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Beginnings

By Lily Samuels and Bill Drakeley

From mine shafts to subway tunnels, from fountains to swimming pools, shotcrete has long been the preferred material of construction for major projects worldwide. This process, which involves the spraying of concrete material at a high velocity onto a receiving surface to achieve compaction, offers substantial advantages over alternative approaches with respect to durability, versatility, integrity, and sustainability.

This has been the case ever since the technique was invented at the turn of the twentieth century, yet only now are watershapers—professionals who have made concrete such a crucial part of their livelihoods—truly coming to understand and appreciate shotcrete for what it is.

Emergence

Shotcrete was born in the heart of a different world. In the late 1800s, the vast mining operations in the Lehigh Valley of Pennsylvania turned out huge quantities of iron ore, but the digging also extracted limestone, chalk, clay, and shale—the basic components used to manufacture portland cement, which, when mixed with water and aggregate, becomes concrete.

Fig. 1: Carl E. Akeley, father of shotcrete

First came the Lehigh Portland Cement Co., founded in 1897, and then the American Concrete Institute formed in 1904, with both emerging in response to the growing interest in using concrete as the foundation of modern construction.

In the 2000 years from the Roman Empire through to the early twentieth century, concrete was primarily cast-in-place—that is, liquid concrete was placed into tightly constructed molds of dense forming. While time-honored, this method limited the use of concrete to applications in which forming was possible.

This severely restricted concrete's use in tunnels, for example, and in other underground settings—which is ironic, given the fact that the Lehigh Valley's cement was a byproduct of iron-mining operations. The need for a different approach was clear. Happily, an inventor came

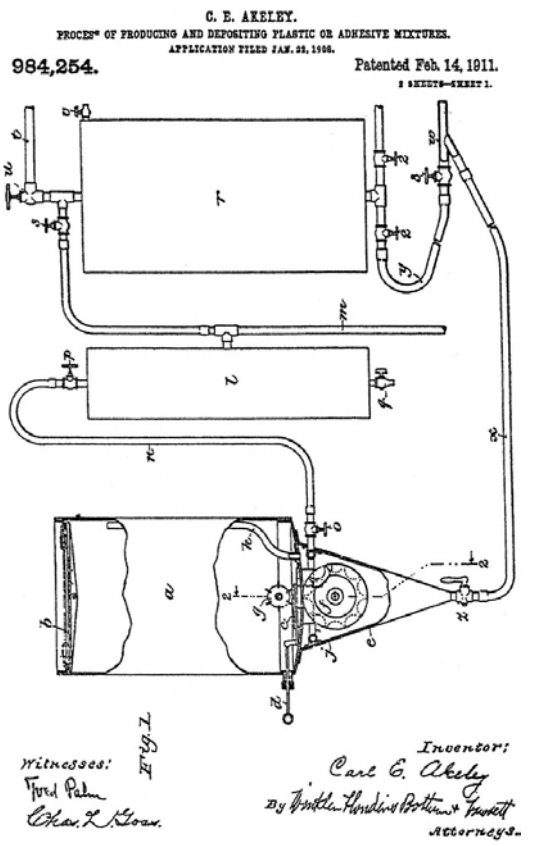

Fig. 2: Figure accompanying Akeley's patent application

along who found a way to break concrete out of its figurative shell.

A brilliant taxidermist, accomplished explorer, and mechanical genius, Carl E. Akeley was working just after the turn of the last century on techniques for hand-tooling realistic skeletal and musculature frames over which to fit the preserved skins of animals for museum displays. In 1907, a particularly insightful museum director saw what Akeley was accomplishing and gave him a different sort of challenge, asking him to replaster the faded façade of the Field Columbian Museum in Chicago.

To simplify the application process, Akeley assembled a pressurized, double-chamber "gun" that sprayed material onto the museum's vertical surfaces. No less a friend than Theodore Roosevelt, with whom Akeley had traveled for a year on an expedition to Africa, heard about this innovative system and encouraged Akeley to patent it—which he did. In 1911, he was awarded Patent No. 991814 for "an apparatus for mixing and applying plastic or adhesive materials."

The gun made its public debut that same year at the Cement Show in New York, where the publication *Cement Age* reported that "the cement gun was another revelation in the way of mechanical ingenuity."

The term gunite was coined a year later, based on the description of "gunning" of material through the device onto the receiving surface. In short order, the word "gunite" was trademarked and would go on to define the technology and its usage until the 1950s.

Growth

In 1916, Akeley sold his patent to Samuel Traylor, a mechanical engineer and the owner of the enormously successful Traylor Engineering and Manufacturing Co., which made its fortune in munitions manufacturing during World War I. Traylor had first encountered Akeley's machine at the Cement Show in 1911, and while he was fully aware of the initial mechanical problems Akeley had experienced with his early models, Traylor was convinced of its potential and moved forward accordingly.

For his part, Akeley engaged his wanderlust once again and ultimately succumbed to fever in the Belgian Congo in 1926. He died a relatively poor man, despite more than 30 patents he held for a variety of other inventions.

In 1920, Samuel Traylor acquired the Cement Gun Co. of Allentown, PA. His aim was to perfect and effectively market the cement gun, and along the way he singlehandedly launched the shotcrete industry. His new company fiercely guarded the "gunite" trademark while producing equipment and as a subcontractor, applying the material in

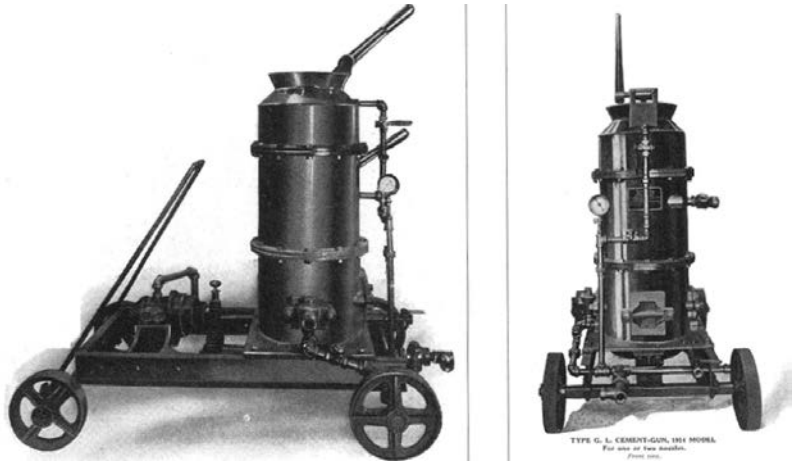

Fig. 3: A later cement gun model available through the Cement Gun Co.

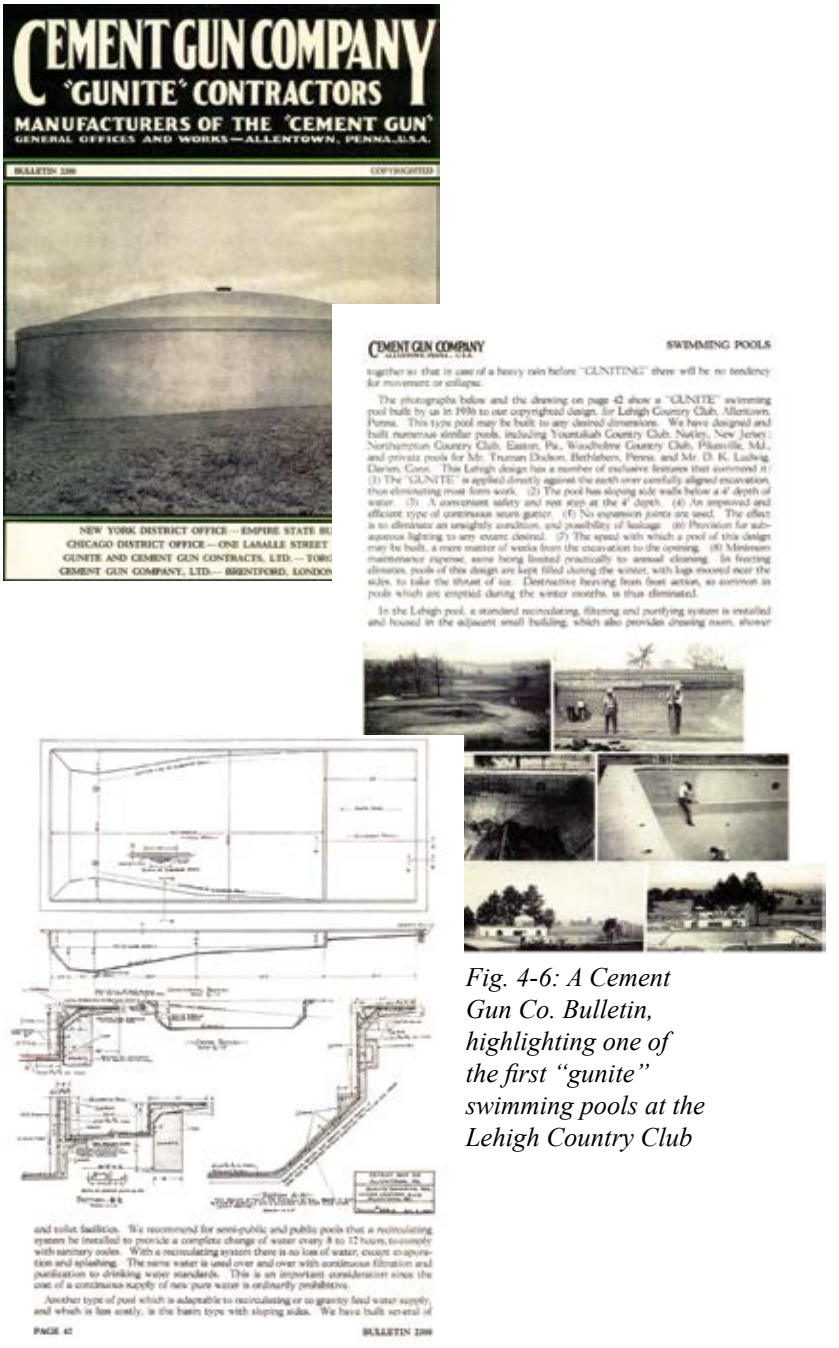

Fig. 4-6: A Cement Gun Co. Bulletin, highlighting one of the first "gunite" swimming pools at the Lehigh Country Club

thousands of projects globally using the dry-mix process. (Wet-mix had not yet been invented.) The company kept tight control by selling the equipment and simultaneously granting permission to use the application technology. Essentially, gunite was open for franchising.

In a savvy blend of due diligence and good marketing, the Cement Gun Co. relentlessly tested the gunite method and mixture designs, reporting their findings in technical papers and bulletins. One of the more fascinating examples here is a discussion of the installation of the swimming pool at the Lehigh Country Club in 1936. One of the first recognizable gunite pools, the structure was shot using a rock wall as the support substrate—the first "form" used in swimming pool construction.

This document is fascinating from a historical perspective, with a construction plan that was a model of careful engineering. But such publications were a method of control as well: They enabled the Cement Gun Co. to set the standard, defining what gunite was (and was not); regulating and setting patterns for use of the new technology; and popularizing both the product and the craft.

Traylor also took pains to see that the engineering community was engaged. The Cement Gun Co. published articles in magazines including *Concrete*, *Engineering News*, and *Structural Engineer*. In addition, testing was conducted at Lehigh University in Pennsylvania and later at the University of California to compare the gunite and cast-in-place methods—and thereby prove gunite's superiority. The wealth of data in circulation served to legitimize the method and consolidate the company's control over the young industry.

Domination

These efforts paid off. The Cement Gun Co. was a force to be reckoned with through the 1920s and 1930s, with the technology spreading to all 50 states and more than 120 countries around the world and finding uses in myriad structural, industrial, and geological applications.

But, as historians point out, while the Cement Gun Co. did much to popularize the method and promote best practices, its aggressive legal team and the tight grip it held on the trademark and the technology severely limited the development of equipment in response to the real-world needs of designers, engineers, and applicators.

This control had begun to diminish somewhat by the late 1930s, but real change came in the aftermath of World War II, when the hyperactive American industrial sector grabbed hold of gunite technology and forced both the company and the technology to diversify.

This diversification did not come without tradeoffs. Once gunite (and what would be known as shotcrete) was released from the powerful grasp of the Cement Gun Co., the industry—despite continuing growth trends—began losing its credibility and faced a lingering decline before coming to the present-day revival brought about by increased interest and investment in knowledge, best practices, and standards for shotcrete applications.

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