24-calibers were produced, while the rest of the calibers were made only in the hundreds or less. By 1866 also, the Brazilians counted 92 chests of war rockets in their batteries and 330 in reserve, plus 100 chests of tails (guidesticks) and 380 in reserve, but is not clear whether these were individual rockets or chests with more than one object; other numbers relating to rockets on hand in this account are similarly hard to interpret.¹¹

But, as in the Old World (Europe), the popularity of war rockets gradually waned toward the end of the century. Of course the lower production figures also reflected a peace time output. In 1873, only 200 central stick (Congreve type) of 68 mm (2.72 in.) caliber were produced at Campinho, and, while the *Relatório* of 1877–1878 records that the laboratory still made them, it does not appear any were manufactured at all during the 1880s, with one exception. In 1882, so-called “Martin rockets” (“foguetes Martin”) were made. These may have been either battlefield illumination or signal types, possibly as described by Henrique Martins in *Noções gerais de artilharia (General Ideas about Artillery)* (1895), a work cited by Pondé, page 91, but not available to the authors. In 1884, no rockets at all were made, while in 1886 only 50 signal types were produced. In 1890, the Campinho Laboratory was abolished, and the factory produced strictly ammunition for small arms including rifles. As for the fate of remaining rockets after the peak production of 1865–1870, it is interesting to note that the *Relatório* for 1874 reported that some 1,112 kg (2,451.5 lb) of powder were extracted from old (surplus) war rockets for reuse, though no mention is made of what happened to the extra cases and sticks; most likely the cases were remelted and reused, or discarded, while the sticks were probably discarded.¹²

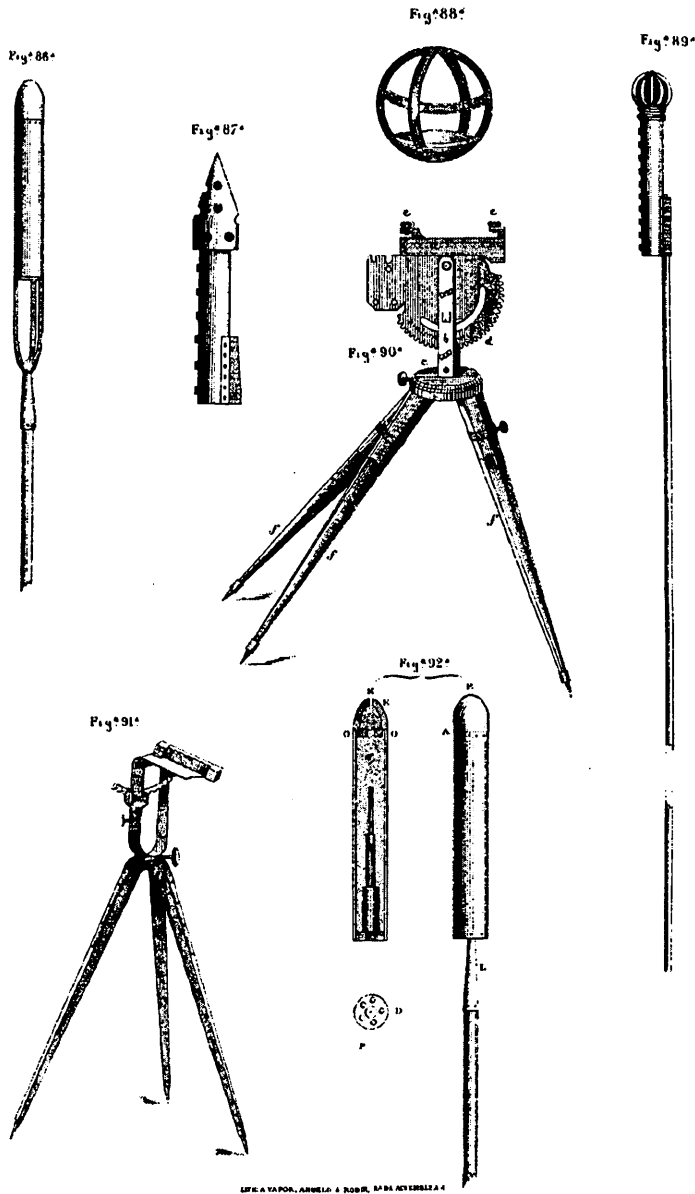


Figure 1: European and South American (Brazilian) war rockets (Congreve type) and launchers used by Brazil during the 19th century. Top, left to right, [Fig. 86] is a centrally mounted stick rocket of Prussian design; [Fig. 87] is an incendiary rocket, with holes in the warhead to permit the incendiary and “suffocating” gases to escape. (The author says that suffocating rockets were actually abolished in actual wars.) The sphere [Fig. 88a] shows the inner construction of a light ball for illuminating battlefields and projected by rocket or shell; [Fig. 90] is a standard tripod launcher; [Fig. 89] is a lateral tail rocket. Bottom, left to right, [Fig. 91] is a simplified lateral tail rocket launcher; [Fig. 92] is a centrally-mounted stick model, English style. From: Antonio Francisco Duarte, *Manual do Aprendiz-Artilheiro* (Rio de Janeiro, 1880) (Smithsonian photo 75-685).

Details on Brazilian Rockets

Detailed contemporary descriptions of 19th century rockets are scarce and those of rockets in Latin America are particularly rare, as are rocket publications, although they are better covered in Brazil than in any other Latin American nation. For example, some details are found in *Nomenclatura Explicada de Artilharia e Guia do Fogueteiro de Guerra* (*Explained Nomenclature of Artillery and Guide to War Rocketry*) by Antonio José do Amaral, which appeared in a third edition in 1879. Judging from a statement at the beginning of this work, and the date of the third edition, it appears that *Nomenclatura* was actually written much earlier, in 1860, and was ordered to be printed the following year (1861) “for teaching material at the Military School.” Amaral, who commanded the Brazilian rocket battery at Monte Caseros in 1852, where he says the Auxiliary Division containing the battery attained “marked triumphs,” became a lieutenant-colonel of Artillery when the third edition of *Nomenclatura* appeared, and was a professor of the school, at Rio. He reveals that while the composition of rockets “is a secret in different states [countries],” he did go on to give a formula which is “ordinarily” used, and perhaps was a standard one for Brazil at the time (1860). This was 53.7 parts of [potassium] nitrate, 30.93 parts charcoal, 11.37 parts of sulfur, and 14 parts of water. The excessive water in the formula may have been added because of the extreme heat in Brazil, which would have rapidly dried out the composition, causing cracks that could have led to explosions. The Spanish authorities in Cuba who made rockets during the 1820s, as given below, faced similar problems in making rockets and similarly used more water additive than was found in European powder rockets.¹³

It is of interest to note that do Amaral calls the rocket’s conical cavity, the “alma,” or “soul,” as it was called for centuries in Europe. Like his European counterparts, do Amaral did not have a clear idea of the physical principal of why the rocket ascended. He only knew from a trained artilleryman’s experience and standard artillery custom that a “soul” was incorporated by all rocket practitioners and was needed, otherwise the rocket simply would not fly. (The term “soul” stretched back to Medieval pyrotechnists and became universally adopted because the “soul” seemed to be the mystical life of the rocket; in fact it served as a crude combustion chamber and provided maximum burning area to generate combustion gases that exited the constricted part of the rocket, what pyrotechnists and artillerymen called the “throat,” or “choke.”) In short, do Amaral’s description of a war rocket showed—as in other Congreve type rockets—it differed little from a conventional pyrotechnic skyrocket. It also had a wood guidestick like skyrockets. Do Amaral suggests the stick must be 5-3/4 to 7-1/2 times the length of the body, or cartridge. There were also, of course, stickless or tangential (Hale) rockets in which “the tails were substi-

tuted by different holes of oblique directions, and by means of which cause the rocket to revolve, and thereby shift the violence of the flight away from its trajectory.”¹⁴

Rockets in Brazil were smaller than their counterparts in Europe. Do Amaral wrote that the calibers of rockets (in his country) were determined by “pollegadas,” [later spelled “polegadas”] or inches, and “linhas,” or “lines,” which were equal to 1/12 of an inch. Generally, rockets in Brazil were known by two calibers, 12 and 6, although this was confusing to both Latin Americans and non-Latin Americans as these designations did not relate either to true measurements or weights. Rather, the Brazilian artilleryman only remembered, or read in his artillery guide, that rockets “of 12 [caliber]” had a cartridge length of 16 pollegadas, 10 lines (16-10/12 inches) (approximately 43 cm). The stick lengths are not given but may be roughly calculated from do Amaral’s suggested lengths above to approximately 97.5–127.5 in. (8–10.6 ft, or 2.4–3.2 m). The cartridge diameter was 2 “pollegs,” 6 lines (2-6/12 in.) (approximately 6.3 cm), while its empty weight was 1 lb 17 oz (about 0.94 kg). The full weight was 6 lb, 6 oz, 4 “oit” (4/8ths) (about 3 kg). Rockets “of 6 [caliber]” were 13 pollegs, 4 lines (13-4/12 in.) long (34.2 cm). The diameter, or “true caliber,” as do Amaral rightly says, was 2 pollegs, 0.6 lines (2.06 in. or about 5.2 cm). The stick lengths were approximately 77.6–101.2 in., (6.4–8.4 ft or 1.9–2.5 m) The empty weight of the 6 caliber rocket was 1 lb, 17 oz (0.94 kg), while the full weight was 6 lb, 6 oz, 4 *oit*, (4/8ths) (about 3 kg). Do Amaral does not cite the calibers of Hale rockets but it is known from the specimen mentioned above in the Museu Histórico Nacional that a standard one was 3-in. (7.62 cm) caliber. Nor does do Amaral cite the larger 18, 24, and 32 calibers give in the *Relatório*. The 12 and 6 calibers were therefore probably the most popular or widely used.¹⁵

Do Amaral also describes a rocket “estavia,” or stand, which was a standard tripod type launcher of the day, although the legs somewhat resembled a music stand. As in some European launchers, the Brazilian estavia came with graduated disc quadrants to permit correct firing elevations for achieving the desired range. Pressure screws locked in the firing angle. Like British Hale trough launchers, Brazilian launchers could delay the rocket’s departure until the rocket had gained the necessary force (or thrust, in later terminology) to lift itself “without falling to the ground.”¹⁶

Do Amaral enumerated advantages of rockets (they could be easily transported to all kinds of terrain; easy to operate; they have no recoil; could make quick, successive firings; and could concentrate on a point.). However, it was also necessary for him to explain different trajectories and how to adjust for them. These included: lateral deviations, lateral dispersions, longitudinal deviations, and longitudinal dispersions. Rockets, he continued, could be employed a number of ways, as

incendiary projectiles, in mountain warfare as substitutes for conventional artillery where artillery could not be transported, for the passage of rivers, as a vanguard in rapid marches, for reinforcing sharp shooters, against infantry squares, against cavalry transports and for creating disorder among the horses, against artillery and for burning artillery caissons and munitions chests, and as signals. (In the war against Paraguay in 1865–1870, Brazilian Congreve rockets were occasionally used as signals, such as at the battle of Tuyuty, on 24 May 1866.) Besides these there were battlefield illumination rockets which might even illuminate the night movements of friendly troops. The remainder of do Amaral's work deals with the tactical employment of war rockets.¹⁷

Another valuable Brazilian work of the period that describes rockets in detail is the *Manual das Munições e Artificios de Guerra (Manual of Munitions and War Artifices)* (1874) by Major Augusto Fausto de Souza who was then the director of the Laboratorio Pyrotechnico do Campinho where the rockets were made. Rockets, de Souza says, could be transported, not only to inaccessible places like mountains, but escarpments, gorges, and terraces, and were good for coastal uses. They did not require special preparation of the terrain for use. De Souza next offered theories on the movements of rockets, one attributed to the resistance against the atmosphere (which, of course, was incorrect, although it had been readily accepted by the majority of artillerists and pyrotechnists for centuries). The other theory held that the pressure within the rocket was exerted on all sides and created an equilibrium that came out from the open orifice and thereby launched the rocket in the opposite direction. (This theory was much closer to the correct principle of Newton's Third Law, although de Souza surprisingly believed that both hypotheses had valid points and could be adopted simultaneously.)¹⁸

De Souza mentions the two most popular calibers of 54 and 68 mm, known as 2 and 2-1/2 pollegadas, which he said corresponds to calibers "of 6 and 12." He then, at length, described the differences, advantages, and disadvantages, construction, and operation of lateral tail, or side-stick mounted rockets; central stick types; and "rockets without sticks," or Hale rockets.¹⁹

In describing the various attributes and shortcomings of the different types of rockets, de Souza makes it unequivocal that the side-stick mounted models were the least successful. Pointedly, he also explains why smaller calibers of all rockets were preferred in his country, and suggests that the Brazilians had unpleasant experiences with making larger ones. Larger calibers were difficult to make, expensive, and required stronger powder; hard to handle, transport, and store; subject to "successive accidents during manufacture," had a greater "irregularity of trajectories," and required a heavy firing apparatus. For these reasons, larger calibers were "motives for completely banishing" them. The central stick types, which he says were introduced

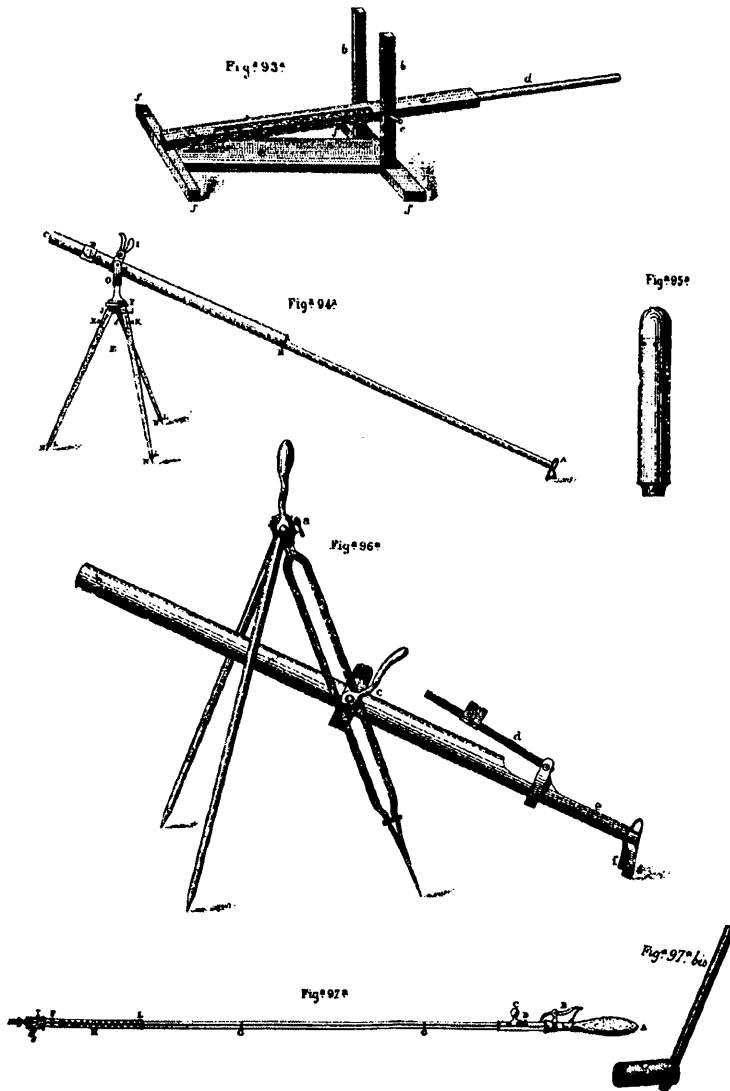
at the end of 1867, during the Paraguay campaign, were far superior in construction (made of sheet metal of “excellent quality”). They were capable of withstanding manufacture by hydraulic pressures (hydraulic rather than hand or weight-operated rocket presses), and traveled in much straighter paths and also avoided being caught in launching tubes like the side-stick models, which exploded “many times” on their launchers causing “grave physical and moral” effects on Brazilian troops who handled them. The Brazilian central stick rockets, as described by de Souza, were comparable to British models in having five equidistant exhaust vents around a central hole through which was screwed the wood guide-stick that was either a circular or octagonal section. Hale rockets, de Souza said, were the more superior designs than the central-stick rockets and praised them. It is also observed that neither do Amaral nor de Souza seem to cover incendiary rockets greatly, but rather, describe explosive or grenade warhead types. It therefore appears that grenade rockets were the more favored types in Brazil during this period.²⁰

A third work, *Manual do Aprendiz-Artilheiro (Apprentice Artillerist Manual)* by Antonio Francisco Duarte (1880), is written in a catechism format of questions and answers on all artillery matters, including rockets, although by that date they had all but ceased to be used. However, this was the second edition of Duarte’s book. (It may be, as in England, that war rockets were also still “on the books” in Brazil long after their operational life.) Duarte also covers aspects of rocketry not given in the previous works, like transporting the rockets. For example, they were carried by carts and, as a safety measure to prevent accidental ignitions, the carts for the different fuses were separated at prescribed distances from one another when in transport. He also touches on what apparently is a species of earlier rockets with (cannon) balls called the “foguete militar” or “foguete de bater” (“military rocket” or “rocket for striking,” respectively). These, he adds, had actually been abolished. Perhaps they were among the larger rockets alluded to by de Souza as being too difficult to handle. In addition, there had been “foguete suffocantes,” or “suffocating rockets,” with cylindro-conical heads full of asphyxiating or incendiary mixtures, but these too were abolished and evidently never used. Duarte does not specifically state who designed them (which country or individual) or who made these rockets. Mainly, being an artillerist, Duarte dealt with the tactical employment of rockets, including how to avoid deviations caused by wind gusts and understanding different trajectories, and so on. On closer study there is an appreciation of the actual employment of Congreve rocket armament in combat. For example, Duarte recommends that if it was necessary to launch a rocket at a certain elevation, troops could improvise and use a stone or stick to raise the launcher. He recommended that rather than strike a gun with rockets, the rockets should be aimed at the incendiary munitions cart usually following the gun, since its explosion would inevitably blow up the cannon. In those

years, the infantry marched in squares of men. In this case, few rockets were needed to penetrate the squares. He also cautioned artillerymen to be wary of the kinds of terrain on which to fire. If the ground was hard, and if the rockets happened to strike it, they could ricochet sharply whereas if the ground were soft, and even wet, the rockets would have a tendency to bury themselves into the soil.²¹

Duarte too gives a formula. This is 25 parts powder (probably nitrate, rather than mixed gunpowder), 1-3/4 parts sulfur and 3-3/4 parts carbon (charcoal). Like de Souza, he only speaks of two calibers, 2 or 2-1/2 pollegadas, also given as 54 and 68 mm, but “inappropriately known as rockets of 6 and 12.” Duarte then similarly goes into the nomenclature of rockets parts for each specie (side-stick mounted, central stick, and rotation rockets) and mentions that guidesticks for the former two of pinewood and of various lengths from 2–3 m (6.5–9 ft), which agrees with de Souza. He likewise goes into stands and mentions one Brazilian-made rocket stand of 90 kg (198 lb) but admits it was difficult to transport. When posing the question, “How many stands form a battery?” Duarte answered that “The [Brazilian] Government up to today has not fixed the number” but was probably eight for a battery, while the usual number of men for servicing a stand was five, which could be reduced to three in urgent situations. Duarte then went on to describe at length an improved stand made by “Major Dr. Fausto” [de Souza] which “barely” weighed 32 kg (70.5 lb) and could be taken apart in three parts (two iron tubes and a tripod) and carried by three men. It could fire from 0–45 degrees and was easier to aim than the former stand. Likewise Duarte cited another invention of “Major Dr. Fausto de Souza,” an igniter stick for rockets made of steel with a copper head and using friction to activate the fulminate tip. The *Relatório* for 1873 indicates that both Major de Souza’s stand and the igniter stick were approved in 1872 and were available for use by the Escolas Militar (Military Schools) and for firing practice at the [Estande de] Tiro do Campo Grande. (Great Camp Firing Range).²²

While none of the above cited works give ranges and corresponding firing angles—perhaps because the firing tables were only available to soldiers in the field and have long since been lost—it is clear enough, that the Brazilian Laboratorio Pyrotechnico do Campinho and Brazilian artillerymen were on par with any of their European counterparts in their knowledge, design, and handling of Congreve and Hale type rockets during the 19th century. It is also apparent that they had much experience with rockets, although their experiments and results are still unknown.



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Figure 2: Rocket launchers used in Brazil, late 19th century. Top, [Fig. 93], shows a 90 kg (198 lb) Brazilian wood and iron experimental launcher for firing centrally mounted guidestick rockets (the whole is of wood, with the exception of the tube, d, which is of iron). Second row, left, [Fig. 94], is a tripod-type launcher designed by Major Dr. A. Fausto de Souza, Director of the Laboratorio Pyrotechnico do Campinho, and this design had distinct advantages over the earlier one (weighing less at 32 kg, 70.5 lbs, could fire from 0 to 45 degrees, and came in three parts for ease in transporting). Second row, right, [Fig. 95], is a Hale rocket which was the type purchased by Brazil in 1852, and may have seen their second use in battle that year, in Brazil's war against Argentine dictator Juan Manuel de Rosas of Argentina. (The first use was by the Americans, in the Mexican War, 1846-1847.) Brazil later manufactured Hale rockets in 1867 and 1869, at their Laboratorio Pyrotechnico do Campinho, near Rio. Third row, [Fig. 96], is a launcher for Hale rockets. Bottom, left, [Fig. 97], is a fulminating powder friction igniter for rockets (slow match rocket igniter stick), designed by Augusto Fausto de Souza. Bottom, right, [Fig. 97 bis], shows details of the end. From: Duarte, *Manual*. (Smithsonian photo 75-684).

Chile and Peru

The histories of Congreve rockets in Chile and Peru are interrelated and date from the joint liberation of those nations from Spain. In 1819, Thomas Cochrane, a British sailor and adventurer, was appointed commander of the Chilean Navy. A partisan of Congreve rockets who was favorably impressed with them in their engagement at the Basque Roads in 1809, Cochrane decided to employ them in burning the Spanish fleet at Callao, Peru. To save money, he arranged to have them made in Chile rather than import any. To supervise the manufacture, Cochrane hired Stephen Goldsack, who allegedly had worked with Congreve as a superintendent at Woolwich in 1809. Expenses were further cut in the local rocket manufacture by using Spanish prisoners. This proved to be a disastrous mistake. According to Cochrane's own account, on 1 October of 1819, the rockets were test fired from several rocket rafts "with no perceptible effect," while at the main attack on Callao, the rockets turned out to be utterly useless. Some, in consequence of the badness of the solder used, bursting . . . and setting fire to others[,] took a wrong direction in consequence of the [guide] sticks not having been formed of proper wood, while the greater portion would not ignite at all from a cause which was only discovered too late. . . . The filling of the tubes was, from motives of parsimony, entrusted to Spanish prisoners who . . . embraced every opportunity of inserting handfuls of sand, sawdust, and even manure, at intervals in the tubes, thus impeding their progress of combustion . . . the result being complete failure in the object of the mission.²³

Major (afterward General) John Miller, one of Cochrane's officers, wrote of the same engagement: "Not more than one rocket in six went off properly. Some burst, from the badness of the cylinder; some took a wrong direction, in consequence of the sticks being made of knotty wood; and most fell short."

Despite this farce, the rockets were not altogether abandoned. A few were fired against the Spanish garrison at Pisco, Peru, on 7 November, while others helped repel the enemy during the crossing of the river at Mirabé, and there were other actions with the rockets into early 1820, but the overall effects of the rockets were still poor. There is an indication that Chileans used them at a later date, and they were probably of foreign origin due to limited resources. European Congreve type war rockets are described, for example, in *Curso de Instrucción Especial de Artillería (Course of Special Instruction of Artillery)* (Santiago [de Chile], 1848), although this was a Spanish translation of a European text by Chilean Col. D. Justo Artega.²⁴

Then, in the 1850s, following the annual *Memoria presentada al Congreso Extraordinario (Memorial Presented to the Extraordinary Congress)* reports by the Peruvian minister of war and marine (comparable to Brazil's annual *Relatório*), a

general trend is detected toward Peru's final adoption of rockets. The *Memoria* for 1851 observed: "another species of light artillery is known by the name of Congreve rockets . . . that at all costs should be introduced." The *Memoria* for 1858 shows that the Peruvian Congress took action, though details are not provided: "Europe was asked for an amount of rockets of the Congreve type . . . they are easy to transport and simple handling makes them very appropriate for our country." Then, in 1860, the *Memoria* says: "There is also in service two siege batteries and a sufficient number of Congreve rockets."²⁵



Figure 3: Thomas William Lion (1829-1894), British-born soldier of fortune who attempted to raise rocket batteries in Peru and Ecuador during 1860. He was not successful but he did succeed in raising the New York Rocket Battalion, New York Volunteers, during the U.S. Civil War. Courtesy, Mrs. L. T. Callahan, Rockville, Maryland (Smithsonian photo 74-5054).

About this time, Englishman Thomas William Lion, a soldier of fortune, made his own attempt to establish rocketry in Peru. In 1849, Lion departed his country for the Gold Rush in California. En route, he stopped in Peru and decided to settle there, marrying a Peruvian woman. He also joined the Peruvian Army. On the death of his

wife, Lion resigned from the Peruvian Army, and on 2 March 1860 wrote from Callao to a high-ranking officer in Lima: "Being present without employment . . . I desire to offer my services to your Excellency for the defense of our country. I find myself capable of giving instruction to the [Peruvian] Artillery in the use of Congreve rockets; also their operation and method of manufacture in Peru." Lion received a positive response on 17 March 1860, but requesting a demonstration of the rockets first. This trial apparently never came about, since on 1 October, he was at Guayaquil, Ecuador, making the same offer to the head of that country, Juan José Flores, though Lion did not succeed there either, but he did wind up as the commander of the short-lived New York Rocket Battalion during the U.S. Civil War. In any event, it is not known whether the Peruvian rocket units (the siege batteries) formed by 1860 were ever deployed in combat, nor the origin of their rockets, nor their nature, or how long these units lasted.²⁶

Many years later, from 1895, Peruvian engineering student Pedro E. Paulet reportedly undertook what may have been the first successful experiments with liquid propellant rocket motors in test stands, while a student at the Sorbonne, in Paris. His claims—which were first published in 1927 in the newspaper *El Comercio* of Lima—have never been proven, although they were extensively researched by Frederick Ordway III in an earlier International Astronautical Federation article and therefore need not be covered here.²⁷

Argentina

As early as 1807, William Congreve, in *A Concise Account of the Origin and Progress of the Rocket System*, wrote that Congreve rockets were *not* used at Buenos Aires during the early struggle for independence for the so-called Republic of Buenos Aires, but *should* have been. José de San Martín, the famed Argentinean-born revolutionary leader, certainly knew of Congreve rockets early in his career. He lived in Spain for most of his early life and must have known of their successful employment by the British during the Peninsula War. (San Martín left Spain for his native Argentina at the close of the war in 1812.) In 1818, two associates, Doctor Antonio Alvarez de Jonte and Sergeant Major José Antonio Alvarez Condarco, informed San Martín of Lord Cochrane's use of rockets, in letters on 13 January and 22 November, respectively, but San Martín was not able to procure any immediately himself for the revolutionary army he had raised since 1817. Not until 1823 did Cochrane, another friend of Congreve's, and the man who had failed miserably in trying to introduce this weapon to Chile, finally succeed with them in Argentina. Cochrane did not face any disasters with the rockets as he had in Chile, but used

them sparingly from this time. Yet, according to Anschutz, perhaps the first rocket engagement by Argentina actually took place earlier, on 22 May 1821, at Mirabé, apparently in southern Peru against Royalist and Spanish forces by the Argentine Marine Artillery using two rocket tubes. This was during San Martín's efforts to liberate neighboring Peru from Spain. (He soon succeeded, entering Lima on 12 July, and proclaiming that country's independence on 28 July 1821.) By 1826, it was also reported that rocket launchers were fitted on the Argentine naval vessel *San Martín*. Possibly the launchers and rounds on this ship were leftovers from Cochrane's operations, or from those in the Mirabé engagement. They were, in any event, most likely obtained from England since there is no indication that Argentina manufactured any of these weapons itself during this time. The same could be said for the 6 caliber Congreve rocket launcher that was included in a battery established in December of the following year, during the war with Brazil (1825–1827), on the strategic island of Martín García with the help of Irish-born Admiral of the Argentine Navy William Brown (known to them as Guillermo Brown).²⁸

Congreve rockets next appear in a naval action on 9 December 1841 between seven Argentinean and four Uruguayan ships under the command of Juan Halsted Coe, in which the *San Martín* dispatched five rockets. Congreve rockets continued to be used in Argentinean naval engagements on the Uruguayan coast during this period, such as in the action on 14 November 1842 on the point of the Conchas, with one Congreve launcher on the *Libertad*, by the Argentine Confederation in the squadron of the Argentinean dictator Juan de Rosas. Rosas also deployed them in the siege of Montevideo, Uruguay, from 1842, when he intervened in that country's civil war. Again, while the source of the rockets is unknown, they were Congreve incendiary types. Díaz says the rockets did not cause many deaths or injuries "but they had a morale effect on our retreating militia." It is also well known, both in Argentinean and British naval annals, that British seamen used Congreve rockets in 1845 *against* Rosas, at San Lorenzo on the Paraná River and shortly after at the battle of Obligado. The San Lorenzo action is covered, for instance, in the article "The Rocket Battery at St. Lorenzo, on the Paraná," in the *United Service Journal* (London) for April 1847, in addition to the account of one of the Englishmen who participated, Lauchlan Bellingham Mackinnon. Mackinnon's account was translated to Spanish by Busaniche and summarized for Spanish readers by Kirbus, with briefer accounts by Henry N. Sullivan, Winter, and also in the classic history *The Royal Navy* by Clowes, so the details of the St. Lorenzo engagement need not be recited here.²⁹

Rosas again employed rockets against his rival, Justo José de Urquiza, in the Argentinean Revolution of 1852. At the important battle of Monte Caseros, on 3 February of that year, cited above, both the Brazilians and Argentineans

fielded war rockets. The Argentineans had four tube launchers and were in the artillery division of Colonel José María Pirán. The batteries were stationed at the strategic base of the circular building known as El Palomar adjacent to the house of Caseros from which the battle took its name. To further complicate matters, Uruguayan forces under Manuel Oribe were involved and also had Congreve rockets at Caseros. As at Montevideo, Beverina remarks that at Caseros the rockets had more morale than material results. Later, in 1859, General Bartolomé Mitre, who had earlier helped Urquiza overthrow Rosas, was now resisting Urquiza's plan for the Buenos Aires province to join the newly proclaimed Argentine Republic, and attempted to use rockets. But on 21 July of that year, an "apparatus for firing Congreve rockets" was tried on one of his schooners on the Piraná though found it "totally useless." Despite this, at the important battle of Pavón in late September 1861, war rockets surfaced again in which Mitre had rounds of several calibers of rockets which were now effective and helped him finally defeat his Urquiza. In the following year, Mitre became president of the republic. Rockets were continued to be carried by the Army, though in relatively small numbers and appeared with Argentina's participation in the War of the Triple Alliance, 1865–1870. Seeber cites a letter from an Argentinean soldier who wrote from Tuyuty to a friend on 6 July 1866: "I know a great number of our young and very distinguished men in the Company. Among the surprising intellectuals is Carlos Pellegrini, scarcely 20 years old. I visited him at the command of a rocket stand." Yet the *Memoria Presentada por el Ministro de Estado en el Departamento de Guerra y Marina al Congreso Nacional* (*Memoria Presented by the Minister of State in the Department of War and Marine to the National Congress*) [of Argentina] for 1868 reported there were but 100 Congreve rockets and two "Coheteras de tripade" (probably Congreve tripod launchers) in the artillery from May 1867. After this period, almost nothing is heard further of war rockets in Argentina during the remainder of the century.³⁰

Cuba

Not surprisingly, Cuba's first efforts to produce war rockets were made by the island's Spanish military authorities during the period when Cuba was still a colony of Spain. Early in 1832, on his installation as governor of the island, Captain General Francisco Dionisio Vives, who had witnessed the successful use of Congreve rockets at the battle of Bayonne in 1814 during the Peninsular War when he commanded a Spanish infantry brigade, ordered rocketry experiments at Havana's military works. The experiments were placed under Brigadier General Michelina, the assistant artil-

lery inspector of Cuba (in 1814 Michelina had also witnessed Congreve rockets, during the siege of Barcelona). Later tests in Havana were conducted, also under Vives order, by Brigadier General Fernando Cacho and assisted by Colonel Manuel Calleja and a "board of officers." In addition to their experiments, they also "followed the theories [of pyrotechny] of the most reliable authors." But it was difficult for them to produce the right propellant formula, however, because of the dry climate. This is why extra moisture was added, to prevent cracking, which could lead to explosions. The projectiles were small "light field rockets." There was a 2 inch, 3 line diameter (model with a total length of 19 inches without the stick, a weight of 4 lb, 15 oz, 10 "adarmes" (1 adarme equaled 1/16 of an ounce) loaded; and total weight of 6 lb, 10 oz, 11 adarmes with the stick. The range of this model was about 500 "varas Castellanas" or "Castellan yards (1 Castellan yard equaling 2.78 ft, or 1,400 ft or 424 m) when fired at a 35 degree elevation, or 300 Castellan yards (834 ft, or 254 m) when fired at a 10 degree elevation. An even smaller model was 1 inch, 8 lines in diameter; 14 inches, 11 lines without the stick. It weighed 2 lb, 11 oz, 11 adarmes loaded and 3 lb, 2 oz, 11 adarmes with the stick. The standard formula for these rockets was 70 percent saltpeter, 10 percent sulphur, and 20 percent charcoal, but Cacho made the propellant for the climate of Cuba, and different from the (Iberian) Peninsular and added more water. The formula was also prepared for giving maximum ranges. The launcher was a tube about six times as long as the rockets.³¹

At first, Cacho found that 14 percent water was excessive for the propellant and he therefore used half that dose, but then the rockets exploded in the launcher. According to Cacho, the water had weakened the mixture and dragged out a portion of the saltpeter, thus decomposing it and when the powder was allowed to dry, fissures were formed and "the fire [combustion] spreads out and the rocket blasts [explodes]." It also took too much time for the rocket to dry. The firing trials were held before the governor and also used different elevations. Two reports, or "Memorias," were later sent to the governor and to the Spanish Junta. But the problems were never fully solved and these early efforts were apparently abandoned.³²

About 1850, the ubiquitous William Hale, or his sons, tried to sell the Cuban authorities their stickless rockets, but there is no evidence these were picked up. A pyrotechnical laboratory was established in Havana in 1869, but it is unknown if it produced war rockets. Standard stick-guided, Congreve type rockets may have been reintroduced to the island during the Cuban insurrection period, as late as 1895. Spanish newspapers, and Spanish artilleryman Gabriel Vidal y Ruby, reported that either 5,000 or 500 rockets (probably due to a typographical error), invented by a French officer named Couspi re, were carried by insurrectionist leader Enrique Collazo y Tejada in one of his expeditions that departed from Florida. The rockets were said to be of aluminum to save weight and contained dynamite in their warheads, set

off by a lead-fulminate impact-detonating fuse. Interestingly, Collazo, who was born in Santiago de Cuba in 1848, embarked for Spain in 1857 where he studied in the Colegio de Artillería (College of Artillery) in Segovia in January 1862 where he might have learned of war rockets, and, when ready to take up the cause of his country, he first “fled” to France—where he may well have heard of Couspière, or his alleged rockets, then went to New York to prepare for his expedition to Cuba. The name Couspière is not on the 1895 list of French officers, although there was a Jean Baptiste Couspeire, a reserve lieutenant in the chasseurs (engineers) who, interestingly, was born in Laguna, Cuba, in 1866. Perhaps he was the inventor. In any case, Collazo’s expeditions failed, so the alleged rockets would not have had any effect. Nor does Collazo himself mention any “cohetes” in his memoirs, known as *Cuba Heróica (Heroic Cuba)*, originally published in 1912, but which frequently mentions other weapons used by the insurgents.³³

In 1895–96, one Spaniard, the artilleryist and former professor of the Academy of Segovia, Lt. Col. Gabriel Vidal y Ruby, proposed that the Spaniards themselves might consider raising rocket troops for use *against* the insurgents. Vidal y Ruby, who had not only studied the rocket literature of the time, but also personally interviewed Brigadier General Don Miguel Orús, who had commanded the Spanish rocket battery in the war against Morocco in 1859–1860, when he was a captain, favored British Hale rockets that did not have incendiary warheads like those of Congreve years before, because there is too much “exuberant vegetation” on the island, “though rockets might come in usefully on certain occasions.” In any case, mountain artillery, which included rockets, seemed to be the most suitable for the Cuban terrain. “Since the artillery is a system used to hurl projectiles a long distance,” he wrote, “if this could be achieved by cannons, would not the end be achieved very simply? All this can be achieved by using the war rockets known as ‘Congreve style.’ They are highly mobile, can even be carried by hand, and can be fired from inaccessible places. What may be lost in range and accuracy can be gained in simplification. . . . The rocket only needs simple sawhorses or tripods, and this only in the case of firing at a high elevation.”

He advised parabolic trajectories to miss trees, which are usual obstacles; incendiary type rockets should only be used in exceptional cases. He also believed the “French pattern” of rocket “with [star-shaped] central tail-piece” would also serve (but without incendiary warhead) and was suitable. “It should be fired by a percussion tube. The tripod should be of the English pattern.” He also specified a small caliber of 7 cm (2.75 in.) with an explosive shell of 8 cm (3.15 in.) for a total weight of 8.8 lb (4 kg). The length of the rocket would be about 19 in. (48.2 cm), without tail piece, but about 39 in. (99 cm) with it. The launcher was a lanyard operated tripod with level, while a weather cock on a pole would also be taken to determine

wind direction during firings. One mule could carry two boxes of a dozen rockets each and the boxes would be adapted for carrying by mule or “hand transport.” Vidal y Ruby even specified the makeup of a rocket battery of 80 men, including gunners, artificers, mule drivers, a shoeing smith, and collar maker. Besides the rockets, the men were to be armed with carbine rifles and sword-bayonets or machetes. Colonel Vidal y Ruby then went into tactics, explaining that “Rockets could be employed against masses of infantry in the open, against the insurgents” and they would also have a “material effect against cavalry,” and advocated barrage type fire to compensate for inaccuracies. Ideal targets were infantry soldiers when in the open and especially cavalry because they were affected both materially and psychologically. For entrenched insurgents in Cuba, he advised arched fire. But he recognized there were difficulties at that point of adopting the rockets, including manufacturing them and training personnel on short notice. The rockets could be either manufactured in Spain at the Brass Foundry of Seville or loaded and assembled at the Pirotechnia and the tubes purchased from abroad, or the rockets might be imported from England. Neither the Spanish Army nor the government paid heed to Vidal y Ruby’s well thought-out plans, but his proposal makes an invaluable addition to the overall study of the actual complexities of this early rocket technology and systems as applied to Latin America and both the logistical and tactical problems involved.³⁴

Mexico

As in other Latin American countries, it is extremely difficult to trace the actual history of early rocketry in Mexico because of continual revolutions, which also meant frequent changes of armies and appearances of guerrilla groups. In both cases, arms were often raised by any means possible, either locally or from foreign sources. Likewise, as one Mexican authority pointed out, there is “no adequate iconographic study of the Mexican Army during its formation.” Nor are there adequate histories of arms in that region. The difficulty is compounded for researchers outside Mexico in that there are few books available in Spanish or English of the Mexican side of the Mexican War and other military campaigns in that country.

As early as 1825, the *Instrucciones y Señals para el Regimen y Maniobras de Escuadra* (*Instructions and Signals for the Regimen and Maneuvers of the [Mexican] Squadron*) included one signal that read: “[Carry out] Exercise of rockets, grenades, powder flasks, and the remaining artifices,” but most likely this referred to standard naval signal rather than war rockets. It is known for certain that Mexicans used a few war rockets against the Americans during the Mexican War of 1846–1848 but nothing has been found of their history, calibers, or performances. (As

mentioned, the Americans too used rockets in this war, which has been well documented elsewhere.) Yet, throughout the campaign, it is only heard of them being used by Mexicans in the operations at the Gulf of Mexico port of Veracruz and vicinity during the landing of the U.S. forces there in March 1847, when they were expended on American ships and troops. It is possible the rockets were made at the Maestranza (Arsenal) in Veracruz, although the Mexican War Department's *Memoria del Secretario de Estado y del Despacho de Guerra y Marina (Memorial to the Secretary of State and Dispatches of [Departments of] War and Marine)* for these years only lists mortars and cannons among the arms production, no "cohetes de guerra." Another possibility is that since this was a naval engagement on both sides, the rockets were fired by Mexican Navy forces. It might also be speculated that since Veracruz was Mexico's largest port, the rockets were imported from overseas. In either case, it may never be known. The available evidence of their use by the Mexicans is meager as follows. George Brinton McClellan, then a young American officer and future top general of the Union forces during the U.S. Civil War, wrote in his diary of the Veracruz operations on 20 March 1847: "They [the Mexicans] fired rockets etc. at us during the early part of the night." While Colonel Albert C. Ramsey, U.S. Ordnance, observed: "The [Mexican] rockets were of very little service." Alcarez, a contemporary Mexican writer on the war, similarly makes only one terse remark at the height of the bombardment on 24 March: "Both the enemy and the city now threw Congreve rockets." The term "Congreve rocket" was of course generic and in itself does not offer any clue other than that the Mexican obviously did not use Hale rockets, as were the Americans employing against the Mexicans in the same war. Earlier in his book, Alcarez lamented that "The artillery of the Americans [is] much superior to ours."³⁵

As for the Mexicans using rockets elsewhere in the state of Veracruz, Alexander Slidell Mackenize, the American Naval commander and inspector of Ordnance of the squadron, reported to Commander of the Squadron Matthew C. Perry on 9 April 1847 that among his discoveries, after the fall of the Mexican fort at the port of Alvarado, about 60 miles (96 km) south of Veracruz, "There was a stockade prepared for a rocket battery and musketry." Again, no specifics have surfaced. The same applies to other Mexican rockets found by the Americans. Some 36 Congreve types were included in the U.S. (Army) Ordnance Department's "Statement of Ordnance Stores Captured in Mexico . . . on the Lower Rio Grande and Monterey, at San Juan de Ulúa and Veracruz, and in the Valley of Mexico." However, this list does not single out specifically where the rockets were found. The U.S. Navy reported a solitary rocket seized at Tuspan, or Tuxpan, another Gulf of Mexico port, about 120 miles (193 km) north of Veracruz, Jalisco state, in February 1847, and an additional 60 at Tobasco on 19 June 1847. The latter may have been either war or

signal types. Also, on the 19th, Commander of the U.S. Army, General Winfield Scott, wrote in a dispatch from his headquarters near the city of his victory at Veracruz the previous day and of the capture of Mexican artillery: “The small arms and their accoutrements, being of no value to our army here or at home, I have ordered to be destroyed, for we have no means of transporting them.” Thus, in all likelihood, Mexican war rockets and possible launchers were among the disposed weapons. More than a decade later, the Mexicans apparently again used war rockets, under General (later President) Porfirio Díaz during the War of “War of Reform” in 1857–60, but their use was insignificant, and there were also battlefield illumination or standard signal rockets.³⁶

Paraguay

War rockets may have first appeared in tiny Paraguay in 1858. Apparently some Hale types were taken, along with the 19-ship, 2,500-man American “Brazil Squadron” under William B. Shubrick in the “Paraguay Expedition.” This was a little known affair to settle commercial and other difficulties between the United States and that Latin American nation. On 25 September 1858, Captain D. N. Ingraham, chief of the U.S. Navy’s Bureau of Ordnance and Hydrography, wrote the following: “As this projectile [the Hale rocket] is new to our officers, I respectfully suggest that some of those designate to accompany the expedition to Paraguay be detailed to witness the trials referred to, and that at least should remain here during the preparation of the rockets to acquire all possible information in regard to their use.” Ingraham then wrote to Captain J. Rudd: “As soon as the ‘Hale’s Rocket Stand’ is received from the Washington Arsenal at the [Navy] Yard under your command, you will be pleased to have four made like it immediately, for use in the Paraguay Expedition.” Finally, there is a follow-up letter from Ingraham dated 17 November 1858: “You are requested to have forwarded to the Navy Yard, New York, for the Paraguay Expedition, all the War Rockets [*sic*] that are now ready.” The expedition was successful in that only a minimum number of gunshots was exchanged—but probably did *not* include the rockets—and the affair was peaceably settled with diplomacy.³⁷

The Paraguayans themselves were active in putting rockets into battle in the War of the Triple Alliance (1865–1870) mentioned previously. The rockets were both made in Paraguay, and also imported, and thus came from a variety of sources, making it difficult if not impossible to trace all their sources. As one example, they included conventional Congreve stick models, some of which were produced by William Wagener, or Guillermo Wagener, as the Paraguayans called him, a profes-

sional German (Prussian) “master armorer” whose services were contracted to Paraguay because Paraguay’s dictator, Francisco Solano López, relied on foreigners to supply his small army. In addition, says Hutchinson, López had “been for many years amassing the most perfect and extensive collection of European armaments” and had likewise inherited many arms from his father, Carlos Antonio López, which unquestionably included rockets. “None of the republics in South America,” wrote Graham, “not even the great empire of Brazil, had nearly so great an armament.” (Francisco succeeded Carlos on his death in 1862.) Wagener had arrived at the Paraguayan capital of Asunción on 16 December 1863 on the steamer *Ypora* and on 10 March 1864 signed a contract to work for a year at the rate of 100 pesos monthly. He experimented with a multiple launcher, which later “sobered Brazilian inspectors for its advanced design and efficiency” according to Kolinski. This was actually a triple-tube or barreled Congreve launcher. The launcher still exists as a captured war trophy in Brazil’s Museu Histórico Nacional (National Historic Museum) in Rio de Janeiro. It appears like a heavy musket with locks on the sides of each barrel and each barrel has a caliber of 19 mm (0.75 in.) Therefore, the rockets were indeed, of small caliber. For certain, it was made by Wagener and has the inscription “Invented and made by Wagener—Asunción—1864.” It had been captured during the war by Brazilian forces, but the date of capture and engagement are unknown. Jourdan says the Paraguayans also had “Congreve rockets of 24 [caliber]” onboard their vessels when they invaded Matto-Grosso, Brazil, embarking Asunción on 14 December 1864, and first used them against the fort of Coimbra. But considering that these rockets were of medium to large caliber, they may not have been Wagener’s. Vittoné, reports López, also acquired Congreve rockets from the British Navy (he does not say how) and these rockets achieved “excellent results” in setting fire to the sails of enemy ships and against enemy cavalry.³⁸

One of Paraguay’s employments of rockets in the war was in the important naval battle of Riachelo against the Brazilians on 11 June 1865, where they had two “baterias de cohetes á la Congreve,” while Jourdan mentions as many as eight stands near Goya in the same year. Paraguay also used them in the battle of Tuyuty, in southern Paraguay, near Paso la Patria, on 24 May 1866. One was to be fired at day-break to signal the advance but did not go off until about 11:55 a.m. against the Brazilians, initiating the bitterest fighting of the war. Best and Baez mention the capture of a Paraguayan rocket launcher on this day by the Allies but do not specify the launcher type. Mitre, on the Argentinean side, reported that “from 3:30 to 4:00 in the afternoon the enemy [Paraguay] returned to carry out an attack on our advanced guard, with considerable forces, bringing five strong battalions and two regiments of cavalry, with four rocket tubes . . . Various rockets penetrated in our forces, causing some damage . . . Congreve rockets had [also] burned the field of pursuit.” Para-

guayan rockets were heavily employed in the combats of Boquerón and Tuyuty, both on 16 July, and Sauce, on 18 July of that year. At Boquerón, reports Argentine Col. Beverina, the “rockets decimated the lines of the flanked battalions in Boquerón . . .” and elsewhere says, the Paraguayans were “reinforced by Congreve rocket[s] which they did not cease to launch on us.” At Sauce, Rodó and others reported that the Paraguayans had come up with new rocket stands. “The new rocket stands,” he wrote, “are more simple and portable than the others,” but otherwise did not go into details. (The Paraguayan rocket battery on this occasion, of two stands, was commanded by Second Lt. Hilario Amarilla.) Yet, in the end, at least one Paraguayan rocket stand ended up in the hands of the Allies since Beverina, quoting an official Argentinean dispatch, writes: “As trophies of this action we obtained for the Brazilians, ‘besides the Congreve rocket launcher and the tools abandoned by the enemy in the conquered trenches, we encountered . . . 900 rifles and 600 bayonets.’” Similarly, Beverina writes that at Tuyuty the Allies “surprised the [Paraguayan] workers of the trenches, abandoning there a quantity of Congreve rockets and 146 implements of the sappers.” The rockets themselves were considered of good quality as one Argentine soldier, cited in Seeber, wrote from Tuyuty to his friend back home that: “The projectiles and rockets which they [the Paraguayans] used were also superior to ours, which understandably caused us pain and lamentations.” At Sauce, Beverina says, “The Paraguayans did not delay in attacking with its infantry and with the fire of the rockets.” In the Allies advance for Bellaco in 1866, writes Frago, “the firing of artillery and enemy [Paraguayan] rockets was very badly directed.” Rockets also showed up in the last major action of the war, in August 1869, at the battle of Campo Grande, or Acosta Nú to the Paraguayans.³⁹

Also, in 1866, at the battle of Humaitá, yet another type of rocket appeared among the “motley armature of the Paraguayans,” according to English observer Captain Richard F. Burton. “By the side of . . . self-rifling shells and balls,” he wrote, “were found . . . Hall’s [Hale’s] rotating rockets.” Perhaps they were captured from Brazil, or they were old rounds left over from the U.S. “Paraguayan expedition” of 1858, or perhaps they were among the collection that the López father and son had been amassing; it is not known if William Hale or his sons directly approached the Paraguayans, though there were still other English agents for Solano’s rockets.⁴⁰

These Englishmen were the brothers John and Alfred Blyth of Limehouse, London, listed in the London *Post Office Directory* for the period as boiler and iron and brass founders, but in fact, they ran an arsenal and shipyard as London’s leading arms merchants who were regularly shipping out munitions to Asunción. In August 1864, the López government commissioned the Blyths to furnish rockets and other war material and by September they had sent “articles for the rocket factory” on the

steamer *Ygurrey*, which delivered these to the port of Buenos Aires, Argentina, under the watchful eye of Félix Egusquiza, Lopéz' agent in that city. From here, they then went up the Paraná River, which becomes the Paraguay River, to Paraguay. In a note on the 21st of that month to the Paraguayan Consul, José Rufo Camino, was an order for additional articles for the fabrication of rockets which are said by Acosta to be "cohetes a la Congréve," but also could have included Hales. The Paraguayan Navy, as mentioned, also employed rockets and had two Congreve batteries in their fleet garrison in the naval battle of Riachuelo on 11 June 1865. Generally, the Paraguayans seemed to have had success with their rockets. Yet the following statement was made either in fact or sarcasm by Argentine General Mitre to General Osorio on 30 January 1866: "The Paraguayans carry a Congreve rocket launcher and scatter 16 rockets that do not cause any damage." Yet in another instance, the Argentine paper *La Esperanza* reported a series of large "incursions" by the Paraguayans into Argentine territory at Itapirú on 17 February 1866, in which the correspondent, quoted by Beverina, reported: "Moreover, we had many horses wounded, one dead by a [Paraguayan] rocket and its horseman run through by the stick of the rocket." One Argentinean, quoted in Seeber, wrote home that at Tuyuty in July "The [Paraguayan] rockets did not cause damage, and only one consequently set fire to a nearby field." Even so, the war devastated the limited resources and manpower of Paraguay and after the War of the Triple Alliance there is nothing more heard of war rockets in that country.⁴¹

Uruguay

Almost nothing is known of rocketry activities in the small country of Uruguay, although, as seen previously, its capital city of Montevideo was bombarded with Argentine Congreve rockets from 1843, and it was certainly exposed to the use of these weapons in other ways by its larger neighbors, Argentina and Brazil. It is therefore not surprising that in the *Memoria del Ministerio de Guerra y Marina* by the Defensa Nacional of Uruguay, as late as 1879, there are listings of 30 Congreve rockets in the country's military stores in Montevideo. Whether the rockets were made in that city's laboratorio (laboratory) in the maestranza (arsenal) is unknown, but the same report complained that the overall quality of the laboratory's gunpowder was bad.⁴²

Finally, as in Europe, the state-of-the-art artillery had markedly progressed in Latin America toward the end of the century, with such improvements as rifled guns and motorized artillery, advances in metallurgy that led to stronger gun construction, plus the introduction of more powerful, double-based (nitroglycerine-nitrocellulose)

smokeless propellants for conventional firearms. The old gunpowder war rocket, whether the stick type or Hale's "tangential" "stickless" rockets, had become outmoded and disappeared in this region also.

Looking back, it is also interesting to observe that both Congreve and Hale rockets had a more international impact than is generally believed. Speculation might suggest that there may well have been other private rocket entrepreneurs, like the Waehneltdts, Blyths, Wageners, Hales, or Lions, who must have similarly plied their trade—which, for a period, must have been quite lucrative—elsewhere in Latin America in the 19th century, during the age of Congreve and Hale.

Addendum

Since writing this paper, we have found more examples of rocketry in Latin America during the 19th century.

Nicaragua

First, during May 1857, it was reported that the British-born soldier-of-fortune Major-General Henningsen (Charles Frederick Henningsen, 1815–1877), had earlier experimented with Hale's rockets when he was in England. Henningsen, an able artilleryist and munitions expert, subsequently became the commander of artillery of General William Walker (1824–1860), the American adventurer who conquered Nicaragua and became its President in 1857. More research is required to determine if Henningsen acquired and used any Hale or other rockets in his services in Nicaragua. If any rockets were used here, this (these) would be the first and only known instance(s) of war rockets employed in Central America during the 19th century. However, General William Walker's *War in Nicaragua* only mentions standard artillery and related weapons and does not mention rockets at all by any of the sides of his campaign in Nicaragua, although the possible use of rockets during this or other periods in Central America still cannot be completely discounted.⁴³

Cuba

On 29 October 1858, there occurred a huge accidental explosion of stores at the Naval Powder Magazine at Havana, Cuba, causing the loss of property and hundreds of lives. Included among these stores were gunpowder, grenades, and some 400 Congreve rockets. The manufacture of Congreve rockets by the Spanish military in Cuba is thus far older than was generally believed although no details are known

of when this was started as well as the application of these rockets by the Spanish Navy in that country.⁴⁴

Peru

In December 1857 or January 1858, the Minister of War and Marines of Peru considerably increased the size of its forces and armament. This armament included the purchase of Congreve rockets from England, although it is not mentioned in this report whether the rockets were obtained from the British government or from a private manufacturer.⁴⁵

New Granada (Present Day Colombia)

On 26 April 1861, a Congreve rocket was used by “revolutionary troops” to set a government building on fire during a military engagement against government forces at the port of Buenaventura at New Granada (present day, Colombia). Here again, no details are known, as to how and where the revolutionists obtained the rockets, nor who was involved.⁴⁶

Brazil

Finally, it should also be mentioned that thanks to the diligent work of Mr. Adler Homero Fonseca de Castro of Rio de Janeiro, it is learned that there are more extant 19th century war rocket specimens in Brazil. These include: a Hale rocket at the Museu Histórico Nacional (National Historical Museum) and in the same museum, the rocket musket made in Asunción by the Prussian armourer Guillermo (Wilhelm) Wagener captured by the Brazilians in ca. 1864 from the Paraguayans. They also have a “flare” (i.e. illumination head) used in rockets as well as fired by guns. There is another Hale rocket, of the same pattern as above, in the Museu da Cidade (City Museum of Rio de Janeiro) and in the same museum, a central stick “English” style rocket, with five vent holes (but without its guidestick). Some years ago, this museum also had a complete series of Brazilian-made rockets, but they presently cannot be located. There is an Austrian type incendiary rocket with its tripod stand at the Comando Militar do Sul Museum (Museum of the Southern Military Command) at Porto Alegre, capital of Rio Grande do Sul, the southernmost state in Brazil. The Austrian type rocket and stand were both made at the Campinho Laboratory. Lastly, there is a modern reproduction of a tripod and rocket at the Museu Mallet, 3° Grupo de Artilharia de Campanha (Mallet Museum of the 3rd Field Artillery Battalion), at Santa Maria, Rio Grande do Sul.⁴⁷

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