Soviet Rocketry

Soviet Rocketry:

PAST, PRESENT, AND FUTURE

BY MICHAEL STOIKO

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To my wife, Margaret Jane Hoehn Stoiko,
for our nineteenth wedding anniversary

Preface

In spite of the many Soviet pronouncements that preceded its flight on October 4, 1957, Sputnik 1's launch occurred with the suddenness and surprise of a Pearl Harbor and with the impact of a Hiroshima atomic explosion. Perhaps at no other time in human history had a single event so changed the course of mankind. The streaks of white light and the "beep-beep-beeps" of the first Soviet sputniks in the fall of 1957 served as a warning to the free world of the achievement of Russian science and technology. On October 16, 1957, Richard Nixon, then Vice President, gave one of the sanest Administration reactions to Sputnik 1 when he said, "We could make no greater mistake than to brush off this event as a scientific stunt. . . . We have a grim and timely reminder . . . that the Soviet Union has developed a scientific and industrial capacity of great magnitude."

Starting with the first sputnik, through at least the first five years of the space age, the Soviet Union continued to reap enormous world prestige from its space accomplishments. Worldwide public opinion polls conducted between 1957 and 1962 by the U.S. Information Agency confirmed that, with the successful launching of Sputnik 1 through the launchings of their first Cosmos in 1962, the Soviet Union's prestige abroad increased, while producing a corresponding decrease in United States' prestige. Moreover, each subsequent launch tended to produce shifts in world estimates of the United States' and the Soviet Union's scientific capability, but with the Soviet Union always maintaining a substantial prestige lead over the United States.

The affects of these early Soviet successes were revealed in a 1960 world Gallup Poll that asked the question, "Looking ahead ten years, which country do you think will have the leading position in the field of science?" Of the American respondents, 70 percent named the United States, 16 percent cited the Soviet Union, 2 percent mentioned other countries, and 12 percent did not know. In Europe, only two of the nine countries polled, Greece and West

Germany, assigned a superior position to the United States, and then by a margin of less than 10 percent.

Sputnik's success was not easily achieved. Prior to its launch very little was known about near or far space. The only available information came from terrestrial observations and sounding rockets. In all cases, the data was either incomplete or not accurate enough to allow development of a realistic atmospheric profile.

In the decade that followed, hundreds of Soviet spacecraft, unmanned and manned, have performed many complex missions proving beyond doubt the high state of its technological development. Yet, within that same ten years' time, the American public has learned little about the phenomenal growth of Soviet space power. In fact, the image of presputnik Russia was that it was populated with heavy-bearded Moujikas and with scientists possessing no unique scientific or technological know-how.

Even after ten years, the assessment of Soviet capabilities and intentions continues to be misinterpreted by some of the most knowledgeable individuals, creating unnecessary confusion and apprehension. This situation need not exist, for in the last few years, great care has been taken in both the United States and in the Soviet Union to compile and document factual material on the development of Soviet rocketry and space flight. In the preparation of *Soviet Rocketry* many of these official and authoritative sources were minutely researched.

In selectively compiling notes it was my intention to write a factual book depicting chronologically for the first time the events following the introduction of rocketry to Russia up to the end of the first decade of the space age. The descriptive texts taken from official Soviet sources have been edited only when absolutely necessary in order to retain their authenticity. In specific cases where it appears the Soviet texts have, for one reason or another, "overshadowed" known facts, I have rewritten that portion in an objective manner retaining the historical content of notes and research. And in a comparable manner, source material which originated outside of the Soviet Union was also carefully researched, updated, and objectively presented.

Because a knowledge of the past and present can help us prepare for tomorrow, it is my hope that this account will provide the reader with the information he needs to judge the real importance of the "spectaculars" and the "firsts," as well as the long-term implications of space flight as far as he, his country, and the world are

concerned. Then, and only then, can he realistically assess his country's future in terms of his support and aspirations for his nation in space.

A book is almost always the product of the efforts of many people. This one was no exception. Accordingly, I want to thank the many people at the Library of Congress who were so helpful in researching material for this book. In particular, the help of Marvin W. McFarland, Chief of Science and Technology Division; the assistance and cooperation of Analyst Leonard N. Beck and Alexsander Dolgich, Supervisor, of the Aerospace Vehicles and Space Exploration Unit; of Dr. Charles S. Sheldon II, Acting Chief of the Science Policy Research Division; Dr. Ivan M. Soukhanov, Supervisor of the Aerospace Science Unit; and Dr. Joseph G. Whelan, Analyst, Foreign Affairs Division, are especially appreciated and gratefully acknowledged.

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M.S.

Towson, Maryland
January 1970

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1 The Legend and the Record

Most people consider astronautics a heretical idea and refuse to entertain it at all. Others are skeptical, regarding it as an absolute impossibility while others are too credulous, considering it a simple matter easily accomplished. But the first inevitable failures will discourage and repel the fainthearted and destroy the confidence of the public.

K. E. Tsiolkovsky, 1929

THE STORY of early rocketry began before the birth of Christ, its exact origin lost in legend and antiquity. The recorded use of saltpeter (potassium nitrate) by primitive Eastern tribes for curing meat provides us with our first link in the evolution of propulsion and rocketry. The explosive use of this ancient household item was very likely discovered when some was dropped accidentally into a fire, resulting in a bright flash flame. These flame-supporting properties no doubt were responsible for man trying to combine saltpeter with wood for fire making. Since sawdust or fine wood particles were not available, the saltpeter was probably added to charcoal. Saltpeter and charcoal are two of the three ingredients of gunpowder. In this period, however, there is no record that sulfur, the third ingredient, was ever added. It is certain, however, that a composition containing saltpeter and charcoal, known as "Chinese Fire," was used in the East long before the time of Christ. The use of Chinese Fire for propulsion probably de-

veloped initially from its use in hollow bamboo rods or arrows. It must have been accidentally observed that the bamboo rods had a tendency to propel themselves due to the expansion of gases through the hollow tube.

The Aeolipile

Another important link in the evolution of rocketry was the demonstration in A.D. 160 of the aeolipile (named after Aeolus, the god of winds) by Hero of Alexandria, a Greek mathematician and scientist. This apparatus consisted of a hollow sphere mounted so that it could rotate between two supports that carried steam from a closed container suspended over a fire. The rotating sphere had two right-angle pipes located 180° apart on the sphere. The steam jet escaping through the pipes caused the sphere to revolve. The aeolipile was probably the first known device used to demonstrate the jet propulsion principle.

Earliest Rockets

The first reference to the rocket principle is recorded in a Chinese chronical, *T-hung-lian-kang-mu*, where the use of the reaction principle is dated A.D. 1232, during the Mongol siege of the city of Kai-fung-fu (Pien-king). During this siege, the Chinese used two new weapons. The first, called "heaven-shaking thunder," had a bomblike function and was dropped from the walls of the city on the invaders. The second, called "arrow of flying fire," is generally regarded as the first application of the rocket principle. The "arrow of flying fire" was probably an extension of the stuffed bamboo rod and most likely consisted of a small package of incendiary material tied to an arrow.

From this beginning, the use of gunpowder rockets grew rapidly, and the pyrotechnic art spread from Asia to the Middle East and then to Europe and England.

It is evident from chronicles written in the next few centuries that much progress was made in pyrotechnics and rocket design.

Roger Bacon, an English monk, is credited with the introduction of rockets into Europe prior to 1249. In "De Mirabili Potestate Artis et Naturae," he established the composition of gunpowder as follows: ". . . but of saltpeter take 7 parts, 5 of young hazel tweigs, and 5 of sulphur; and so thou wilt call up thunder and destruction, if thou know the art."

Early European Rockets

In 1258, the first mention of a rocket in Europe appeared in the Chronicle of Cologne, and, in 1379, an Italian historian credits a rocket with a significant victory in the battle for the Isle of Chiozza.

A German engineer, Konrad Kyeser von Eichstädt, experimented with gunpowder mixtures in 1405 and is credited with advancing the art of pyrotechnics.

A technical paper, entitled "Treatise upon Several Kinds of War Fireworks," published in 1561 in France, describes the use of military rockets in the defense of Orleans against the English in 1429, during the siege of Pont Andemer in 1449, against Bordeaux in 1452, and at Gand in 1453. This particular treatise is significant in that it suggests an alternate material for the rocket casings, which up to that time were still bamboo. This bamboo technique was probably the same one that had been in use for fifteen hundred years.

In 1630, the rocket evolved in the form of a grenade, and in 1645, during the Thirty Years' War, the rocket was credited with the downfall of Phillipsburg, France.

In 1668, Col. Friedrich von Geissler, a German, conducted the first purely scientific research in rocketry. Successful propellant experiments were conducted on a 55-pound and 132-pound rocket utilizing wooden rocket cases reinforced with linen.

Newton's Laws

In the latter part of the seventeenth century, Sir Isaac Newton opened the third period of rocketry when he interpreted

and correlated many diverse observations and combined the results into three fundamental laws known as Newton's Laws of Motion. These laws simplified the science of mechanics and the Third Law forms the basis of modern rocketry. The Third Law states: "For every action there is an equal and opposite reaction, and the two are along the same straight line." Such a reaction takes place regardless of external conditions—underwater, in the air, or in a vacuum.

Sir William Congreve

In the accounts of the India Campaign in the latter part of the eighteenth century, the British forces in India were defeated with severe losses by an opposing Indian rocket force of 5,000 men. In this campaign, the rocket case had gone through still another step in its evolution. It was now made of iron, being some 8 inches long by 1.5 inches in diameter. However, the rocket still carried an 8-foot stick as a stabilizer.

It was at this time that Sir William Congreve became interested in the military rocket. His experiments at the Royal Laboratory at Woolwich resulted in several successful military rockets with ranges up to 2,000 yards.

During the European wars of the early nineteenth century, these rockets were successfully employed against Boulogne (1806), Copenhagen (1807), and Danzig (1813). Just about this time, two other uses for the rocket were found, namely bomb carrying and shrapnel.

By this time the military rocket had become so popular that, in 1817, the British Army formed the Field Rocket Brigade. The rocket brigade took part in virtually every important battle against Napoleon and distinguished itself particularly well in the final battle at Waterloo. Probably Congreve's rockets are best remembered for their use against Fort McHenry, which inspired Francis Scott Key to write, "The rockets' red glare, the bombs bursting in air," in "The Star-Spangled Banner."

The evolution and utilization of the Congreve rockets were milestones in the development of rocketry. They had first been

developed as an incendiary rocket, which had limited military value; then the rocket was given bomb and shrapnel-type warheads resulting in a far greater destructive capability. Finally, rocket stabilization in flight, by the application of jet vanes in the nozzle, increased the rocket's accuracy and consequently its usefulness as a military weapon. Even with all these improvements, military rockets became obsolete at the end of the nineteenth century with the development of the more accurate artillery gun.

Early Russian Rocketry

Among the many documents dealing with the development of rocketry, we find numerous mentions of the introduction of rocketry into Russia. Some historians feel that the arrival of rockets in Russia coincided with the first use of gunpowder for military purposes. The rockets, however, were used solely for firework displays and celebrations and would be for many years to come.

In *Russian Rocketry, A Historical Survey,* I. A. Slukhai writes that rocket know-how and experience was handed down from generation to generation until the 1600s, when the accumulated experience was documented by the Russian gunsmith Onisim Mikhailov. Between 1607 and 1621, Mikhailov compiled the "Code of Military, Artillery, and Other Matters Pertaining to the Science of Warfare," at present the oldest preserved written document in existence in the Soviet Union. This document contains a detailed description of rockets, or, as the author calls them, "Cannon balls which run and burn."

V. N. Sokolsky, in his book *Russian Solid-Fuel Rockets,* however, disputes Russian rocket historians who based their information on Mikhailov's manuscript. These authors relied on the dates of the manuscript compiled by Mikhailov, between 1607–1621, but it was not printed until 1777–1781. Thus they regard its information on rockets as proof of their use before the beginning of the seventeenth century. One must remember that Mikhailov's manuscript is not an original work, but a collection

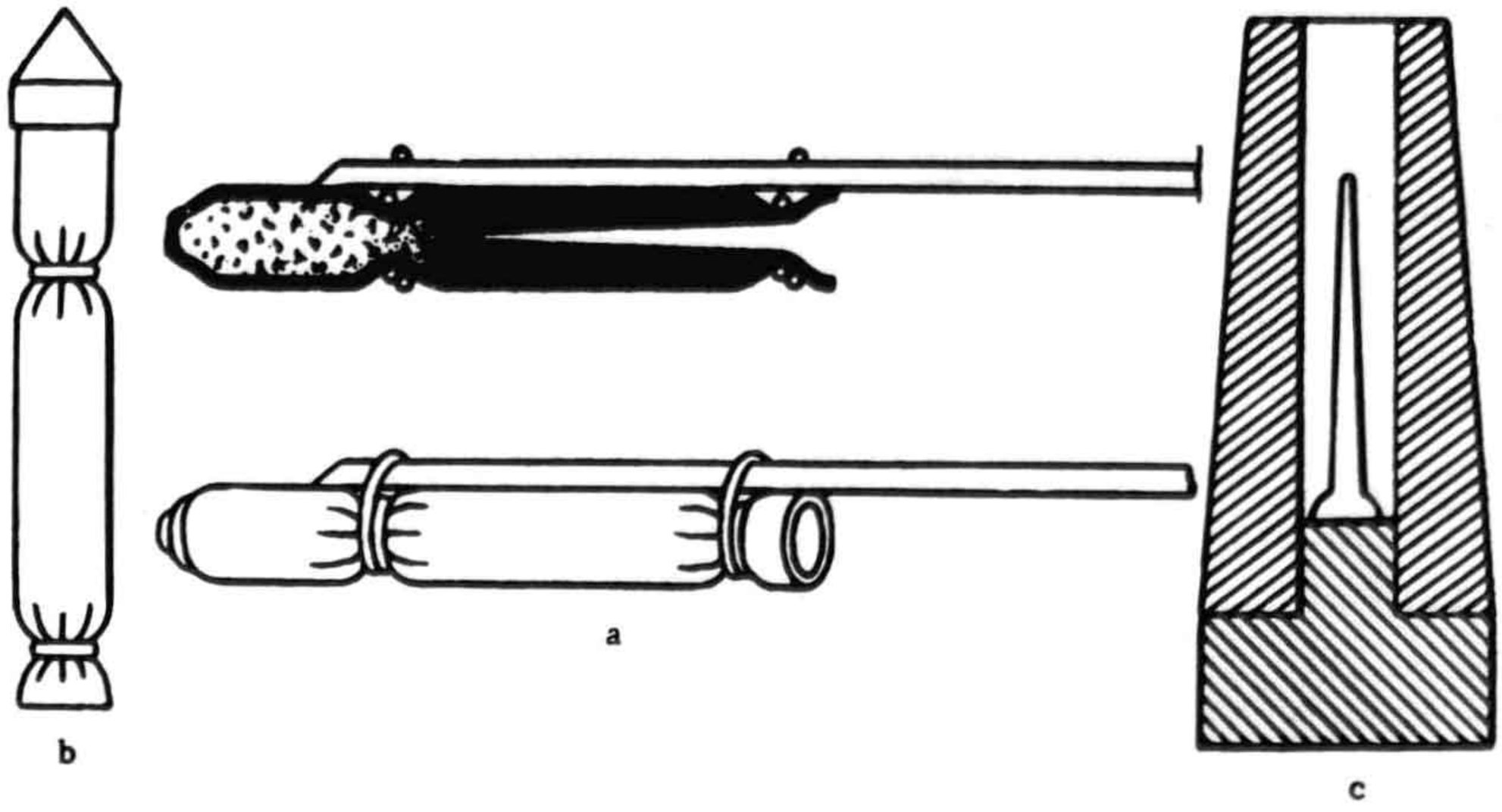

FIG. 1 Eighteenth-century pyrotechnic rockets: a) general view and cross section of rocket; b) rocket casing with cap; c) mold for packing rocket casings (hollow molding).

of 663 decrees or articles selected from foreign military books, therefore it cannot serve to confirm the use of rockets in Russia before the seventeenth century.

Sokolsky claims that the first reliable information on the use of rockets in Russia dates only from the second half of the seventeenth century. Specifically, he refers to a fireworks display that was held in the town of Ustyuga in 1675. He also provides additional proof to his claim by referring to a book by Balthasar Koiet that describes a birthday celebration for a member of the Tsar's family in 1675 which was marred by the accidental explosion of fireworks and rockets.

Peter the Great Unlike Sokolsky, who went to great pains to substantiate dates about Russian rocketry, other Russian historians were content to state that rockets were not used at all in Russia until the time of Peter the Great. Tsar Peter I devoted his life to the building of Russia's military might. One of the many things that he accomplished was, according to I. A. Slukhai, the founding in 1680 of the first Rocket Works in Moscow, where standard signal and illuminating rockets were made for the Russian army. Later in the 1700s, Peter moved the Rocket Works to his new capital in St. Petersburg and vastly

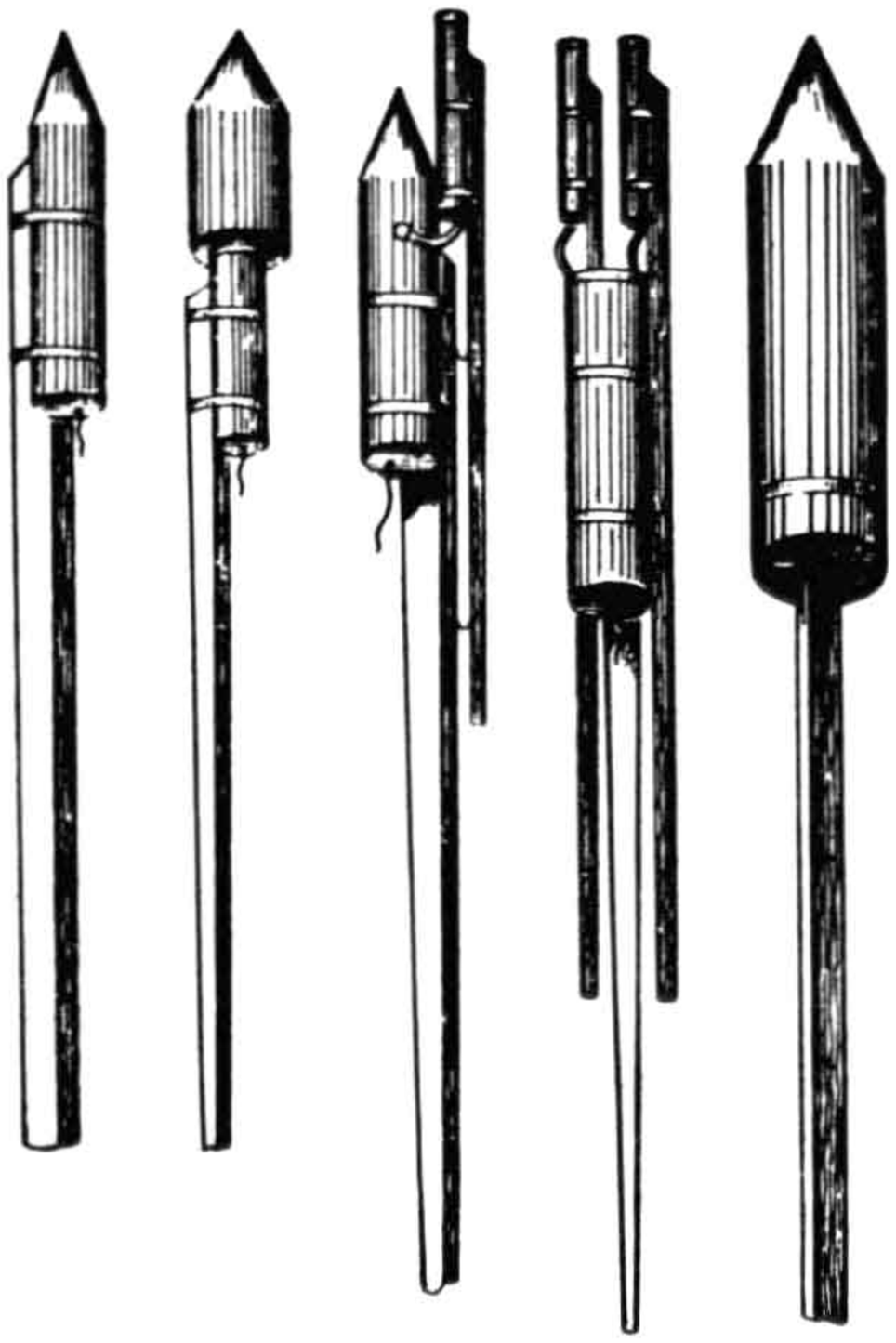

FIG. 2 Pyrotechnic rockets at the beginning of the nineteenth century.

expanded its operation. Peter hired English, Scottish, Dutch, German, and French officers to modernize his armed forces. His Russian soldiers fired rockets under the guidance of this Western command. The Scotsman, Patrick Gordon, who was both a general and an admiral in Peter's service, mentions in his diary Peter's personal supervision of the production of rockets for his entertainment. The primary use of rockets in Russia was still, at this time, limited to celebrations and signaling.

Alexander Zasyadko Alexander D. Zasyadko (1779–1837), an officer of the Tsar's artillery, after noting Congreve's inventions and studying the Rocket Works' files accumulated in the 135 years of the factory's existence, came up with rocket designs of his own. Some of these rockets were tested in 1817 in St. Petersburg and were successful. As a direct result of these successes, Zasyadko was assigned to western Russia to train the Tsar's first soldiers to use military warhead rockets. In the following year, Zasyadko was promoted to major general and made head of Russia's first artillery school. Beginning in the

1820s, the production of rockets in Russia was concentrated first at the St. Petersburg Pyrotechnic Laboratory and subsequently at the St. Petersburg Rocket Institute (P.R.Z.) established expressly for that purpose.

Zasyadko's solid fuel rockets were first used in the Russo–Turkish war of 1828–1829, during the sieges of Varna, Schumla, Silistra, and Braila. Also, Russian ships armed with the rockets operated successfully in the Black Sea and on the Danube. Zasyadko emerged from the war as a national hero. Later after his death, his rockets, by the thousands, were deployed in the conquest of the Caucasus and more widely in the Crimean War of 1853–1856. In 1959, at the Exhibition of Achievements, Nikita Khrushchev added the portrait of General Zasyadko to the collection of the Moscow Space Museum.

Konstantin Konstantinov Zasyadko was followed by Konstantin I. Konstantinov (1817–1871), also an artillery officer with still a greater mathematical capability than his predeces-

FIG. 3 *Left:* High-flying incendiary rocket.
Right: Rebounding rocket with explosives, designed by Zasyadko.