A Brief History of Explosives and Blasting Caps

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INTRODUCTION

I am not an expert on explosives. Far from it. But my interest in collecting blasting cap tins has led me to seek more information about the history of explosives and the use of blasting caps as a means of detonating high explosives.

The history of the blasting cap is closely related to the history of explosives and the transition from black powder to nitroglycerine to dynamite. Although that history is lengthy and complex, I hope to give you a "Readers Digest" version here. In doing that, I will make liberal use of quotations from others who know more about this subject than I do.

A BRIEF HISTORY OF EXPLOSIVES

In his excellent book, *Blown to Bits in the Mine*, Eric Twitty (2009) writes,[1]

> "The introduction of blasting technology to North American mines and stone quarries set in motion a chain of events which propelled the Industrial Revolution. The art of blasting made possible mining, quarrying, and the development of a transportation system on the immense scale capable of meeting the demands of the Industrial Revolution in North America. Blasting permitted mining companies to tap into North America's vast pool of precious industrial metals, giving the United States the economic and material resources that transformed the nation into an industrial juggernaut."[2]

Black Powder

Twitty writes:

> "Among all of the contraptions, inventions, and machines used in mines throughout North America, explosives had perhaps the greatest impact on the lives of hardrock and coal miners. … At first the only explosive for blasting available to American miners was blasting powder, also known as black powder."[3]

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[1] Eric Twitty, *Blown to Bits in the Mine: A History of Mining & Explosives in the United States* (Lake City, CO: Western Reflections Pub. Co., 2009).
[2] Twitty, vii.
[3] Twitty, 1.

Tenney L. Davis (1943), in his book, *The Chemistry of Powder and Explosives*,[4] writes:

> "The discovery that a mixture of potassium nitrate, charcoal, and sulfur is capable of doing useful mechanical work is one of the most important chemical discoveries or inventions of all times … by reason of which the ecology of the human race will be different in the future from what it has been [in the] past."[5]

Gunpowder, a combination of saltpeter (potassium nitrate), sulfur and charcoal in specific ratios, is popularly considered to be "one of the four great inventions of China." It was invented during the Tang Dynasty (9th century), while the earliest recorded formula dates to the Song Dynasty (11th century). Roger Bacon (1267), in his *Opus Majus*, introduced it to Europe, where it was employed in warfare for centuries before someone thought to use it in mining in the early 1600s.[6] Twitty writes:,

> "The history of blasting began in 1627 at a mine in Hungary, where Kaspar Weindl documented the first use of gunpowder to fracture rock. … Excited at the prospects of using something other than brutal labor to break rock, mining engineers conducted further experiments and spread the concept of blasting through Northern Europe."[7]

Cornish miners probably introduced black powder into the United States in the early to mid-1800s.

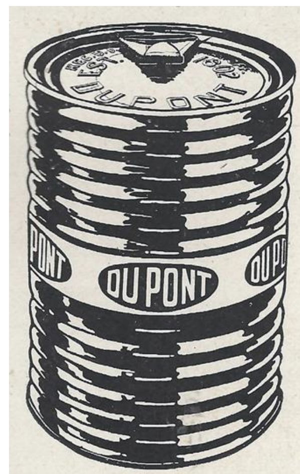


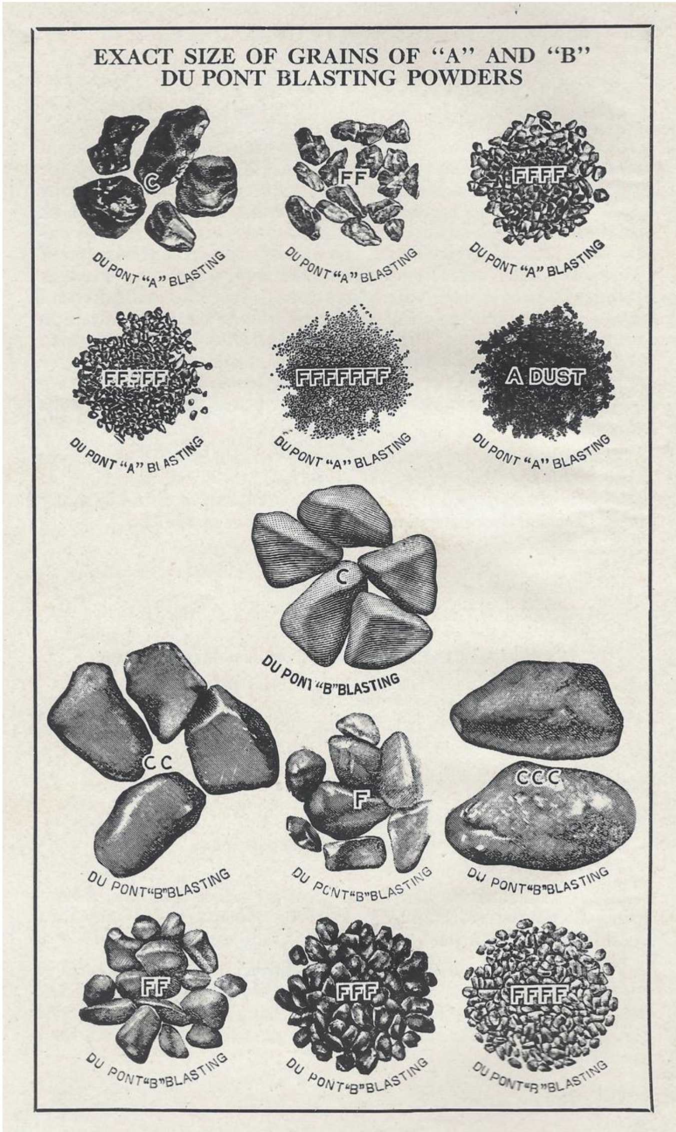
Fig. 1.– 25-pound keg of du Pont Blasting Powder.

> "German engineers brought blasting to Cornwall in 1670 … Over the course of several generations the Cornish miners significantly improved the then-primitive blasting methods, and they brought their practices to North American mines between the 1820s and 1850s."[8]

Black powder was classified as a *low explosive*, "a substance that exploded only when sufficiently confined; when unconfined the powder merely burned."

> "An explosion occurred only when gases created during combustion were blocked, which for blasting in mines, was achieved by placing the powder in drill-holes. Because many different rock conditions were encountered in mines, adapting explosions to the different rock types was important for the most efficient use of blasting powder. A quick, shattering explosion was not good in soft and crumbly rock such as coal and shale because energy was wasted pulverizing the material into undesirable, small fragments without moving the mass much. However, a quick, shattering explosion was very effective in hard rock because that kind of energy was most effective for fracturing it. To control the speed of explosion, miners and quarrymen used powder that manufacturers had sorted into uniform grain sizes. Fine grains presented greater surface area, allowing for rapid

[4] Tenney L. Davis, *The Chemistry of Powder and Explosives: Complete in One Volume* (Hollywood, Calif: Angriff Pr, 1943).
[5] Davis, 28.
[6] "Explosives manufacturers made blasting powder by combining finely powdered sulfur, charcoal, and saltpeter in a specific ratio. The ingredients of the quickest-burning blasting powders, used in hard rock and in stone quarries, were mixed in ratios 1:1:6 and 1.2: 0.8: 6. Manufacturers used variants as a means of adjusting for impurities and maintaining performance while reducing expensive saltpeter." Twitty, *Blown to Bits in the Mine*, 3.
[7] Twitty, 4.
[8] Twitty, 5.



combustion and, most importantly, for rapid escape of gases. When confined, this resulted in a quicker and more shattering explosion. Large grains produced a slower explosion because they offered less overall surface area. To denote grain sizes, powder manufacturers used a scale with FFFFFF as the finest, F as medium-small, C as medium-large, and CCC as the most coarse."[9]

Black powder in larger grains produced a heaving effect that fractured coal and other softer materials without shattering or pulverizing them.

At left is an illustration of the types ("A" and "B", explained below) and grain sizes of blasting powder offered by Du Pont in 1922.[10]

"By the 1840s the grade of powder manufactured and marketed specifically for blasting became known as mining powder. Early mining powder was frequently inferior to gunpowder and it was not uncommon for small powder mills to turn out batches of gunpowder which failed quality tests, only to be packaged instead as mining powder.[11]

"Saltpeter, chemically known as potassium nitrate, was an oxygen carrier indispensable to blasting powder. With it, blasting powder burned in a self-contained reaction; no outside source of oxygen was necessary. Prior to [the mid-1800s], the only sources of usable saltpeter were in the deserts of India, under control of the British. Under the British monopoly, the price of Indian saltpeter rose in the 1850s and shipments became unreliable in quality, quantity, and timeliness. These problems caused inventive minds to search for a substitute. Lammot DuPont (1881-1934) of the famed DuPont family worked out a solution and patented it in 1857. Vast deposits of *sodium* nitrate were available in Chile. However, sodium nitrate tends to absorb water, ordinarily rendering it unsuitable. DuPont solved this problem by refining and specially drying the Chilean saltpeter, then glazing the finished blasting powder with a protective

[9] Twitty, 3.
[10] E. I. du Pont de Nemours & Co., *Blasters' Handbook* (Wilmington, DE, 1922), 6.
[11] Twitty, *Blown to Bits in the Mine*, 6.

> coating of graphite to shield it from moisture. Lammot named his new powder *B Blasting Powder*. Powder made with Indian saltpeter came to be known as *A Blasting Powder*."[12]

Twitty writes:

> "Prior to the introduction of dynamite in the 1870s, miners worked almost exclusively with blasting powder, and over the course of several generations they had honed the process of preparing and shooting it. Even after dynamite's popularity grew in hardrock mining, some miners continued to use blasting powder into the 1890s, and it reigned supreme in coal mines into the 1920s."[13]

Nitroglycerine

The next major advancement in the development of explosives was the discovery of nitroglycerine.

Dean B. Ivey (1959) writes:

> "The search for a better substitute for black powder had been in progress during the latter half of the [1700s] and the first quarter of the [1800s]. Chemists had tried to nitrate anything that could possibly serve as an explosive, but each attempt had failed. In 1846, however, two new discoveries opened up the right door for the laboratory chemist. In Switzerland, a professor of chemistry discovered guncotton [nitrocellulose], and in Italy, another discovered nitroglycerine."[14]

Guncotton proved too unstable to use as a substitute for blasting powder and was eventually replaced by celluloid. Nitroglycerine, however, was used successfully for a time in both construction and mining until it was replaced by dynamite. Nitroglycerine was discovered –

> "… by Ascanio Sobrero [1812-1888], a young Italian chemist, in his laboratory at Turin University. He produced nitroglycerine by adding anhydrous glycerine drop by drop to a mixture of two parts of sulphuric acid to one part of nitric acid. The resulting compound separated as a heavy, oily liquid and sank to the bottom of the solution. When subjected to testing, this oil exhibited high explosive qualities."[15]

Sobrero was certain that nitroglycerine was too violent and unstable to have any practical use as an explosive. However, Emmanuel Nobel and his son, Alfred Nobel (1833-1896), having become aware of Sobrero's discovery, were convinced that nitroglycerine had significant financial potential as an effective substitute for black powder. Their two major challenges were (1) developing a process whereby nitroglycerine could be manufactured in commercial quantities and (2) figuring out a way by which nitroglycerine could be detonated reliably and safely.[16]

In 1864, Alfred Nobel successfully modified the process by which nitroglycerine was made, for which he received British Patent No. 1813. Between 1864 and 1867, Nobel also solved the problem of reliably detonating nitroglycerine by inventing what became the conventional blasting cap.

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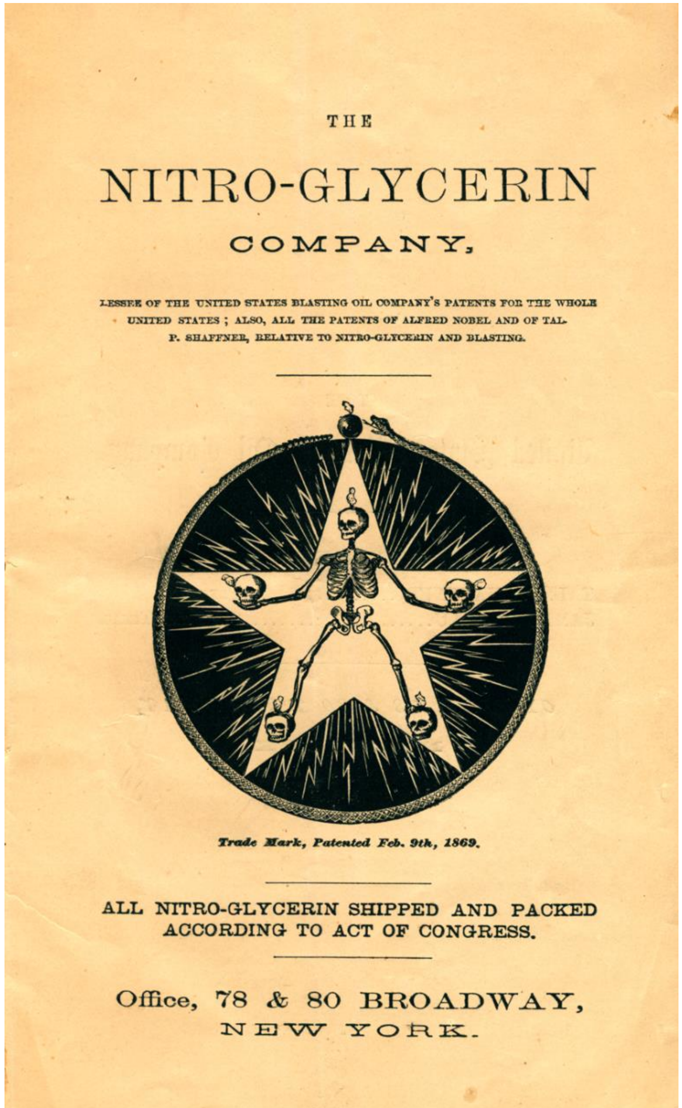
[12] Twitty, 6.
[13] Twitty, 76.
[14] Dean B. Ivey, "The Beginnings of the High Explosives Industry in the United States, 1868-1880" (1959), 2-3. Available at https://digital.hagley.org/MS1645_043, accessed August 31, 2021
[15] Dean B. Ivey, 4.
[16] Dean B. Ivey, 6.

Van Gelder and Schlatter (1927) write:

> "The common blasting cap owes its origin to the necessity of having a stronger initiating agent for nitroglycerine and high explosives than the black powder fuse which acts merely by flame. When Nobel found that he could not detonate these explosives in the same manner as black powder and have them develop their full force, he tried to accomplish this by means of black powder which was either confined in a cartridge and immersed in the liquid nitroglycerine or was packed around the cans of liquid nitroglycerine; but he found this also unsatisfactory. His next step was to evolve a 'cone-shaped receptacle made of tin-plate and filled with fulminate of mercury.' He patented this in 1867, specifying, however, a copper shell instead of the tin-plate receptacle. This is in effect the common blasting cap of today, except that later about 10% of potassium chlorate was added to the fulminate."[17]



By the 1870s, Nobel's "blasting oil" was being used in many areas of Europe as a substitute for black powder. His nitroglycerine was first introduced into the United States "on or about" July 15, 1865 by a Col. Otto Burstenbinder (no kidding) of Hamburg, Germany. Burstenbinder was a friend of one of the partners in the Nobel Company of Germany and was interested in forming a holding company in the United States that could license the Nobel patent for nitroglycerine to other companies and monopolize the market for the explosive. His efforts to promote nitroglycerine to American investors were unsuccessful.[18]

In 1866, however, two new efforts bore fruit in the United States. One was a nitroglycerine factory in Massachusetts and the other was a partnership between Alfred Nobel and Col. T. P. Schaffner. Nobel wanted to organize a company in the United States to make sure that his British patents were protected. Nobel transferred to Schaffner the exclusive rights to exploit nitroglycerine for military purposes. In June 1866, the United States Blasting Oil Company was incorporated in New York. Schaffner was a prominent member of the Board.[19]

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[17] Arthur Van Gelder and Hugo Schlatter, *History of the Explosives Industry in America* (New York: Columbia University Press, 1927), 756.

[18] Dean B. Ivey, 9.

[19] Dean B. Ivey, 9–13.

The Nitroglycerin Company formed by Schaffner went out of business in 1873. However, a company formed by George M. Mowbray in Massachusetts continued to supply nitroglycerine for construction projects in the East, and he expanded his operations into Canada and Kentucky.[20]

Dynamite

Throughout the period during which liquid nitroglycerine was in active use, it was often handled and shipped with cavalier disregard for its extremely dangerous nature. This led to horrific accidents.

> "The ignorance of nitroglycerine's instability and the violent power of its explosion added a touch of grim humor in its transportation. The acids in the nitroglycerine ate holes in the tin containers [in which it was stored and shipped] and the oil would leak out. This lost oil would be used in a variety of ways, as a substitute for such products as axle grease and boot polish. Railroads and shipping lines handled the material as if it were lard to be tossed carelessly here and there. Salesmen called on prospective customers with the explosives in their suitcases, which often received rough handling. This unfortunate ignorance soon bore fruit in the most devastating ways. Serious explosions occurred in all the countries that either manufactured or imported nitroglycerine."[21]

In 1864, an explosion destroyed Nobel's original works at Heleneborg, Sweden, killing the head chemist and Nobel's younger brother, Oscar, and causing his father to have a paralytic stroke from which he never recovered.

> "Due to all of the chronic mishaps and deadly accidents engendered by nitroglycerin, by the fall of 1866, Alfred Nobel was doggedly pursuing a means with which he could render a safer application of the chemical. He found the most promising means of doing so through the use of an absorbent. In these efforts, he mixed nitroglycerin with everything from powdered charcoal, sand, and wood shavings to brick dust and cement. Yet it wasn't until he stumbled upon a solid absorbent called *kieselguhr*, also known as diatomite or diatomaceous earth, that he really saw some promise. Heavy testing was conducted in October of 1866 in which combinations of nitroglycerin packed with kieselguhr were used. It was through this trial run that dynamite came into being. Alfred Nobel's patent for the invention then came roughly a year later, with an English patent obtained in May of 1867, followed by a Swedish one in September."[22]

Nobel's invention of dynamite revolutionized the explosives industry.

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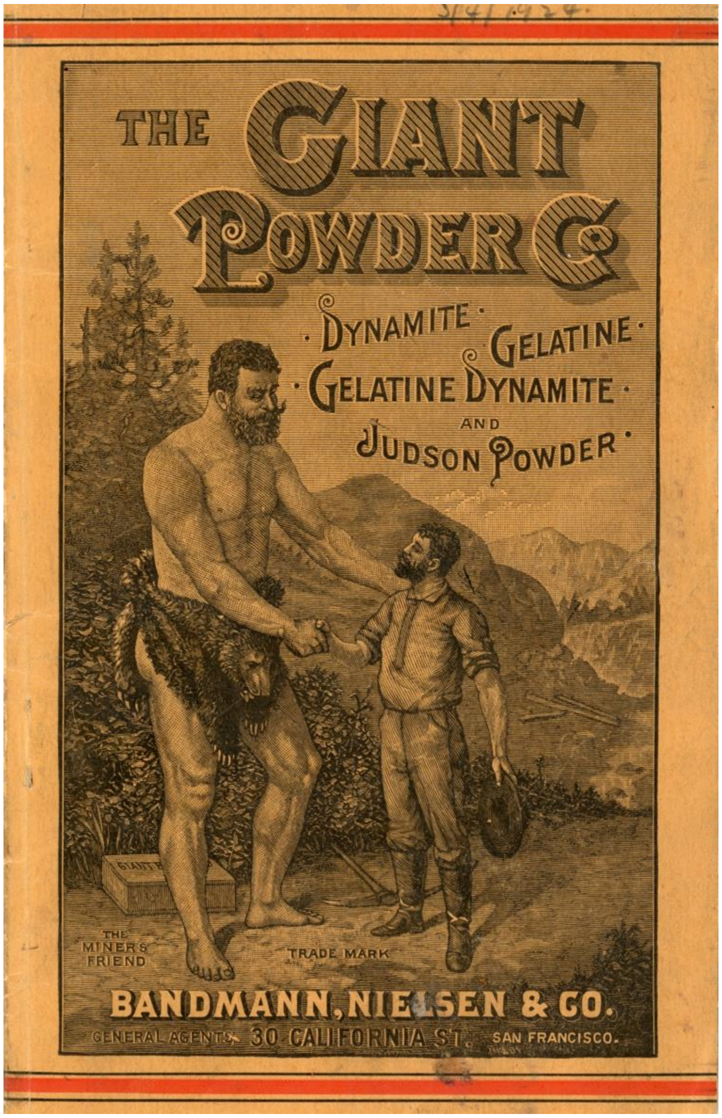
[20] Dean B. Ivey, 10–11.
[21] Dean B. Ivey, 7.
[22] History, Hourly. *Alfred Nobel*, p. 12. Kindle Edition.

"The year 1868 held one of the most momentous events in American history, one which forever changed the mining and construction industries. In that year, the Giant Powder Company, organized in San Francisco in 1867, introduced dynamite to North America. Although hardrock miners did not know it, this was a fateful year for them too, because dynamite dramatically impacted their work environment. During the 1870s and 1880s, miners had to learn to handle dynamite in harsh mountain and desert climates without ruining the product or killing themselves, and they were forced to develop an effective blasting process in the dark underground. For the most part, miners took the processes they traditionally employed for blasting powder and adapted them to the requirements of dynamite. By the 1890s they had developed consistent preparation and loading practices, but it took several decades to refine the process into something efficient and safe."[23]



"Miners generically applied the name dynamite to nearly all high explosives. The definition of a high explosive, including dynamite, is a substance that explodes, confined or not, without combustion. This behavior differs from blasting powder, which combusted and exploded only when confined. High explosives are said to detonate, which is the rapid decomposition of the solid and its transformation into gases, accompanied by a burst of energy during the phase change."[24]

"By and large, the invention of dynamite was widely hailed as a success, although in the next few years certain flaws would emerge. It was found that the kieselguhr configuration that Nobel used substantially reduced the explosive yield of the nitroglycerin. Even more alarming, the dynamite sticks also were said to 'sweat,' causing nitroglycerin to leak from

[23] Twitty, *Blown to Bits in the Mine*, 93.
[24] Twitty, 8.

> the packing. In order to correct this problem, Alfred Nobel created his next great invention in 1875: blasting gelatin, also known as gelignite. This was a concoction of nitrocellulose and nitroglycerin that Nobel put together that helped to maintain the integrity of dynamite while not dampening its explosive power."[25]

Another extremely important advancement in the development of dynamite was Nobel's formulation of dynamite with an "active" base as opposed to an "inactive" or inert base like kieselguhr. The absorbents in the active base were materials such as potassium, sodium, or ammonium nitrate mixed with wood meal, charcoal, rosin, sugar, or starch. These materials were not themselves explosive, but unlike kieselguhr, they contributed to the explosion. In 1943, Davis wrote:

> "Dynamite with an active base is manufactured and used extensively in this country … It is known as *straight dynamite*, or simply as dynamite, presumably because its entire substance contributes to the energy of its explosion. [26]

> "[Straight dynamite] . . . is made simply by mixing the explosive oil [nitroglycerine] with the absorbent materials; the resulting loose, moist appearing or greasy mass, from which oil ought not to exude under gentle pressure, is put up in cartridges or cylinders wrapped in paraffined paper and dipped into melted paraffin wax to seal them against moisture.[27]

> "The strength of straight nitroglycerin dynamite is expressed by the percent of nitroglycerin which it contains. Thus, '40% straight nitroglycerin dynamite' contains 40% of nitroglycerin, but '40% ammonia dynamite,' '40% gelatin dynamite,' etc., whatever their compositions may be, are supposed to have the same strength or explosive force as 40% straight nitroglycerin dynamite."[28]

Variations in the formulae for straight dynamite were also created to deal with problems other than sweating, such as its tendency to freeze at comparatively high temperatures (between 40° and 50° F), to make it more water-resistant and effective in wet conditions, and to make it safer for use in coal mining where methane ("fire damp") and coal dust were present ("permissible" dynamite).

> "By the mid-1880s, the diversity of dynamite products began expanding, making the decision of which explosive to use more difficult. Between the mid-1880s and 1900, mine supply agencies in hardrock mining districts typically carried or could order straight dynamite, dynamite extra, gelatin, gelatin extra, ammonium nitrate, railroad powder, blasting powder, and in rare cases, chlorate/nitroglycerine-based dynamite.[29]

> "In addition to selecting an appropriate type of dynamite, mining companies had to supply their miners with the most efficient percentage strength. … To meet the varying rock types that miners encountered underground, before 1910 explosives manufacturers offered three principal grades of dynamite, consisting of 60%, 40% and 30% nitroglycerine, which they labeled as No. 1, No. 2, and No. 3, respectively."[30]

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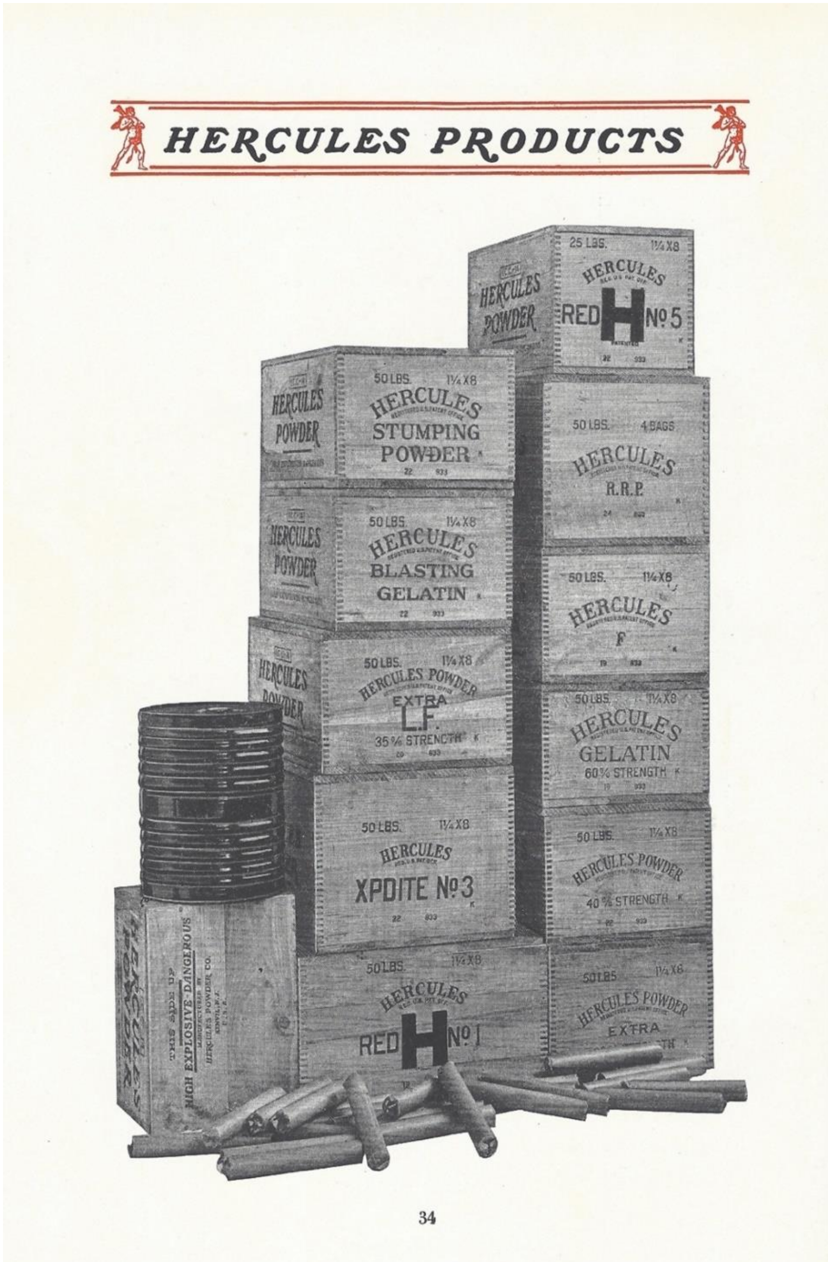
[25] History, Hourly. *Alfred Nobel*, pp. 14-15. Kindle Edition.
[26] Davis, *The Chemistry of Powder and Explosives*, 333.
[27] Davis, 338.
[28] Davis, 338–39.
[29] Twitty, *Blown to Bits in the Mine*, 94.
[30] Twitty, 96.

“The percentage strength of dynamite chosen by miners and mining companies was based more on performance and less on economics. Most mining companies supplied their miners with 60% strength for blasting very hard rock because it had a quick, shattering explosion. But it was used only when necessary because it cost more than a low-percentage dynamite. For soft, friable rock, miners favored 20% to 30% dynamite, because the explosion was long and heaving, and they used 40% strength dynamite for nearly everything else.”[31]



Explosives Offered by Hercules Powder Company in 1918[32]

[31] Twitty, 97.

[32] Hercules Powder Company, *Hercules Products* (1918), 34.

A BRIEF HISTORY OF THE BLASTING CAP

The Common Blasting Cap

High explosives such as dynamite detonate under the influence of the shock of the explosion of a primary explosive. “They do not function by burning; in fact, not all of them are combustible, but most of them can be ignited by a flame and in small amount generally burn tranquilly and can be extinguished easily.”[33] The importance of the invention of the common blasting cap as the initiating device for the detonation of dynamite cannot be overemphasized.

As Van Gelder and Schlatter (1927) write in *The History of the Explosives Industry in America*, “The application of an initial detonation, by means of the fulminate cap, to the firing of nitroglycerine *was of immense portance and made the use of high explosives as blasting agents practical*.”[34]

Tenney Davis (1943) writes in *The Chemistry of Powder and Explosives*:

> “The discovery of the phenomenon of initiation by Alfred Nobel and the invention of the blasting cap *stand at the beginning of the development of modern explosives, perhaps the most important discovery and invention in the history of the art*. The phenomenon has supplied a basis for the definition of high explosives which are incapable, without the invention, of being safely and controllably or perhaps even of being used at all. Nobel’s experiments quickly led him to the form of the blasting cap which is now in use, a cylindrical capsule, generally of copper but sometimes of aluminum or zinc, filled for about half of its length with a compressed charge of primary explosive. The charge is fired either by an electric igniter or by a fuse, crimped into place, its end held firmly against the charge in order that the chances of a misfire may be reduced. … Fulminate of mercury was the only substance known at the time of Nobel’s invention which could be prepared and loaded for the purpose with reasonable safety, and caps loaded with straight fulminate were the first to be manufactured. The original fulminate detonators were numbered according to the amount of fulminate which they contained . . ..”[35]

Eric Twitty (2009), in his *Blown to Bits in the Mine*, provides the best modern overview of the history of the common blasting cap:

> “Known throughout the industry as conventional caps, standard caps, detonators, and primers, blasting caps consisted of a copper casing slightly smaller in diameter than a quarter of an inch, and between one and two inches long. The casings were manufactured with drawn construction, resulting in a seamless copper head, but the bottom was open so manufacturers could pack in a mercury fulminate charge, and to allow the cap to slip over the end of safety fuse. By the 1940s cap manufacturers switched to aluminum casings.
>
> “The caps sold by mine supply houses in North America during the 1870s were small and barely adequate for detonating straight dynamite. Caps of this vintage came mostly from Europe … in strengths labeled No. 1 and No. 2. By the 1880s American manufacturers, such as … the California Cap Company, and the Metallic Cap Manufacturing Company were selling strengths labeled No. 3, No. 3 Extra, and No. 4, which were strong enough to detonate straight dynamite. By the 1890s, cap companies had introduced No. 5 and No.

[33] Davis, *The Chemistry of Powder and Explosives*, 3.
[34] Van Gelder and Schlatter, *History of the Explosives Industry*, 756 [emphasis added].
[35] Davis, *The Chemistry of Powder and Explosives*, 413–14 [emphasis added].

6 strengths in response to a demand for stronger caps needed to detonate new dynamite formulas. By the [early to] mid-1900s, cap manufacturers introduced No. 7 and No. 8 strengths to their product lines in association with a wave of unconventional high explosives manufactured for the minerals industry. By the late 1910s cap manufacturers dropped all strengths less than No. 6, and they continued to make No. 7 and No. 8 caps, which remained fairly popular for detonating gelatin, nitrostarch, and ammonium nitrate dynamites. Blasting caps came packed in tins of ten, twenty-five, fifty, and one-hundred, the latter by far being the most common quantity consumed by miners, who used caps by the crateload."[36]

Blasting Cap Sizes, Types, and Periods of Popularity[37]

Cap Type	Trade Name	Length (Inches)	Compatible Explosives	Relative Popularity
No. 1		5/8	Nitroglycerine, Straight Dynamite	1870-1885
No. 2	Double	3/4	Nitroglycerine, Straight Dynamite	1870-1885
No. 3	Triple, Triplex, Treble, "XXX"	1	Straight Dynamite, Dynamite Extra, Railroad Powder	1880-1915
No. 3 Extra	Extra		Straight Dynamite, Dynamite Extra, Railroad Powder	1880-1900
No. 4	Quadruple, Quadruplex, "XXXX"	1 1/8	Straight Dynamite, Extra Formulas, Railroad Powder, Gelatins	1880-1915
No. 5	Quintuple, Quintuplex, "XXXXX"	1 1/4	Straight Dynamite, Extra Formulas, Railroad Powder, Gelatins, Low Freezing Formulas	1880-1915
No. 6		1 1/2	Straight Dynamite, Extra and Low Freezing Formulas, Railroad Powder, Gelatins, Ammonium Nitrate, Nitrostarch	1900-1960
No. 7		1 5/8	All High Explosives	1915-1960
No. 8		1 7/8 – 2 1/2	All High Explosives	1915-1960

Davis provides much more detail with respect to the charge of fulminate of mercury used in blasting caps of various sizes.

"The charges of fulminate for the various sizes are shown in the following table, along with the usual (but not universal) dimensions of the cylindrical copper capsules. The same numbers are now applied to commercial blasting caps of the same sizes, whatever the weights and characters of the charges. A No. 6 cap, for example is the same size as one which contains 1 gram of straight fulminate.[38]

Charges of Fulminate for Various Sizes of Blasting Caps (Metric Units)[39]

Weight of Mercury Fulminate			External Dimensions of Cap	
Detonator	Grams	Grains	Diameter (mm)	Length (mm)
No. 1	0.03	4.6	5.5	16
No. 2	0.04	6.2	5.5	22
No. 3	0.54	8.3	5.5	26
No. 4	0.65	10.0	6	28
No. 5	0.80	12.3	6	30-32
No. 6	1.00	15.4	6	35

[36] Twitty, *Blown to Bits in the Mine*, 9–10.
[37] Twitty, 10.
[38] Davis, *The Chemistry of Powder and Explosives*, 414–15.
[39] Davis, 414.

No. 7	1.50	23.1	6	40-45
No. 8	2.00	30.9	6-7	50-55

Charges of Fulminate for Various Sizes of Blasting Caps (English Units)[40]

Weight of Mercury Fulminate		External Dimensions of Cap	
Detonator	Grams	Diameter (Inches)	Length (Inches)
No. 1	0.03	0.217	0.63
No. 2	0.04	0.217	0.87
No. 3	0.54	0.217	1.02
No. 4	0.65	0.236	1.10
No. 5	0.80	0.236	1.18-1.26
No. 6	1.00	0.236	1.38
No. 7	1.50	0.236	1.57-1.77
No. 8	2.00	0.236-0.276	1.97-2.17

> "The fulminate in detonators was first modified by mixing it with potassium chlorate. The chlorate mixtures soon attained commercial importance in the United States, and by 1910 had largely displaced straight fulminate."[41]

The actual manufacture of the common blasting cap resembled the process for the manufacture of a metallic cartridge of ammunition. The process no doubt changed somewhat over time, especially to make it safer, but it is described in an April 1919 article in *DuPont Magazine*,[42] and in Davis's 1943 book, *The Chemistry of Powder and Explosives.* The process was described in 1919 by DuPont as follows:

> "Blasting caps and electric blasting caps nowadays consist of various detonating agents … Manufacturing the small copper shell, or container, to receive the detonating composition is a very interesting process. The copper is received in sheets and placed in a punching machine which cuts small circular discs from the sheet. These discs then pass into another machine which has a descending plunger that cups the flat disc. From the cupping machine, the cups are conveyed to a drawing machine, which cups them still more and starts the formation of the shell. After passing through two more drawing machines, the copper is further drawn out and the shell is formed with a rough top. This rough top is cut off smoothly in a cutting machine, and the shell is complete. The shells are then dumped into hoppers, from which, by pulling a lever, the operator can load them, 100 at a time, into block trays having holes into each of which a shell fits in an upright position, ready to receive a charge of detonating substance."

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[40] Davis, 414.
[41] Davis, 416–17.
[42] J. B. Stoneking, "Detonators for Blasting," *Du Pont Magazine* (April 1919), 10-11, 23. Available at https://digital.hagley.org/1919_10_04#page/1/mode/2up, accessed September 3, 2021.

Illustrations of the Stages of Drawing a Shell for a Blasting Cap[43]

"[F]ulminate of mercury is made by mixing mercury, nitric acid, and alcohol in proper proportions. A white precipitate called fulminate is the result. [The fulminate is washed, placed in small fabric bags, and stored in wells filled with water.] When wanted for use, [wet fulminate is] taken to a barricaded dryhouse where gentle currents of warm air remove the moisture. Dried fulminate is extremely sensitive, hence handling from this point must be done with extreme care. The dry fulminate is carried in small rubber-lined boxes to the dry-storage house, located a considerable distance from the rest of the plant as a safety measure. From dry storage, the fulminate is taken in small quantities to the mixing house, where it is mixed with other detonating ingredients in the correct proportions in automatic, specially constructed vibrating machines.

"The mixed fulminate is then taken to the [loading] house where it is filled by automatic machines into the copper shells held in the trays, then to the press, which has 100 small plungers that fit exactly into each cap or shell … This gently presses the detonating mixture, and compresses it sufficiently to keep it in the shell. Explosions are frequent at this step in the process, hence the press is surrounded by thick walls, and the operator remains outside during the operation."

"From the press, the caps are conveyed in sawdust to rumblers and screens where any loose particles of the detonating agent are removed along with the sawdust, and the blasting caps are ready to pack. They are first packed in felt-lined tin boxes, each holding 100 caps, then into heavy paste-board cartons, and finally into strong wooden cases for shipment to any point where man may require their aid in his undertakings."[44]

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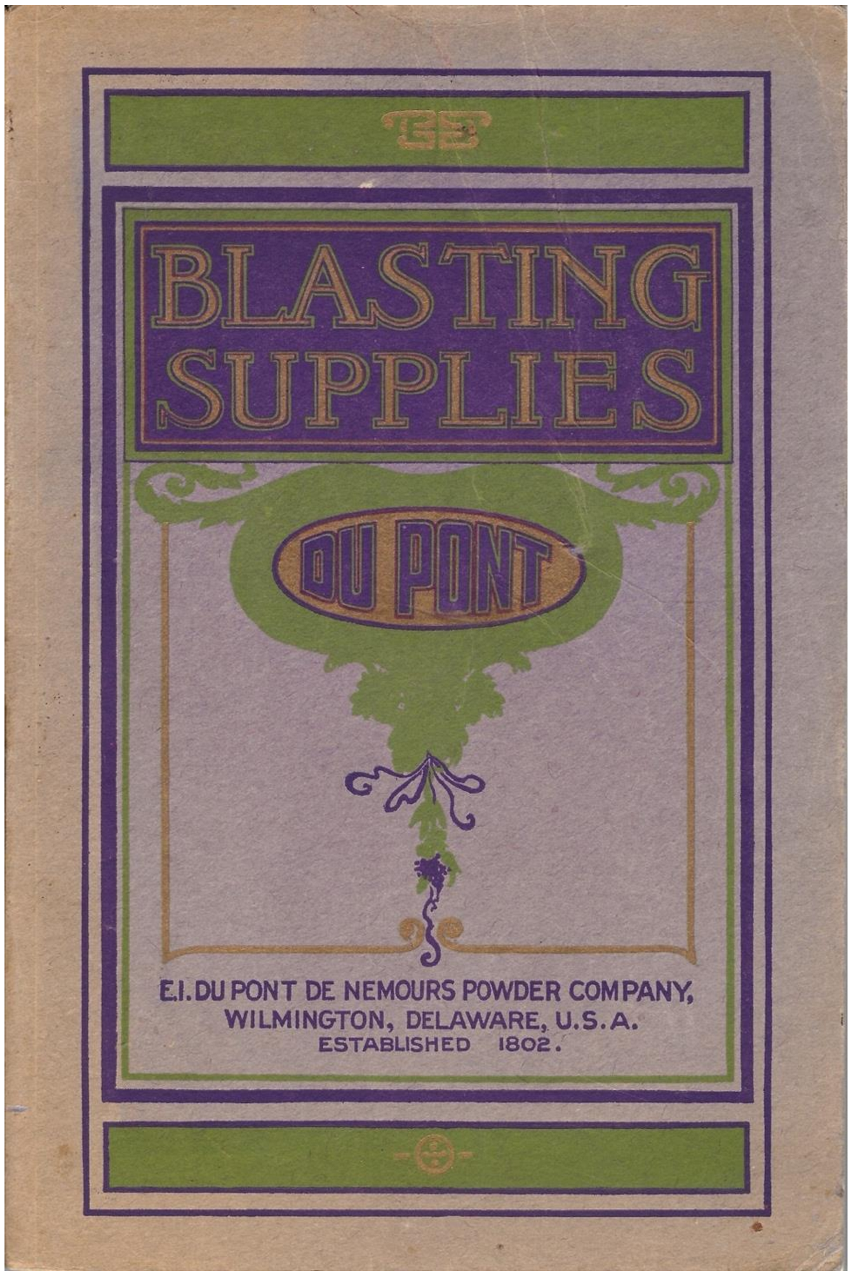
[43] J. B. Stoneking, 11.
[44] J. B. Stoneking, 11, 23.

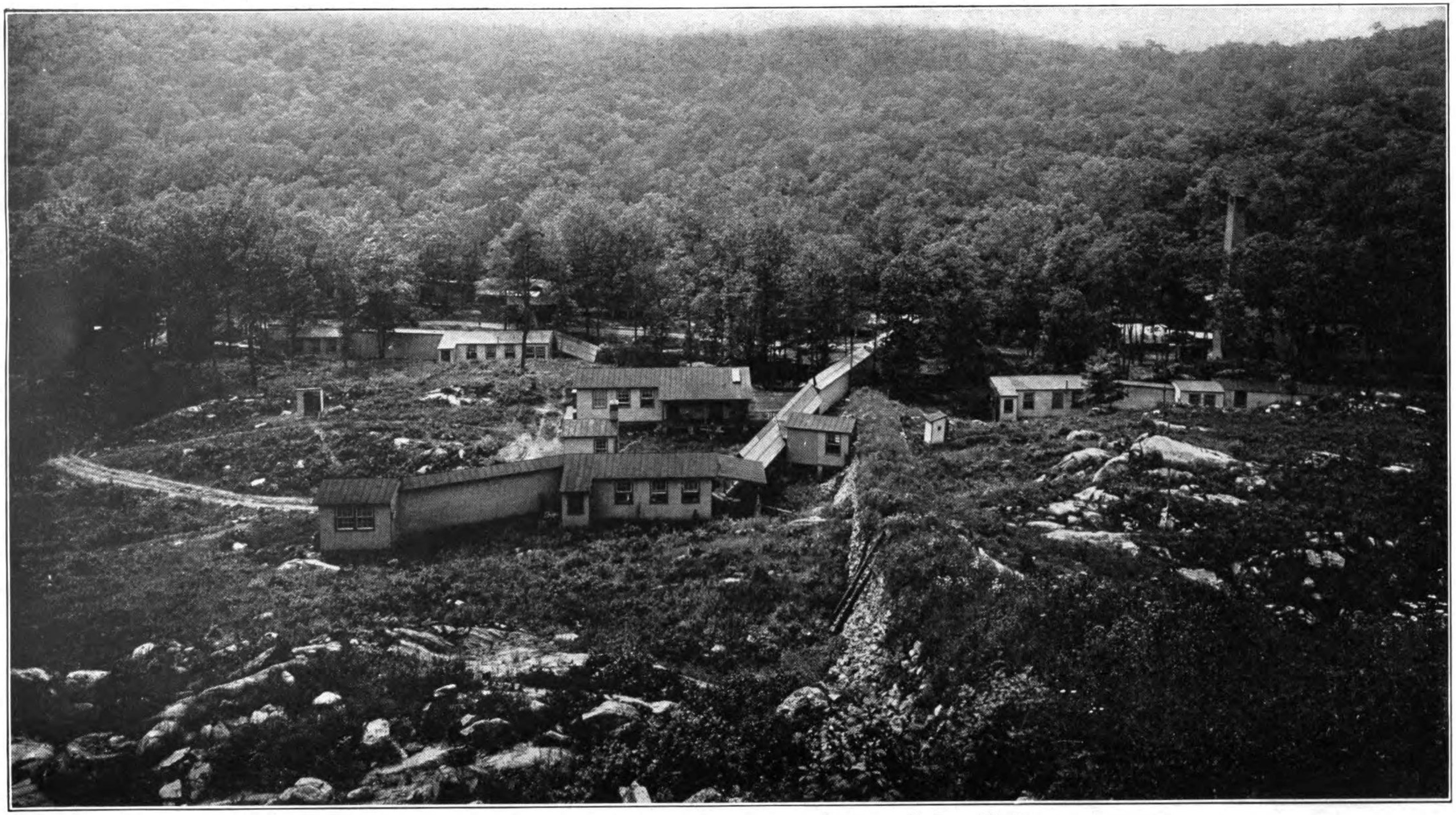
Cover of April 1919 Du Pont Magazine

The following illustrations are from one of my favorite catalogues, a 1911 Du Pont catalogue titled "Blasting Supplies." Other than the cover, shown below (scanned from my copy), I have used illustrations from a pdf version of the catalogue, which is available for free on-line from Google Books. This catalogue includes several photographs of Du Pont's blasting cap manufacturing facilities at Pompton Lakes, New Jersey, and beautiful illustrations of Du Pont's blasting cap tins.



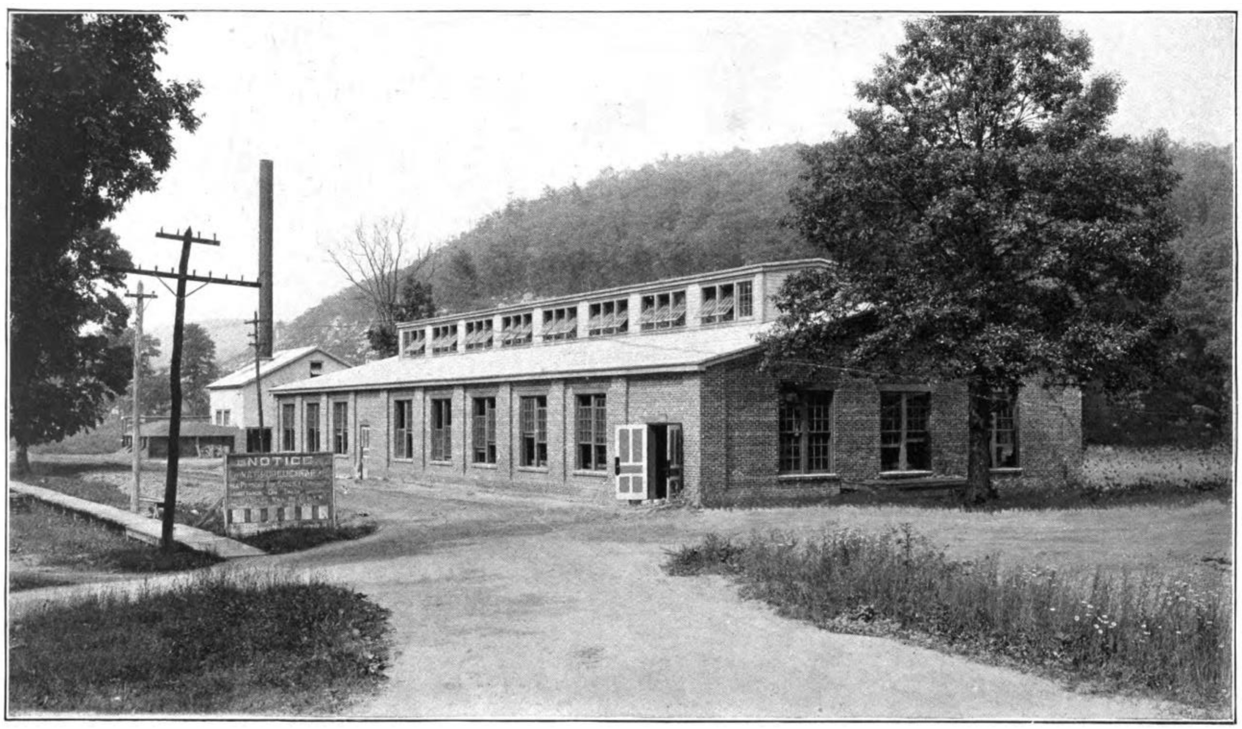
Du Pont Blasting Supplies Catalogue dated 1911[45]

[45] E. I. Du Pont de Nemours Powder Company, *Blasting Supplies* (Wilmington, Delaware, 1911).

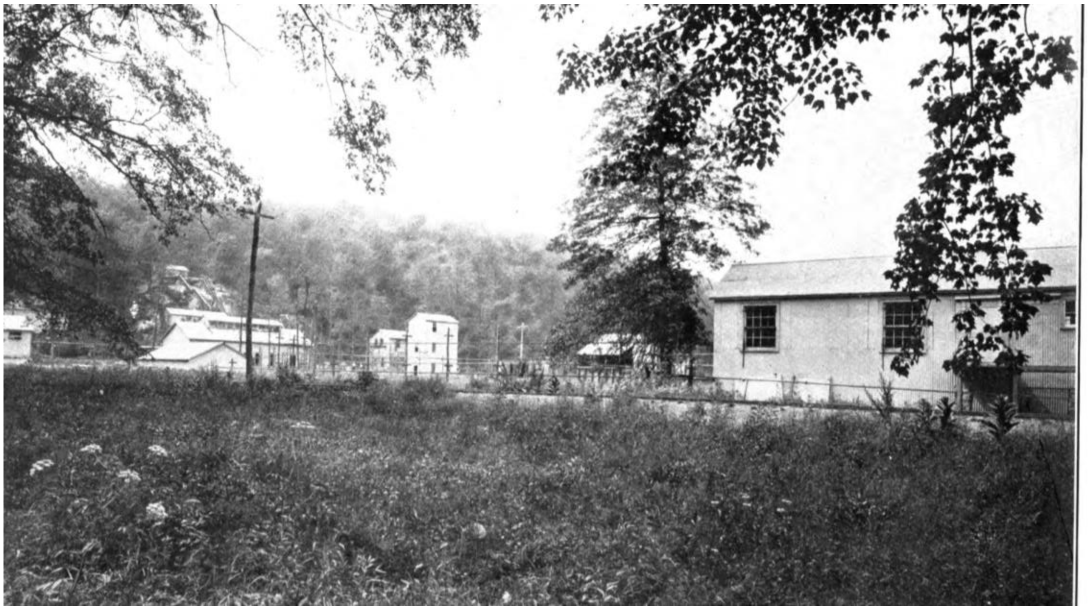


Part of Du Pont Blasting Cap Works, Pompton Lakes, N. J.

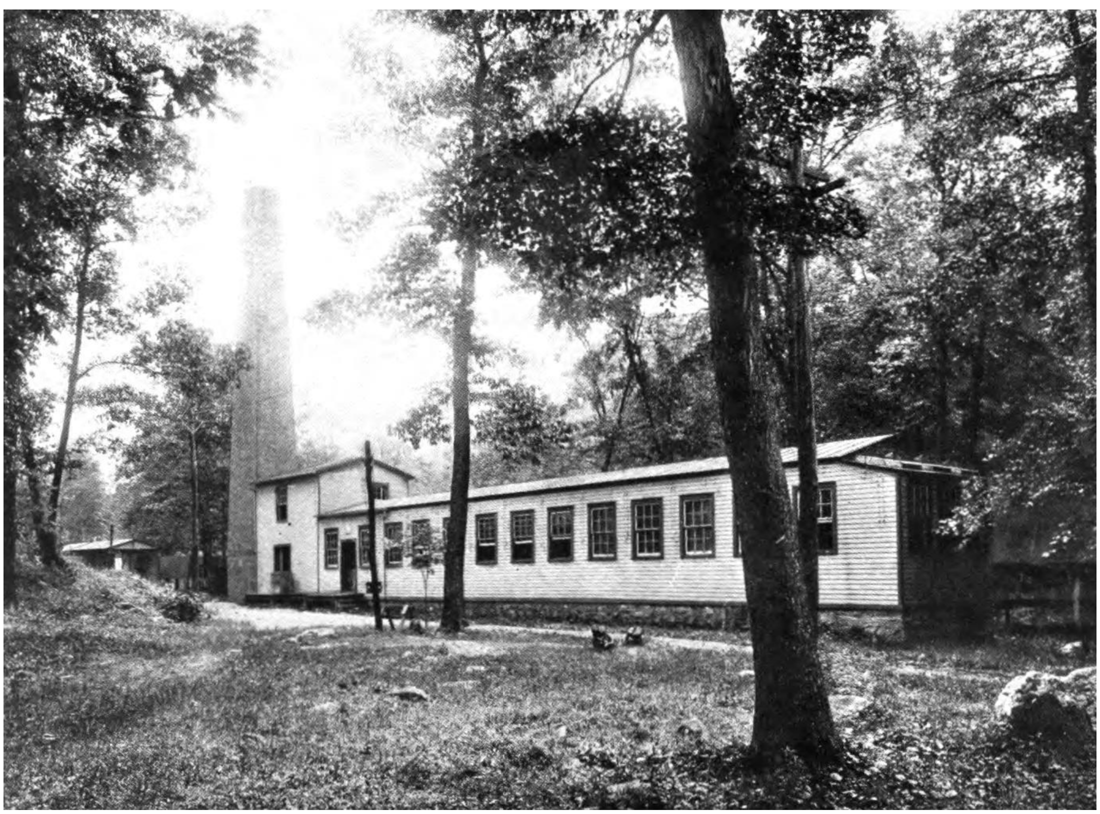
Unit—Du Pont Blasting Cap Works, Pompton Lakes, N. J.



Du Pont Shell Drawing Plant, Pompton Lakes, New Jersey.



Du Pont Fulminate Plant at Pompton Lakes, New Jersey.

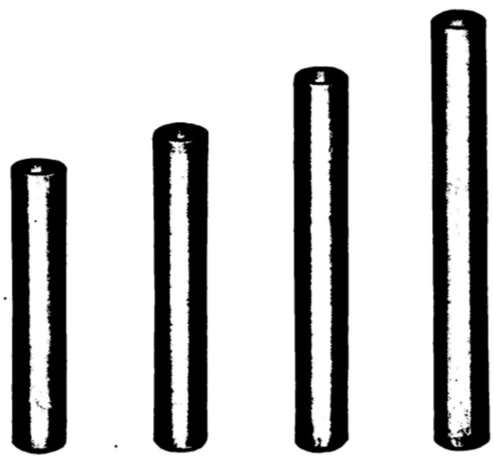


Charging and Pressing House, Du Pont Blasting Cap Works at Pompton Lakes, New Jersey.

DU PONT

Blasting Caps

BLASTING CAPS are made in four different grades, according to the quantity of explosive material with which they are charged. This explosive material is very sensitive to shock, high temperature or a spark, which necessitates careful handling if accidents are to be avoided.



Du Pont No. 5 Gold Medal No. 5 | Du Pont No. 6 | Du Pont No. 7 | Du Pont No. 8

Blasting Caps (Actual Size)

The following table describes the Blasting Caps illustrated above:

Grade		Gold Medal No. 5	Du Pont No. 5	Du Pont No. 6	Du Pont No. 7	Du Pont No. 8
Color of Box		Black	Blue	Red	Brown	Green
Length of Shell		1¼"	1¼"	1⅜"	1⅝"	1⅞"
Caliber of Shell		.234"	.234"	.234"	.234"	.234"
Distance between Top of Charge and Top of Shell		.78"	.78"	.765"	.765"	.718"
Weight of Charge	Grains	12.34	12.34	15.43	23.15	30.86
	Grams	.80	.80	1.00	1.50	2.00

Strengths and Sizes of Blasting Caps Available from Du Pont in 1911
(Not to Scale)

Blasting Caps manufactured by The E. I. du Pont de Nemours Powder Co.

In 1943, Davis also described and illustrated the processes for making blasting caps. These processes don't appear to have changed much from earlier methods, except perhaps through increased use of mechanization and shielding. Davis's photographs and their captions are especially helpful and are reproduced below.

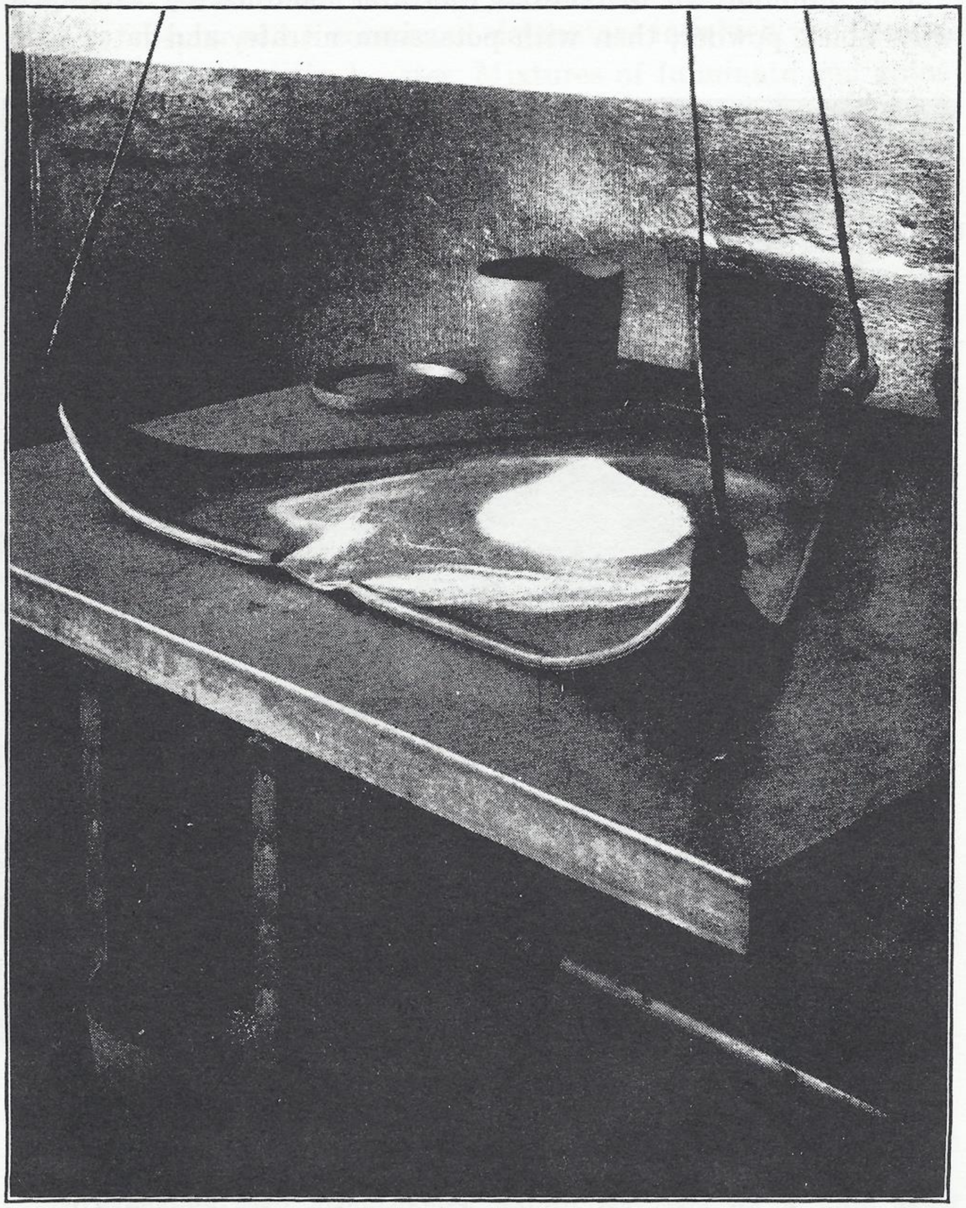


FIGURE 96. Manufacture of Detonators. (Courtesy Hercules Powder Company.) The safe mixing of the primary explosive charge for blasting caps is accomplished mechanically behind a concrete barricade by lifting slowly and then lowering first one corner of the triangular rubber tray, then the next corner, then the next, and so on. In the background, the rubber bowl or box in which the mixed explosive is carried to the building where it is loaded into caps.

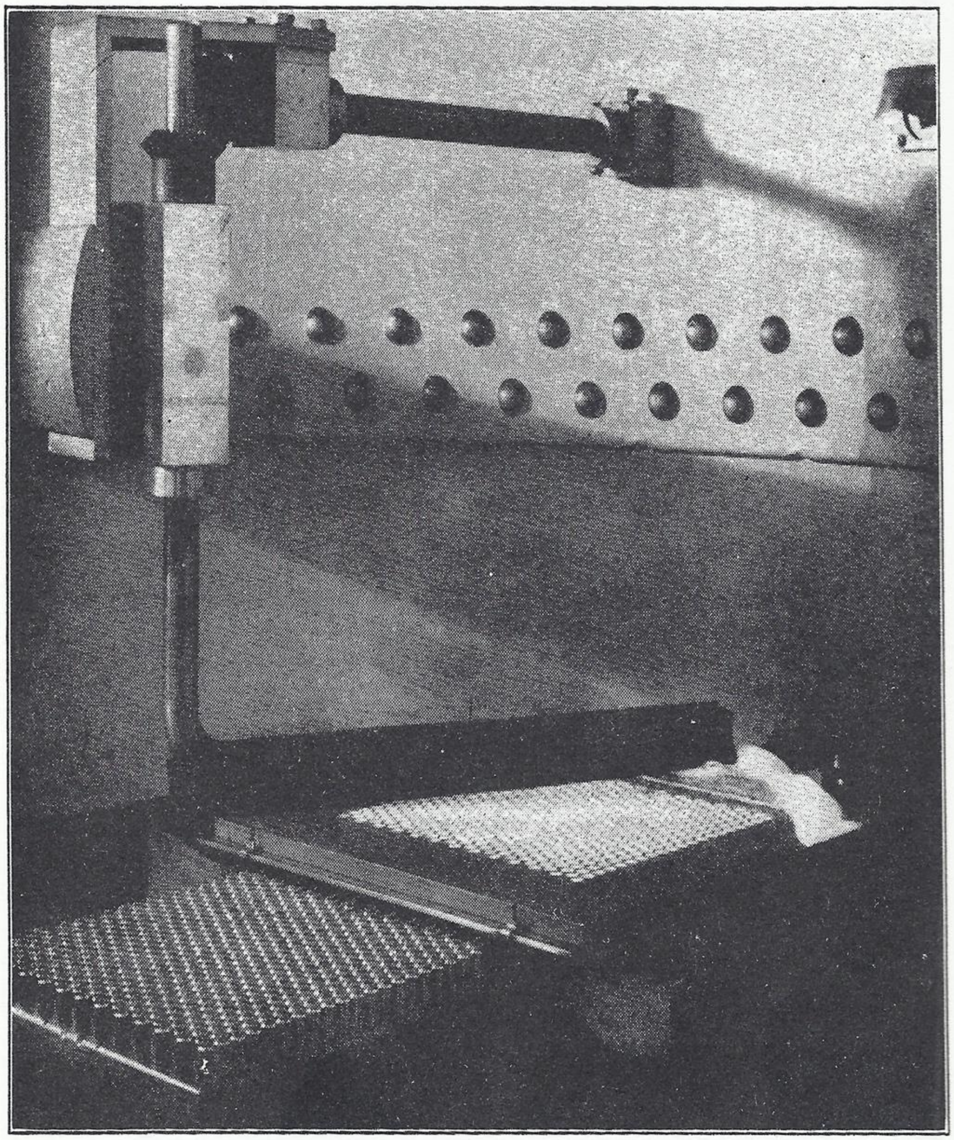
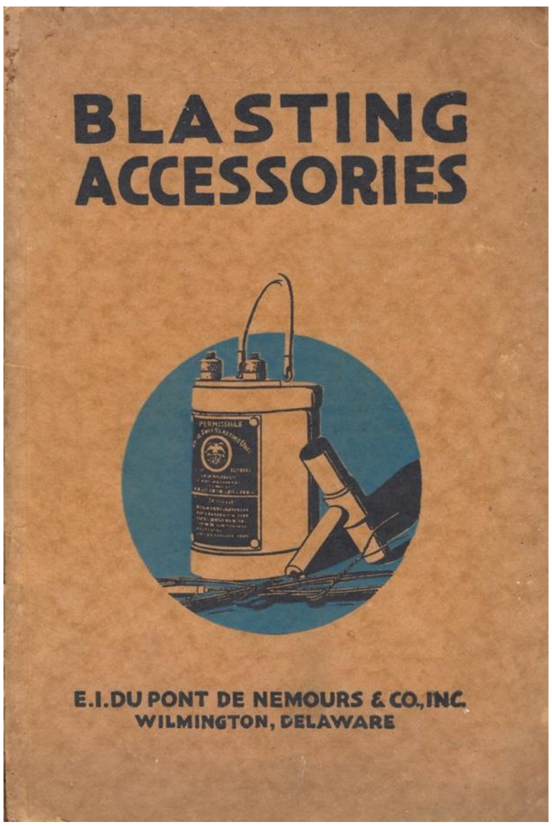


FIGURE 97. Manufacture of Detonators. (Courtesy Hercules Powder Company.) Charging the capsules. Each of the holes in the upper steel plate (*charging plate*) is of the right size to contain exactly enough explosive for the charging of one detonator. The mixed explosive is emptied onto the plate, the rubber-faced arm sweeps the material over the charging plate filling all the holes and throwing the excess into the box at the right. Under the charging plate is the thin *indexing plate* which supplies a bottom to all the holes in the charging plate. The detonator capsules, seen at the left, are placed under the indexing plate and in line with the holes in the charging plate; the indexing plate is then removed, the explosive falls down into the capsules, exactly the right amount into each, and is later pressed into place.

The above illustrations are from Davis's, *Chemistry of Powder and Explosives* (1943).[46] This book is also available, but for purchase, from Google Books, or in modern hardcopy from Amazon. Sadly, the photographs contained in both the Google Books and the modern hardcopy versions are too muddy for reproduction. Thankfully, I was able to acquire an original version recently on eBay, from which I scanned the above illustrations. Note that they were provided to the publisher by the Hercules Powder Company.

Manufacturers of high explosives did not typically manufacture their own blasting caps. Some did, but not all, by any means.[47] However, many manufacturers, even those that did not make their own caps, sought to be full-service companies, so they coupled the manufacture and sale of their explosives with the sale of other blasting supplies. In their 1927 *History of the Explosives Industry in America*, Van Gelder and Schlatter write:

> "The term 'blasting supplies' includes a variety of accessories required in the application and use of explosives, such as fuse, squibs, blasting caps, electric exploders, blasting machines, thawing apparatus, leading and connecting wires, cap crimpers, etc. These supplies are generally sold through the explosives manufacturers, as this system simplifies their distribution."[48]



Those of us who have an interest in this hobby have examples in our collections of ephemera (such as company catalogues and advertisements) that describe and picture the explosives and blasting supplies marketed by the larger companies. Some companies like Du Pont published whole catalogues devoted to blasting supplies, such as the one pictured on page 15 and the 1925 Du Pont catalogue shown at left. Others like Hercules devoted large sections of their explosives catalogues to blasting supplies. The following pages are excerpts from this 1925 catalogue, and a 1918 Hercules catalogue describing the fuse caps available from those two companies as of the dates of the catalogues. Note that the blasting caps offered by Du Pont in 1925 were No. 6 and No. 8 caps. No. 7 caps could only be obtained from Du Pont by special order. The catalogue also contains illustrations of No. 6 and No. 8 caps and explains how they were packaged. The earlier Hercules catalogue advertises only No. 6 and No. 8 caps.

[46] Davis, *The Chemistry of Powder and Explosives*, 415–16.

[47] Knowledgeable collectors, most notably Andy Martin and John Kynor, Sr., have observed that the blasting caps sold by many companies were probably manufactured by a few large companies, like California Cap Company and Metallic Cap Manufacturing Company. Andy Martin, *Blasting Cap Tin Catalogue* (Tucson, AZ: Old Adit Press, 1991), 20-23; John C. Kynor, Sr., *Blasting Cap Workbook, Tins and Boxes* (Belen, New Mexico: B.B.B. Ltd., 2008), 20-21.

[48] Van Gelder and Schlatter, *History of the Explosives Industry*, 721.

To summarize, strong detonators should always be used with high explosives because they give greater assurance of complete detonation and thus increase the execution of the explosive, reduce fumes to a minimum, decrease the size and duration of the flame, and prevent the loss of the charge by burning. Strong detonators also tend to counterbalance careless and improper practices in loading, priming and tamping and offset to some extent, deterioration of explosives and detonators caused by improper storage, thus reducing the chances of misfires.

Blasting with Cap and Fuse

Blasting Caps

Blasting caps are small drawn copper cylinders, closed at one end and loaded with a small charge of a very sensitive and violent explosive that is exploded by the spit of sparks from safety fuse.

Blasting caps and safety fuse may be used to detonate high explosives when it is not desired to fire a number of charges simultaneously. However, when it is desirable for two or more charges to explode at the same moment, electric detonators are required, and under various other conditions electric blasting, which is discussed on pages 23-62, has numerous advantages over the cap and fuse method.

METAL BOX CONTAINING 100 No. 6 DU PONT BLASTING CAPS

Du Pont Blasting Caps are manufactured in two sizes, No. 6 and No. 8. The No. 8 cap contains nearly twice as much explosive as the No. 6 and is nearly twice as strong.

A No. 7 blasting cap is intermediate in strength between Nos. 6 and 8, but as one of these two numbers is adaptable to all general classes of blasting, the No. 7 strength is not recommended and is furnished only on special factory order.

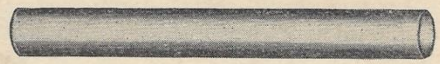
Dimensions of du Pont Blasting Caps

	No. 6	No. 8
Outside Color of Box	Red	Green
Length of Copper Shell	1½″	2$\frac{11}{32}$″
Outside Diameter of Copper Shell	.234″	.239–.24″

NOTE.—The *inside* diameter of both the No. 6 and the No. 8 du Pont Blasting Cap is .2205″

1925 Du Pont Blasting Supplies Catalogue

No. 6 DU PONT BLASTING CAP



No. 8 DU PONT BLASTING CAP

Both the explosive charge and the copper shells for du Pont Blasting Caps are manufactured with the greatest care and a certain percentage of the loaded caps is regularly tested in order to make sure that they are efficient detonators.

Blasting caps should be stored in a dry place. When conveying them to the work where they are to be used no moisture whatever should be permitted to get into the charge which they contain, as this charge is very quickly affected by dampness, and will absorb moisture and deteriorate. Storage in damp places, such as open sheds or tool boxes in mines, is likely to affect the charge in blasting caps, and may weaken them to such an extent that they will not properly detonate high explosives.

The methods of attaching the blasting cap to the fuse, and of priming high explosive cartridges with the blasting cap and fuse, are described on pages 18-23.

Packages of du Pont Blasting Caps for Domestic Shipment

All blasting caps are packed in tin boxes, each containing 100. Ten boxes are in turn packed in cartons and the cartons, with sawdust, in wooden shipping cases.

Gross Weight of Packages
No. 6 Blasting Caps

No. of Case	Quantity per Case	In Oblong Boxes
0	500	6 pounds
1	1000	10 "
2	2000	17 "
3	3000	25 "
5	5000	41 "
10	10000	89 "

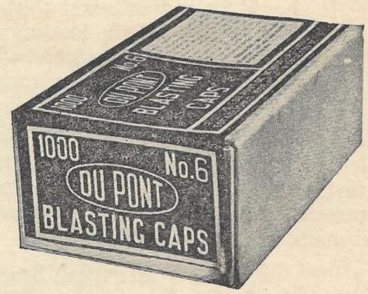
No. 8 Blasting Caps

0	500	10 pounds
1	1000	16 "
2	2000	30 "
3	3000	41 "
5	5000	63 "
10	10000	129 "

1925 Du Pont Blasting Supplies Catalogue

It will be seen that with the exception of case No. 0 the number of the case indicates the number of thousands of blasting caps in the case. As no cases contain 4000 caps, there is no No. 4 case.

In each box of blasting caps there is a small card known as the "follow-up" card or inspector's ticket. In case trouble is experienced with the blasting caps this ticket, with any unused blasting caps, should be preserved in order to facilitate investigation.



CARTON OF BLASTING CAPS

Safety Fuse

Safety fuse is the medium of bringing sparks to fire blasting caps or to ignite a charge of blasting powder. It is made up of a thin train of powder tightly compressed in inner and outer wrappings of jute, cotton or tape with waterproofing material between them.

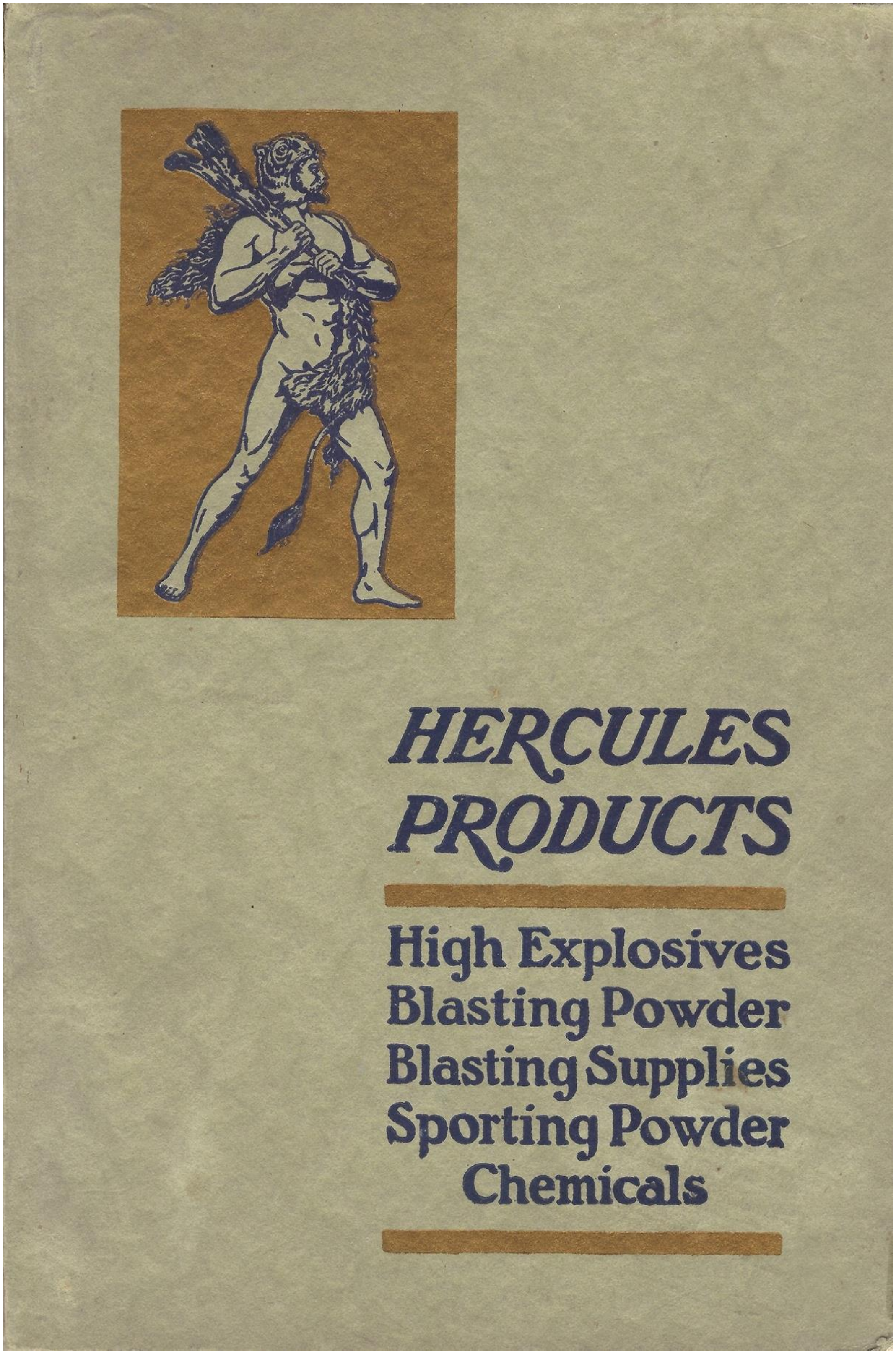
Brands of Fuse

The different kinds of safety fuse made may be grouped into four classes according to whether they are intended for dry work, damp work, wet work or under water work. The classification of brands of fuse sold by the du Pont Company according to this standard is:

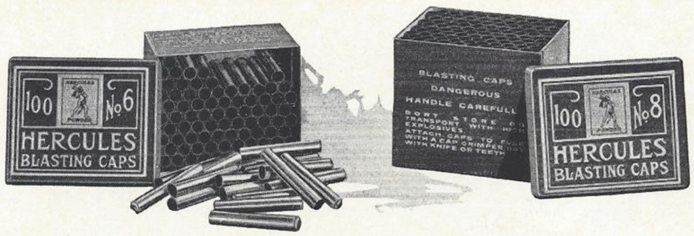
Dry Work	Damp Work	Wet Work	Under Water
	Beaver (a) (1)	Charter Oak (Gray) (a) (2)	Crescent (a) (1)
	Charter Oak (White) (a) (2)	Victor (c) (2)	Clover (a) (2)
Cotton (a) (1)	Sylvanite (b) (2)	Bear (d) (2)	Pacific (c) (2)
	Blue Label (c) (2)	Dreadnaught (c) (2)	Eclipse Special (c) (2)
	Single Tape*	Monarch (White and Black) (b) (2)	Sequoia (c) (2)
		Double Tape*	

(a) Sold in the States east of Montana, Wyoming, Colorado and New Mexico or the Eastern States.
(b) Sold in the States of Montana, Wyoming, Colorado and New Mexico or the Middle West States.
(c) Sold in the States west of North Dakota, Wyoming, Colorado and New Mexico or the Western States.
(d) Sold west of and including Montana, Wyoming, Colorado and New Mexico.
(1) Standard burning speed 90 seconds per yard subject to 10% variation.
(2) " " " 120 " " " " " 10% "
* Sold in all States. Taped fuses manufactured by the Ensign-Bickford Co. for the Eastern States are on the 90 second per yard standard. All others are on the 120 second standard.

1925 Du Pont Blasting Supplies Catalogue



1918 Hercules Products Catalogue



HERCULES BLASTING CAPS

The efficiency of any high explosives depends directly on the violence of the initial shot, causing detonation. It has been proven conclusively by the Government Testing Station, and by our own tests, that good results cannot be secured from Blasting Caps having a strength less than the standard No. 6. For this reason we market no detonators under the Hercules brand weaker than No. 6.

Blasting Caps should not be stored with explosives, and special care should be taken not to allow them to come in contact with moisture.

Hercules Blasting Caps consist of a small copper capsule, having a caliber, or inside diameter of 0.2205 inches, which allows ample room for the insertion of a standard sized fuse. In the bottom of the shell is a charge of Fulminate of Mercury, nitrovene or tetryl mixture. This is detonated by the spark from a fuse, which in turn detonates the explosives.

The following table describes the Blasting Caps illustrated on this page:

	Hercules No. 6	Hercules No. 8
Color of box	Red	Green
Length of shell	1½″	2″
Caliber of shell	.2205	.2205
Approximate distance between top of charge and top of shell	⅞″	1¾″
Weight of charge in grains	15.4	30.8
Weight of charge in grammes	1.00	2.00

1918 Hercules Products Catalogue

No history of blasting caps would be complete without mention of the two earliest American manufacturers, the California Cap Company and the Metallic Cap Manufacturing Company. Van Gelder and Schlatter describe the early history of these two companies.

California Cap Company

> "The first common blasting caps used in America were imported from Germany, although at the time electric blasting caps or fuses were being manufactured in America to a considerable extent. … Dependence on a foreign source of supply for the common caps was, however, unsatisfactory, particularly on the West Coast, and it is there we find the first American manufacture of these blasting caps was started about 1877 by William Letts Oliver and Freeborn J. Fletter. … [Oliver and Fletter] started a small cap factory at Stege, California, near the Tonite plant [north of Berkeley]. The California Cap Company was incorporated in April 1880, and the business begun by these two pioneers in a small way, developed to large proportions."[49]

A short on-line biography of W. L. Oliver says this:

> "William Letts Oliver (August 6, 1844 – November 4, 1918) was a mining engineer who, along with Freeborn Fletter, founded the California Cap Company, the first U.S. manufacturer of blasting caps used for explosives in mining. … W. L. Oliver and his son Roland were amateur photographers, with over 2,700 of their photos [now residing at U. C. Berkeley]. Upon W. L. Oliver's death in 1918, Roland Oliver became president of the California Cap Company, which ceased operating in the 1940s."[50]

Below is one of the Oliver Family photographs of the products made at California Cap Company.

Early Blasting Caps Made by California Cap Company[51]

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[49] Arthur Pine Van Gelder and Hugo Schlatter, 757–58.

[50] William Letts Oliver, https://localwiki.org/oakland/William_Letts_Oliver, accessed August 30, 2021.

[51] The Bancroft Library, University of California, Berkeley. Oliver family photograph collections (circa 1880-1920). Caps and cap tins, California Cap Company. Local Call Number: BANC PIC 1960.010 ser. 2 :0581--NEG (5x7).

Metallic Cap Manufacturing Company

What the California Cap Company was to the West, the Metallic Cap Manufacturing Company was to the East. Van Gelder and Schlatter describe the history of the company as follows:

> "Soon cap manufacture was also started in the east. In 1879, H. S. Chapman and his brother-in-law, Frank Kendall Brewster (1862-1921), formed the Metallic Cap Manufacturing Company and started to make blasting caps in a small way on the Brewster farm near Suffield, Connecticut. After three years' operation the plant was destroyed by a fire and explosion … A new plant was erected near Bethayres, Pennsylvania, and as the demand increased, a fulminate factory was built at Prescott, Ontario.
>
> "The Bethayres plant was operated until 1890, when it was also destroyed by an explosion. A new site was then found near Pompton Lakes, N.J. … The new plant was sold to the duPont company in 1907 and is now being operated as their cap works. In 1909 a fulminate plant was built at [Pompton Lakes] and the Prescott [Ontario] plant was abandoned. … In 1910 a shell drawing plant was added to the [New Jersey works].[52]

Photographs of the Pompton Lakes blasting cap manufacturing facilities, taken from my 1911 DuPont "Blasting Supplies" catalogue, are shown above. Andy Martin (1991) writes that DuPont was still operating the Pompton Lakes plant in 1969. He also writes that, after Du Pont's acquisition of the Pompton Lakes plant, tins were labeled Metallic Cap Mfg. Works (not Co.).[53]

Metallic Cap Manufacturing Co. Envelope, ca. 1900

Filename: brk00013265_31b.tif, http://www.oac.cdlib.org/ark:/13030/kt5j49q6sw/?brand=oac4, accessed August 31, 2021.

[52] Van Gelder and Schlatter, *History of the Explosives Industry*, 759–60.

[53] Martin, *Blasting Cap Tin Catalogue*, 56.

REFERENCES

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Twitty, Eric. *Blown to Bits in the Mine: A History of Mining & Explosives in the United States*. Lake City, CO: Western Reflections Pub. Co., 2009.

A number of illustrations used in this article are reproduced from books, catalogues, and other ephemera in the author's personal collection.

Several of the references and illustrations used in this article were provided courtesy of the Hagley Museum and Library in Wilmington, Delaware. These include:

1. At page 5, the second page of the pamphlet entitled, "The Nitro-Glycerin Company, lessee of the United States Blasting Oil Company's patents for the whole United States: also all the patents of Alfred Nobel and of Tal. P. Shaffner, relative to nitro-glycerin and blasting," (circa 1869) (available at https://digital.hagley.org/PAM_08037938, accessed September 3, 2021);
2. At page 7, the Cover, Giant Powder Company Catalogue, Giant Powder Company, "Dynamite, Gelatine, Gelatine Dynamite, and Judson Powder" (1884), (available at https://digital.hagley.org/20091120_Giant, accessed August 31, 2021); and
3. At pages 11-14, the article by J. B. Stoneking entitled "Detonators for Blasting" and its illustration of the stages of drawing a shell for a blasting cap that appeared in the April 1919 issue of *Du Pont Magazine* and the cover of that issue (available at https://digital.hagley.org/1919_10_04#page/1/mode/2up, accessed September 3, 2021).

Complete copies of all issues of the *Du Pont Magazine* from 1913 through 2003 are available from the Hagley Digital Collections, https://digital.hagley.org/dupontmag (accessed September 3, 2021). The Hagley is an invaluable resource for all things related to the history of the explosives industry. Many items are available in their Digital Collections. Many more are available in their Library. See https://www.hagley.org/research/search-hagley-collections.

Photographs from the Oliver Family Photograph Collections, including a number of photos related to California Cap Company, are available from the Online Archive of California. See https://oac.cdlib.org/findaid/ark:/13030/ft0q2n99r1/, accessed September 3, 2021.