near Pittsburg. The span was first assembled on piles near the shore. Then nine large barges, partly submerged, were floated beneath it. Timber trestles were built from their decks to the lower side of the steel girders. When the water was pumped out of the scows, they lifted the entire structure clear of its former supports. The long, flexible line of boats, carrying the great mass of steel & timber 150 ft. high and weighing 3,600,000 lbs., was pulled out into the river, revolved through a quarter circle, & towed by steamboats to the bridge site, where the span was deposited on top of its 80 ft. piers.

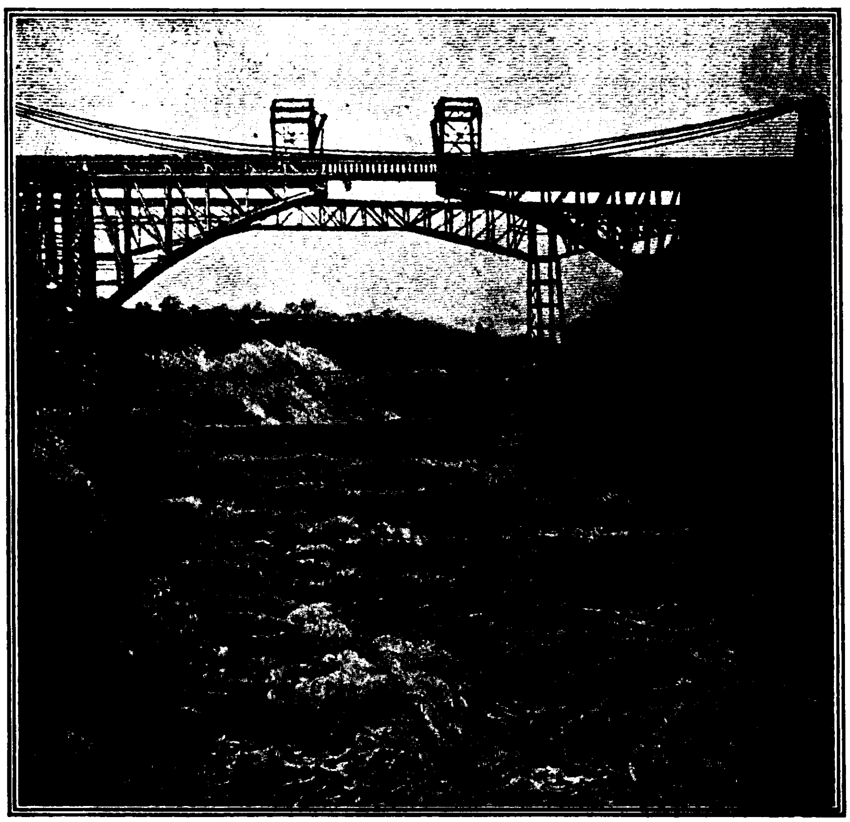
An unusual method was adopted recently for replacing a heavy 236-ft. span carrying the main line of the Pennsylvania R. R. across the Schuylkill river. Temporary timber piers were built in the river above & below the old span at both ends. These piers supported a low bridge, the top of which formed a platform on which the new span was assembled. Double sets of long steel rails were laid across the tops of the piers at both ends, & 150 solid steel rollers placed between the top & bottom rails of each set. The new & old spans were lowered to rest on the upper rails, & four powerful tackles being attached to them, & operated by as many hoisting engines, moved both spans sidewise until the new span completely displaced the old one & was ready to receive traffic. Then the low bridge which had formed the erecting platform was rolled across underneath, as the main spans had been, & was used to support the old span while it was being removed. This operation involved moving 950 tons 27 ft., & it was accomplished in 2½ minutes, in an interval between the crossing of two trains, an achievement which probably has never been paralleled.

In foreign countries a favorite method of erecting bridges is to assemble all the spans together in one continuous structure on shore at one end of the bridge, & then to push the whole mass forward on rollers till it advances successively from pier to pier, resting on rollers on top of each, & finally attaining its required position. The protrusion is usually effected by gangs of men with long ratchet levers laboriously turning the rollers.

The longest trussed spans in the world are two 1,710 ft. cantilevers of the famous Forth bridge in Scotland—a gigantic structure which weighs over 100,000,000 lbs., which was over seven years in building, & which cost $16,000,000 & scores of human lives. From each of the three main piers rise huge wedge-shaped steel towers that cover spaces nearly a city block in area & reach 361 ft. above the water. From each side of each tower there extends a pair of great curved trusses, 680 ft. long, that balance each other, &, approaching the ends of corresponding arms from the next piers, sustain between them separate complete bridge-spans of 350 ft. that are there suspended above the loftiest topmasts of the ocean ships passing below. These overhanging arms that are unsupported at their outer extremities are cantilevers. They have been adopted for all the greatest trussed spans, because by their use the opening can be virtually subdivided into three parts, each having its separate trusses, & thus can be made lighter, & can be more advantageously built. On the American continent the largest cantilevers have been built of struts & ties & beams manufactured at the shops & rapidly fitted together with single large bolts or pins, but in the Forth bridge the principal members of the trusses are enormous steel tubes made of thick plates, curved, fitted, & riveted in place. Large shops were built on shore, special machinery was designed for them, & the manufacture of the bridge progressed there adjacent to its erection.

First the inclined posts of the main towers were built up from the bottom. Each of the four columns forming a tower is a 12 ft. tube large enough to run a railway train through. These columns were built together & braced against each other, while powerful hydraulic presses inside of them supported & constantly lifted in advance pairs of heavy iron girders, themselves as massive as ordinary railroad bridges, & from these girders the machinery & materials were supported. Following them, circular cages inclosed the tubes & supported the men & machinery that riveted the cylinder plates together. After the towers were completed the cantilever arms were extended from both sides, & sustained themselves at all times by their own rigidity without requiring any support. The curved arch-like top & bottom pieces of the trusses were also 12 ft. steel tubes, which were ingeniously built out in their approximately horizontal extensions by means of a sleeve-like framework that projected beyond the end & was furnished with derricks for assembling the steel plates of the cylinder. As fast as the sections were fitted together the rear part of the inclosing sleeve was removed and built on in front, so as to advance it enough to support the next section, & so on.

The Forth bridge is characteristically English, massive in design, & ponderous in the very methods of construction & erection. The contrast with American types is exemplified by our great cantilevers that span the Missouri, the Hudson, the Niagara, & other rivers. These latter are lofty, slender structures that look against the sky like etchings on glass, yet they inflexibly sustain express trains & endure without a tremor the hurricane blasts that sweep through the chasms which they span. Another distinction between English & American methods of bridge construction is found in the greater rapidity which the latter make possible. In building the Mississippi river bridge at Cairo, Ill., a 2,000,000 lb. span 518 ft. long was erected in six days. Probably no European span of equal length was ever assembled in tenfold this length of time.


Three great types of long-span railway bridges over the Niagara River, showing engineering progress in the last half-century; the 800-ft. suspension bridge built in 1855; the 550-ft. arch replacing it in 1897; the 470-ft. cantilever (one of the first ever built) erected in 1883—each of the three about 240 ft. above the head of the Whirlpool Rapids.

The four great railway bridges across the Niagara river gorge stand as an epitome of American bridge engineering. They illustrate the development of bridge construction during the past half-century, & afford examples of all the types of heavy spans. These bridges cross a chasm more than 200 ft. deep, at the bottom of which water of great & unknown depth rushes along at tremendous speed. It is said that the first communication between the opposite banks was established by flying a kite across, & that the string of this kite served to pull across a rope, which in turn conducted above the stream the cables sustaining the light highway bridge erected in 1847. In 1855 this bridge was replaced by the famous suspension bridge, the first of its kind. The successful creation of this structure was a monument to its builder, Roebling, and vindicated his designs.

The general construction of the suspension bridge, & the manner in which its trusses were supported from four great cables, each formed of 3,640 parts of an endless straight iron wire, wrapped together in a cylindrical bundle 10¼ ins. in diameter, have been so often described as to be generally familiar. But the first building of the bridge was scarcely more remarkable than the manner in which it was from time to time repaired and reconstructed.

After the bridge had been in service for 22 years, it was found that some of the small wires of the main cables were being weakened by rust. The defective portions were removed, & new pieces were spliced in under strain, & so delicately adjusted as to carry their exact proportion of the total load. A little later it was discovered that, while each cable had a resisting strength of 6,000,000 lbs., the strength of the anchor chain was less than 3,500,000 lbs. To remedy this discrepancy the anchor pits were opened, the chains which supported the whole weight of the bridge & of the constantly passing trains were disconnected, & new bars were added