History has demonstrated that patents are excellent means of fostering creativity. By obtaining patents, civil engineers can protect their inventions and encourage others within the profession to devise better solutions to today’s problems. By Christopher A. Rothe, J.D.

The civil engineering patents issued today differ little from those issued during the early 20th century. Some patents—U.S. patents 976,939 (“Street-Traffic System”) and 6,900,740 (“Autonomous Highway Traffic Modules”), for example—suggest that such issues as traffic control will always be a component of civil engineering practice. Others—U.S. patent 511,713 (“Lift Bridge”), for instance—illustrate how the profession has evolved from a field that invents structures to one that not only invents them but also devises innovative ways of adapting those structures to new uses. These parallels are indicative of the evolutionary nature of civil engineering.

Most civil engineers understand that the profession advances through the shared experiences of each engineer. Solutions to modern-day challenges are often shaped through the exchange of ideas. Contrary to the notion that patents limit access to an idea or invention, patents are among the best ways of sharing solutions and inviting others to improve upon those solutions. Engineers who treat patents as an afterthought typically wait too long to file a patent application and ultimately miss the opportunity to obtain a patent. If a new solution is applied to a design but is never communicated to anyone, the profession will not benefit from this new solution. An engineer’s failure to obtain a patent, therefore, represents not only a missed opportunity for the individual engineer but also a missed opportunity for the profession.

The patent system in the United States is designed to reward innovation and advance invention. A patent for an invention is the grant of a property right to the inventor that is issued by the United States Patent and Trademark Office for a term of 20 years. This property right is considered a reward for the inventor’s investment of time and resources in testing and developing the invention. In exchange for the right to exclude others from...
employing the invention, the inventor agrees to disclose the invention to the public in the form of a patent, which is published by the Patent and Trademark Office. Once the 20-year term of the patent expires, the inventor’s exclusive right expires, and the invention enters the public domain for all to use.

The patent system also encourages innovation by motivating inventors to design alternatives that avoid issued patents. This practice, which is sometimes referred to as designing around patents, can lead to improvements over patented inventions that advance technology even further. Patented inventions and “design around” inventions are jointly responsible for many advances in the fields of science and engineering.

There is little doubt that the U.S. patent system fueled enormous progress in America during the late 19th and early 20th centuries. Civil engineers played a major role in this progress by inventing and building an infrastructure that enabled industry to expand. Those civil engineers who secured patents for bridges, dams, roads, and other civil engineering projects promoted progress in two ways: by sharing their inventions with the public and by inspiring their peers to improve upon those inventions.

The contributions of civil engineers are not always covered in history textbooks. Nevertheless, early U.S. patents tell the story of a time in American history when civil engineers were leading innovators in building the nation’s infrastructure. This infrastructure paved the way for other engineering disciplines to expand. The challenges faced by civil engineers have changed over time but have been no less significant in scope. As a result, the U.S. patent system remains an important tool in advancing civil engineering.

The framers of the U.S. Constitution proposed to provide government with “the power to grant patents for useful inventions.” The U.S. Constitution was ratified with a number of important provisions establishing governmental powers. Article I, section 8, of the Constitution authorized Congress to establish a patent system “[t]o promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries.”

Today, patent rights are set forth in Title 35 of the United States Code, which provides the patent owner with the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States. If the invention is a method or process, the patent owner is granted the right to exclude others from using the method or process in the United States and from using, offering for sale, or selling throughout the United States, or importing into the United States, products made by that method or process. Patent protection is available for different categories of inventions, among them processes, machines, articles of manufacture, and compositions of matter, and it also covers improvements to processes, machines, articles of manufacture, or compositions of matter. Title 35 sets forth a number of requirements and limitations that must be complied with in order to obtain a patent. For example, an invention must be “novel,” meaning that it cannot be subject matter that is already publicly known. Additionally, the invention must be nonobvious—that is, even if the invention differs from what is known in the art, the difference between the invention and what is known in the art must not be the result of an obvious change.

Within the context of civil engineering, patentable subject matter may include components or methods used in structural designs, water treatment, transportation engineering, or any other related discipline. The following examples of patents represent only a small selection of patents that were significant in their time. In some cases, the patents were significant for the inventions that they contributed. In others, they were significant for how they inspired others to make improvements.

On August 3, 1840, the Patent and Trademark Office issued U.S. patent 1,711 to William Howe. The patent was directed to a “Manner of Constructing the Truss-Frames of Bridges and Other Structures.” The truss design, which became known as the Howe truss, was considered revolutionary in many respects. Most notably, it was the first truss to employ vertical tension rods made of iron in place of vertical posts made of timber. Additionally, the Howe truss was among the first trusses to be designed using stress analysis. Figure 1 is a drawing that Howe submitted as part of his application.

The narrow vertical members represent iron tension rods; the diagonal members are braces and counterbraces that form compression members. The vertical tension rods are threaded rods furnished with adjustable screw nuts. The horizontal members, or stringers, that run along the top and bottom of the truss are drawn together by adjusting the screw nuts on the tension rods. In this arrangement the screw nuts can be adjusted to achieve a desired camber, or arching, of the truss. The Howe truss proved to be very strong over long spans. It was also relatively simple to erect because it could be prefabricated and transported to the installation site. These advantages prompted the railroad industry to incorporate the Howe truss into many of its railroad bridges.

The Howe truss aptly illustrates the benefits provided by the U.S. patent system in the mid-19th century. Howe’s patent gave him the right to exclude others from employing his design. This motivated other engineers and agencies to design alternative trusses. While the Howe truss was popular, it was not without its critics, and several engineers set out to invent superior truss designs to compete with it. Alternative designs emerged from such inventors as Caleb
Pratt, who in 1844 developed and patented a similar design that was known as the Pratt truss. Thus the Howe truss was important not only in terms of bridge projects, but also in how it encouraged others to improve upon its design.

In addition to trusses, civil engineers in the 1880s introduced innovative column designs. In 1862 the Patent and Trademark Office issued U.S. patent 35,582 (“Improvement in the Construction of Columns, Shafts, Braces, &c.”) to Samuel J. Reeves. The patent was for a column formed of three or more bars of wrought iron. The so-called Phoenix column, named after the Phoenix Iron Works Company—in Phoenixville, Pennsylvania—which produced it, was widely used to construct vertical posts, horizontal braces, and compression chords in buildings, piers, and bridges. Phoenix columns had very high load-bearing capacities, which made them particularly useful in constructing taller buildings because they eliminated the need to construct larger load-bearing walls and foundations. The use of wrought iron brought not only strength in bearing loads but also the ability to use riveting. Figure 2 is a drawing that Reeves submitted as part of his patent application.

In 1871 David O. Saylor was granted U.S. patent 119,413 (“Improvement in the Manufacture of Cements”). The Saylor patent was for an improved hydraulic cement manufactured from limestone and a process for manufacturing the cement. Saylor is credited with holding the first U.S. patent for portland cement. His patented process used a calcination step before crushing the material and passing it through a mill containing sand or buhrstone. Saylor, however, was not the first to market a hydraulic cement in the United States. At that time, vast amounts of portland cement were being imported from Britain. Saylor's cement was found to be comparable to the imported cement and was widely substituted for the import. The success of his manufacturing process was followed by improvements made by other inventors, including Thomas Edison, who patented a rotary kiln for manufacturing portland cement.

In 1893 the Patent and Trademark Office issued U.S. patent 511,713 (“Lift Bridge”) to William Scherzer. At that time, bridges for railways were being constructed over rivers. Because the bridges were built close to the water surface, they had to include mechanisms for opening the span to allow ships to pass. Before Scherzer’s patent, railway crossings were constructed as swing bridges. The bridge was opened to water traffic by pivoting the span in the horizontal plane. A significant amount of lateral clearance space around the bridge was required in order to accommodate the turning span, which typically crossed a section of riverbank adjacent to the end of the bridge. The need for clearance was undesirable because it rendered portions of the riverbank unusable—particularly those areas along the bank that were closest to the bridge.

To address this problem, Scherzer successfully built and patented the first bascule bridge in the United States. The span of a bascule bridge pivots or rotates in a vertical plane. This made bascule bridges far preferable to swing bridges because there was no requirement for lateral clearance space adjacent to the bridge. Scherzer’s design utilized a rolling lift that lifted the bridge span out of the shipping lane. The span featured a rounded end with a gear plate that engaged a horizontal rack plate. The span was opened by rocking the span along the rack plate under hydraulic or electric power. Figure 3 is a drawing that Scherzer submitted as part of his patent application.

Bridge construction was extremely competitive in the 1890s, and Scherzer’s engineering firm obtained a number of patents for its bridge structures. Backed by this patent protection, Scherzer’s firm won a number of construction contracts and built hundreds of bridges throughout the United States. Scherzer’s patents motivated a number of his competitors to design around his patents, and many of those designs were subsequently patented. The Scherzer rolling lift bridge was eventually replaced with a simpler design that used a horizontal steel pivot, or trunnion.

Bridge construction was a major step in building America’s transportation systems. As transportation systems expanded, engineers turned their attention to traffic control issues. By
the early 1900s, urban streets were becoming increasingly congested with various forms of vehicular traffic. Horse-drawn carriages began sharing roads with an increasing number of gasoline-powered automobiles. To control traffic, cities sometimes employed traffic police to regulate the flow through major intersections. Given the number of intersections that required traffic control, this practice tested the resources of municipalities. Additionally, traffic police could not establish a synchronized flow of traffic through multiple city blocks.

In 1910 Ernest E. Sirrine patented an automated system for controlling traffic that could be used to regulate traffic in large cities and other busy traffic areas. U.S. patent 976,939 (“Street-Traffic System”) disclosed a “changeable sign device” for installation at a street intersection, preferably in the middle of the intersection. The sign device had two display conditions that could be alternated. In the first display condition, the device signaled that traffic moving in a first line of travel could proceed through the intersection while traffic moving in the second line of travel—perpendicular to the first—had to stop. In the second display condition, the device directed just the opposite, signaling that traffic moving in the first line of travel had to stop while traffic in the second line of travel could proceed. Figure 4 shows the front and side views of the sign device that Sirrine submitted as part of his patent application.

Sirrine’s sign device included two separate display arms, each incorporating a display that faced one direction of traffic. Each arm rotated about a fixed horizontal axis between two alternating positions. In the first position, the arm displayed a first signal that directed the line of traffic to proceed through the intersection. In the second position, the arm displayed a second signal directing that same line of traffic to stop. The displays on each arm were arranged so that the signal conveyed to one line of traffic was the opposite of that conveyed at the same time to the crossing line of traffic.

The display arms were connected to reciprocating arms, which in turn were connected to a motor-driven cam and motor mounted in the base of the device. The cam rotated at a predetermined speed corresponding to an estimated traffic flow. To illuminate the signal device, the display arms were formed with glass panels and contained electric lamps mounted behind the panels to provide a back-lighted display.

The Sirrine patent was significant in at least two respects. First, it was the first U.S. patent to expound an automated traffic control method. The patented traffic control system did not require manual operation or assistance from traffic police. Second, the Sirrine patent was the first to depict a system of multiple traffic controls operating simultaneously to regulate traffic over large areas. Sirrine proposed installing signal devices at multiple intersections, each device operated at interrelated cycles. Figure 5 is a schematic plan view of the system that Sirrine submitted as part of his patent application.

Sirrine proposed using a signal device at each intersection. A central power source provided power to the motor in each signal device. Sirrine’s patent was soon followed by a number of other U.S. patents that sought to improve traffic control devices.

![Figure 4](image1)

![Figure 5](image2)
The patent is for a lining system formed of two staircaselike linings installed in the bank of a river or other waterway. The linings are formed of a series of lifts arranged in a stepped configuration. A separate grade control structure interposed between the two linings has a stepped configuration similar to that of the linings. The grade control structure forms a unified mass with the two linings to stabilize the bank. The linings and grade control structure are formed of soil cement.

The lining system may be installed at intervals along a bank. According to the patent, the grade control structures in adjacent installations are preferably spaced between 200 and 400 ft (61 and 122 m) apart. Figure 6 provides a schematic view of the lining system and a detailed view of a lining.

According to the patent, the linings and grade control structure offer a number of advantages over conventional concrete linings. For example, the lining system acts as a gravity retaining wall while offering more flexibility than concrete. In addition, the use of two separate linings requires a shallower excavation for each lining, resulting in a less invasive installation.

In the early 20th century, civil engineers were charged with designing and building bridge structures. Today’s civil engineers are being asked to upgrade existing bridge structures in response to such factors as increased traffic volumes. For example, engineers are now adding additional traffic lanes, pedestrian paths, and bicycle paths to existing bridges. These additions increase the weight of the bridge deck. The inherent flexibility in the structure of a cable suspension bridge allows a significant amount of downward deflection to occur when additional weight is added to the bridge deck. This downward deflection changes the vertical profile of the bridge, decreasing the vertical clearance beneath its deck. Such a change can affect shipping lanes that run beneath the bridge.

In 2004 engineer John D. Hinman received U.S. patent 6,728,987 (“Method of Adjusting the Vertical Profile of a Cable Supported Bridge”). According to Hinman, bridge engineers historically addressed downward deflection of bridge decks by offsetting the additional weight introduced by the new load. Hinman describes the example of a bridge modification in which a bicycle path is added across the bridge. According to Hinman, a known solution for addressing the increased load and resulting deflection is to replace the original concrete deck with a lighter steel structure. Off-setting the weight increase by replacing the deck structure allows the vertical profile to remain substantially unchanged. Hinman notes that the cost of such a deck replacement, however, is high.

Hinman proposes a method of modifying the vertical profile of a bridge by adjusting the relative position of the supporting cables relative to the deck superstructure. The method may be applied in two scenarios. In one scenario, the method can be used to permanently increase the vertical clearance between the bottom of a bridge superstructure and the water or ground level beneath the bridge. In the other, the method can be applied to temporarily raise the vertical profile of the bridge, allowing for a subsequent addition of dead load to the bridge so that the final bridge profile under the new load is substantially unchanged.

The physical steps of the bridge modification method involve sequentially lowering the lower ends of the supporting or hanger cables relative to the bridge deck. Depending on the type of cable attachment structure used, the attachment structure is moved or modified so as to connect the lower end of the supporting cables at lower positions relative to the deck. The lower end of each cable may undergo a series of adjustments until a final desired position is reached. Once the final position is reached, the new dead load is applied to the superstructure.

In one application of the invention, a tentative cable adjustment sequence is applied to a mathematical model of the bridge. An adjustment sequence is necessary to achieve the desired change in the vertical profile without overstressing the bridge elements. Once established, the adjustment sequence provides a proper order for adjusting the cables along with an appropriate distance for adjusting each cable. A properly tested adjustment sequence also allows the engineer to predict the final vertical profile of the bridge superstructure before commencing physical adjustments to the bridge itself.

Structural engineers are not only inventing new ways to improve our existing infrastructure. A number of engineers are patenting new ways of building commercial venues, particularly those in the sports and entertainment industry. The enormous popularity of college and professional sports has led to a recent surge in the construction of new stadiums and entertainment venues. Structural engineers are being asked to design state-of-the-art facilities to provide a superior venue for viewing sporting events.

In the past 40 years,
engineers have built stadiums in which roofs can be opened during warm and clear weather and closed during inclement weather. These designs have had mixed results.

In 2004 a group of structural engineers obtained U.S. patent 6,789,360 ("Retractable Roof System for Stadium"). The system includes a roof assembly composed of a fixed roof panel, an upper movable roof panel, and a lower movable roof panel. The fixed panel and the movable roof panels are positioned within a large opening in the top of the stadium roof. The movable panels move with respect to one another in an overlapping manner to open and close the roof opening. Figure 7 provides a schematic view of the system.

The two movable roof panels are supported between a pair of major trusses that extend along the maximum length of the stadium. Each major truss is structurally configured as a tied arch having a curved convex upper chord and a downwardly curved convex lower chord. A plurality of vertical structural members is connected between the upper and lower chords. According to the patent specifications, this configuration eliminates or substantially eliminates the use of diagonal structural elements within the major trusses. The elimination of diagonal truss elements is asserted to have two benefits. First, crisscrossing diagonal truss elements can create a much more significant visual obstruction for spectators seated in high areas of the stadium. Eschewing diagonal truss elements therefore decreases the potential that the superstructure will create a visual obstruction. Second, the tied-arch configuration is asserted to be substantially lighter than conventional trusses, placing less load on the roof. Figure 8 provides a schematic elevation view of a stadium with the tied-arch truss design described in the patent.

The major trusses each have guide tracks or rails for the movable roof panels. Each roof panel is supported on the guide tracks by a number of motor-driven carrier assemblies that glide along the tracks. The carrier assemblies are connected to the roof panels by a linkage system that compensates for movement of the two major trusses as a result of thermal exposure and the deflections caused by wind forces on the panels.

According to the patent, the roof panels may be lifted upward off the guide tracks in response to wind forces and other factors. By significantly reducing traction between the carrier assemblies and the guide tracks, this lifting can prevent the panels from moving. Therefore, each carrier assembly is configured with a retention assembly that biases the carrier assemblies downward onto the guide tracks to maintain traction along the track.

Highway systems represent another area undergoing modernization in the 21st century. As our highway systems continue to evolve, engineers are patenting new traffic control methods. In 2005, for example, a group of inventors received U.S. patent 6,900,740 ("Autonomous Highway Traffic Modules"). The invention provides a vehicle and safety control system that alerts drivers of accidents and other problems that lie ahead on the roadway.

In one illustration of the invention, the system uses ultra-wideband radio technology. A network of remotely located modules is located along the side of a highway or within a lane of a highway. Each module includes a measurement system with one or more sensors. The sensor obtains position and velocity data pertaining to vehicles on the adjacent section of roadway. These data may be collected from a plurality of modules and used to determine the position of a traffic accident or other flow stoppage on a roadway. Once a stoppage is found, the modules detecting the stoppage communicate with other modules in the network, particularly...
those positioned near traffic that is approaching the stoppage. The modules include lights or other display features to signal to drivers that they are approaching a flow stoppage. Module lights may be illuminated several miles in advance of an accident, flow stoppage, or slowdown to provide an early warning to approaching drivers.

In another example of the invention, the system includes a multiplicity of modules leading up to a major intersection. The modules determine the vehicular traffic queue status in each direction and adjust the traffic lights to clear the intersection efficiently. In contrast to earlier traffic control systems, the module system is described as being capable of monitoring traffic queues at locations farther away from the intersection and adjusting the signal times according to the distribution of traffic in each direction.

The process for obtaining a patent in the United States (referred to as patent prosecution) begins with the filing of an application with the Patent and Trademark Office. Once the application is filed, the application goes through an examination process. Inventors may prosecute their patent applications themselves or retain patent attorneys or patent agents to do it for them. In the United States, the inventor is considered the applicant. If the invention has more than one inventor, all of the inventors are considered coapplicants. Unless the patent application is assigned to another entity, the U.S. patent is issued in the name of the inventor. Patent prosecution is a somewhat lengthy process owing to the large number of patents the Patent and Trademark Office receives each year. The length of time between filing a patent application and receiving a patent may be anywhere from 18 months to three years or longer.

The laws and regulations that govern U.S. patent practice impose many technical requirements on the patent applicant, and a full discussion of these requirements is well beyond the scope of this article. In general, the patent application is required to include three components: a specification, one or more drawings, and one or more claims. The claims, which are generally regarded as the most important component of the application, define the boundary that surrounds the subject matter that the applicant regards as the invention. After the application is filed, the application is assigned to an examiner, who reviews the claims to determine whether the claims meet all of the requirements for obtaining a patent. If the claims meet all of the requirements for “patentability” and if the applicant satisfies all other requirements, the Patent and Trademark Office issues a patent.

A number of circumstances may bar an inventor from receiving a patent in the United States, but again a complete discussion of these circumstances extends well beyond the scope of this article. One restriction that is significant in the United States is a one-year bar imposed under section 102(b) of Title 35 of the United States Code. Under this section, an inventor is barred from obtaining a patent on any invention that has been patented or described in a printed publication anywhere in the world for more than one year. Likewise, no patent is possible on an invention that has been in public use or on sale in the United States for more than one year. An inventor who places his or her invention in public use, for example, must file a patent application within one year from the first date of public use. If the inventor does not file a patent application within this one-year window, he or she surrenders the invention to the public domain, and any patent application filed on the invention will be rejected by the Patent and Trademark Office. The patent laws of the United States encourage inventors to be diligent about developing their inventions and bringing them to the attention of the Patent and Trademark Office as early as possible. Accordingly, inventors are encouraged to treat patent protection as a priority when beginning the development of an invention.

At present, the civil engineering profession appears to focus less on patent protection than other engineering disciplines. While there may be a number of reasons for this, the civil engineering profession should continue to use the patent system as a mechanism for advancing the profession. Such works as bridges, buildings, dams, and roads will remain a part of this country’s infrastructure. Therefore, there will always be a demand for engineering designs that are better able to withstand natural disasters, acts of terrorism, and other destructive forces. Moreover, such problems as traffic management and stabilization of riverbanks will require more creative solutions as these problems become more acute. Patents provide a key resource for ensuring that solutions to these problems are shared and improved upon within the civil engineering profession. By communicating inventions through patents, civil engineers can ensure that the civil engineering profession remains in step with challenges, both old and new.

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