THE ST. JOHN STEEL CANTILEVER BRIDGE.

This splendid structure, illustrated by four engravings herewith, has for the first time afforded direct rail connection between the railroads of the State of Maine and the United States in general and those of New Brunswick and Nova Scotia. Previously, communication was broken by a ferry at St. John, N. B., where all freight and passengers had to be transferred to other cars, the ferry not being adapted to the transportation of cars.

The bridge was opened for general traffic on the first day of October, the opening ceremonies taking place September 30. It crosses a natural site for a bridge, if there ever was one which could be called such, and the project has existed in an inchoate state almost from the beginning of railroad construction in the regions concerned; but it has been only recently that the decreasing cost of such structures and the increasing volume of the traffic to be accommodated have made it practically possible.

From its source in northern Maine, the St. John River, flowing first northerly and then easterly, sweeps in a large semicircle around the highlands which form the eastern extremity of the mountain system of Maine, and thence runs southerly to the Bay of Fundy. For some hundred miles above its mouth it is more an arm of the Bay of Fundy than an ordinary river, but almost directly at the mouth of the river, for a few hundred feet only, its current is greatly contracted, to pass through a narrow gateway between two solid ledges which rise abruptly a hundred feet above the water surface, and are now spanned by the structure illustrated. Through this gateway the river passes directly into the bay of the city of St. John, and thence to the Bay of Fundy at a point some forty-five miles east of the international boundary line.

The well known excessive rise and fall of the tide in the Bay of Fundy prevented the adoption of car ferriage, necessitating the complete break referred to in the railroad system at this point, passengers and freight alike having to be transferred.

As will be seen from Fig. 4, the tide rises and falls 22 feet directly under the bridge twice a day, making a current which at certain hours is almost unparalleled in its violence. A cantilever or suspension bridge was therefore the only reasonable type for the locality. A highway suspension bridge just below the site of the new bridge (shown in Fig. 2) has existed for many years, but the choice between the cantilever and suspension types for railroad purposes is no longer doubtful.

The main river bridge consists of a central span of 477 feet, supported on granite piers, which are 9x27½ feet on top, the east pier being about 96 feet high and the west pier about 50 feet. The cantilever arms are 143½ feet on each side of the pier at the east side and 191 feet at the west side, the end of the east arm being supported on masonry abutments placed in an excavation made in the solid rock, and the west arm

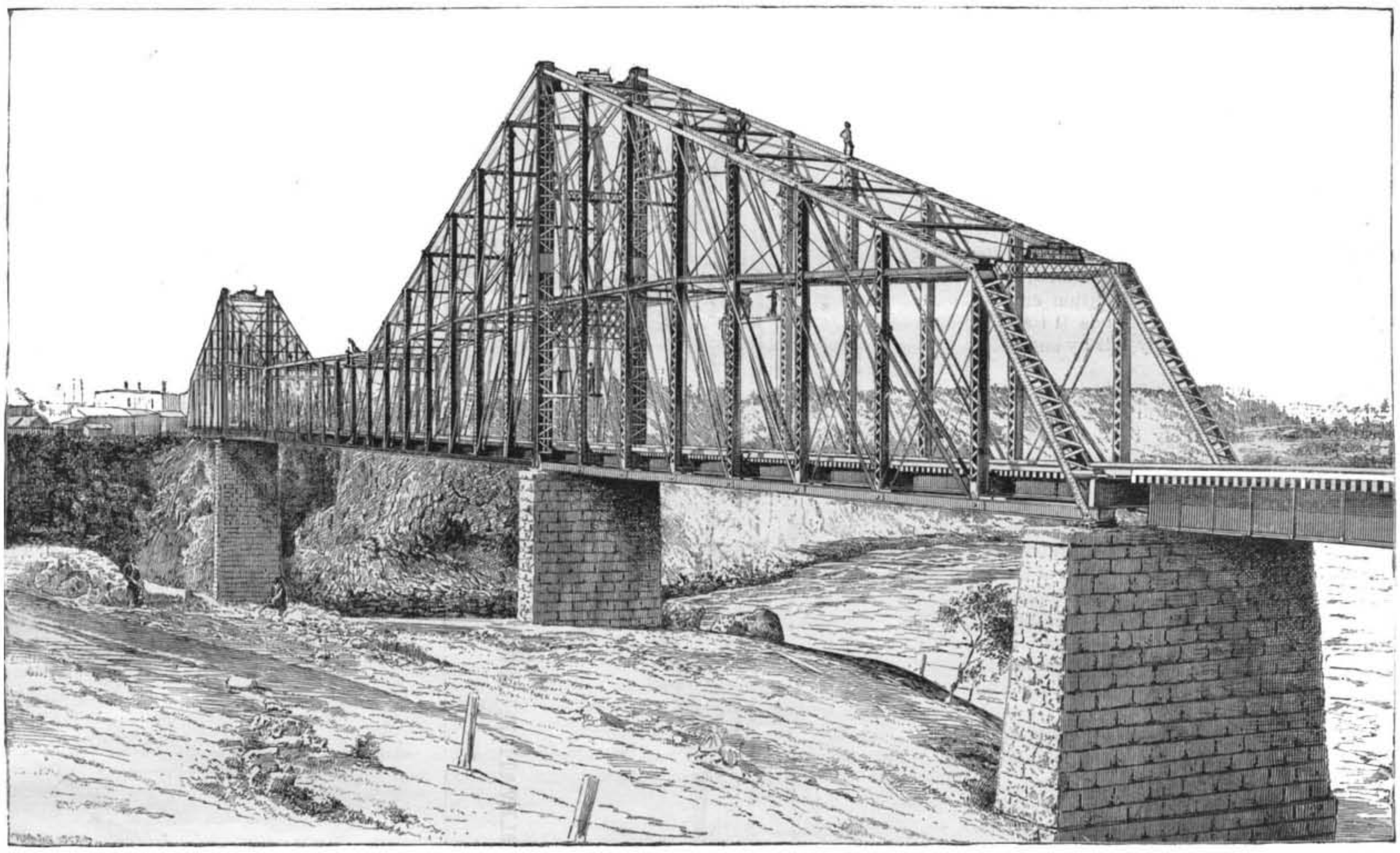

Fig. 1.—STEEL CANTILEVER BRIDGE OVER THE ST. JOHN RIVER, AT ST. JOHN, N. B.—VIEW FROM WEST END.

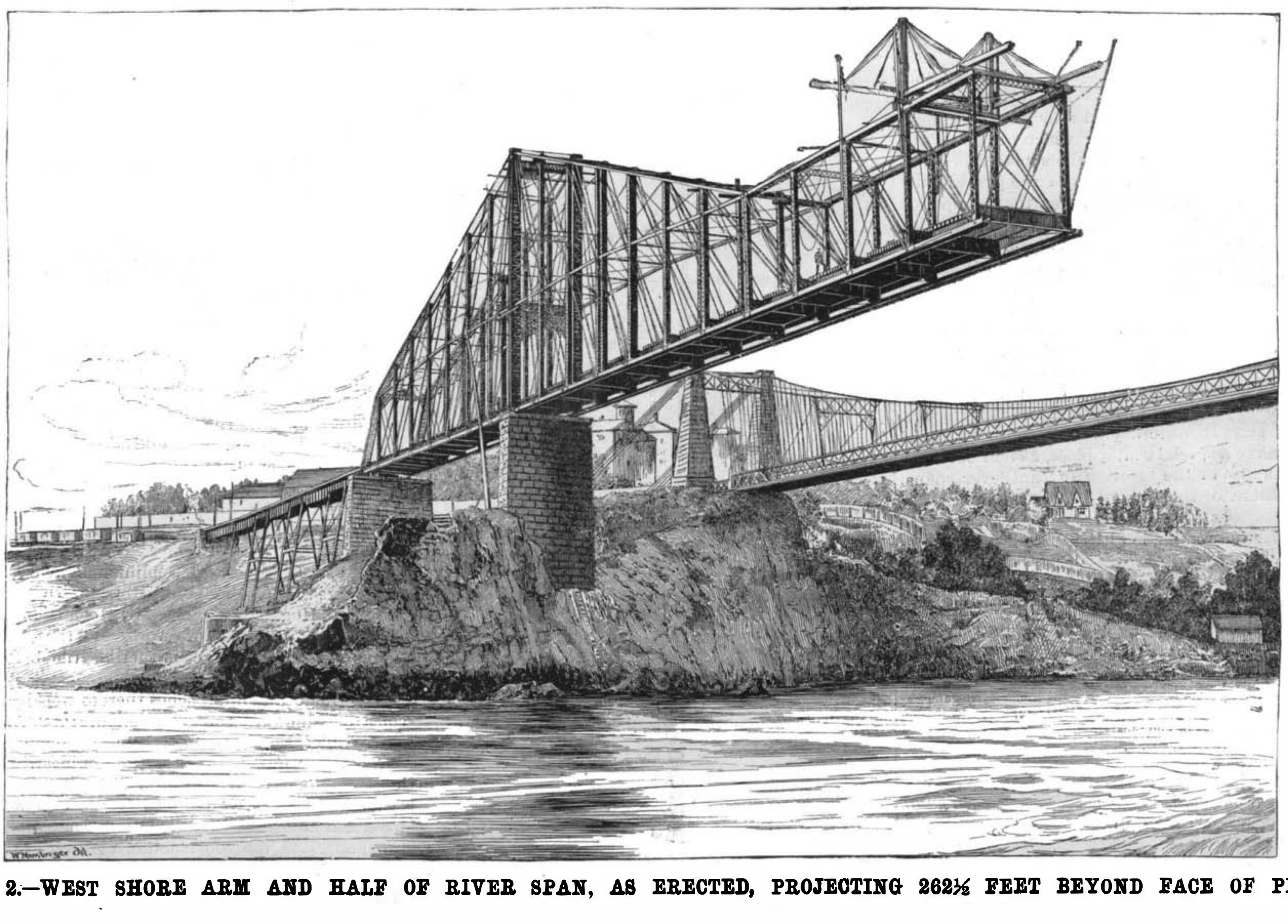

Fig. 2.—WEST SHORE ARM AND HALF OF RIVER SPAN, AS ERECTED, PROJECTING 262½ FEET BEYOND FACE OF PIER.

being supported by a granite pier 8x34 feet at the top and of about 40 feet in height. The central span is 143½ feet, and is essentially an independent truss span, as in other bridges of this type, the ends being supported by the ends of the cantilevers. The depths of the trusses over the piers are respectively 65 and 80 feet, and the short arms at the ends and the center span are each 27 feet in depth. The panel lengths of the trusses are about 24 feet, and the track is supported on the lower chord by means of steel floor beams 3 feet in depth, riveted between the struts and posts, and by four lines of longitudinal stringers 30 inches deep, riveted between the floor beams. Upon these are placed the wooden ties carrying the rails, 8x8 inches in section and 17 feet long, placed 8 inches apart.

The structure is proportioned to sustain a train load of 1¼ net tons to the running foot in connection with two engines weighing 45 tons each and followed by tenders each, with the usual strains per square inch for various parts. [The Niagara cantilever was constructed for a rolling load of two 50 ton consolidation engines followed by a train weighing 2,000 pounds (1 ton) per lineal foot, the latter being generally felt by engineers to be too light.]

The ends of the cantilevers at the abutments are secured by anchor rods to a gridiron of rolled beams placed 27 and 32 feet respectively below the bridge seats at the east and west ends, upon which rests a weight of masonry amounting to about 780 and 880 tons, about three and half times the greatest calculated upward strain with the span on the piers loaded and the shore arms unloaded. The arrangements for allowing expansion and contraction consist of a nest of rollers placed under the shore arms at each abutment, which allow the shore arms to expand and contract by simply swinging the anchor rods round the pin connection in the gridiron of beams beneath the masonry. The expansion in the center span is allowed by slotting the upper and lower chords at the ends of the cantilever arms, and allowing the center span to swing on the vertical post which supports it at the end of the cantilever arm.

The shore arms of the bridge were erected by means of false work placed between the piers and abutments, upon which was placed the lower chord and floor system of the span. Upon this part was erected a movable tower derrick 100 ft. high, 24 ft. long, and 16 ft. wide, running on a temporary track of 14 ft. gauge, which serves as a means of raising the different pieces of the shore arm and holding them in position while being connected, the hoisting of the pieces being effected by means of an engine having eight hoisting winches, which was placed on the track and moved along in connection with the tower derrick. The shore arms having been thus erected and the derrick brought up to the post over the pier, the traveling crane for erecting the river arm, shown in Fig. 3, was raised up and set on top of the pier post, and the tower derrick was taken down and removed. The traveling crane shown in Fig. 3 is 72 ft. in length, the forward portion projecting out over the river 1½ panel lengths, or 36 ft., and the rear arm being secured to the upper chord of the shore arm already erected.

The tackle for raising and supporting the parts constituting one panel of the river arm was suspended from the overhanging crane, and they were connected to form the complete panel, after which the crane was moved forward on temporary timbers placed between the upper chords until it rested on the post already put in position. The next panel was then completed in the same manner, and this process was continued until the center of the river span had been reached.

The same mode of erection was then applied to the opposite side of the bridge, and continued until the two spans joined in the center. The connection between the center span and the cantilever arms was made solid during the process of erection by means of adjusting screws at the lower chord and adjustable stirrups at the upper chord, which were so arranged that the two halves of the center span could be moved in and out for the purpose of making a connection at the center without having to make a special center piece, as had been the previous practice in the erection of cantilever spans; and the location of the masonry and construction of the ironwork was so accurately carried out that the center connection was made without the slightest delay or difficulty.

The chief dimensions of the bridge were in detail as follows: We add for comparison the similar details of the Niagara cantilever bridge, the nearest similar work, which was begun about the same time, but reached completion some eighteen months earlier:

		St. John. ft. in.	Niagara. ft. in.
Length over all, centers of end pins		812 6	910 1⅝
Length center span		143 6	119 9
Length each cantilever		287 0 / 382 0	395 2½
Length center opening in the clear		477 0	470 0
Height wrought iron towers		.....	130 6½
Height masonry piers		96 and 50	39 0
Length of panels	cantilevers	24 0	25 0
	center girder	24 0	24 0

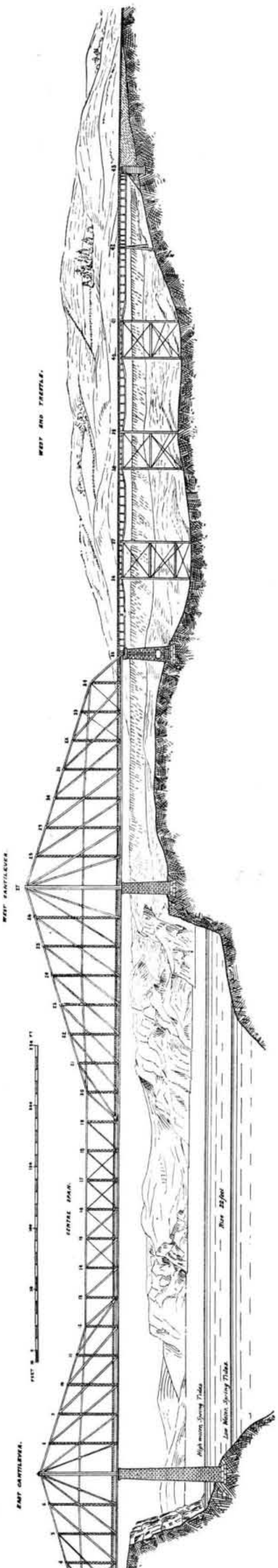

Fig. 4.—STEEL CANTILEVER BRIDGE AT ST. JOHN, N. B.—SIDE ELEVATION, LOOKING DOWN THE RIVER.

		St. John. ft. in.	Niagara. ft. in.
Width, center to center of trusses		20 0	28 0
Depth cantilev. trusses	over towers	80 and 65	56 0
	over river ends	27 0	26 0
	over shore ends	...	21 0
Depth floor beams		3 0	4 0
Depth longitudinal stringer		2 6	2 6
Ties (white oak) center to center		16 in.	18 in.
Ties, size		8 ft. x 8 in. (x 17 ft.)	9 ft. x 9 in.
Guard timbers			8 ft. x 8 in.
Weight (tons of 2,000 lb.)	steel	....	636·0
	wro'ght iron	....	1,546·3
	cast iron	....	63·2
Timber in floor, M feet B. M.		....	153·7

In rapidity of erection of ironwork, however, the St. John bridge compares very favorably even with that surprising example of rapid construction, the Niagara cantilever, when the proper allowances are made, notably for the fact that work was prosecuted on both ends at once on the Niagara bridge, but from each side in succession at St. John. Where both records are so remarkably creditable, comparisons would be odious, but those who choose to make them can do so from the following details of the erection records:

ST. JOHN CANTILEVER BRIDGE.

			Days
Erection of west shore arm	begun	April 9	
	finished	May 4,*	25 days.
Erection of west river arm	begun	May 9,	5 "
	finished	June 4,	26 "
Erection of east shore arm	begun	June 6,	2 "
	finished	June 21,	15 "
Erection of east river arm	begun	June 24,	3 "
	finished	July 9,	15 "
Total			91 "

First engine crossed July 20, 1885.

NIAGARA CANTILEVER BRIDGE.

		American side.	Days.	Canadian side.	Days.
Erection of towers	begun	Aug. 29		Sept. 10	
	finished	Sept. 8	10	Sept 18	8
Shore arms	begun	Sept. 25	17	Oct. 8.	20
	finished	Oct. 15	20	Oct. 22	14
River arm	begun	Oct. 28	13	Nov. 4	13
	finished	Nov. 22	24	Nov. 22	18
Total			84		73

First engine crossed Nov. 30, 1883.

Whole structure completed and opened Dec. 20, 1883.

The bridge was tested by the government engineers July 31, less than four months after the commencement of the erection, by two trains, each having two engines weighing 60 and 65 tons, followed by loaded flat cars weighing about 30 tons each.

These trains were placed first on the shore arms without any load on the central portion of the structure between the piers, which caused a deflection of one-quarter to three-eighths inch in the center of the shore arms, and an elevation of three-eighths to five-eights inch in the center span.

On the second loading, the four engines were brought together at the center of the center span, and the cars allowed to cover the entire length of the bridge on each side, under which load the deflection was 3¾ inches at the center of the center span, and less than one-eighth inch at the centers of the shore arms.

The third loading was the same as the second, except that the cars on the shore arms were removed, and under this load the greatest deflection at the center of the center span was 4 inches, and the elevations of the centers of the shore arms were one-fourth and seven-eighths inch respectively for the east and west arms.

Every part of the main bridge, including the wind bracing, is made of mild, open-hearth steel. Repeated tests during construction showed its average tensile strength to be about 60,000 pounds per square inch, with an elastic limit of about 36,000 pounds per square inch. The average elongation of specimens before fracture amounted to about 32 per cent, and the reduction in area at the point of fracture amounted to about 43 per cent.

The structure is the first through cantilever bridge that has ever been erected, all the previous structures on the cantilever plan having had the track laid on the upper chord, and hence being much easier to erect than the through bridge. The manner in which the work was executed, both as regards its construction in the shops and its erection at the site, makes a very creditable record for the Dominion Bridge Company, of Montreal, the joint contractors for the work with Mr. M. J. Hogan, of Quebec, Mr. Hogan doing all the masonry and substructure work, and the bridge company furnishing and constructing the bridges and superstructures.

The bridge and approaches thereto were located and constructed under the direction of P. S. Archibald, C.E., Chief Engineer of the Intercolonial Railway, with G. Brown, C.E., as Resident Engineer. The plans for the superstructure of the main river bridge and other ironwork were designed by Job Abbott, C.E., President and Chief Engineer of the Dominion Bridge Company, and the construction of the work was car-

* A week's time was lost in this period by a breakage of the hoisting engine.

ried out under the supervision of W. S. Thompson, superintendent of the company's work at Lachine.

The plans for the erection of the bridge were designed by Phelps Johnson, C.E., of the Toronto works of the bridge company, and the erection of the bridge was done under the supervision of M. H. Hasler, foreman of the bridge company, assisted by F. E. Came, C.E., Resident Engineer.

The total cost of the bridge, we are unofficially informed, says the *Railroad Gazette*, to which paper we are indebted for the foregoing particulars and the accompanying engravings, is not likely to reach a total of more than $550,000, including in that sum the cost of 1¾ miles of connecting railroad between the New Brunswick and the Intercolonial railways, land damages, and all other expenses. About $350,000 of that sum represents the cost of the main structure only, *i. e.*, that shown in Fig. 4. The contract price for the Niagara cantilever bridge was $680,000, which amounts to some 15½ cents per pound of metal (this including, however, cost of all foundations, masonry, and timber), and is generally understood to cover a very handsome and satisfactory profit. The great and rapid change which has taken place in the cost of such large structures as this is evidenced by the fact that only ten years or thereabouts ago the lowest estimates which could be obtained for the structure were $750,000 to $1,000,000, causing its indefinite postponement.

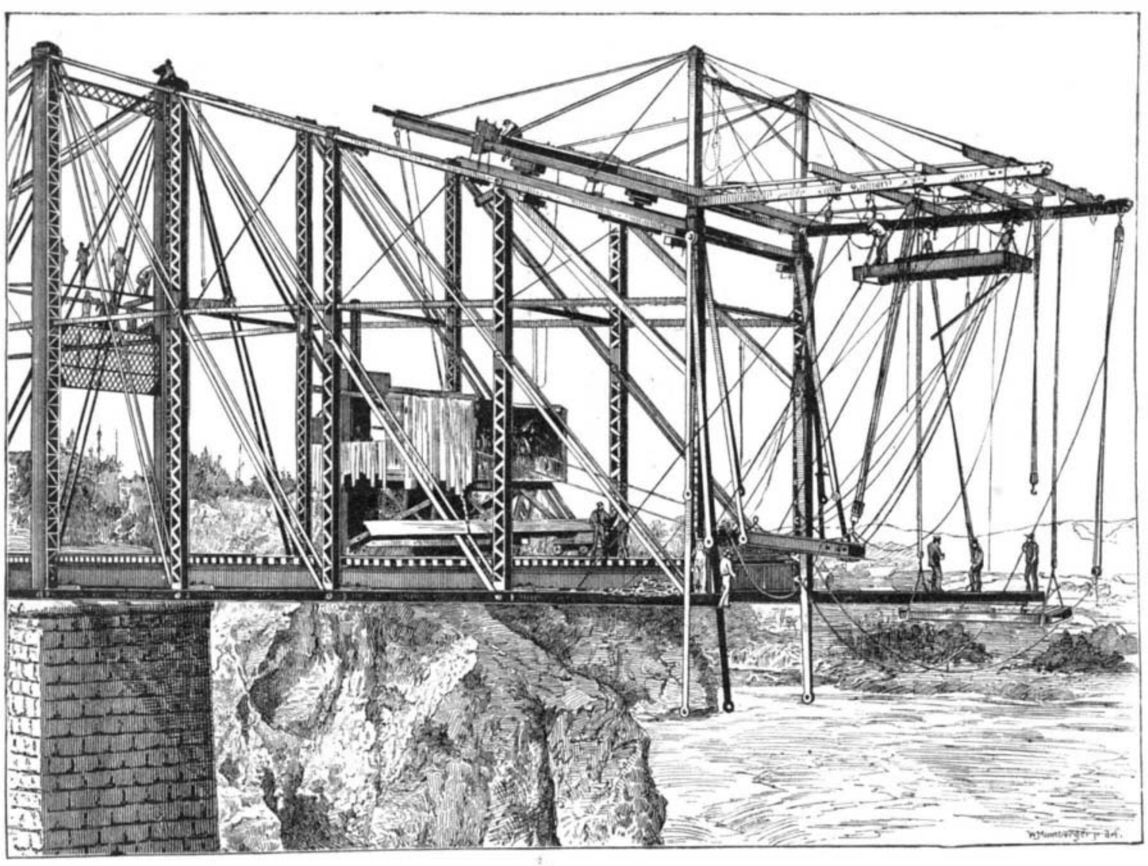

Fig. 3.—STEEL CANTILEVER BRIDGE AT ST. JOHN.—PROCESS OF ERECTION AND PLANT.

The Unexpected.

At the last meeting of the American Society of Mechanical Engineers, Mr. John E. Sweet quoted a number of instances of unexpected results in practical mechanics, and gave them particularly for the encouragement of the inventor, who has so frequently to work in the face of the most unmerciful ridicule. Though the savant is often slow to admit that he has met something, for the time, unexplainable, or that the results of any experiment have been the reverse of what he anticipated, yet the experience of most men of observation is, that there are matters constantly coming up, which defy their powers of explanation, and are the opposite of their expectations.

Every day things, which are perfectly familiar to mechanics of one class, are totally unintelligible to the workers in another branch. Men who have worked a lifetime in fashioning cast iron under the lathe are greatly surprised on learning that the same material, when employed in the heating pipes of a blast furnace stove, grows from six inches to a foot in length from constant use. And the furnace man is equally unprepared to hear that the core bars used for casting pipes lose as much as three inches in casting twenty or thirty pieces. In practice, for instance, we use a piston rod packing of easy fitting Babbitt bushing. When these bushes become sufficiently worn to leak, we close them up by compressing them in the water cylinder of a hydraulic press. In this operation a mandrel somewhat smaller than the piston rod is put inside, and with all the pressure we can bring to bear, we have never been able to compress the bush so as to grasp the mandrel tight, and yet occasionally we have had these bushes shut down while the engine was running so as to grasp the piston rod as if gripped in a vise, to break the bushes asunder, indeed, or to make this necessary in order to get them off.

Again, in the formation of embossed work, two dies are used, the female die often being made by driving the hardened male die into a block of soft steel. This operation is easily performed by a few blows of the drop hammer. It drives in and raises the soft metal without distorting the block in any other particular. Had the same operation been attempted by means of the hydraulic press, the block would probably be upset one-fourth its depth, the sides bulging out or the piece crushed, without producing other than a faint marking of the outline of the male die.

When the lawn mower was first introduced, the inventor was considered little short of a mechanical heretic to imagine that he could get sufficient traction with two light wheels to rotate a cylinder six times their own weight at six times their velocity, and cut the grass in addition. The worm that drives the bed of a Sellers planer does not wear out half as fast as it should, and there is possibly something unexpected about it, even to the makers themselves.

A 12 x 18 inch cylinder engine, which had been running a year at 185 revolutions per minute on an unusually solid foundation, began one day without apparent cause to shake endwise, and before night had shaken itself loose. As no harm resulted, and the work was pressing, the repairing of the foundation was postponed until vacation time, about a month distant. Before that time arrived, however, the shaking ceased, and the engine ran perfectly smooth in spite of the impaired foundation.

Another and even more curious instance of the unexpected was that of a well known electrician who built and tested for three years a certain piece of apparatus, which promised to be extensively used. As it worked perfectly, a large amount of capital was put into buildings and plant for the production of these pieces of apparatus for the market, and many were built, but the manufacturers were totally unable to reproduce the original either in effect or durability.

In another case, two similar boilers were connected by necks at top and bottom, and a fire built under each of them, the boilers being about half full. The water, without apparent cause, behaved very strangely, all going into one boiler and then into the other. When the play was at its height, the boss, considering the lives of the men and the premises of more value than the cause of science, ordered the fires drawn, and the cause could never be determined.

These instances have been taken from practical life, but experience seems to show that scientists are equally liable to be puzzled in just the same way. It is said that Crookes invented the radiometer, and then made it, but to his surprise the action of the instrument was the reverse of what he had anticipated. We might also add the well known case of the Thompson-Houston arc lamp, which is the worst in theory as it is among the best in practice of all the lamps in the market. Even its inventors are unable to give an entirely satisfactory explanation of the action of its mechanism.

Such instances might be quoted almost indefinitely, but we have given enough to show that it is often the part of wisdom to doubt, and that a disputed point, when possible, is best settled by actual experiment. The process of invention is a series of just such discoveries. It is the seizing upon the unexpected, and applying and developing it to meet some need. The transmission of speech by electricity is the basis of a monopoly which represents a value of a hundred million dollars, and yet, but ten years ago, if the possibility of conversing with people fifty miles away had been publicly suggested, it would probably have been denounced as absurd.

Prof. Lesley, in his presidential address at Ann Arbor, stated that the young writer could always be detected by his repeated use of the positive adverbs, while the veteran in science, schooled by experience to acknowledge the universality of error, made frequent use of the modifying clause, and often introduced the element of uncertainty into his statements. The positive up and down assertion is more attractive to one's hearers, but it cannot be denied that there is nothing so sure as the unexpected.

Chemical Composition of the Milk of the Porpoise.

Prof. Purdie, of Scotland, has analyzed a small specimen of milk extracted from the mamma of a porpoise recently caught in the Bay of St. Andrews. It contained:

Water	41·11
Fat	45·80
Albuminoids	11·19
Milk sugar (?)	1.33
Mineral salts	0·57
	100·00

The most remarkable point about the composition of the milk is the large percentage of fat it contains, a constituent of food which, I presume, the cetacean, from its mode of life, would require in larger proportion than ordinary mammals do. The milk was not of an inviting appearance, being of a yellow color and thick consistency, and possessing a "fishy" smell. The specific gravity of the milk, in spite of its solid contents, differed little from that of water.

A Novel Torpedo Boat.

The new torpedo boat David Bushnell, to be used at Ft. Willetts, East River, for laying torpedoes and submarine mines was successfully launched Sept. 26 at the Continental Iron Works, Brooklyn, N. Y., in the presence of a large number of naval officers and engineers. The keel of the vessel, which was designed by Mr. T. F. Rowland, was laid in May. The vessel is of the composite type, and is 85 feet long, 20 feet beam, 9 feet depth of hold, and has a displacement of 300 tons. She is equipped with a pair of inclined engines, the diameter of cylinder being 14 inches, with a 15 inch stroke, which can be run at either high or low pressure. Her boiler, which is of steel, is of the tubular pattern, and is 10 feet long, 8½ feet diameter, capable of carrying 100 pounds of steam. The vessel is fitted with a Mallory propeller, which enables it to turn on its own center. The operations of the vessel are under the absolute control of the pilot, being worked directly from the pilot house. The entire cost is about $35,000. The naval officers present expressed their admiration, and complimented Mr. T. F. Rowland, the builder, Mr. Warren E. Hill, designer of the engine, and Dr. L. A. Smith, who laid the hull.

John Clare.

The death is recorded of Mr. John Clare, of Liverpool, a well known nautical inventor. Deceased was one of the persons who suggested the protection of war vessels by means of iron plates, out of which theory the existing system of iron shipbuilding was developed. On the ground that his suggestions had been practically adopted and carried out by the officials of the Government dockyards, Mr. Clare made a claim upon the Government for a sum of about a million sterling for compensation. The claim was rejected, and the matter was several times brought under the attention of Parliament, but with an unfavorable result. In 1856 Mr. Clare published his correspondence with the Admiralty, under the title of "Mechanical Defects of Things resembling Iron Ships, but constructed upon the Tin-pot Principle." In 1868 he published a work entitled "Life Preserving Ships, hydrodynamically developed upon Metallic Principles, and now forming the National Defenses of Great Britain."

Cotton Items.

In the cotton mills of the United States in 1870, there were employed 134,860 people, men, women, and children combined. The amount paid in wages per head, on an average, was $288.10 for a year's labor; or at the rate of 92 cents per day for 313 days, the number of working days in the year. In 1880 there were employed in the cotton mills 172,544 people, and they received in wages for their year's labor $243.65, or $44.45 less than in 1870, or about 80 cents per day. Now, if we allow for a 20 per cent of a reduction in wages since 1880, it would leave the average wage of each operative 64 cents per day; while the consumption of cotton between the two periods 1870 and 1880 had increased 40 per cent per head.