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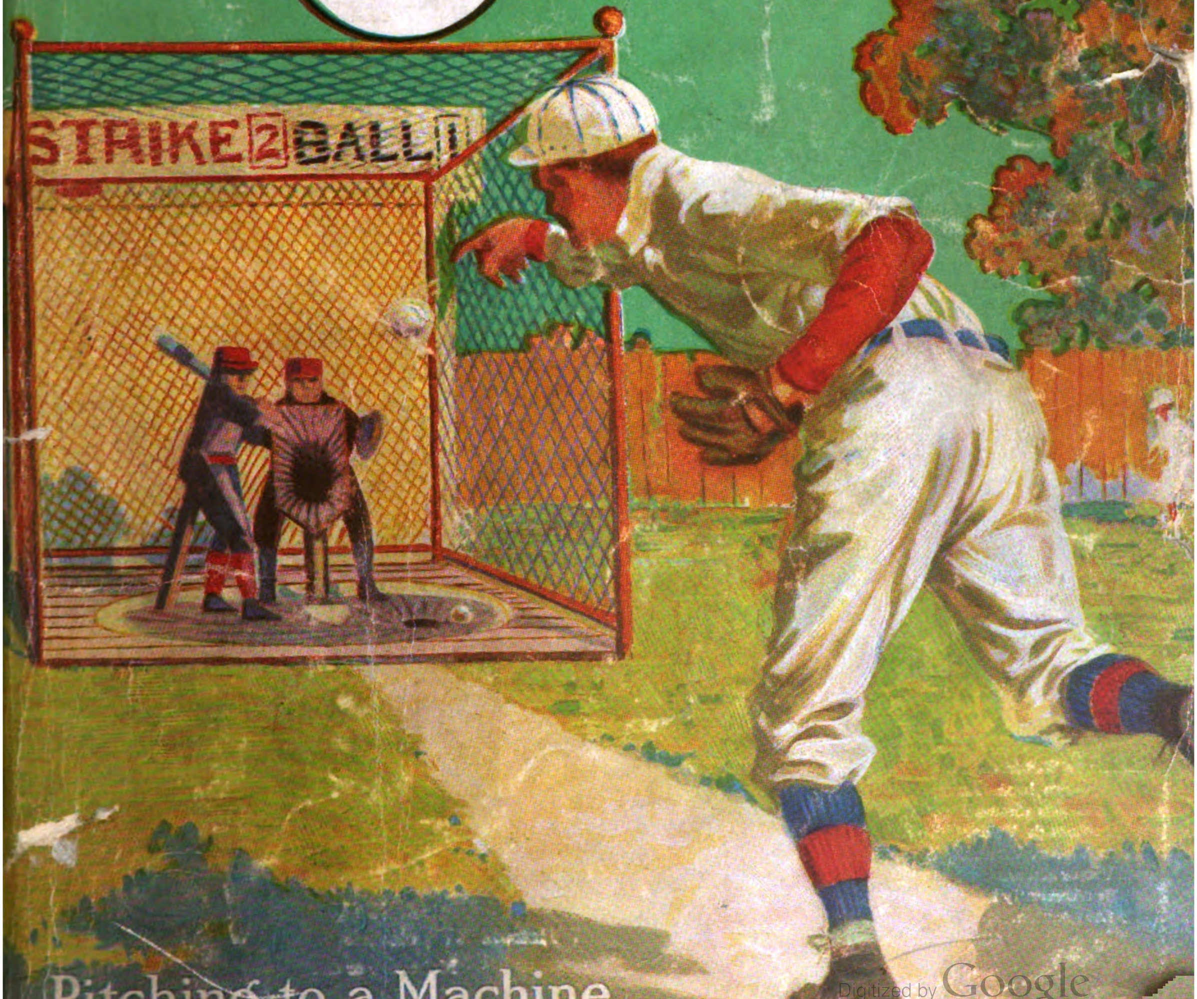

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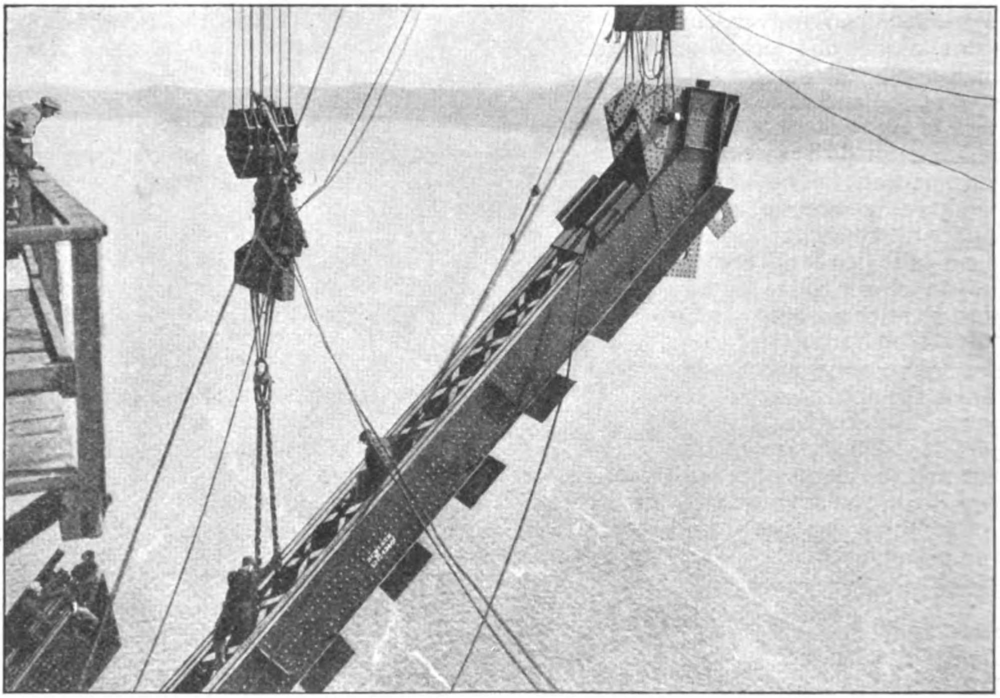
Mahogany or oak

Quebec's Disastrous Bridge

How the principle of a diver's spring board is applied in the building of the biggest cantilever bridge

By C. E. Drayer



One of the cantilever arm-compression diagonals being placed in position. Like the operations of an army in the field, the work of erection has a dash of danger and romance. As the success of the army in action is due to the output and character of the shops behind the lines, so the speed of erection of a structure is due to the excellence of the shop work

THE new Quebec cantilever bridge ranks among the most important and brilliant of all construction. The boldness of a great general in war pales by the side of the courage of its builders, who had little precedent to follow in some of its vital and most difficult features of design and erection. Besides, they had to proceed in the shadow of the ghastly catastrophe of its predecessor which crumpled and fell, carrying to death nearly a hundred men.

That this shadow was not an imaginary one is evidenced by the recent disaster when the suspended span fell from fifteen feet above the water while being hoisted to position. The best engineers in American erred not in design, but, if at all, in failing to be superhuman. The latest failure can delay for but a short time the finishing of the great structure. Very soon the successful placing of a new span will be recorded.

It all happened in about five seconds. While practically all dependable evidence of the cause of the last disaster is under two hundred feet of water, eye witnesses agree that, following a report like a cannon, the south upstream corner slipped off its lifting girder and corkscrewed into the river.

The most probable explanation of the failure is that the steel rocker casting under the south upstream corner suddenly crumpled (see diagram page 732). The truss then dropped on the short carrying girder, kicking it out, or turning it enough to let the corner of the truss slip off. Had the accident happened an hour earlier, many prominent engineers of the United States and Canada who were on the span witnessing the lifting would have been lost. As it was but a dozen lives were lost.

The failure of the summer of 1907 cannot happen to the new bridge. While the lower chord of the old bridge was but four and a half feet square and had seven hundred and eighty-one square inches of solid steel in its cross-section, the same chord of the new bridge is seven feet two inches deep and ten feet four inches wide and has a cross-section of nineteen hundred and two square inches of steel—two and a half times the amount in the old bridge.

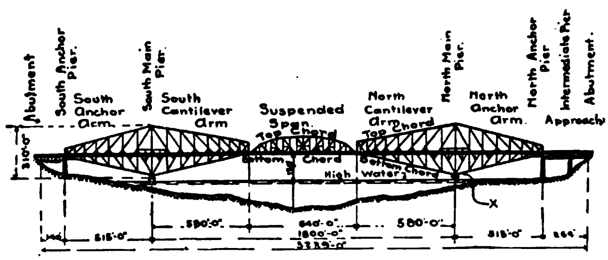
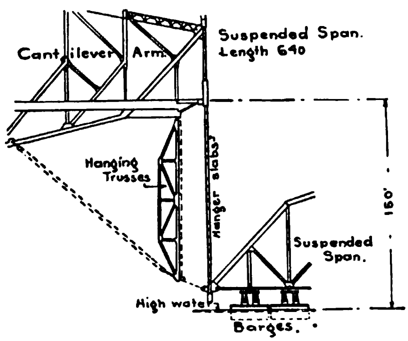


Diagram of the new Quebec Bridge. "X" marks the point where the bottom chord of the old structure crumpled. The expansion of cantilever arm and suspended span, due to temperature changes, is taken up by brake shoes at the connections, each capable of resisting a force of one hundred and twenty-five tons. Even the difference of temperature, due to one side of the bridge being in the sun and the other in shadow, was calculated with accuracy

The familiar spring board at the swimming hole is a good example illustrating the principle of cantilever construction adopted for the Quebec bridge. The load is carried by the projecting portion, which is supported by a weight at the back end sufficient to keep it from raising. The suspended span is like the boy standing on the end of the spring board. The suspended span and cantilever arm tend to raise the anchor arm, which must be heavy enough to prevent that under any circumstances. Naturally the bridge engineers desired to keep the suspended span and cantilever arm as light as possible. Hence they made all the truss members of the suspended span and the greater part of the trusses of the cantilever arm of nickel steel, which contains one per cent of nickel and is one third stronger than ordinary steel.

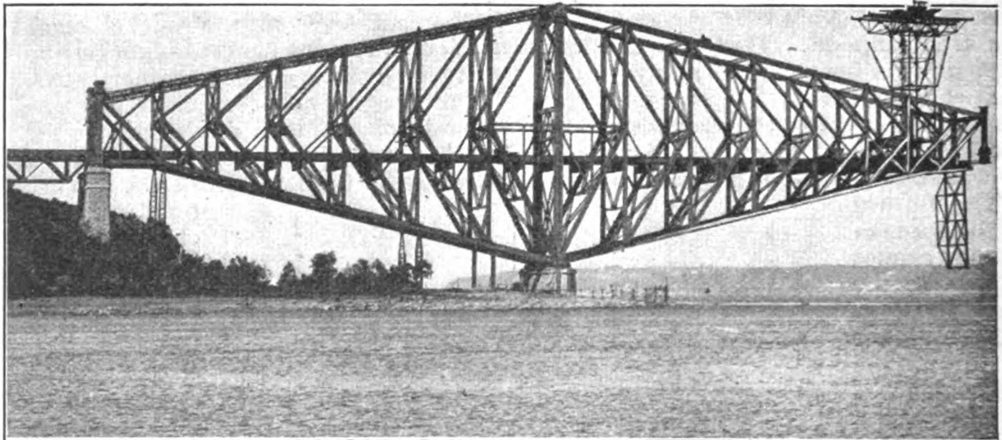


The method of raising the suspended span in position. When the tide came in, the span was afloat and was towed by tugs to the bridge, where it was anchored to the hanging trusses and coupled to the hanger slabs. It was raised by hydraulic jacks

The designer must consider first the natural and artificial limitations of the location and then the traffic to be carried. At the location of the Quebec bridge, the channel of the St. Lawrence River is nearly two hundred feet deep. The stream is swift and subject to high tides. The traffic of ocean-going ships must not be interrupted. These considerations, together with the kind of foundations available, determined that the span over the channel should be eighteen hundred feet long, ninety feet longer than the famous Firth bridge in England, heretofore the longest span ever built. The length of span, together with economy and rapidity of erection, determined the type of bridge, a cantilever. The bridge will carry a double track railroad and two sidewalks.

After the main dimensions of the steel, "superstructure" it is called, had been figured out, plans for the masonry were made. The north stone masonry pier was carried to fifty feet below the bed of the river, twenty feet above bed rock, where a satisfactory foundation was found in the form of large and small boulders firmly wedged together. The south pier encountered sand for the whole distance. So it was carried to bed rock, eighty-six feet below the river bed. Most of the sand was removed by blowpipes.

The Quebec Bridge—A Modern Wonder of the World



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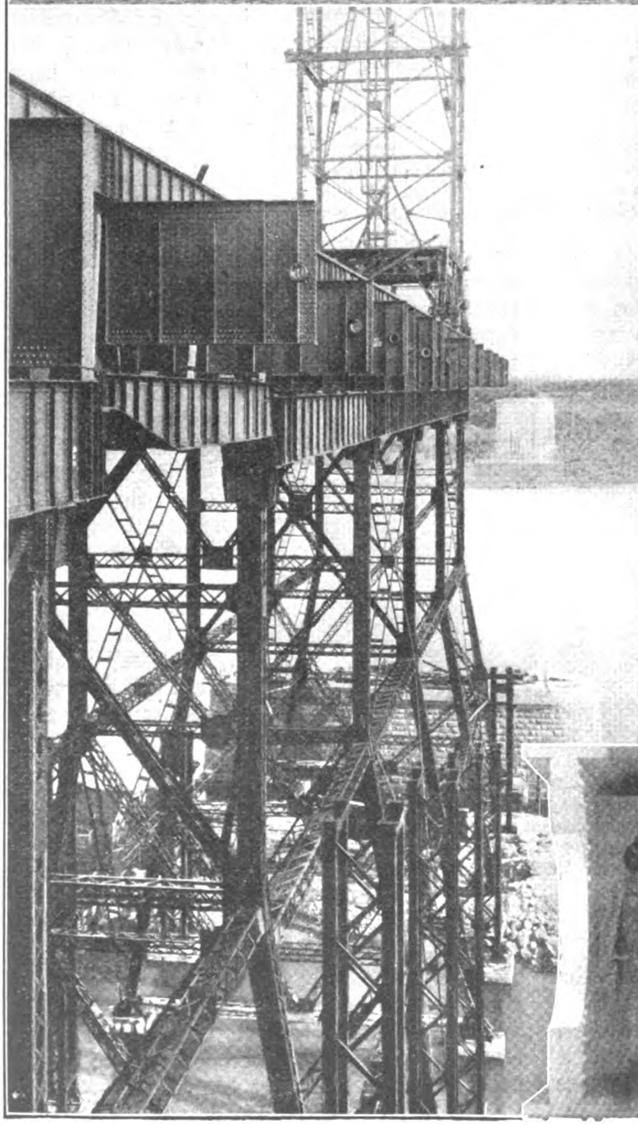
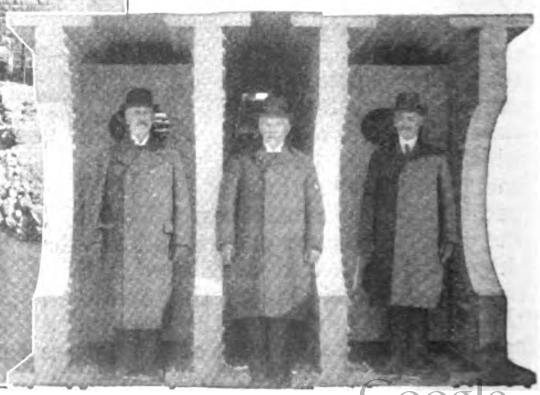


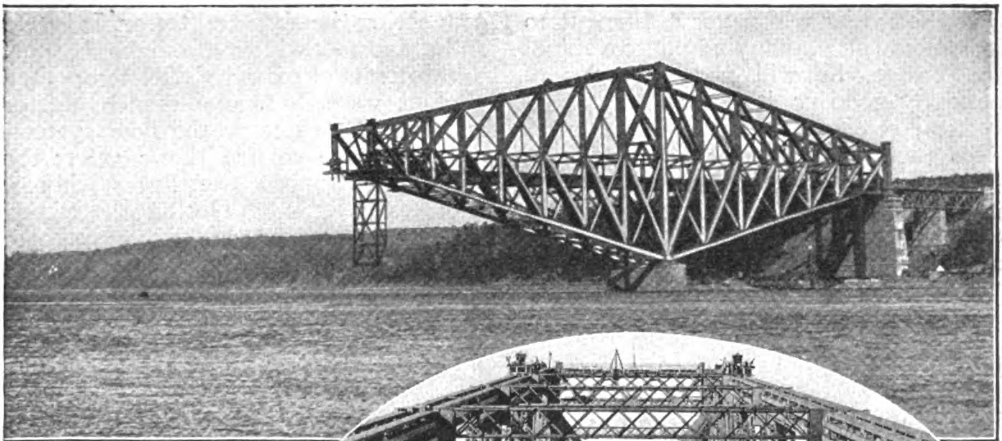
The Quebec Bridge has a span over the channel of eighteen hundred feet, which is ninety feet longer than the famous Firth of Forth Bridge, heretofore the longest span built. Near the main post, the bottom chord for each panel weighs 400 tons, making it necessary to split it into four pieces in order that it could be carried by railway to the site

To the left, a picture showing how the floor of the anchor arms was erected on temporary staging. In order to manufacture the steel work an entirely new plant was built, equipped with machinery of unprecedented size and accuracy, costing a million dollars

Below is shown the bottom chord of the cantilever arm. The men are standing at the pin-bearing for the main shoes. The diameter of the pin is forty-five inches. Each rib is eight inches thick



and the Terrible Disaster that Befell It



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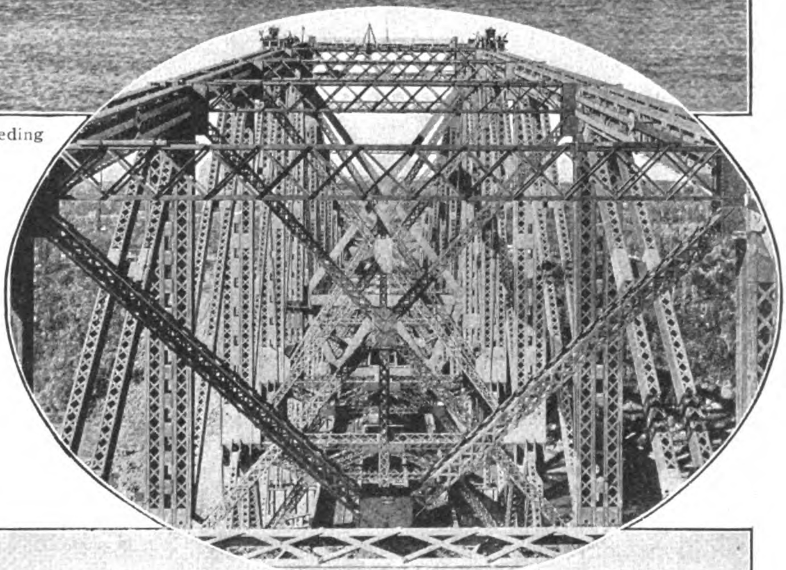
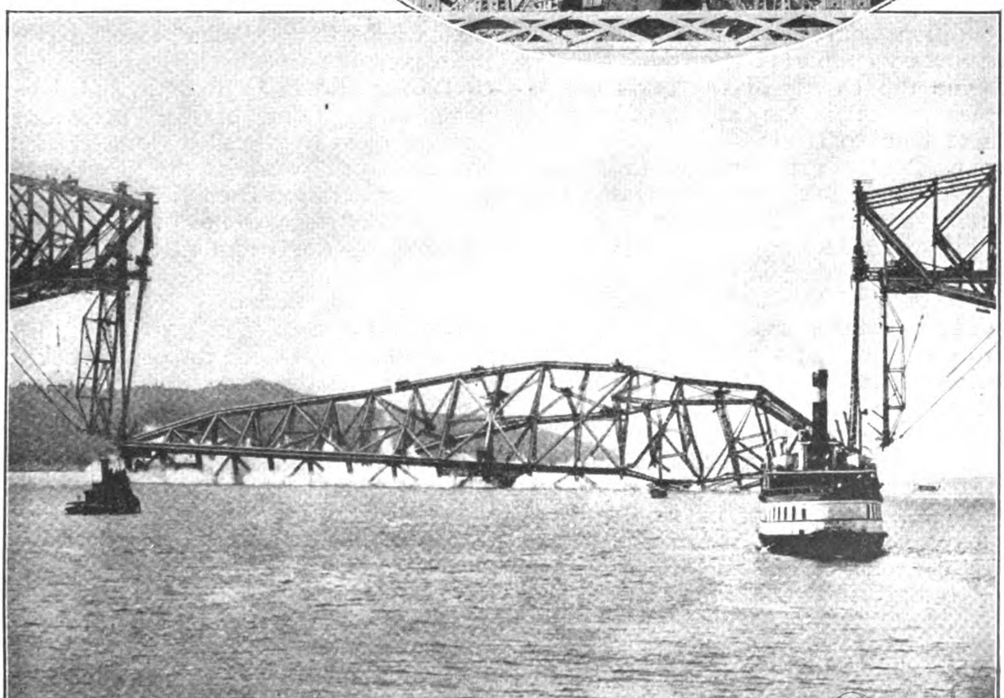
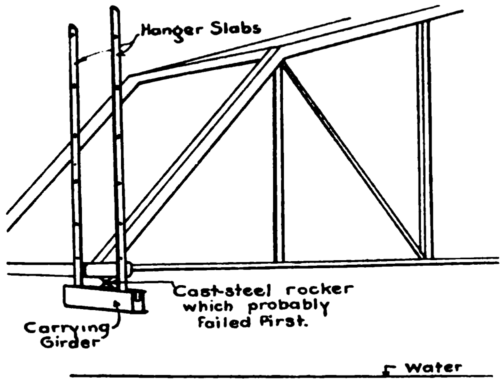


Above: The steel frames hanging from the end of the cantilever arm. The picture shows the hanging trusses in place. To the right: The wind-bracing

Below: The suspended span, weighing 5000 tons, photographed at the instant the mass struck the water



If the reader will pause a moment to look at the accompanying photograph of the bridge, he will note a series of perfectly good capital K's made up of vertical steel posts and diagonal rods. This picture shows also the traveler, which is nothing more or less than a great steel tower carrying gigantic movable cranes on top to handle the heavy pieces of steel, some weighing one hundred tons. By examining the diagram of the bridge, it will be seen that both north and south sections of the bridge, symmetrical about the main piers, are made up of a series of K's. The "K" system has a number of advantages for a bridge of great size. Chief of these is that during erection of the cantilever arms, each panel or "K" can be completed without temporary supports and the traveler moved out to the end. It will be remembered that conditions at this bridge site made temporary supports out of the question.



How did the disaster occur? Probably the steel rocker casting under the south upstream corner suddenly crumpled. The truss then dropped on the carrying girder, kicking it out or turning it enough to let the corner of the truss slip off

The top chords of the arms are in tension; that is, the forces acting upon them tend to stretch them. So, they are made up of great eyebars, thirty-two of them on either side of the main posts having a cross-section of eight feet of solid steel. The bottom chords are in compression; that is, the forces acting on them tend to shorten them.

The great post over the main pier is three hundred and ten feet high and weighs fifteen hundred tons. It is composed of four posts latticed together into a rectangular tower nine feet by ten feet. The shoe under the main post has a bearing on the stone pier of twenty-two feet by twenty-six feet and is nineteen feet high, and weighs four hundred tons. Like some other parts of the bridge, it was shipped in pieces, each weighing one hundred tons. Another measure of the magnitude of this modern wonder of the world is the pin connecting the shoe and tower. It is two and a half feet wide and weighs six tons.

Two sets of massive steel temporary viaduct were built under each anchor arm, one set to carry the floor system, which in turn carried the traveler; the other to support the lower chords. During the winter of two years ago, the traveler, weighing a thousand tons, was built on the north shore. In the spring it was moved to the main pier and the shoes placed. The traveler then moved back from the main pier, placing the lower chords on the temporary viaducts. It was moved out to the main pier again and on the way back the trusses erected up to the point where the vertical and diagonal legs of the "K" intersect. Arriving at the anchor pier, it began to erect above the intersection of the legs of the "K."

Thus the anchor arms were erected. But when the traveler reached the main pier, it naturally had to erect the cantilever arm in front of it, panel by panel. A "flying bridge," projecting forward from the finished work, carried the permanent work of the panel until it was riveted up. The flying bridge was composed of pieces of steel with one end fastened to the completed work, the other projecting out into space and held up by suspension rods.

The suspended span was assembled in a shallow cove some three miles below the bridge at the same time the south cantilever arm was being erected. Six barges thirty-two feet wide by one hundred and fifty feet long were placed under as many panel points. When the tide came in the span was afloat and was towed by tugs to the bridge, where it was anchored to the hanging trusses and coupled to the hanger slabs. The plans were to raise it to its final position in a few hours by eight one thousand-ton hydraulic jacks, two at each corner.