PATENTS

In October 1861, the United States Patent Office issued a patent (No. 33,384) to Zenas King and Peter Frees, both of Ohio, for an improvement in trussed beams for bridges, specifically for tubular arch bridges. Their invention related to the tubular construction of the arch top chord. By increasing the section area of the arch toward center, and correspondingly decreasing it toward the ends, they could supposedly strengthen the structure by reinforcing the areas under the most stress. The primary objective was to design a bridge of the same strength with less metal or, as they indicated, make a stronger bridge, using the same amount of metal. The increase in sectional area was usually limited to the vertical dimensions, and did not ordinarily include the width or lateral measurements. Although they based their improvement on a rectilinear cross-section, they claimed it was also suitable for tubular wrought-iron arches in other forms. To prevent problems of decay, they inserted a cast-iron washer or plate into the recess of the top channel; the bottom of the washer or plate was grooved to allow rain to pass over the top of the arch to the ground.[16]

Six years later, King received another patent (No. 58, 266) for an improvement on his earlier design. Although his claim rested primarily on a unique bottom chord connection, it included a reference to the top chord sectional area. Ironically, the top chord was designed wider at the ends than in the center, exactly the opposite configuration as in the earlier patent. The justification, however, remained the same: to give the bridge more strength. The design of the Milford Bridge top chord is based upon this principle.[17] In another patent revision received the following year, King completely eliminated the varied sections of the tube.

KING IRON & BRIDGE MANUFACTURING COMPANY

Zenas King first became involved with the bridge building industry in 1858, when he started working as an agent for the Moseley Bridge Company in Cincinnati. Thomas Moseley invented the first practical tubular arch bridge in America made from wrought iron boiler plate. Within several years, King and Frees started their own bridge building firm in Cleveland, Ohio, an operation that also included a boiler works. In 1864, they dissolved their partnership, allowing King to devote himself full-time to bridge construction. King established an enormously successful business. He chose to concentrate heavily on the bowstring and swing designs prior to 1880. The bowstring was lighter than other iron bridges and, therefore, less expensive to manufacture. In addition, his use of standardized, prefabricated parts in the manufacturing process gave him a competitive edge in the market. His firm could produce large quantities of bridges (200 feet of bridges daily). His use of agents and subsidiary companies throughout the country allowed him to distribute his bridges over a geographic area. The size of the Cleveland firm increased rapidly in the 1880s, from 40 to 360 workers. Although King died in 1892, the firm continued into the twentieth century.[18]

BRIDGE CONSTRUCTION

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BRIDGE CONSTRUCTION

The two bridge spans vary in length (5 feet) and slightly in height (4 inches). The top chord is constructed of two side and parallel plates. They are connected by an upper and lower plate running the entire length of the arch, the edges turned at right angles so they could be riveted to the side plates, a design forming recessed channels on the top and bottom. If the section area had been increased to accommodate a longer span, a third channel plate would have been riveted to the middle of the tube for additional stiffness. Another innovation on King bridges was the use of continuous wrought iron plates. For short spans, the company usually used a single piece to make the sides, top and bottom of the tube. For longer spans, the plates were not continuous, but bolted together with splice plates.[19] The Tivoli Island Bridge uses non-continuous plates.

The bottom chord consists of two parallel flat iron bars forged from large rods, the rod shape still evident at the ends of the bars. Except for the riveted plates of the upper chord, pin-connections secure the joints. The cruciform posts extend through holes in the upper chord with nuts and cast iron washers fastening the ends. The diagonals and bottom lateral bracing consist of cylindrical rods with threaded ends. U-bolts hold deck beams against the

KING BRIDGE AND IRON WORKS

Zenas King was born in Vermont in 1818. Five years later, he moved with his family to upstate New York, where he grew up on the family farm. He left the farm in 1840 and went to Milan, Ohio, where he held a number of successive positions, as a carpenter, a clothing merchant, and a salesman.(19) King's first experience with bridge building occurred in 1858, when he became an agent for the Moseley Bridge Company in Cincinnati, Ohio. The company's owner, Thomas W.H. Moseley, was the inventor of the first practical tubular arch bridge in America made from wrought iron boiler plate.(20) In a relatively short time, King began to experiment with a tubular bowstring design of his own. Moseley moved to Boston about 1860, and King went to Cleveland, where he established a bridge and boiler works.

Although King hoped to establish his business on the basis of marketing an innovative bowstring arch bridge, it was more likely his introduction of mass-produced wrought iron bridge parts that eventually led his company to become one of the leading bridge companies in the United States during the second half of the nineteenth century.(21)

In 1870 King established a branch of his bridgeworks in Iola, Kansas. About a year later, the branch moved to Topeka, claiming that they needed better transportation facilities.(22) Fragmentary documentation, however, indicates that the company branch went bankrupt.(23) The Springfield-Des Arc Bridge was probably one of a very few bridges manufactured by the Iola plant. Despite the failure of the Iola branch, the Cleveland firm thrived throughout the next few decades. King's use of standardized parts allowed his company to manufacture large quantities of bridges, and agents and subsidiary companies allowed King to distribute his bridges over a large geographical area.(24) Although King died in 1892, the firm continued into the twentieth century.(25)

ZENAS KING'S PATENT

The rapid growth of highway and railroad systems in the second half of the nineteenth century "fostered bridges which were efficient in their use of materials and labor."(26) The bowstring was considered a very efficient design because of its high carrying capacity and use of a relatively small amount of iron.(27)

King's bowstring arch bridge design incorporated a tubular arch, which increased in size toward the crown of the arch, where the strain would be greatest. (See patent in appendix.) A uniform section would be wasteful of materials. The first two times King and his assistant, Peter Frees, applied for a patent, they were refused on the grounds that the concepts were not new, because Charles DeBergue, an Englishman, had patented a similar design in 1848.(28) Eventually, in 1861, King and Frees received their patent, after showing that their design incorporated continuous wrought iron plate in the top chord, as opposed to DeBergue's short cast iron sections.(29) King received a second patent in 1866, for an "improvement" to his original design, which in effect reversed the configuration of the first design. This time, the tubular section of the top chord increased at the ends of the arch, and got smaller at the crown. The following year, he revised the patent again, eliminating the varied section of the arch.(30) The Springfield-Des Arc Bridge follows the design of the 1866 patent reissue, with the tubular chord of the arch getting larger at either end.