THE ELECTRIC BLASTING CAP

by Eric Twitty

Hardrock mining, coal mining, open pit mining, and quarrying had many technological differences, but they also had many similarities. One of the most fundamental characteristics they shared was their reliance on blasting for economic viability. Prior to the early 1870's the only explosive available to miners and quarrymen was low grade black powder ignited with safety fuse.

Then came nitroglycerine in the mid-1860s, and dynamite in 1867. Both high explosives could only be effectively detonated with blasting caps, also known as *exploders*. During the late 1860's and early 1870's inventors developed two basic classes of blasting caps - those detonated with safety fuse, and those detonated electrically. Electric caps set off dynamite according to identical principles as conventional caps and fuse, their explosive material was the same, and they also were made of copper or brass tubing. However, their internal construction differed; electric caps had a platinum bridge embedded in a densely packed mercury fulminate charge which abutted against another, looser fulminate charge in the tip of the cap. The wires attached to the poles of the platinum bridge trailed out of the cap's end, which was sealed with a plug of sulfur glass (Fig. 1). The functioning of a cap was simple in its brilliance - as electric current passed through the wires, it met resistance in the bridge, which heated up to the point of detonating the mercury fulminate. Although each electric cap manufacturer had its own particular specifications, most caps were designed according to the these general features.

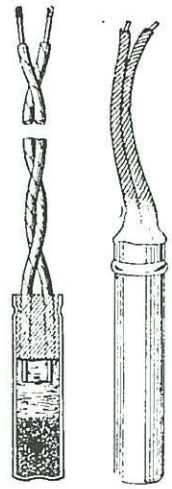


Figure 1

The history of the electric cap has roots predating both nitroglycerine and dynamite, and its development was a result of explosives inventors trying to devise military weapons. Dr. Robert Hare, one such inventor, developed the forerunner of the electric exploder in Philadelphia in 1830 (VanGelder, 1927:738-739). Hare's contraption was a wood vial filled with sensitive potassium chlorate packed around multi-strand wires, which became progressively thinner inside the cap until only one hair-like wire remained. The purpose of reducing wire thickness was that its capacity for conducting electrical current decreased, resistance increased, and the thinnest wire functioned as a bridge. Without knowing it, Haze had established the basic form of the electric cap, which future inventors would only improve upon.

Between 1830 and approximately 1850 other inventors tinkered with electric exploders and came up with devices such as the "magnet fuze" and the Statham Fuze, but electric caps did not experience popularity because there was no efficient and reliable source of current to detonate them, the early exploders were unreliable, and igniting blasting powder with safety fuse was a cheaper alternative for the blasting done in the minerals industry.

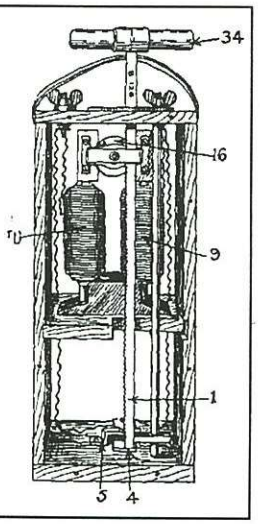
Label used by the Electric Exploder Co. (Courtesy Hagley Museum & Library).

Alfred Nobel indirectly revived interest in electric exploders in the mid 1860's when he began manufacturing nitroglycerine. Proper detonation of nitroglycerine, Nobel found, required blasting caps, which included electric exploders. A number of progressive mining companies in the Mother Lode, the Comstock, Michigan's Upper Peninsula, and several construction contractors in the East began blasting with the liquid explosive, which they found performed much better in hard rock than blasting powder. A small demand for caps and electric exploders began to take shape.

Notable explosives pioneers, including H. Julius Smith who blasted on Massachusetts' Hoosac Tunnel project, T.P. Shaffner who was president of the U.S. Blasting Oil Co., Jabez B. Dowse, Charles A. Browne, and George Mordey Mowbray who also blasted on Hoosac, began to devise and manufacture electric exploders for their work with nitroglycerine. Mowbray beat his kindred explosives pioneers in devising the modern electric blasting cap during the late 1860's. Mowbray's cap consisted of a small charge of a powerful explosive wrapped in gutta purcha placed adjacent to a second charge, encased in a varnish-smothered copper tube. Like Haze's early exploder, Mowbray's cap utilized a bridge, albeit more sophisticated.

Electric blasting was not made practicable on the improvement of exploders alone, equally as important was the development of a portable, reliable source of electricity. The experimental blasting done between 1830 and 1865 utilized acid batteries weighing in excess of 100 pounds to generate the electric charge. Because of their fragility, their ease of spilling, and unreliable current, the one-hundred pound glass vessels of acid were not the best sources of electricity for military or commercial blasting. In the late 1850's or early 1860's Baron Von Ebner made the first great stride toward the first practical blasting machine in Austria (VanGelder, 1927:741). The Baron's machine was a wood box encasing a heavy dynamo, turned by a hand crank on the box's side. Although the machine's weight was not much lighter than the batteries, it was certainly less fragile, had no acid to spill, and produced a reliable current.

The concept of Ebner's machine traveled to the United States where inventor Moses Farmer modified it into something practicable for blasting in mines and quarries. Farmer's machine weighed a mere 120 pounds, it also was activated with a hand crank, and when its operator had it turning at what he guessed to be the correct RPM, he depressed a key on the box's top, completing the circuit.



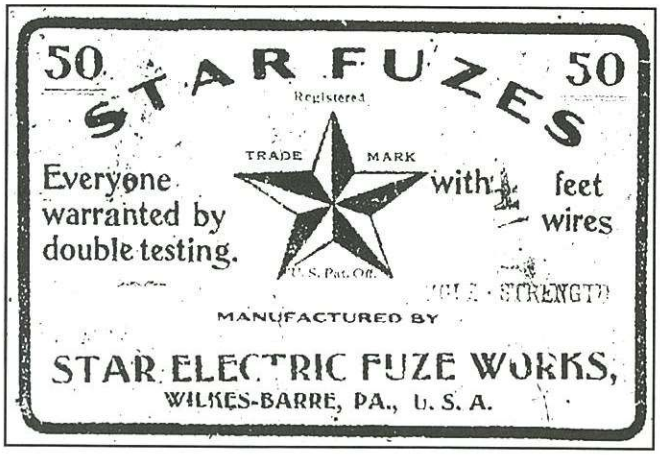
View of a U.S. Standard blasting machine with its side removed, showing the internal mechanism. This blaster, featured in an early 1920s DuPont Blasters' Handbook, has changed little from Smith's original machine. Item 9 is the copper coil, and 16 is the drum turned by the rack bar (1).

While working on the Hoosac Tunnel, explosives genius H. Julius Smith took the next steps toward improving blasting machines, bringing electric blasting closer to a form usable by the minerals industry. First, Smith took Farmer's machine, improved the dynamo, lighted the entirety to 77 pounds, and made the key self-activating when the machine produced the desired current. Not satisfied with the above machine, Smith continued development work, and devised another model in the early 1870's. Smith's alternative blasting machine measured five inches wide, eight deep, and sixteen high, it

weighed less than 30 pounds, and its smaller, more efficient dynamo was activated by rack and pinion gearing (VanGelder, 1927:750). To use the machine, its operator simply drew the rack bar up, and slammed it down, the pinion gear turning the dynamo. Smith had developed the modern blasting machine, which explosives engineers would improve, but never replace. At least as far back as the 1880's blasting supply makers began offering machines labeled *No. 3*, capable of shooting 20 to 30 holes, *No. 4* which could fire 40 to 50 caps, and the *No. 5*, which was a pull-up type capable of detonating 75 to 100 caps (Firing Blasts by Electricity, 1905: 55).

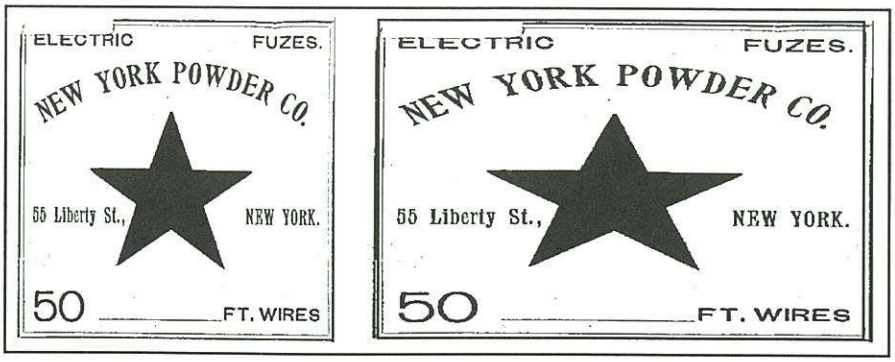
Inventors, electric blasting caps, blasting machines, and their demand were all in place by the early 1870's to support a small electric blasting industry. The Laflin & Rand Powder Co. and the Oriental Powder Co. were first in North America to undertake the manufacture of caps and machines with any measurable amount of energy. Between approximately 1869 and the early 1870's Smith's electric caps were sold by Oriental, and Browne's through Laflin and Rand. This arrangement changed in 1874 when the Browne brothers sold their small plant to Laflin & Rand, which hired H. Julius Smith as chief engineer at its Wayne Mills in New Jersey (VanGelder, 1927:748, 750). Smith continued development of caps and machines at Laflin & Rand's facilities. In addition to the above two companies, the Giant Powder Co. involved itself in the electric blasting market by developing and manufacturing its own exploders in 1874.

The electric blasting industry was quite small as the 1870's gave way to the 1880's, but through the decade it quickly picked up and a number of manufacturers went into business. Laflin & Rand was on the forefront of the industry, even when its relations with H. Julius Smith soured in 1886. Smith dissociated himself from the company and started his own electric blasting supply outfit, which became successful and provided Laflin & Rand with considerable competition (VanGelder, 1927:751). Smith's son took over their Pompton Lakes, New Jersey factory when H. Julius died in 1901, and when Smith's son died in 1905, holders of the estate sold the plant to DuPont, which ran it under its own name. At approximately the same time DuPont acquired Laflin & Rand and absorbed the large company. The H. Julius Smith and Laflin & Rand names would appear on electric blasting supplies and exploders no longer.



This label was used by the Star Electric Fuze Works, started by German interests in Pennsylvania's coal fields. During World War I the Alien Properties Custodian, a conservative government bureau, seized Star because of its German ownership. The government sold Star to the Atlas Powder Co. in 1919, with no proceeds going to its previous owners. According to the label, the caps were single strength and had four foot wires, indicating these were the least expensive, and they were used in shallow drill-holes. (Courtesy Lane Griffin).

These labels were used by H. Julius Smith between 1886 and 1905, the left being older.



The center row was used by the New York Powder Co. between 1891 and 1905, the left being older. (Courtesy Hagley Museum & Library).

Rising interest in electric blasting in the 1880's prompted a number of other manufacturers to go into business. Among them was the partnership of Walter Hill and J.J. Blakely in Rhode Island, which sold their plant to the Aetna Powder Co. in 1889 (VanGelder, 1927:752).During the mid 1880's, under the direction of Karl Sundstrom the American Forcite Powder Mfg. Co. began to manufacture electric caps, the Hecla Powder Co. entered the business, and the New York Blasting Supply Co. sprang to life. In 1887 Sundstrom left American Forcite, formed a partnership with James Macbeth and the two entrepreneurs went into the electric blasting supply business themselves. Sundstrom supplied the technical knowledge and Macbeth supplied the capital.


JUNE 2, 1900. THE ENGINEERING AND MINING JOURN.

Electric Blasting Apparatus

Adapted for Firing all Kinds of Explosives used in Blasting.

Victor Electric Platinum Fuses

Superior to all others for exploding any make of dynamite or blasting powder. Each fuse folded separately and packed in neat paper boxes of 50 each. All tested and warranted. Single and double strength with any length of wires.

Blasting Machines.

The strongest and most powerful machines ever made for electric blasting. They are especially adapted for submarine blasting, large railroad quarrying, and mining works.

Victor Blasting Machine.

Fires 5 to 6 holes; weighs 16 lbs.; adapted for prospecting, etc.

Insulated Wires and Tapes.

Blasting Caps, Fuse, Etc.

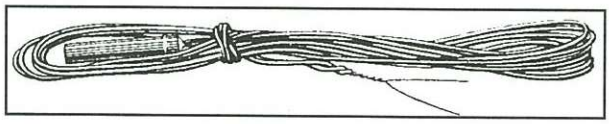
SEND FOR CATALOGUE. MANUFACTURED ONLY BY

JAMES MACBETH & CO., 128 Maiden Lane, New York, U.S.A.

This advertisement, run by James Macbeth in the Engineering & Mining Journal from the late 1890s to the early 1900s, shows a pull-up blasting machine on the left, and the type of machine based on Smith's design on the right. (Courtesy Erroll Christman).

Together they formed James Macbeth & Co., which made rack and pinion blasting machines under the U.S. Standard name, pull-up machines, and electric caps and crank blasting machines under the Victor name (see cover). Last, the Electric Exploder Co. also went into business at this time. By 1905 DuPont, well on its way to controlling the American explosives industry, acquired all of the above companies either through direct purchase or through its subsidiary, Eastern Dynamite.

Many early, visionary mining engineers touted electric blasting as being superior to conventional caps and safety fuse. Electric caps were more fool-proof than standard blasting caps, in part because they came from the manufacturer wired and ready for use. Since they required no assembly on the part of miners, as did conventional caps and fuse, the chances of electric caps causing a misfire were greatly reduced. In addition, since they required no assembly, miners spent much less time on preparing charges, which, in a large mine, added up to a considerable quantity of man-hours



Electric cap makers usually packed their caps into boxes using the form shown in the illustration.

Electric blasting offered several undeniable safety features. Because electric caps had no spark or open flame, they lessened the danger of setting off mine gas or coal dust in coal mines (Munroe & Hall, 1909:43). Electric caps were a sure-fire means of shooting a round in sopping-wet blasting conditions because they were waterproof (Coal & Metal Miners' Pocketbook, 1902:46; DuPont, 1932:61). Moreover, in some conditions, such as

underwater, there were the only reliable means or shooting a round. Last, electric caps offered no danger of hangfire, which is when the flame in safety fuse temporarily stalled, and resumed often when miners were examining the face to ascertain why one of their charges failed to go off.

Despite the benefits electric blasting offered, prior to the 1910's it was not popular among mining companies for four major reasons. First, purchasing a blasting machine, electric caps, and specialized supplies required capital, which many small mining companies either did not have or would not spend. Why should they spend the money when in the short run conventional caps and safety fuse cost least? Second, until approximately 1910 most available blasting machines were not suited for shooting the number of holes usually required by hardrock mining. Most blasting machines predating 1910 had a 10 cap capacity, while blasting most hard rock working faces required between 10 and 30 charges. H. Julius Smith and Laflin & Rand did offer higher-capacity machines, but they were exceedingly rare and had to be special-ordered, and they required a special wiring technique, discouraging would-be electric blasters. The most significant reason why electric blasting was not popular among mining companies was that early electric circuits detonated the charges simultaneously, which was very undesirable in hardrock mining, and only slightly less so in coal mining. Driving tunnels, sinking shafts, and bringing down ore or coal was accomplished efficiently by drilling holes in groups, and shooting the groups in a sequence known as a *firing order*. The *cut group* was shot first, and it blasted a cavity out of the working face which served as a weakness for the other groups. *Relievers* were shot next, and they blasted away the bulk of the working face, utilizing the weakness created by blasting cut group. *Trimmers* followed, outlining the tunnel, shaft, or stope, and *lifters* defined its floor. Blasting these groups simultaneously, as electric blasting did, ruined the effect of using the firing order, necessitating a greater quantity of explosives and more drill-holes, which ultimately drove the cost up. In addition, bigger explosions had the potential to cause structural damage to the workings, and it scattered the shot-rock, making considerably more work for the mucker.

Prior to the 1910, the only way to adapt electric blasting to a firing order was to wire an expensive circuit delay box into the line, which was not made available until the 1890's, or wire each group of holes separately, run the wires to the blasting station, and hope shooting each bunch of charges did not damage the wires running to the individual hole groups to be shot later in the sequence.

Prior to 1910 electric blasting saw greatest popularity in quarries. The blasting pattern quarries often used was a line of closely spaced drill-holes, which was very effective at parting blocks of stone when the holes were shot at once. In addition to quarries, electric blasting became somewhat popular in coal mines prior to the 1910's for the safety factors it offered. Although it was more efficient to shoot the drill-holes in a coal breast in a firing order, it was not as critical as it was when blasting hard rock.

By the 1910's several events had come together to make electric blasting efficient and easier. First, shortly before 1900 H. Julius Smith, the Giant Powder Co., and other explosives inventors devised several varieties of delay-action electric caps. They had miniature lengths of safety fuse attached to them, which were ignited by the cap's platinum bridge. Once the length of fuse ignited, it burned to the cap's core charge, delaying the cap's detonation by the length of the fuse. By 1910 leading explosives makers offered three different delays, at last granting hardrock miners their firing order. The second event came in the 1910's when mining

and explosives engineers, explosives makers, and the Institute of Explosives Makers began pursuing a campaign aimed at improving the safety of blasting.

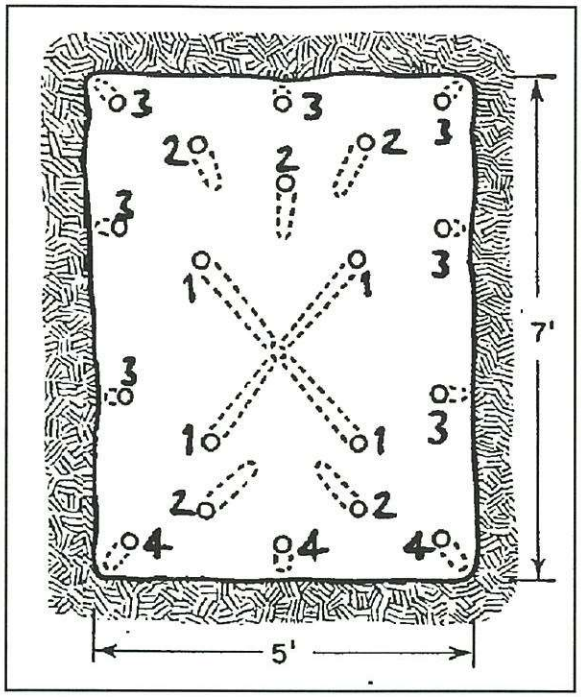
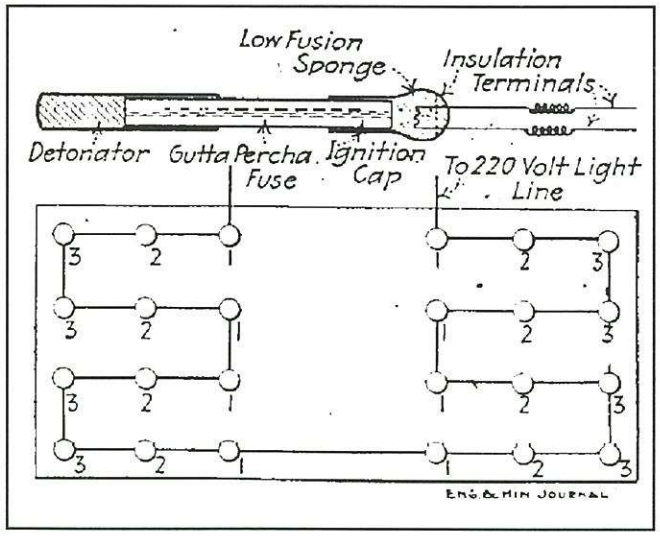


Illustration of the hole pattern miners commonly used for driving a tunnel, known as the Pyramid. The circles represent drill-holes, and the dashes show the hole angles. Group #1 is cut shot which miners loaded with standard electric caps , #2 is the reliever group which was loaded with 1st delay caps, #3 are trimmers loaded with 2nd delay caps, and #4 are lifters loaded with 3rd delay caps. (Author).

Some engineers felt electric blasting was one way of achieving this goal, and they set about educating miners and their bosses on the merits of and technicalities of electric blasting. Last, makers upgraded their standard blasting machines to a 30 cap capacity, enough to shoot most working faces in hardrock mines. Because of these improvements, by the 1920's many large metal and coal mines, underground and open pit, had switched to electric blasting.

When blasting electrically, miners had to prime their dynamite cartridges before loading them into drill-holes. The process was similar to the methods used for priming with standard cap and safety fuse.



The top illustration shows a cut-away view of a delay-action cap. The schematic below the cap is a wiring diagram for shooting the working face of a shaft, which could not be done electrically without the delay-action cap. The hole pattern is a wedge cut, and all holes angle toward center. Circles numbered 1 are the cut shot and were primed with standard electric caps, #2 is the reliever group and were primed with 1st delay caps, and #3 are trimmers primed with 2nd delay caps. (Engineering & Mining Journal July 12, 1913 p65).

The most popular method was to side-prime and tie the cap's lead wires in a half-hitch knot around its waist (Coal & Metal Miners' Pocketbook, 1902:333). The benefit to this method was if the wires were tugged the knot tightened without dislodging the cap. Another method miners used to prime with electric caps involved inserting the cap into the end of the cartridge and passing the lead wires back to its middle and through a hole in the cartridge's center (DuPont, 1932:61; Young, 1946:136). A third method of priming combined the above two ways, but it was less popular because it took longer (DuPont, 1932:61; Young, 1946:136). Once

one cartridge for each drill-hole was primed, miners slit all of the cartridges to be loaded end to end so they could expand during tamping. Following this, the cartridges were laid out with the tools, and loading the round began.

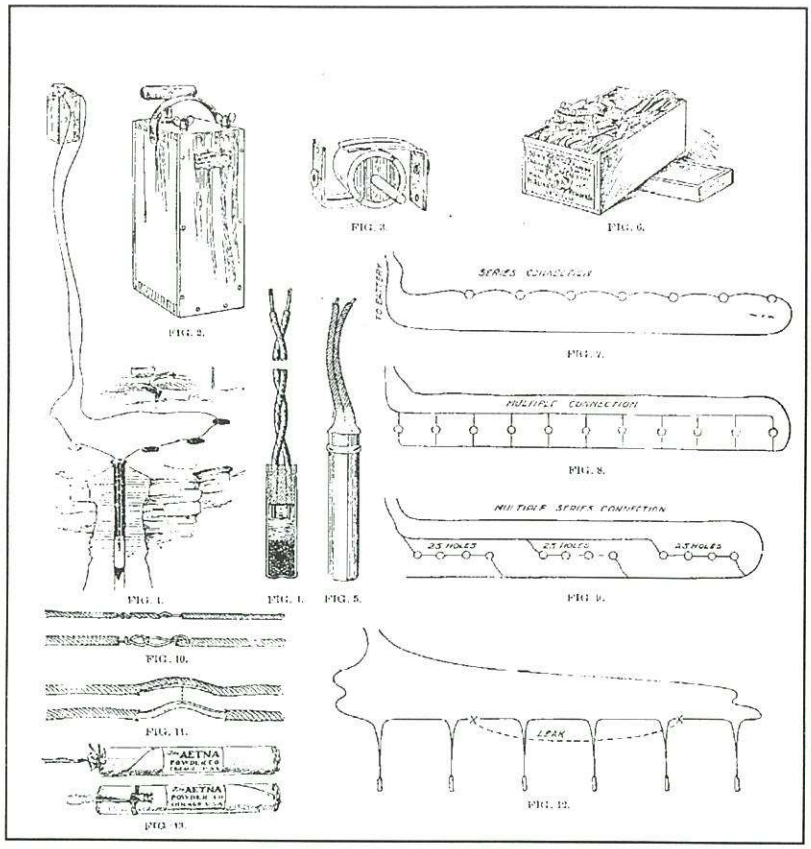
This advertisement was run by the California Cap Co. in the Explosives Engineer during the mid 1920's. The ad neatly illustrates standard electric caps, delay-action caps, conventional caps, and their respective packaging. Delay caps 1 - 4 were commonly used for driving most tunnels and shafts, while higher delays were used for blasting stopes and large tunnels (Hercules, Inc).

What a miner was faced with as he looked at a working face loaded and primed with electric caps was an array of sealed drill-holes with two wires hanging out of each one. How the miner wired the shot depended on the number of holes to be fired and the source of electricity to fire the shot. The easiest and most commonly used wiring arrangement was the *series*, represented by Figure 7 (Firing Blasts by Electricity, 1905: 55). If there were over 75 holes to be fired, then the *multiple series* pattern was best, ensuring each cap received adequate current (Fig. 9). H. Julius Smith, recognizing the multiple series as best for blasts containing numerous charges, developed a blasting machine with three screw terminals on its top; two positive and one ground terminal. The concept behind this arrangement was that breaking the wiring into two circuits provided adequate current to all caps (Firing Blasts by Electricity, 1905: 55). By 1910 manufacturers dropped these machines from their lines.

Some large mines, such as the Utah Fuel Company's Castle Gate Mine, used electricity tapped from the mine's electric lighting system to fire their rounds (Harrington 1909: 243). The problem with shooting holes with this source of power was that the electric current was so great it detonated the first cap, breaking the circuit before the others in the round went off. To overcome this problem, the *multiple connection circuit* (Figure 8) was devised, eliminating the circuit's dependency on each cap remaining intact long enough for all to receive their charge before exploding (Firing Blasts by Electricity, 1905: 55).

Once the miner checked and polished all of the connections after wiring the round together, he connected the circuit's two remaining free wires to spools of blasting wire and paid them out to the nearest point of safety, where his blasting machine awaited. When he thought all was clear, the miner connected the circuit's lead wires to the terminals on the blasting machine, shouted the traditional "fire in the hole" and slammed the blasting machine's handle down, shooting the round.

Advertisement run in the Engineering & Mining Journal by the Electric Exploder Co. between the late 1890's and early 1900's. The blasting machine shown is an accurate reproduction.



The Aetna Powder Co.'s illustration accompanying the article Firing Blasts by Electricity run in the Mining & Scientific Press in 1905. The box of electric caps shown in the upper right, the blasting machine in the upper left, and the dynamite cartridges in lower left are probably an accurate representations of the products Aetna offered between 1889 and 1914. The cardboard box in the upper right was standard packaging for electric caps until approximately the 1940's, but the label is indicative of pre 1920's.

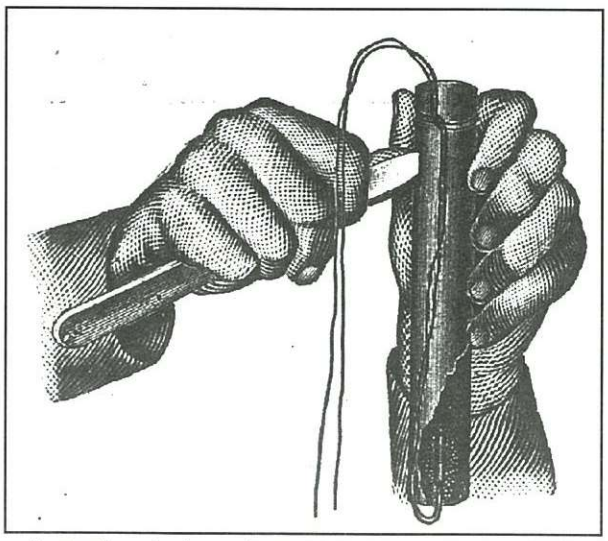
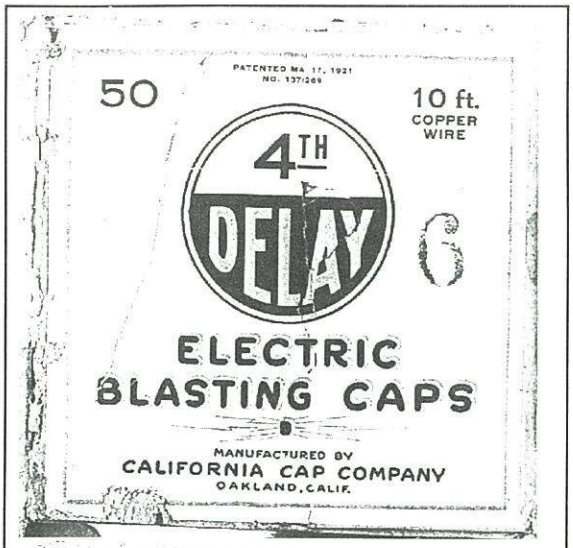
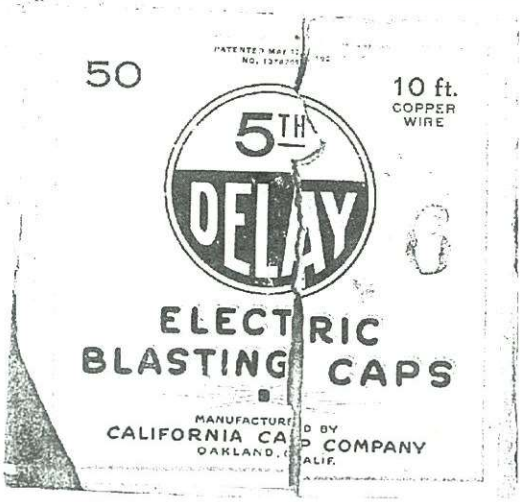
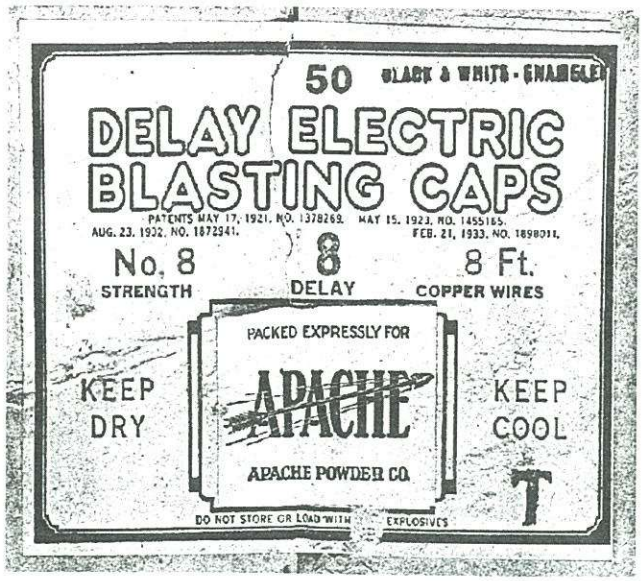


Illustration of a dynamite cartridge, properly primed with an electric cap, being slit end-to-end so it will expand in the drill-hole during tamping.

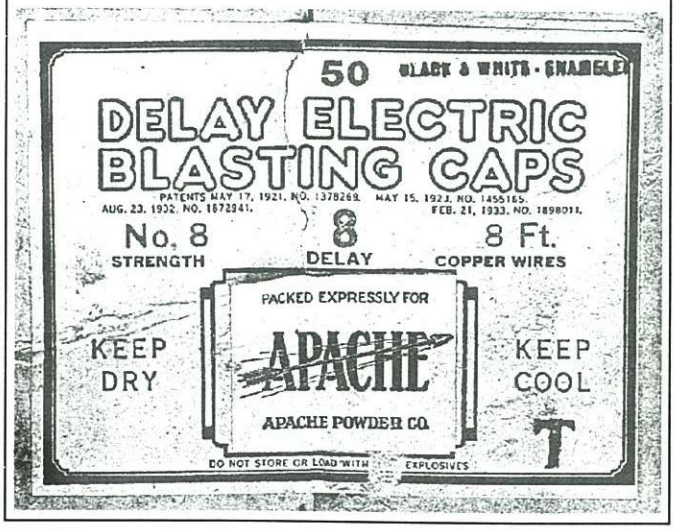


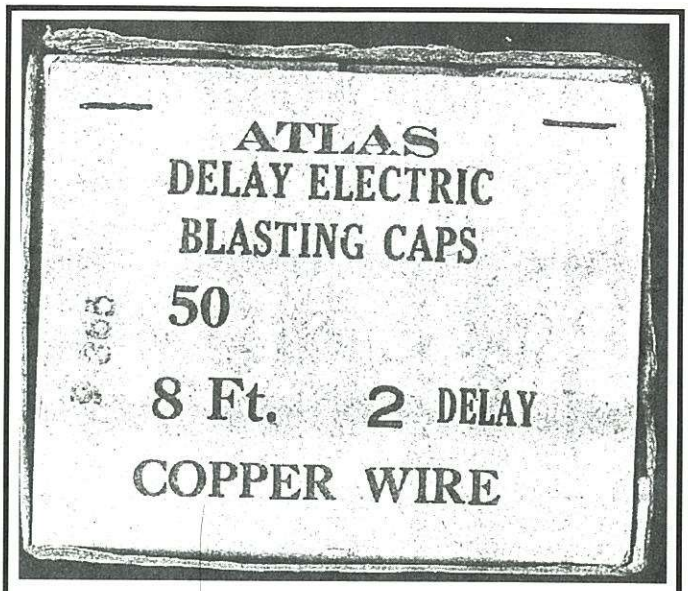


Photocopies of rare actual electric cap boxes made by the California Cap Co. sometime between the early 1920's and the late 1920's. Compare these labels with those shown in the ad. The variety of delays suggest either blasting in stopes, or driving a large tunnel. (Courtesy Andy Martin).

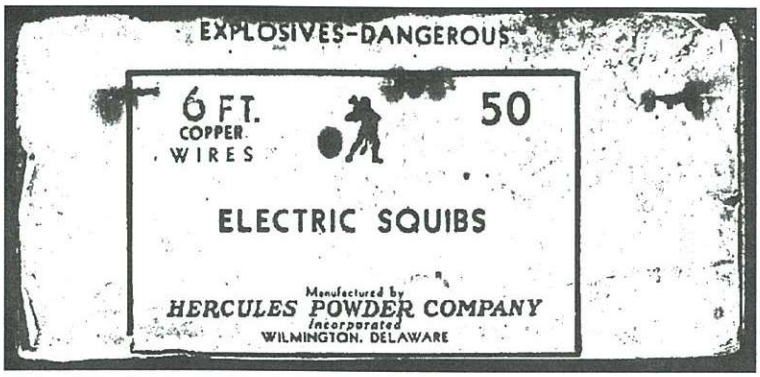


The two sides of a rare electric cap box sold by the Apache Powder Co. The patent numbers indicate this box dates between the mid and late 1930's. Several of the patent dates are those claimed by the California Cap Co. This fact, coupled with conventional California Cap tins featuring Apache's name, suggests the box was wholesaled from the California Cap Co. (Courtesy Andy Martin).





The two sides of a rare electric cap box sold by the Atlas Powder Co. The patent dates and company logo indicate this box dates between the late 1930's and late 1940's. (Courtesy Andy Martin).



Photocopy of a cardboard box containing electric squibs. Electric squibs operated according to the same principles as electric caps, and they were used to ignite blasting powder. They made their appearance in the 1910's, but never experienced popularity because safety fuse and match squibs were cheaper for igniting powder. Coal miners, which constituted the greatest consumers of powder, tended to buy the cheapest supplies. (Courtesy Larry Kuester).

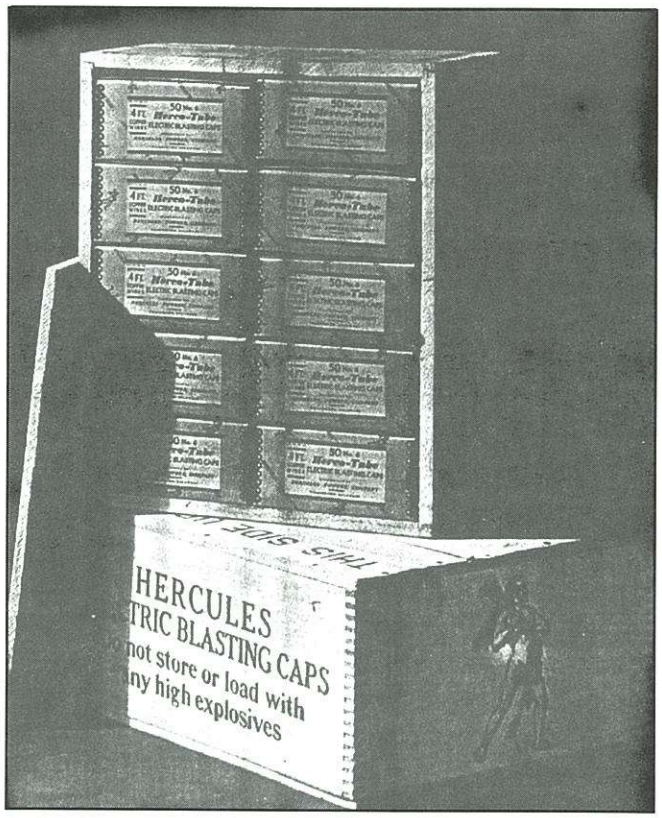
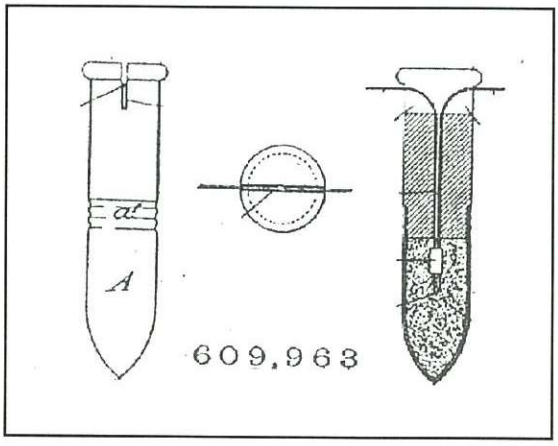


Illustration showing how manufacturers packed cardboard boxes of electric caps into the larger wood boxes for distribution to customers. The label on the wood box indicates it dates from the late 1920's to the mid 1930's. (Courtesy Larry Kuester).



A fundamental step in priming a dynamite cartridge was piercing the paper wrapper so the cap could be inserted. In 1898 William P. Fergusen patented an electric cap with a pointed nose designed to save the miner the trouble. Why this concept never became popular for electric and conventional caps is a mystery.

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Note: Many of the photocopies had to be reduced from their original size to fit this publication.