THE HISTORICAL-TECHNOLOGICAL EVOLUTION AND LEGAL REGULATION OF PYROTECHNIC DEVICES

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Abstract

This article explores the emergence, development, and modern approaches to pyrotechnic devices from a historical, scientific, and technological perspective. Pyrotechnics first appeared in the 9th–12th centuries in China with the accidental discovery of gunpowder, initially used for religious and ceremonial purposes. The technology later spread across Eurasia through trade, military campaigns, and scientific exchanges, with significant contributions from Arab-Islamic scholars. From the 14th to 18th centuries, pyrotechnics evolved into an art form in European countries such as Italy, Germany, and France. The industrial era brought about mass production and militarization, especially during the 19th and 20th centuries. In the 21st century, the field has seen further development through automation, environmental safety, and artificial intelligence. Given their inherent risks, pyrotechnic products require strict legal regulation, including certification, licensing, and international standards. The article argues for the integration of historical experience, scientific innovation, and legal mechanisms to ensure the safe and lawful use of pyrotechnics.

Keywords: pyrotechnics, history of gunpowder, scientific-technological development, militarization, legal regulation, international standards, environmental safety

The history and development of pyrotechnic devices are closely linked with the scientific, military, cultural, economic, and religious progress of human civilization. Their evolution has been gradual and systematic, reflecting broader socio-technological changes. Based on historical sources, scientific works, and technical approaches, the field of pyrotechnics can be examined through several key phases.

The origins of pyrotechnic devices trace back to the 9th–12th centuries in China, where gunpowder was discovered, often described as an "accidental alchemical invention." During the Tang Dynasty, simple fireworks were used in religious ceremonies and to ward off evil spirits. These early devices, implemented using bamboo tubes, integrated elements of chemistry, mysticism, and spiritual tradition.

Between the 12th and 14th centuries, pyrotechnic technologies spread throughout Eurasia via trade routes, military expeditions, and intercultural exchanges. Empires such as the Mongols, Seljuks, Timurids, and Ottomans played key roles in disseminating these techniques. Prominent Arab and Islamic scholars like Jabir ibn Hayyan, Al-Biruni, and Al-Razi contributed scientific explanations on gunpowder composition, proportions, chemical reactions, and safety measures.

From the 14th to 18th centuries, pyrotechnics rose to an artistic level in Europe, especially in Italy, Germany, and France. They were used in royal courts, theatrical performances, and public festivals. Works by scholars such as Giovanni Fontana and Vannoccio Biringuccio are recognized as some of the earliest scientific treatises on pyrotechnics. During this period, the discipline became a complex system combining mechanics, chemistry, design, and art.

The 19th–20th centuries marked the industrial and military applications of pyrotechnics. Advancements in chemistry led to mass production in countries like the USA, Germany, France, Russia, and the Soviet Union. Explosive factories were established, and pyrotechnic products were widely used in military operations, including ammunition, shells, grenades, and signaling devices. During World War I and II, hundreds of millions of explosive units were manufactured, highlighting the strategic and destructive potential of pyrotechnics.

In the 21st century, pyrotechnic technologies are evolving with a focus on safety, environmental balance, automation, and artificial intelligence. Innovations include computer-controlled fireworks, drone displays, low-smoke mixtures, biodegradable components, and advanced signal systems. Pyrotechnics are now considered not only tools for entertainment or warfare but also objects of scientific, technical, ecological, and legal governance.

Despite their benefits, pyrotechnic products pose risks across all historical periods. Thus, comprehensive regulation is essential. To reduce social harm, strict control, certification, safe production, and responsible usage must be enforced. The European Union's EN 15947 and the ISO 25947 international standards set norms for classification, testing, labeling, and safety warnings. National authorities must implement licensing, monitoring, and certification mechanisms to ensure lawful circulation.

Conclusion

Pyrotechnic devices represent a dual nature of technological achievement and potential hazard. To ensure their safe and legal use, an integrated approach

involving historical knowledge, scientific expertise, legal frameworks, and international standards is required. This holistic view will help minimize risks and enhance the responsible development of pyrotechnic technologies in the modern world.

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