

The Gunpowder Thermometer

Temperature Control in Powder Magazines, Arsenals, Ammunition Depots, and Artillery Production

Leo Shirokov · barometers.info · 17 June 2026

The largest instrument in my collection is also the one that visitors most often take for a joke. It is a thermometer of such a size that it has to be photographed beside a person to be believed: a glass tube on a massive board nearly a metre and a half long, with figures legible across an entire room (Fig. 1). Everyone assumes it is some Victorian whimsy, an antique shop's idea of a conversation piece. Yet it is a working instrument, and everything odd about it — the length, the wooden case, the exaggeratedly large scale — is an answer to one entirely serious question: how do you keep watch on the temperature of a room packed with explosives while spending as little time as possible inside that room?

To understand this instrument, one has to give up two comfortable misconceptions: that gunpowder is merely a charge — something inert that waits quietly to be set alight — and that a mercury thermometer exists only to take the temperature under one's arm.

The temperature control of gunpowder belongs to those technically "humble" practices without which the history of industrial warfare is unthinkable. Already in the 18th century the commands of armies and navies understood that gunpowder is not an abstract "charge" but a sensitive chemical-technical material whose properties change under the influence of heat, cold, damp, condensation, and time. For the age of sail and early industrial artillery the question had above all two dimensions: the preservation of the stock in the powder magazine and the predictability of fire. With the transition to large-calibre naval artillery and to smokeless nitrocellulose and cordite powders in the late 19th and early 20th centuries, the importance of temperature control grew further still, since the matter now concerned not only damp and misfires but the chemical stability of propellant charges, their slow decomposition, and the risk of catastrophic accidents. It is in this context that one should understand the appearance and wide diffusion of special "gunpowder thermometers" — long, easily read, and often self-registering thermometers designed for installation in magazines, stores, arsenals, and production facilities. In English-language literature and museum practice such instruments were variously called *gunpowder thermometer*, *powder magazine thermometer*, or *magazine thermometer*. They formed part of a broader infrastructure of explosives safety: ventilation, thermal insulation, dry storage, regular inspections, temperature logs, and chemical stability testing of powders.¹



Fig. 1. The Pieterman–Van Baaren gunpowder thermometer, c. 1955; solid-oak frame, 1.35 m high. Author's collection.

1. A Brief Introduction to the Subject

Historically, the need to control temperature in places where gunpowder was stored arose from a combination of three factors. First, gunpowder and the later propellants changed their ballistic properties with temperature: the warmer the charge, the higher, as a rule, the burning rate and the muzzle velocity; the colder it was, the greater the risk of uneven performance. Second, in enclosed magazines and stores the decisive issue was moisture: sharp temperature swings led to condensation on barrels, cartridge bags, cases, and wooden packing. Third, from the introduction of smokeless powders onward, there arose the problem not only of ignition from an external source but of the chemical degradation of the material itself during prolonged storage under an unfavourable thermal regime.²

The gunpowder thermometer was therefore not a minor piece of household equipment but part of the discipline of military administration. Its readings tied together the chemistry of explosives, the architecture of stores, ventilation regimes, the organisation of shipboard service, and artillery practice. Whereas in the 18th century such control was more often limited to watching for damp and the general state of the magazine, by the turn of the 19th–20th centuries it had become a regulated procedure, with daily maximum and minimum readings, the keeping of temperature cards, prescribed limit values, and periodic chemical stability tests of powder batches.³

2. What Gunpowder Is: Its Types and Dangers

In the historical-technical sense, under "gunpowder" one should distinguish at least two large groups of propellants. The first is smoky, or black, powder — a mechanical mixture of saltpetre, charcoal, and sulphur. The classic military formula of the 19th century hovered around 75% saltpetre, 10–15% charcoal, and 10–12% sulphur.⁴ Its advantages were relative technological simplicity and predictable burning; its drawbacks were heavy smoke, a large quantity of solid residue, hygroscopicity, and a marked dependence on storage conditions. In the technical literature the ignition temperature of black powder is usually given as something on the order of 280–320 °C, although actual ignition depends on grain size, moisture, degree of compaction, and the source of heat. For the manufacture of prismatic artillery powder, as early as the 1860s it was considered safe to dry it in warm air only at temperatures around 100 °F (about 37.8 °C) — that is, many times below the ignition threshold.⁵

The second group comprises the smokeless powders based on nitrocellulose, and then the nitroglycerine–nitrocellulose compositions (cordite, ballistite, various colloidal powders). Their wide adoption began in France after P. Vieille's work on *poudre B* (1884), in Britain with cordite, in the United States with pyrocollodion and other nitrocellulose compositions, and in Russia in the 1890s, when smokeless powder was introduced for small arms and artillery.⁶ Their ballistic advantages were obvious, but they made far stricter demands on supervision: nitric-ester materials are subject to slow autocatalytic decomposition, releasing nitrogen oxides and acidic products. It is precisely for this reason that, at the end of the 19th century, "heat tests" (the Abel test and its modifications) and constant monitoring of storage temperature became so important.⁷

The dangers of the powders were not uniform. For black powder the chief threats remained open flame, spark, impact, the accidental ignition of packing, and spoilage from damp. Moisture did not always lead to an explosion, but it lowered combat quality, caused caking, and resulted in incomplete combustion. For smokeless powders these dangers were joined by hidden processes of decomposition. British material of the late 19th century stressed that cordite should not be continuously subjected to temperatures above 100 °F (37.8 °C), although brief heating to 130 °F (54.4 °C) was not regarded as critical; prolonged storage above 100 °F allowed slow degradation, manifested above all in ballistics.⁸ Conversely, temperatures that were too low were also undesirable: the report of the joint U.S. Army and Navy powder board in 1911 noted that at temperatures below 45 °F (7.2 °C) cordite could "sweat," through the exudation and subsequent melting, on warming, of crystallised nitroglycerine.⁹

History abounds in catastrophes that made the control of temperature and of the general state of charges a matter of daily concern. As industrial examples it is enough to recall the explosion at the powder works at Grenelle near Paris in 1794 and the numerous accidents at European and American powder mills throughout the 19th century; in Russia, the death of Captain S. V. Panpushko during trials of pyroxylin shells in 1891. For navies and coastal fortresses the terrifying background was provided by explosions of ships' magazines and artillery stores: the causes did not always come down to overheating, but it was these very disasters that convinced military administrators that temperature, ventilation, and the chemical stability of charges had to be considered together.¹⁰

3. Why and How the Temperature of Gunpowder Was Monitored

Temperature control served several aims. The first was to ensure consistency of fire. Even in the era of black powder, gunners knew that damp or overheated powder gave a different burning rate and therefore a different trajectory. For 20th-century coastal and field artillery the temperature of the propellant charge was taken directly into account in firing; in American artillery manuals the gunpowder thermometer was by then inserted directly into the charge to determine the powder temperature before firing.¹¹

The second aim was to prevent condensation and damp. In magazines — especially underground or shipboard ones — the danger lay not only in absolute temperature values but in their daily fluctuations. If cold walls or metal elements fell below the dew point, moisture settled on packing and ammunition. For black powder this meant a loss of serviceable qualities; for smokeless charges, the risk of corrosion of metal parts, deterioration of packing, and complication of chemical supervision. Hence the requirements to arrange charges so that air could circulate freely between the stacks, and to ventilate the spaces well.¹²

The third aim was the early detection of degradation in smokeless powders. Here temperature control worked in tandem with laboratory testing. American and British instructions of the early 20th century provided for retaining samples of every batch and testing them periodically for chemical stability; if samples showed signs of decomposition, the entire batch held in forts, arsenals, or ships' magazines was withdrawn from service.¹³ In American naval practice, powder samples in bottles with indicator paper served as a preliminary sign of incipient decomposition; this was followed by a regular heat test, by a method akin to the Abel test.¹⁴

Finally, temperature supervision was administrative and regulatory in character. The thermometer's readings were entered in logs and cards, compared against limit values, and any exceedance called for action: increased ventilation, the switching on of cooling, the restacking of stores, and sometimes the relocation of ammunition. In later American shipboard practice the daily minimum and maximum were recorded every day, and any temperature above 100 °F was specially noted and required hourly observation.¹⁵ Although these instructions belong to a later period, in essence they develop principles already formed at the end of the 19th century: to measure not "warmth in general" but the regime of a given space as a parameter of combat and chemical safety.

4. What a Gunpowder Thermometer Is

By a gunpowder thermometer one should understand a specialised thermometer intended for monitoring the temperature in powder magazines, arsenals, and other spaces connected with the storage or handling of propellant charges. In its simplest form it was a long, straight mercury thermometer in a wooden frame or on a board, with a Fahrenheit scale, sometimes supplemented by a Celsius one. From the late 18th century, however, self-registering maximum–minimum instruments of the Six's type (Fig. 2) spread in adjacent fields; in military applications these were especially convenient, since they recorded not only the "current" temperature but the daily extremes, without requiring a permanent observer.¹⁶

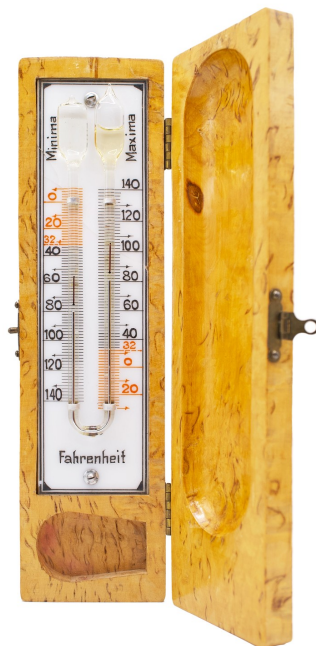


Fig. 2. A Six's-pattern maximum–minimum thermometer (Fahrenheit), with separate Minima and Maxima columns — the self-registering type referred to here.

Surviving museum pieces and catalogue descriptions show a wide range of sizes for such instruments — from comparatively small wall-mounted examples about 10–20 cm long to very long thermometers of 1–1.5 m and more. This is explained not by exoticism but by the conditions of service. In dark, poorly lit magazines a large scale, legible from a distance, was needed; in deep shipboard compartments the instrument was often hung high or in narrow passages; at factories and drying houses, remote or elongated versions were required so that readings could be seen from a safe distance. A frame of hardwood was cheap, sparked poorly on accidental impact, and was convenient for wall mounting; brass or bronze elements were used where strength and resistance to sea air were required.¹⁷

The gunpowder thermometer of the Dutch firm Pieterman–Van Baaren [in my collection](#) was made around 1955. It is a long wall-mounted instrument in a massive oak frame, 1.35 m high; the thermometer proper is liquid-in-glass, mercury-filled, with an opal-glass scale graduated in Celsius from -2 to +55 °C. The range covers exactly the corridor of temperatures within which stored powder begins to give trouble — from the cold at which nitroglycerine compositions can exude nitroglycerine, to the warmth that accelerates decomposition. The narrow band between 25 and 30 °C is printed in red: a threshold of alarm stamped directly onto the scale (Fig. 3).

5. The Particulars of Powder Storage and Thermometry in Different Facilities

A powder magazine is a specialised, usually isolated and maximally protected space for storing powder proper or finished propellant charges. Its architecture was subordinated to the requirements of dryness, coolness, the minimising of spark formation, and the limiting of the consequences of a possible explosion. Here the typical instrument was a wall-mounted "magazine" thermometer or a maximum–minimum device, fixed where one could judge the general thermal regime of the space but away from the direct influence of doors, hatches, and sunlight. For coastal fortresses and stationary stores, large mercury thermometers in wooden frames were more usual; in a later period, self-registering or bimetallic instruments. An arsenal differed from a powder magazine in that it was not only a store of explosives but a complex for storage, repair, assembly, and the administrative accounting of weapons and ammunition. In an arsenal, temperature was controlled across several zones: in the powder rooms proper, in the workshops, in the assembly areas, and in the general stores. Here the thermometer was part of a system of supervision over materials, especially after the spread of smokeless powders and loaded rounds. More important became inspection logs, the comparison of temperature data with chemical tests, and the withdrawal of batches on the results of laboratory checks.¹⁹

An ammunition depot, as a broader category, included not only powder but shells, cartridges, fuzes, and pyrotechnics. In such spaces the thermometry regime depended on the range of stored matériel. For black powder and bagged charges, dryness and the absence of sharp fluctuations were important; for fixed rounds and smokeless charges, also the prevention of overheating of stacks and the control of stability by batch. Here several thermometers were more often used across different sections, since the temperature inside large stores could differ markedly. Artillery production made particular demands. At powder and shell-filling factories, not only the storage temperature was measured but also the temperature of technological operations: washing, gelatinisation, pressing, drying, the filling of cartridge bags, and the curing of finished charges. It was here that gunpowder thermometers could be especially large or of a remote design, so that the operator could see the readings from a safe zone. As early as the 19th century, the technical literature stressed the importance of moderate and controlled heating in the drying of powder; too low a temperature lengthened the process, while too high a one brought the material closer to the danger zone.²⁰

Shipboard powder magazines. On ships the problem was especially complex. In the 18th century powder was stored as low as possible, below the waterline, far from galleys and engine sources of heat; the spaces were insulated, lined with wood, ventilated, and kept dry. In the 19th century, with rising rates of fire and the shift to smokeless charges, ships' magazines became a carefully regulated system with special hatches, supply hoists, sprinkler devices, and constant temperature supervision. British material on cordite stressed that magazines could be arranged so that the temperature did not exceed 100 °F even in the tropics; 20th-century American practice required at least one direct-reading maximum–minimum thermometer in every ship's magazine, with the data transferred daily into a log.²¹ On board, the thermometer was placed where the greatest temperature changes were expected, but so that it did not interfere with the handling of ammunition. The sailing fleet and the early steam period were characterised by long mercury wall thermometers; in the 20th century, because of vibration, rolling, and safety requirements, bimetallic high-low models spread. In the Russian Imperial Navy, as in other fleets, the shift to smokeless powders in the 1890s heightened attention to ventilation, the insulation of magazines, and the general regime of storing charges; although the specific types of instrument are described less well in published Russian sources, the logic of service was pan-European and was determined by the same chemical properties of nitrocellulose charges.

6. Specific Historical Examples

For the powder magazines of coastal fortresses, the American *Coast Artillery Drill Regulations* of 1909 are telling: they prescribed retaining samples of every batch of smokeless powder in the laboratory of the Ordnance Department and subjecting them regularly to stability testing; at signs of deterioration, the whole batch held in the forts was recalled. This is already a thoroughly bureaucratized system, in which the magazine temperature, the inspection log, and the laboratory test worked as a single whole.²²

For arsenals and central depots, a good example is the American *Ordnance Safety Manual* of 1931. It systematized the requirements for magazines, storage areas, observation, and stability tests of smokeless powder. Although the document belongs to the interwar period, it sums up a practice already formed at the end of the 19th century: the separation of spaces by hazard, the control of microclimate, the periodic inspection of batches, and the recording of data in regulated form.²³

For artillery production, one may point to the English practice of manufacturing prismatic artillery powder described in *Scientific American* in 1869: after pressing, the powder was dried in hot air at a temperature of about 100 °F for roughly two weeks, reducing its moisture from 7% to less than 1%. Here the thermometer was not a "passive" storage instrument but a tool of technological discipline, without which safe drying could not be carried out.²⁴

For the navy, the British and American examples connected with smokeless powders are especially telling. British notes of 1896 stressed that cordite should not be kept continuously above 100 °F, though in a tropical climate, with magazines properly arranged, this limit could be maintained. In 1911–1912 the Joint Army and Navy Powder Board also discussed lower limits, pointing to the undesirability of cooling cordite below 45 °F followed by rapid warming. These data show clearly that for a ship's magazine it was not only "heat" that mattered but the very range of fluctuation.²⁵

Finally, for Russia an important milestone was 1895, when smokeless powder was introduced for small arms and artillery. From that moment Russian arsenals, factories, and ships' magazines inevitably met the same problems as their French, British, and American counterparts: the storage of pyroxylin and other nitrocellulose charges required not only dryness but systematic thermal and chemical supervision. The death of S. V. Panpushko in 1891, during trials of new explosives, shows clearly how closely, in this period, scientific experiment, industrial risk, and the need for standardised control were intertwined.²⁶

Conclusion

The gunpowder thermometer holds a particular place in the history of military technology: it made it possible to translate the abstract danger of "powder heat" into a numerical regime of observation — what is happening in the magazine, how the store behaves over the course of a day, when to switch on ventilation, when to suspect chemical spoilage of a batch, when to change the method of storage. It is for this reason that the gunpowder thermometer mattered both in the classical era of black powder and in the transitional time of smokeless propellants.

The Pieterman–Van Baaren thermometer was made around 1955 — that is, at the close of the very era it represents. By the middle of the 20th century the mercury liquid-in-glass thermometer was no longer a novelty but a mature, fully refined form, and its displacement by electrical sensors was a matter of two or three decades away. Yet for a powder magazine it remained not a relic but a sober choice: a passive instrument, without power, without a spark, without drift in its readings, requiring neither maintenance nor a trained observer. Where any electrical circuit was a superfluous source of risk, plain glass and mercury proved to be exactly what was needed. For strip away the drama, and the gunpowder thermometer really is a modest article of glass and mercury.

In the end it is for just this reason that so unusual an object hangs on my wall. It is not a weapon and not a great machine. It is an instrument of everyday discipline, and to stand beside it is to stand at the point where the chemistry of explosives, the architecture of the powder magazine, and the plain seamanship of keeping a dangerous ship afloat all converge. Grand instruments announce themselves. This one merely asked a quiet question, every day, of a room that could not be allowed to answer wrongly.

Herein lies the value of this example as an illustration. The safety of munitions is determined not only by their composition but by the constant, everyday supervision of the environment in which they are stored — and an object like this is neither a curiosity nor an ornament but an instrument of precisely that supervision, one that has come down to us in working order.

Notes

1. *Ordnance Instructions for the United States Navy*. New York, 1866; Walke W. *Lectures on Explosives*. New York, 1897; *Treatise on Ammunition*. London: HMSO, 1897; Henderson R. W. "The Evolution of Smokeless Powder," *Proceedings of the U.S. Naval Institute*, 1904, vol. 30, no. 2.
2. Bernadou J. B. *Smokeless Powder, Nitro-cellulose: And Theory of the Cellulose Molecule*. New York, 1901; Blaine M. N. *A Discussion of the Stability of Nitrocellulose Base Smokeless Powder*. Ithaca, 1945.
3. *Coast Artillery Drill Regulations, United States Army*. Washington, 1909; *Ordnance Safety Manual*. Washington, 1931.
4. Henderson R. W. "The Evolution of Smokeless Powder"; Walke W. *Lectures on Explosives*.
5. "Manufacture of Artillery Powder in England," *Scientific American*, 1869.
6. Bernadou J. B. *Smokeless Powder, Nitro-cellulose*; Henderson R. W. "The Evolution of Smokeless Powder"; *Mémorial des poudres*. Paris, 1901–1907; materials of the Military Historical Museum of Artillery on the introduction of smokeless powder in Russia, 1895.
7. Abel F. A., works on the testing of nitrocellulose; see also Urbański T. *Chemistry and Technology of Explosives*. Vols. 2–3. Oxford, 1964–1965; "Professional Notes," *Proceedings of the U.S. Naval Institute*, 1907.
8. "Professional Notes," *Proceedings of the U.S. Naval Institute*, 1896, vol. 22, no. 1.
9. *Report of the United States Joint Army and Navy Powder Board in Connection with an Editorial in London Engineering of October 6, 1911, Proceedings of the U.S. Naval Institute*, 1912.
10. On S. V. Panpushko and the introduction of smokeless charges in Russia, see materials of the Military Historical Museum of Artillery; on the chemical instability and surveillance of smokeless powders, see Bernadou J. B.; Blaine M. N.; *Ordnance Safety Manual*.
11. FM 6-40; FM 6-50 / MCWP 3-16.3.
12. *Ordnance Safety Manual*. Washington, 1931; NAVSEA / modern naval ammunition instructions, as a later continuation of the same practice.
13. *Coast Artillery Drill Regulations*, 1909, p. 198; Henderson R. W. "The Evolution of Smokeless Powder."
14. Henderson R. W. "The Evolution of Smokeless Powder"; "Professional Notes," *Proceedings*, 1907.
15. NAVEDTRA *Gunner's Mate*; NAVSEA OP-4, later edition.
16. On the Six's thermometer, see Austin C., McConnell A. "Two Hundred Years of the Six's Self-Registering Thermometer," *Notes and Records of the Royal Society of London*, 1980; also NAVEDTRA *Gunner's Mate*.
17. Hagley Museum, "Mystery Object — Gunpowder Thermometers," 2016; cf. typical descriptions of marine and magazine thermometers in instrument catalogues of the late 19th – early 20th centuries.
18. NAVEDTRA *Gunner's Mate Training Manual*; NAVSEA OP-4.
19. *Ordnance Safety Manual*, 1931; *Coast Artillery Drill Regulations*, 1909.
20. "Manufacture of Artillery Powder in England," *Scientific American*, 1869; Guttman O. *The Manufacture of Explosives*. London, 1895–1900.
21. "Professional Notes," *Proceedings*, 1896; NAVEDTRA *Gunner's Mate*; NAVSEA OP-4.
22. *Coast Artillery Drill Regulations*, 1909, p. 198.
23. *Ordnance Safety Manual*. Washington, 1931.
24. "Manufacture of Artillery Powder in England," *Scientific American*, 1869.
25. "Professional Notes," *Proceedings*, 1896; *Report of the United States Joint Army and Navy Powder Board*, 1912.
26. Materials of the Military Historical Museum of Artillery; for the general history of the introduction of smokeless powders, see Henderson R. W.; Bernadou J. B.

Bibliography

- Abel, Frederick A. *Researches on Gun-Cotton and Explosive Substances*. London: Longmans, Green, 1875.
- Austin, Christopher, and Anita McConnell. "Two Hundred Years of the Six's Self-Registering Thermometer." *Notes and Records of the Royal Society of London* 35, no. 1 (1980): 49–65.
- Bernadou, John B. *Smokeless Powder, Nitro-cellulose: And Theory of the Cellulose Molecule*. New York: John Wiley & Sons, 1901.
- Blaine, Morris N. *A Discussion of the Stability of Nitrocellulose Base Smokeless Powder*. Ithaca, NY: Cornell University, 1945.
- Coast Artillery Drill Regulations, United States Army*. Washington, DC: Government Printing Office, 1909.
- Guttman, Oscar. *The Manufacture of Explosives*. 2 vols. London: Whittaker & Co., 1895–1900.
- Henderson, R. W. "The Evolution of Smokeless Powder." *Proceedings of the U.S. Naval Institute* 30, no. 2 (1904).

Mémorial des poudres. Paris: Imprimerie Nationale / Service des poudres, 1901–1912, esp. vols. 11–16.

Naval Ordnance: A Text-book Prepared for the Use of the Midshipmen of the United States Naval Academy. Annapolis, MD: United States Naval Institute, 1915.

Ordnance Instructions for the United States Navy. New York: D. Van Nostrand, 1866.

Ordnance Safety Manual: Regulations Governing the Manufacture, Storage, Loading, and Handling of Military Explosives and Ammunition at Establishments of the Ordnance Department, U.S. Army. Washington, DC: Office of the Chief of Ordnance, 1931.

"Professional Notes." *Proceedings of the U.S. Naval Institute* 22, no. 1 (1896); 33, no. 3 (1907).

Report of the United States Joint Army and Navy Powder Board in Connection with an Editorial in London Engineering of October 6, 1911. Proceedings of the U.S. Naval Institute (1912).

Treatise on Ammunition. 6th ed. London: Her Majesty's Stationery Office, 1897.

Urbański, Tadeusz. *Chemistry and Technology of Explosives*. Vols. 2–3. Oxford: Pergamon Press, 1964–1965.

Walke, Willoughby. *Lectures on Explosives: A Course of Lectures Prepared Especially as a Manual and Guide in the Laboratory of the U.S. Artillery School*. New York: John Wiley & Sons, 1897.