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Canadian Society of Civil Engineers.

INCORPORATED 1887.

TRANSACTIONS.

SHIP TRANSPORTATION.

By H. G. C. Ketchum, M. Can. Soc. C. E.

To be read Tuesday, 29th December, 1891.

Ship transport, in some form or other, has been practised for ages, even before the Christian era. The first example we have on record is that of the Diolcus of Corinth. Some excavations recently made on the Isthmus of Corinth exposed to view remains of this ancient Diolcus. It was a means for land carriage of ships of that period from the harbour of Schænus to the eastern extremity of Port Lechœum. Ships were run ashore and dragged from one sea to the other. The derivation of the word Diolcus is from the Greek verb ' to drag.' The work existed in the time of Aristophanes 427 B.C. and is said to have been in operation 300 years. The site of Schœnus is now called Cocosi. This ship road is thus described in the Lexicon of Cornelius Schrievelius Διολχος (Diolcos): " *Tractatus in Isthmo* " *Corinthiaco ubi naves ex Ionio in Ægæum et vicissum trahebantur* " —" A track on the Corinthian Isthmus where ships were hauled " out of the Ionian into the Ægœan Sea and neighbourhood." It was such a great advantage to commerce (owing to the difficulty of weathering Cape Malœa) that Corinth became, by its means, the emporium of trade between Italy and Asia. The size of the ships carried is said to be about 149 feet long, 18 feet wide, with a draught of 8½ feet. It is said that this method of ship transport was practised by the Greek Admiral Nicetas Ooryfas in the year 831 in order to enable him to attack the Arabian Corsairs who were then devastating the coasts of the Peloponesus.

In 1438 the Venetians carried a fleet of thirty galleys overland from the River Adige to Lake Garda, a distance of 200 miles, the motive power being oxen, assisted on the mountains by windlasses. One thousand oxen are said to have been employed. This herculean enterprise was proposed by Blasio de Arboribus and Nicolo Sorbolo and was successfully carried out with the loss of but one vessel.

In 1453, at the siege of Constantinople, Soleiman Pacha transferred his fleet by land into the Gulf of the Golden Horn by timber ways, greased and laid on trestles and staging. The feat was carried out in order to avoid a huge chain laid across the Hellespont, which presented an impassable barrier to the entrance of his fleet by water. This *coup de guerre* was accomplished in a single night. The vessels were dragged over two miles, so, on the morning of 22nd April, 1453, the astonished inhabitants saw a large fleet lying close under their walls, and capitulated.

In 1718 Count Emanuel Swedenborg conveyed a shallop, two galleys and four large boats five leagues over mountains and valleys from Stromstadt to Idefjal, in Sweden. Swedenborg was ennobled on account of his invention, which is described as ' a sort of rolling machine." It was also used by Charles XII. to transport cannon to the siege of Frederickshall. All these examples of ship transportation overland were undertaken and carried out principally for warlike enterprises.

Coming nearer our own time, we have the example of a Portage railway, fifty years ago, from Holidaysburg to Johns town, Pennsylvania, where canal boats were carried in sections thirty miles from one canal to another, before the Pennsylvania Central Railroad was opened. The Portage Railway was constructed to connect the canal system of Eastern and Western Pennsylvania. It was a system of "gravity railways," with ten inclined planes, and up and down these steep inclines the large boats of the "Pioneer Packet Line" made regular trips until the Pennsylvania Railroad was built, when it ceased to be operated

There was another of similar construction on the Morris and Essex Canal, in the State of New Jersey.

In Cornwall, England, between Bude and Launceston, the Bude Canal has existed since 1826. At Hobbacote Downs the canal boats, which are furnished with small iron wheels, ascend the uplands by an inclined plane 900 feet long, provided with two lines of rails terminating at each end in the canals. The iron wheels fit the rails and the boats are raised by an endless chain moved by two vast tanks alternately filled with water and descending into wells 220 feet deep. There are seven of these inclined planes in operation on the Bude Canal.

In Germany vessels of sixty tons capacity are carried overland from the upper to the lower part of the Elbing-Oberland Canal, in West Prussia. This transport system has been in successful operation for over twenty years, but when the idea was first broached it was ridiculed by everybody.

In 1860 Sir James Brunlees and the late Mr. E. B. Webb proposed to the Emperor Napoleon III. a ship railway across the Isthmus of Suez in lieu of the present ship canal. Marshal Vaillant, Minister of War for the Emperor, referred the matter to M. de Lesseps, who rejected the idea.. Amongst the advantages mentioned in favour of the proposed Suez Ship Railway was the convenience with which the ship's hulls could be examined whilst on their cradles during the passage from sea to sea. The railway was to have been level throughout. The ships were to be supported on a framing of iron resting on numerous wheels and springs, these, again, on ten rails. The speed was to have been twenty miles an hour, and the estimate of cost was one-seventh that of a ship canal. The passage from the Mediterranean into the Red Sea was to have been made in 16 hours. The speed of steam vessels in the present canal is reduced to about 2½ miles an hour.

The Hydraulic Lift invented by Mr. Edwin Clark, M. Inst. C. E, was proposed to be used for the first time by Sir James Brunlees as the means to be employed for raising and lowering vessels at each terminus of the proposed Suez Ship Railway.

This invention, first carried out at the Victoria Docks, London, renders it possible to construct Ship Railways anywhere on the globe where canals have been projected. The author will have the pleasure of exhibiting a model of the ship lift this evening by which it will be plainly demonstrated that by its means, not only ships can be lifted out of their natural element, but that anywhere on dry land, physical difficulties, hills and valleys may be overcome by the use of the Hydraulic Lift, thus avoiding heavy gradients and obtaining shorter lines than would be possible under any other contrivance.

An hydraulic lift can be used to lift vessels on land as well as from the sea. It only requires a water supply sufficient to feed the engines. The water used in the presses can be supplied from a separate tank, which once filled is a sufficient supply for a very long time by re-using the water which is all the better for a little mixture of grease and oil.

By the use of the hydraulic lift to surmount differences of level, and a simple Turntable to change direction, it is easy to build Ship Railways anywhere.

It was owing to a suggestion of Mr. Edwin Clark, in his paper read before the Institution of Civil Engineers in 1866, that the author turned his attention to the possibility of largely cheapening the construction of the Baie Verte Canal by using the Hydraulic Ship Lift, with boat shaped pontoons to convey large draught vessels on a shallow canal. The first plan for a canal was to have a depth of only four feet, the next plan was for eight feet. When Captain Crawley, R.E., proposed nine feet of water on the sills of the canal locks, he declared it to be impracticable owing to the deficiency of a fresh water supply, and he objected to the use of the Bay of Fundy water, owing to its turbid nature. The clear water of Baie Verte could not be used owing to its lower level, which, without being pumped to the height required to supply the deficiency, could not be made available. The author thought, that with such a working depth as the fresh water obtainable would supply, it would be a great advantage to adopt Mr. Clark's suggestion (vide Minutes Inst. C. E. Vol XXV. page 309): "This system," he said, "affords ready "means, by the construction of a shallow canal of transporting "the largest vessels in cargo, either across an isthmus or over "river shallows; and of removing vessels of war inland, either "for their protection, or for their employment as a means of "internal defense."

The author found a difficulty in working out the problem at the Bay of Fundy *without using some sort of a railway* to transfer these pontoons from the Ship Lift to the proposed shallow canal. This idea led to the present Ship Railway in construction at Chignecto. It became apparent that vessels might as well be lifted to the surface of the ground and hauled across the neck of land on steel rails, thus avoiding all the question of water supply and its various perplexities in this particular locality. It occurs to the author that such a scheme might be used in all the canals of Canada, to convey vessels having any draught, say up to twenty feet. There is no necessity of deepening the existing canals at immense expense when by using pontoons you may so easily and safely convey ocean vessels of 20 feet draught and more through the present canals. All it requires is a lift at or near each terminus at a convenient place where the water is deep enough for the purpose. The pontoon should be open at the top and provided with blocking gear to receive the vessel on the Hydraulic Lift. When lifted the pontoon can be towed away with the vessel upon it to the other end of the canal, in the vicinity of which another lift would be erected, and ready to receive the vessel and release her from the pontoon, when she could continue her voyage to her destination. The simplicity and economy of this method is beyond question.

The hydraulic Lifts could also be utilized as Graving Docks for all sorts of Lake craft. With proper precautions to preserve the pipes from frost, as proposed to be used at Amherst, N.S., on the Chignecto Ship Railway, there is no danger of damage from this cause, or from ice if properly situated and protected. The system of pontoon floating may also be applied to the River Shallows of the St. Lawrence in many places. The pontoons, which may be called "steel rafts," would draw from six to eight feet water according to their size and the load of vessel carried upon them. They are largely used at Malta in the Mediterranean for vessels of 3,000 tons in cargo. (Illustrations are given of the Malta Docks.)

In 1872 a remarkable Ship Railway was proposed by the Republic of Honduras across its territory from Puerto Caballos on the Atlantic Ocean to the Bay of Fonseca on the Pacific Ocean, about half way between the Panama canal of M. de Lesseps and Captain Eads' Ship Railway on the Isthmus of Tehuantepec. It was intended to adopt the Interoceanic Railway, then under construction by the Republic, for the purpose of a Ship Railway. It was to carry 1,200 tons and would doubtless have been carried out if the Republic could have found the money, which they failed to do.

Later on Sir John Fowler prepared plans for a Ship Railway for the Khedive of Egypt to overcome the cataracts of the Nile.

Then the Tehuantepec Ship Railway, the huge enterprise of Mr. Eads, the engineer of St. Louis Bridge and Mississippi Jetties, was projected and a concession obtained by him from the Mexican Government.

This Ship Railway project is still alive. It will be about 130 miles long and will connect the Gulf of Mexico with the Pacific Ocean. The gradients are to be 50 feet to the mile. The elaborate investigation into the merits of this great work, which took place before a committee of the United States Senate brought forward an amount of evidence of experts in ship building which ought to silence forever any objections that might be raised against Ship Railways in general as to the liability to unduly strain vessels during their transport from sea to sea. Mr. Eads and his able coadjutor, Mr. Corthell, have done valuable work in the cause of Ship Railways, by spreading abroad their views and disseminating the evidence given before the committee of Congress. The projectors of all Ship Railways will be greatly indebted to Mr. Corthell for so clearly setting forth the economy to be gained by the introduction of Ship Railways in his paper on "Canals and Railroads, Ship Canals and Ship Railways," read at the Convention of the American Society of Civil Engineers, June 25th, 1885.

The conclusions derivable from Mr. Corthell's valuable paper are "that a canal cannot compete in speed or economy or facilities with a railroad; and that a Ship Canal must also be much more expensive than a Ship Railway in first cost, maintenance and operation, and much inferior to it in dispatch facilities and conveniences."

He says: "The cost on the best railroads is three mills per ton per mile for *through* freight."

Deducting irrelevant items, such as do not pertain to a Ship Railway, the cost can be properly reduced to one and a half mills. But he also maintains that the cost can be reduced on Ship Railways to *one mill per ton per mile*, because much larger loads are carried.

'The ratio of paying to non-paying loads is greater,' 'The frictional resistance to the motive power is reduced,' 'The Line of Railway is straight,' 'The Track perfect,' 'The Gradients, if any, very easy,' 'Greater results are obtained with less fuel and service.'

Detailed plans of a Steamboat Railway on the Dalles of the Columbia River, Oregon, have been submitted to the Secretary of State for war, U.S.A., and General Casey, Chief of Engineers, U. S. Army, in forwarding his report to the Secretary of War pronounced it feasible and the best solution of the problem presented! A Ship Railway has also been proposed across the Peninsula of Florida.

Torpedo boats 35 metres in length have been transported from Brest to Toulon, France, on an ordinary railway, on five specially adapted luggage trucks. In fact, Ship Railways may be largely used in war to transfer even ironclads from one sea to another, and even into the interior of a country.

The author will now turn your attention in general terms to his own project of the Chignecto Ship Railway—17 miles long, to carry vessels of 1000 tons register with cargoes, total 2,000 tons weight. At the time it was conceived he had not the most remote idea of its ever being brought to its present stage of completion, and it was not until Sir Charles Tupper took hold of it that there seemed any probability of its being carried out. It was Sir Charles Tupper who gave it life and prevented the project from being crushed beneath the weight of ridicule and incredulity which assails any great work of a novel description. The declaration of your Ex-president, Mr. Thomas C. Keefer, C.M.G., that a Ship Railway was the only feasible method of overcoming the obstacle to commerce presented by the Isthmus of Chignecto was also of powerful influence in support of the scheme in its early stages.

The first essential of a Ship Railway is to have good ports at each terminus, not only to enable vessels of the maximum depth to enter with ease, but also to provide a receptacle or basin for them to lay in quiet water, so they may take their turn to be floated over the Grid of the Lifting Dock, otherwise in any great breeze of wind, it would be difficult to insert the blocks properly under the bilges of the vessels whilst they are about to be lifted from the water to the level of the Railway.

A few remarks now about Hydraulic Lifts and the strains on vessels will conclude this paper, which is an introduction to another paper on the "Chignecto Ship Railway, the substitute of the Baie Verte Canal," which will be read this evening.

The present paper is a proper prelude as illustrating the many steps leading up to the Chignecto undertaking, whereby Canada will be the first country to actually inaugurate this new and economical system of ship transportation for steamers and large sized vessels.

The Hydraulic Lift Graving Dock at the Victoria Docks, London, has been in operation nearly thirty years and has lifted about four thousand vessels with perfect safety. It is 300 feet long and sixty feet wide; it can lift a vessel of 3,000 tons weight. The successful operation of this first experiment of the kind led to the construction of others in different parts of the world.

In 1876, the Clarence Lifting Dock at Malta was another great success. It was the first to lift vessels in cargo. Ships coming through the Suez Canal stop here when they require repairs without disturbing the cargo. In August, 1886, the ship "Glenasteg" of 2,143 tons gross register was lifted with 2,000 tons of cargo, and many other examples can be given. (An illustration will be given of this Dock.)

Another Hydraulic Ship lift was erected at Bombay, now owned by the Peninsula and Oriental S. S. Company, which lifts vessels of 5,000 tons register.

There is no Hydraulic Lift that the author has heard of in America excepting one at San Francisco. Here vessels are placed and blocked directly on the grid without the intervention of pontoons. All the others named have used open pontoons, for the purpose of floating vessels away to another place to undergo repairs. Any number of pontoons may be employed to multiply the uses of the dock. Without their aid (as in the case of the San Francisco dock) one vessel only at a time can undergo repairs

An Hydraulic Lift is in use at Anderton, Cheshire, where one press lifts a trough of water fifty-five feet high, from the River Weaver to the level of the Trent and Mersey Canal.

Many persons thought a water cradle or a trough of water would be necessary to carry vessels on a railway. A little study will prove the contrary. One vessel would then be inside of another one, really weaker in construction, as the outer vessel could not very well have cross beams like the one to be carried, and it is also carrying double the load.

Mr. W. M. Smith, M. Inst. C. E. of Aberdeen, has patented a Ship Cradle with hydraulic cushions—"a series of plain "tubes of india rubber and canvas filled with water, and placed "side by side athwart the ship from stem to stern, the open ends "of each tube on a level with the deck and the middle of the "tubes bent underneath the ship's bottom, and resting on the "car."

The idea is ingenious, and time will show whether it ought to be adopted. It is desirable not to set up any oscillating motion to prevent the undue distribution of the weight of vessels and cargo while on the cradle. The inventor claims that the vessels would be as good as water borne, but if vibration should be in any way caused by this mode, the advantage of a merely soft cushion would be neutralized by this defect, and it would be better to stick to proved methods of blocking in the first instance. (an illustration of Mr. Smith's plan will be given.)

The author deems no apology necessary for inserting in this paper the opinions of well qualified men as to the strains on vessels whilst being lifted, and the opinion of some of these authorities will now be given.

Sir Edward J. Reed, K. C. B., late Chief Constructor in the British Navy, in his evidence before the Committee on Commerce before mentioned, said:—

"I should like to say at first that, as a naval constructor, I have no fear whatever of a ship undergoing any strain in the process of lifting out of the water (as would be necessary in the case of a ship railway) that she is not liable to at present in ordinary docking. I would say, further, that I am quite sure that the processes of ordinary docking carried on in a vast number of private establishments are very negligent and insufficient in comparison with those which would be adopted in the case of the hydraulic lifts connected with the proposed ship railway.

"They seem to think there are no vibrations or jerking, or forces of some kind the ship would be subjected to on the railway that she is not subjected to at sea. That feeling, I know, is a pretty general one. I can only attribute it to the fact that the gentlemen who so think are not acquainted with the strains that ships undergo at sea.

"The next thing I wonld say is that we have ships on railways and we have them in the worst form. Nothing is commoner than heaving up slips upon which ships are pulled up out of the water. They have to take their bearing first at the bow, and gradually come up until they get upon the solid, and are then hauled up by chains.

"That has been douc everywhere, all over the world, thousands of times in this country, and it is now carried on to a very large extent indeed. With docks for ships of 3,000 or 4,000 tons nothing is thought of pulling these ships up, and nothing is thought of any strains they undergo under the circumstances.

"If it is sufficient on a Ship Railway to provide against something like the worst hurricanes at sea, then I have no hesitation in saying that it is perfectly impossible for these ships on the railway to come to any grief from wind, because the resistance to hold the ship upright on her cradle on the railway track is, I think, very many times greater than the forces which keep her upright at sea.

"With a track like that, and with locomotives adapted to it, there would be no difficulty in transporting ships. It would be best to avoid a very high rate of speed. It would not be necessary, I should think, to move these ships at a greater speed than eight or ten miles an hour, although I am quite prepared to believe that, with a proper track and locomotives, vessels could be transported much faster."

In September, 1882, the author referred the question of ship strains to Professor T. Claxton Fidler, M. Inst. C. E., now of the Dundee University, who reported as follows:—

"In connection with the ship herself, it will be important to arrive at some estimate of the strains to which she may be exposed during the process of land-carriage, as compared with the strains which she frequently undergoes in a heavy sea, and to which her strength *should* be, and generally *would* be proportioned.

"The gross weight of ship and cargo being taken at 2,000 tons, her displacement will be 2,000 x 35 = 70,000 cubic feet; and with an ordinary coefficient of fineness the leading dimensions of a sailing vessel of this displacement may be taken to average roughly.

Length........	200 feet
Breadth.....	35 "
Depth.............................	16 to 17 feet

" As an average example, I may, perhaps, take the case of an actual sailing ship whose length is 205 feet and breadth about 36 ft. 6 in.; the greatest load displacement of this vessel is somewhat greater than 2,000 tons, but she has that exact displacement when loaded to a smaller depth of 16 ft. 3 in. The ends of this vessel are of moderate fineness, while her middle body is very full and for one-third of her length nearly parallel, the average area of the immersed cross section for the middle third of her length is about 520 sq. ft., a nearly 15 tons displacement per foot of length. One half of the total displacement is therefore contained in the middle third of her length, the other half is divided between the two ends and will average $7\frac{1}{2}$ tons per foot. This represents the actual distribution of the supporting forces when the ship is floating in quiet water; the distribution of the *load*, however, will, of course, vary according to the lading of the ship. Assuming, with Prof. Rankine, that one half of the total load may be taken to be distributed in proportion to the displacement and the other half uniformly distributed over the length of the ship, this would give (as a rough calculation) a load of about $12\frac{1}{2}$ tons per foot for the middle body diminishing to 5 tons per foot at the extreme ends, or averaging about $8\frac{3}{4}$ tons per foot for the fore and after bodies, and this rough calculation would show that in still water the vessel suffers a hogging strain of about 7,000 foot tons as the moment due to the excess of weight of the fine ends over their buoyancy. This amount would, of course, vary according to the build of the vessel, being greatest in vessels with very fine ends, but when the ship is supported upon the crest of a wave she undergoes a further hogging strain, which is much more serious and which is greatest in vessels having bluff ends.

" The total hogging moment due to these two causes is given by Rankine equal to the total displacement multiplied by $\frac{1}{20}$ of the length for all vessels of ordinary build. In the case of the 2,000 ton ships, therefore, this will amount to $2,000 \times \frac{200}{20} =$ 20,000 foot tons. In order to compare this theoretical requirement with the strength of vessels as actually built in good practice, the case of an iron sailing ship 205 feet long is taken as a practical example. This vessel is $23\frac{1}{2}$ feet deep from the floor to the stringers of the upper deck, and her neutral axis lies at $\frac{5}{8}$ of the depth. The hogging moment given by Rankine's rule above quoted produces a maximum tensile strain of 3.92 tons per square inch, and a compressive strain of $3.92 \times \frac{3}{8} = 1.47$ tons per square inch only. In the case also of a well built wooden vessel it appears that the strain is within the working strength of the material in nearly the same proportions as in this iron ship.

" We may take it therefore that the safe working strength of any well built vessel is fully sufficient to carry this bending moment, viz: Displ. $\times \frac{1}{20}$ length when acting as a hogging strain, and $\frac{3}{8}$ of this amount as a sagging strain, and that this bending strain will not exceed the strain that she actually suffers at sea whether she is well built or not."

This report goes to show that on a Ship Railway Cradle there would be less strain upon a vessel than she suffers by simply laying in quiet water.

It is impossible within the limits of one paper to enter more largely into the various problems that have to be worked out in connection with Ship Railway Cradles, Axles, Wheels, Rails, etc., and the Society will excuse the author from going into more details, until the problem (which has been carefully worked out at Chignecto) is fully tried there.

THE CHIGNECTO SHIP RAILWAY—THE SUBSTITUTE FOR THE BAIE VERTE CANAL.

By H. G. C. Ketchum M. Can. Soc. C. E.

To be read

The first proposal for a canal to connect the waters of the Gulf of St. Lawrence with the Bay of Fundy was made during the French regime by the Abbé de la Loutre, the enterprising leader of the French colonists of Acadie.

In 1783 Colonel Robert Morse, Chief of the Royal Engineers, was ordered by Sir Guy Carleton, Commander-in-chief of His Britannic Majesty's forces in North America, to make a report on the "state of the defences, with observations leading to the further growth and "security of the colony of Nova Scotia," which then included New Brunswick and a part of the State of Maine. In this report Colonel Morse suggested "the idea of "opening a water communication between the Gulf of St. "Lawrence and the Bay of Fundy," which he said, "would be "attended with good effects," and he spoke of "the many and "great advantages which would result to the country from such "a communication."

In this respect all the engineers who have studied the project from that date have been in perfect accord with Colonel Morse, who, however, looked upon such a communication mostly from a military and naval point of view. He regarded the Canal as a means of naval defence, whereby war vessels could pass from sea to sea for the purpose of attack or defence without running the gauntlet of a hostile fleet on the Atlantic coast of Nova Scotia.

This isthmus of Chignecto is historic ground. Two-and-a-half centuries ago Fort Lawrence was the headquarters of Chevalier de la Vallière, the Seigneur of Chignecto and Governor of Acadie. From his day until the fall of Quebec the country within sight was almost continually the theatre of stirring action. The French regarded the possession of the Isthmus of Chignecto of strategic importance as a half-way station between Port Royal and Louisburg, Cape Breton, on the one hand, and Quebec on the other.

The English fought and struggled for its possession, as it afforded the French a base of operations from which the English settlements could be harassed. The tide of combat rolled around it intermittently for 150 years. It has been captured and recaptured in the French and Indian wars, and during the American revolution a small army of volunteers from the neighbouring republic beseiged Fort Cumberland.

The heights of Fort Cumberland have frequently beheld fleets of warships flying the Lilies of France, and the White Cross of St. George. It ranks with Louisburg and old Port Royal in historic interest and importance, and was rightly considered one of the keys of Canada.

Should there be war between Great Britain and any European power there is no doubt that a highway for vessels of war, such as gunboats and torpedo boats, would be of the greatest possible advantage to Great Britain and Canada in the defence of the Maritime Provinces.

In 1822 the Government of New Brunswick instructed Mr. Robert C. Minnette, Provincial Land Surveyor, to make the first actual survey of a canal, which he accomplished in that year.

In 1825 Sir Howard Douglas, Governor of New Brunswick, employed Mr. Francis Hall, Civil Engineer, to report on the construction of a canal on the line of Mr. Minnette's survey.

In 1826 Mr. Thomas Telford, the most eminent English engineer of the day, was consulted as to the feasibility of Mr. Hall's plans. He reported that "if this canal were completed, ready "access would thereby be opened, not only with Quebec and "Montreal, but also with the upper lakes to a boundless "extent."

In 1843, Capt. H. O. Crawley, of the Royal Engineers, was employed at the joint expense of Canada, New Brunswick, and Prince Edward Island to report on previous schemes. He said: "It is unnecessary for me to dwell upon the importance of an "undertaking which seems to be generally admitted."

After this date public attention was directed to Railways and it was proposed to utilize the Steamship Lines now established on either side of the Isthmus by transhipping freight over a Line of Railway to be built between the Bend of Petitcodiac on the Bay of Fundy, and Shediac on the Gulf of St. Lawrence.

In 1853, a Company was formed and a contract made with Messrs. Peto, Brassey, Betts and Jackson, and work commenced on this Line of Railway from Moncton to Point du Chene, a distance of 18 miles. It was, however, taken out of the hands of that firm in 1856 and completed by the Government of New Brunswick in 1858. This was the first line constructed by the Government of that Province. Cargoes from the Gulf ports were transhipped at Point du Chene, carried over the Isthmus and again put into steamers on the Bay of Fundy. In 1860, this line was extended to St. John, New Brunswick, a total distance of 108 miles, and freight from the Gulf Ports and Prince Edward Island was then transhipped from steamers to the railway and from the railway to the steamship lines plying between St. John, N. B., and Portland and Boston.

A line from Pictou to Truro, a distance of 55 miles, was afterwards completed across another part of the Isthmus by the Government of Nova Scotia.

Subsequently a line of railway from Sackville to Cape Tormentine, and branches from the Intercolonial Railway to Buctouche, Richibucto, Chatham, Caraquet, Dalhousie, N. B., have all been completed, showing the great importance attached to the trade flowing from the Gulf of St. Lawrence towards St. John and the United States.

"The business done on these lines affords evidence of the large "volume of traffic seeking transit between the Gulf and Bay, or "between the Gulf and the Eastern States of the Republic."

"Where there is so large a railway traffic it needs no argument "to show that there must be an enormous water bourne traffic "when once the Short Cut across the Isthmus of Chignecto is "possible."

Notwithstanding these railway facilities there are many bulky articles of commerce which cannot, with economy and convenience, be carried any great distance by rail, and when there is a necessity and expense of transhipment and rehandling, the railway carriage becomes sometimes too expensive to leave any profit. Such is the case with lumber, coal, gypsum, plaster, building stone, potatoes, deals, fish, &c., &c.

In 1869 a Company was incorporated by the Legislature of Nova Scotia to build the canal, as a private work, and the interest in it was accordingly revived.

In 1869 the late John Page, C. E., Chief Engineer Public Works, was called upon to report upon all previous surveys of the Baie Verte Canal, which at this date had again become a live question, and further surveys were ordered by the Dominion Government. In 1871 a most thorough survey was made of the whole Isthmus by Mr. F. Baillargé, Assistant Chief Engineer of Public Works.

In 1872 Sir Casimir Gzowski and the late Mr. Samuel Keefer, C. E., surveyed and recommended a line of Canal approximately on the route of the present Ship Railway.

Samuel Keefer, C. E., observed that in the comparatively isolated condition of the Provinces before Confederation the necessity for this short line of communication was not felt; but now that they form one united Dominion, bound together by ties, political and commercial, the trade growing up between them must tend year by year to give greater importance to the proposed shorter and safer line of navigation.

The estimated cost of this line of canal by these engineers was $5,317,000, but Mr. Page, on examination of the estimate, alleged that there had been undervaluations and omissions, and he added to it 25 per cent. for undervalue placed on works, $1,329,250, and for omissions $450,000, making the probable actual cost of work, according to Mr. Page, $7,100,000.

Mr. Page declared "that the construction of a navigable chan-"nel between the Bay of Fundy and the Gulf of St. Lawrence, on "any line that can be selected, will be an undertaking attended "with unusual difficulty, not only from the nature of the work "to be done, but from the great difference in the elevation of the "respective tides."

The range of the tides in the Bay of Fundy has always been exaggerated in the school books and gazetteers. The most careful observations taken by Mr. Baillargé, C. E., in 1870, resulted in establishing the range of tides to be 38 feet at Neap and 48 feet at Spring tides. The greatest tide ever known occurred on the 5th October, 1869, at new moon. The range was then fifty-seven feet, six inches. It is well known as the Saxby tide, so called from a prediction made nearly a year before it happened, by Lieut. S. M. Saxby, R. N., which appeared in the London *Times* in December, 1868. The following reasons for the prediction were given in his own words: "At 7 a. m., October 5th, the "moon will be at that part of her orbit nearest the earth. Her "attraction will therefore be at the maximum force. At noon of "same day the moon will be on the earth's equator, which never "occurs without marked atmospheric disturbance, and at 2 p. m. "same day lines drawn from the earth's centre would cut the "moon and sun in the same arc of right ascension. The moon's "attraction and the sun's attraction will therefore be in the same "direction. In other words the new moon will be on the earth's "equator and nothing more threatening can occur without "miracle." This prediction was verified by very high tides and terrible storm on the Bay of Fundy.

The extreme range of tides in Baie Verte was observed to be 10 feet 8 inches; the ordinary range being only 5 feet 7 inches. Thus while the fluctuations above and below the mean sea level were only 2 feet 9 inches at Baie Verte, they were at the same time 19 feet above and below mean sea level on the Bay of Fundy at Neap tides, and 24 feet at Spring tides.

A Royal Commission composed of the most representative commercial men of Canada, selected from the different provinces, was appointed by the Government in 1871 to investigate the whole canal system of Canada, with the late Sir Hugh Allan as Chairman. The Baie Verte Canal after full enquiry and examination, was placed by them in the first rank of all the canals of the Dominion. The following is extracted from the report of the Canal Commission: "The growth of Intercolonial trade depends "on cheap transit, since the merchandise passing between the "Maritime Provinces and Ontario *must be of a bulky character*, "requiring large vessels and rapid dispatch to be really profit-"able. When a propeller can go direct with a cargo of coal, or "other produce of the Eastern Provinces, to Kingston and To-"ronto, and there get a return freight of flour, barley, and other "Western produce, Intercolonial trade will have entered on a "new era.

"When Nova Scotia coal of the best description can be supplied "abundantly and cheaply to western ports, a great impulse will "necessarily be given to the transfer of the trade of the St. Law-"rence and Lakes to screw steamers, a transfer already taking "place, as we have previously shown.

"With the canals enlarged, coal freights would be reduced to "the minimum point—a lake propeller would always bring back "from the lower ports a cargo of coal, rather than come empty "—just as the English timber ships have been accustomed to "bring the same article instead of ballast.

"Inseparably connected with the growth of Intercolonial trade "is the construction of the Baie Verte Canal across the Isthmus, "connecting the Provinces of Nova Scotia and New Brunswick. "The advantages that must accrue, not merely to the Dominion "as a whole, but to the commerce of the Maritime Provinces, are "so clearly pointed out by the Boards of Trade of all the lead- "ing cities of Canada, and by men interested in the development "of our commercial interests, not simply the merchants of St. "John and other places in the locality of the proposed Canal, but "merchants of Hamilton, Toronto, Ottawa, Montreal and Que- "bec, that it is superfluous for the Commissioners to do more "than briefly refer to a few salient features of the scheme.

"A steamer laden with flour for St. John, N. B., now goes "down the Gulf as far as Shediac, where the cargo is transported "by rail to its destination. The total distance by water from "Shediac through the Gut of Canso and around the coast of "Nova Scotia to the Bay of Fundy as far as the commercial "capital of New Brunswick is about 600 miles, and the conse- "quence is that there is little or no direct communication be- "tween the Bay of Fundy ports and those of the River St. Law- "rence. By a Canal through the Isthmus the distance from "Shediac to St. John will not be much more than one hundred "miles."

Accordingly the Government of the day decided to proceed with the construction of the canal. His Excellency Lord Dufferin, at the opening of the session of 1873, in his speech from the throne, used the following language:

"I am glad to inform you that plans and specifications for the "enlargement of the Welland, and the construction of the Baie "Verte Canal, have been completed, and that the works can now "be put under contract. The surveys for the St. Lawrence "Canals will, I am assured, be finished in time to commence the "works at the beginning of next year. This will insure the com- "pletion of all these great works at the same period."

In accordance with the promise thus given, one million dollars was placed in the estimates for the construction of the Baie Verte Canal, which, according to the late Mr. Page's estimate of the line surveyed by Messrs. Gzowski and Keefer, was to cost $7,100,000.

In 1875, under a change of Government, another commission was appointed, with the late Hon. John Young as chairman. The report made by this Commission was unfavorable. Indeed, it is said the Commission was purposely appointed to defeat the project and save the new Government the necessity of making the outlay pledged by Parliament.

The Hon. Joseph Lawrence, one of the Commissioners, protested against the verdict of the majority, and ably defended the commercial prospects of the canal in a separate report.

It was afterwards discovered that an error had been made in their computation of the distance to be saved by the Short Cut. The Commissioners had represented the distance saved from Montreal to St. John as only 225 miles, whereas it is actually 500 miles, making an error in their calculations of 275. Their opinion was, that the small distance to be saved would not warrant the expenditure. The prejudice produced in some quarters by the misrepresentation of distance (and hence the erroneous conclusions of the report) endures to this day. The following admissions were however made:

"The evidence taken, and the observations which the Commis- "sioners have had the opportunity of making, have impressed "them deeply with the vast resources of New Brunswick, Nova

" Scotia and Prince Edward Island, and the large increase which " may be reasonably looked for in their trade and commerce."

It was, however, most fortunate for the Dominion that the verdict of this Commission, incorrect as it was, delayed for a while the public expectation. It gave time for a *new idea* to be developed which was happily destined to prevent the country from falling into a most irretrievable error of judgment and from an expenditure counted by millions of dollars,—*a better mode of communication between the two seas was possible.*

1875 the author of this paper submitted his opinion to the public through the Press that a Ship Railway would not only fulfil all the requirements, but in many respects would be preferable to a canal; that there was no engineering difficulty either in the construction or operation of such a line; and that vessels in full cargo could be transported over the Isthmus in perfect safety and at small expense. That the transport would take less time, and the maintenance, repairs and operating would be no greater than by canal. This bold suggestion arrested all further discussions of a canal, and for six years there was no further move made tending to solve the problem of the Isthmian Transit. The Dominion Government had entered upon a policy of fostering its own manufactures and relying upon its own productions for its prosperity. The result soon showed itself in a marked increase in the raising of coal and lumber, which was followed by a corresponding increase in the coasting trade and commercial marine of the Maritime Provinces.

At length, in 1881, the author carried out, at his own expense, a survey and location for a Ship Railway, and having found a good line, submitted a proposal to the Hon. Sir Charles Tupper, Minister of Railways and Canals, offering to form a company to carry out the work, provided the Government would subsidize the work, for about one-third the cost of a canal.

The proposed subsidy took the form of an annual contribution by the Government to the Company of $150,000 per annum for twenty-five years, which, if capitalized at four per cent., would be equal to the sum of $2,343,312.

The proposal, therefore, if adopted, would save to the country the cost of the Canal, to which it was pledged, as before stated, estimated at $7,100,000, less the sum of $2,343,312, the capitalized value of the subsidy, or a saving of no less than $4,756,688.

Hon. Sir Charles Tupper, Minister of Railways and Canals, referred the whole question to the Chief Engineer of his Department, and Mr. Collingwood Schrieber reported as follows:—

1. " That the project is quite practicable of execution."

2. " That the Ship Railway as proposed would be a good sub- " stitute for the Canal originally contemplated."

3. " That the advantage in respect of cost as compared with " that of a Canal would be greatly in favour of the Ship Railway, " the cost of a half-tide canal being calculated by the Govern- " ment Engineers at from $5,650,000 to $8,217,849: whereas the " subsidy asked for by the Company, namely, $150,000 for 25 " years, if capitalized at 4 per cent. would be equal to the sum of " $2,343,312 only."

The Commissioners in their Report on page 51 state: " The " distance from Shediac to St. John by the present route, via the " Gut of Canso, to be 600 miles. This distance would be reduced " by the construction of the Baie Verte Canal to about 100 miles, " and freights would, in their opinion, be diminished by 25 per " cent., greatly benefiting the coal trade and fisheries, and in- " creasing the volume of general business."

They state further (page 53): " This canal cannot be consider- " ed apart from the canals of the St. Lawrence Canal as a Cana- " dian canal, as Sault Ste. Marie is the natural commencement of " the improvements of the inland navigation of the Dominion, so " the work through the Isthmus of Chignecto is the inevitable " conclusion necessary to give unity and completeness to the "whole system. It is Canadian in design and must prove "national in its results."

On page 79 the Commissioners say: "The evidence submitted "points out with remarkable force and unanimity the necessity "of opening a Highway for commerce between the Gulf of St. "Lawrence and the head waters of the Bay of Fundy through "the Isthmus of Chignecto dividing them."

The above statements are now twenty years old, and the tonnage of the ports adjacent to the Isthmian Transit has more than doubled itself since those words were written.

The Chief Engineer further said, that "Assuming that the "importance of a Ship Highway over the Isthmus was, at the "time of the Commissioners' Report so great as therein stated, "it must be much greater now considering the large increase "since that date in the trade of the country affected by the pro-"posed work."

The proposal of the author was accepted by the Government, approved by Parliament, and a company incorporated to carry out the undertaking. The provisional Directors were: Mr. Thomas C. Keefer, C.M.G., the founder of the Canadian Society of Engineers; Mr. Edwin Clark, the eminent engineer and inventor of the Hydraulic Ship Lift; Mr. C. R. Coker, Lloyds Surveyor of Shipping; Mr. R. G. Lunt, the well known Steamboat Manager; and the author.

The Board of Trade of St. John, New Brunswick, passed the following resolutions on the 20th October, 1883:

"*Whereas*, Means of communication between the waters of the "Bay of Fundy and the Gulf of St. Lawrence, whereby products "of the several Provinces bordering thereon may be inter-"changed without encountering the dangerous navigation of the "Atlantic Coast of Nova Scotia, whereby steamers and sailing "vessels, adapted as well for inland as for ocean navigation, may "be safely conveyed across the Isthmus of Chignecto without the "cost and delay of transhipment or breaking bulk, and whereby "the sailing distance between this port and all ports north and "west of said Isthmus may be reduced about 600 miles, would "increase the volume of trade and benefit the shipping interests "of this port and other ports in the Bay of Fundy and Gulf of St. "Lawrence; and

"*Whereas*, By means of a Ship Railway across the Isthmus, "the objects aforesaid may be accomplished, and thus stimulate "the development of the agricultural, mining, lumbering and "fishing resources of the district contiguous to the aforesaid "ports; and

"*Whereas*, A company has been formed for the construction "and operation of a Ship Railway, with commodious Docks and "Hydraulic Lifts for raising and transporting over its line laden "vessels of 1,000 tons register; therefore

"*Resolved*, That this Board is of opinion that the undertaking of said company would "greatly facilitate trade and commerce between the Eastern and Western Provinces; and further

"*Resolved*, That this Board cordially approves the project for "building the said ship railway, believing that this is a movement "which will commend itself to all classes, and prove to be of "great convenience and benefit to our trade and commerce gen-"erally."

In March, 1886, a formal contract was entered into by the Company with the Government which made a change in the annual payments of the subsidy, but reduced the time over which it extended from 25 years to 20 years. The company was not to call upon the Government for any portion of the subsidy except what might be required to make up the net earnings of 7 per cent. on the authorized capital of $5,500,000, and the company agreed to pay over to the Government one-half the surplus profits beyond the 7 per cent. until the whole of the subsidy which may then have been paid to the company shall have been repaid to the Government.

After various unsuccessful attempts by the author to get parties to undertake this novel and difficult work, and find the money, at last, in the early part of the year 1888, Mr. John G. Meiggs, the eminent contractor of South American fame, offered through the author to form a company in London to carry out the undertaking, provided an extension of time could be made to the contract already entered into with the Government.

Application was accordingly made and the extension of time granted by the Dominion Government and Parliament in the spring of 1888.

The plans were prepared and submitted to the Chief Engineer of the Department of Railways and Canals, and formal approval given by the Governor General in Council in, May, 1888.

The line of railway and docks were then finally located under the instructions of the author by Mr. J. S. Armstrong, Mem. Can. So. C. E., and tenders invited for the grading, masonry, and the various works.

The Company was re-organized in London, the preliminary stock subscribed, and the directors appointed.

The Board consists of Mr. Thomas Wood, President; Col. Paget Mosley, Vice-President; Mr. A. D. Provand, M.P., Mr. W. H. Campbell, Mr. A. R. Robertson, and Mr. Arthur Serena, Directors.

Sir John Fowler, Sir B. Baker, and H. G. C. Ketchum were appointed Engineers.

A contract was then entered into between the Company and Messrs. John G. Meiggs & Son for the execution of the work, and subsequently £650,000 of the capital was raised in London by subscription; £300,000 being in preferred shares and £350,000 in first mortgage Bonds.

Under this contract, work was commenced by the Company in October, 1888. Messrs. Meiggs & Son contracted with Messrs. Dawson, Symmes and Ussher, of Niagara Falls, for the earthwork and masonry, for the line of railway and docks, the dredging of the entrance channels, and the platelaying and ballasting; also for the erection of the moles at Tidnish. With Messrs. Easton & Anderson for the supply of the hydraulic lift machinery, its erection and working. With Messrs. Rhodes, Curry & Co., of Amherst, for buildings containing the pumping machinery. They also supplied the heavy pine sleepers for account of Messrs. Dawson & Co. Messrs. Cammell & Co., of Sheffield, supplied the steel rails, which are 110 lbs. to the yard of toughened steel. Messrs. Handyside & Co., of Derby, supplied the ship cradles, which are made entirely of steel. Messrs. Harris & Co., of St. John, contracted for the cradle wheels, and the Canadian Locomotive and Engine Co., of Kingston, are building the heavy tank locomotives.

The engineering staff, under Messrs. Fowler, Baker & Ketchum, consisted of Mr. F. F. S. Kelsey, resident engineer; Mr. J. S Armstrong, principal assistant; Mr. M. Fitzmaurice, assistant engineer; Mr. S. J. Symonds, inspector, and others, on behalf of the Company: Mr. George Buchanan, engineer, and Mr. Arthur W. Bateson, agent, for the Chief Contractors: Mr. J. B. Denison, and Mr. G. F. May, engineers for the Hydraulic Works: and Mr. P. J. O'Rourke, engineer for the Sub-Contractors.

The land required for the line of railway and docks was presented as a gift by the Muncipality of the County of Cumberland, Nova Scotia.

The works were prosecuted vigorously from the date of commencement to the end of July, 1891, when they were unfortunately stopped because of the impossibility of floating the remaining bonds which the company had in hand (viz., £350,000) in the present critcal state of the money market.

Up to the time of suspension, the engineer's certificates for work done and materials furnished by the contractors, amounted to £670,894 5s., paid in cash, bonds and shares, and the engineering and administration expenses of the Company amounted to about £30,000 in addition.

From a careful estimate made of the cost to finish the works, to equip with rolling stock, to provide interest on capital, to finance the remaining debentures, and to provide for further engineering and administrative expenses, it is calculated that $1,500,000 will fully cover all expenses.

The whole work may be said to be three-fourths done, and it would take but one summer season's work to entirely finish the Ship Railway and Docks fit for opening to the public.

The principal excavation yet to be done is that for the entrance channels at each end of the line, which have been commenced and are considerably advanced, but can not be entirely finished until the hydraulic machinery for lifting the vessels is erected.

All the hydraulic machinery has been manufactured and delivered. All the rails, sleepers, and permanent way materials have been delivered. The whole of the line of railway has been graded with the exception of about a mile of broken work. Twelve miles of track have been laid, and the greater part of the bottom has been ballasted with broken stone. The costly work remaining to be done is the masonry and gate of the basin at the Bay of Fundy end of the line, and the masonry of the two lifting docks. The buildings containing the hydraulic pumping machinery have been nearly finished and the machinery in them erected.

The ships' cradles, manufactured of steel, and the locomotives, are nearly ready for delivery. The moles protecting the Basin on Northumberland Straits, have been entirely finished and accepted. The firm of Easton & Anderson, who undertook the supply and erection of hydraulic machinery, as well as the traversers for shunting vessels, has agreed for a specified sum to work and maintain this machinery in good order for one year from the date of the openiug of the line, the Company being required to provide the coal.

The size of vessel provided for is 1,000 tons register; the maximum length would be 235 feet, breadth 56 feet, draught 15 feet, with a displacement of 2,000 tons. Accommodation space for six vessels of this size has been provided in the Basins at each terminus of the Ship Railway. This is the only instance in the history of Canada where a wet dock and harbor basins and dredged entrance channels have been provided at the expense of a private company. The cost to the Company of these entrance channels, dock gates, sea walls, basins and moles will be, when finished, about one million dollars, exclusive of the hydraulic-lifts.

The following extract from Sir Benjamin Baker's description of the Chignecto Ship Railway, as published in the *Nineteenth Century Magazine* for March, 1891, cannot be improved upon, and it is, therefore, embodied in this paper:

"The hydraulic lifts, when raised, form a part of the main railway as regards line and level; and when lowered with the cradle the depth of water over the keel-blocks on the latter is that requisite for floating the vessel on the blocks. Walls of massive masonry, 56 feet in height from foundation to quay-level, surround the hydraulic lifts. The latter each consist of twenty hydraulic rams of 25 inches diameter and 40 feet stroke, enclosed in 26-inch diameter cylinders provided with stuffing-boxes at the upper ends, and with inlet pipes for the admission of water at a test pressure of 1,300 lbs. per square inch. On the top of each ram is a cross-head, from which hang two lifting links, connected at the lower ends with the gridiron upon which the ship and cradle rest when being lifted. The gridiron, 235 feet in length and 60 feet in width, consists of a very stiff combination of longitudinal and cross girders made of steel and firmly riveted together. When lifted to the level of the railway the ends of the cross girders are supported on the quay walls by iron chock-blocks worked by hydraulic power, so that the gridiron then in effect constitutes a solid part, as before said, of the main line. Hydraulic pumping machinery is provided of sufficient power to raise a vessel weighing 2,000 tons, or, including the gridiron and cradle, a total weight of 3,500 tons, the required height of forty feet in twenty minutes. Hydraulic power is also provided for capstans and winches for manœuvring the vessels, and air-compressers are furnished for clearing the pipes and cylinders quickly of water—a precaution specially necessary in a northern climate. Special arrangements are made in the engine-house to enable the engineman to ensure the equable and simultaneous motion of the ten lifting rams on each side of the deck, so that no straining of the gridiron may occur.

"A double line of railway of the ordinary 4 feet 8½ inches gauge is laid along the top of the gridiron, upon which the ship-cradles are run. These cradles are provided in sectional lengths of 75 feet and 57 to accommodate vessels of ranging dimensions. For a ship of 2,000 tons dead weight three sections would be used. The cradles, like the gridirons, are formed of a rigid combination of steel girders carrying keel-blocks and sliding bilge-blocks of the usual lifting-dock type. Each 75 feet section of cradle is supported on sixty-four solid wheels of three feet diameter, having double bearings and four spiral springs of exceptional strength. Unlike ordinary ship cradles, therefore, a considerable amount of elasticity is provided in the present case. It need hardly be remarked that many interesting problems have had to be worked out in connection with these cradles which it is impossible to refer to here.

"The order of procedure in raising a vessel and transporting it seventeen miles across this isthmus to the sea on the other side would be as follows: A vessel coming up the Bay of Fundy on the flood tide would pass through the gate entrance into the dock and wait its turn to be lifted. If the vessel were a 'trader' on this route, its dimensions would have been recorded, and the keel and bilge blocks would have been got ready on the cradle, telegraphic notice having been received of the probable arrival of the ship. If she were a 'tramp,' a ship's carpenter would have to go on board and take some leading measurements for the arrangement of the blocking on the cradle. The blocking being arranged, the cradle and gridiron would be lowered by the hydraulic rams into the water and the vessel would be hauled over it by capstans and winches in the usual way. The gridiron would then be slowly raised until the vessel rested on the keel-blocks throughout her whole length, after which the sliding bilge-blocks would be pulled tight against the ship's bilge by chains attached to the blocks and carried up to the quay on either side. Lifting would then proceed until the rails on the gridiron attained the same level as those on the main line of railway, when, as before explained, the ends of the girders would be securely blocked. The ship and cradle would then be hauled off the gridiron on to the railway by powerful hydraulic winches, and after a final adjustment of the blocking, the vessel would be taken in hand by two of the giant locomotives already referred to, and be transported across the isthmus on to the hydraulic lift on the other side, where the converse operations would be effected to enable the vessel to resume her ocean voyage.

"Various plans have been proposed from time to time for the quick and efficient blocking of the curved surface of a ship's hull to the flat top of the cradle. Hinge bilge blocks, hydraulic rams, elastic bags filled with air or water, and many other contrivances have been suggested, but the present universal practice in docking or in launching a ship is to use simple wooden keel and bilge blocks. In docking a vessel, nearly the whole of the weight comes on the keel blocks, and the bilge blocks are few in number and extend only for about the middle third of the ship's length. In launching a vessel, the weight is transferred from the keel-blocks on to the launching-ways on each side of the same by means of a couple of narrow cradles or bilge-logs, of hard wood packed up to the hull of the vessel by soft wood filling. These cradles carry the ships down the too often imperfectly bedded inclined launching-ways at a speed of some twelve miles an hour. As the vessel is leaving the launching-ways her stern is water-borne whilst the bow is pressing hard on the shore, but yet it is the rarest thing for any mishap to occur to a vessel even under this singularly rough treatment. The best way of blocking a ship on a railway cradle will be quickly determined after a few weeks' experience, but at Chignecto the method adopted in the first instance will certainly be the well-tried one of timber keel and bilge-blocks.

"Nothing calls for special notice as regards the line of railway. It is, as before stated, a double line of ordinary gauge, but the space between the two lines is five feet wider than usual. Very strong steel rails, weighing 110 lbs. per yard, and exceptionally large sleepers, spaced very closely together, give the required support on the ballast to the heavily laden ship cradle. Near the Amherst end a long and deep moss or bog had to be crossed, and, as the floating system adopted by Stephenson for the original Manchester and Liverpool Railway across Chat Moss would obviously be inappropriate for the heavy loads of a ship railway, there was no alternate but to form a solid rock embankment across the bog, and this has now been successfully completed. On other parts of the line there is a heavy rock cutting and a river bridge, but beyond these matters there are no works of importance on the line."

During the construction of the railway Mr. E. L. Corthell, C. E., a distinguished American engineer of Chicago, paid a visit to the Ship Railway for the purpose of ascertaining its merits and to examine into the facilities which Canada could provide for the carrying trade of the West, and, in a letter published in the Toronto *Globe*, he reports as follows respecting the Ship Railway:

"The entire work, in all its general features, as well as in its "details, has been very carefully studied out, and the material "has been properly arranged and well put together for all of the "mechanical work. I also made careful inquiries and obtained "reliable data in regard to the commercial features of this pro-"ject. There is no question, in my opinion, about the entire "success of this work from a commercial and financial point of "view. There is a large commerce now existing which will "certainly seek this shorter and more economical route. The "opening of a line of communication for ships across the isthmus "will develope new commerce, and I do not hesitate to predict, "in view of all that I heard and saw in regard to the commercial "features, that within three years from the opening of the line for "business it will have all it can handle. A Company allied to "the Ship Railway Company has been formed in England for the "purpose of building for this new route several side-wheel steam-"boats adapted to the trade between Prince Edward Island and "the New Brunswick and Maine coast, which, I have no doubt, "will have all the business they can attend to."

Mr. Corthell also in a paper read before this Society in February, 1890, referring to the Chignecto Ship Railway, repeated that, "There is no doubt in his mind of the entire success in the "construction, operation and economy of this railway. There is "nothing novel in the method only in the combination of "methods. Vessels are at present raised out of the water con-"tinually, whether loaded or unloaded, on hydraulic lifts either "by Marine Railways or by Floating Docks.

"The increasing size of rolling stock, both motive power and "freight cars, on ordinary railroads, has proven the great ad- "vantage in carrying greater and greater loads at one time. A "few years ago 10-ton cars were the rule in this country. Now "30 tons are becoming more and more numerous. Cars for still "larger loads for special purposes are becoming more and more "common, and the locomotives have increased in weight and "power from 30 and 40 tons to 90 and 100 tons, and the cost of "transportation has been reduced from 2½ cents to ½ cent per ton "mile.

"A Ship Railway is the logical result of the continual im- "provements in railroad methods from the time of the first rail- "road to the present. If it is possible to raise vessels and "transport them overland with safety and economy, why should "they be compelled to make great detours costing time and "money?

"If the immense business between the St. Lawrence and the "coast of New Brunswick and New England can save 500 to 700 "miles by operating a railway 17 miles long across the Chig- "necto Isthmus, why should it continue to take this long and "dangerous voyage around Nova Scotia?"

According to the official returns from the Report on Trade and Navigation for the year ending 30th June, 1890, the tonnage arriving and departing at the various ports contiguous to the Ship Railway was as follows:—

	Vessels.	*Tons.*
Gulf of St. Lawrence.........	23,787	6,422,976
Prince Edward Island.......	8,703	1,362,861
Bay of Fundy..................	33,345	3,855,932
Grand Total..............	70,925	11,641,769

The rate of increase for several years has been half a million tons per annum according to official Blue Books.

This tonnage does not include any port west of Quebec or on the Atlantic coast of the Peninsula of Nova Scotia. Although the Ports of Portland and Boston might come within the sphere of trade, they, like Montreal, Toronto, and ports west of Quebec, are omitted in the above table.

The Comprny's estimate of traffic is based on only seven per cent. of the tonnage of the Gulf and Bay, or 800,000 tons. Should the Ship Railway draw this moderate proporoion of the tonnage it is estimated that there would be a revenue nearly sufficient to pay a dividend of seven per cent. on the capital of the Company without calling on the Government for any portion of the guarantee, as appears from the following figures:—

800,000 tons freight at an average of 50 cents per ton....	$400,000
800,000 tons vessels' hulls at an average of 12½ cts. per ton.	100,000
Estimated Receipts..................	$500,000
Working expenses and administration as per estimate of Sir B. Baker, being 30 per cent. of the receipts.......	150,000
Net Revenue....................................	$340,000

Setting apart the subsidy to provide interest on the bonds for 20 years, a traffic of only 320,000 tons at the above rates, would provide 7 per cent. on the preferred share capital, and 7 per cent. on the ordinary share capital, thus:

320,000 tons at the average rate of 50 cents per ton......	$160,000
320,000 tons vessels' hulls at the average rate of 12½ cents per ton	40,000
Receipts	$200,000
Working expenses, 30 per cent..............................	60,000
Net Revenue	$140,000
7 per cent. on $1,150,000 preferred shares..................	$105,000
7 per cent. on $500,000 preferred shares	35,000
Total dividend............	$140,000

The working expenses of the Ship Railway, as compared with a railway of the ordinary type, should be very small indeed. The line is perfectly straight. One half of it is absolutely level. The other half has gradients not exceeding 10 feet to the mile. The works are solidly built, the rails heavy; the sleepers of unusual size; the ballast, broken rock, it is believed the cost of maintenance of way will be reduced to a minimum. It may be considered a freight line, without the usual terminal expenses. The freight, that is the vessel with its cargo, loads and unloads itself automatically on and off the railway. The speed will be slow, not exceeding ten miles an hour. Fuel is cheap in the coal producing county of Cumberland, Nova Scotia. Besides the cost of lifting vessels to the level of the railway and depositing them afterwards into the sea, which is very small, the principal cost will be the locomotive power, which on ordinary railways bears the proportion of about 17½ per cent. to the gross earnings. It is believed, therefore, that the estimate of 30 per cent. for working expenses is full. The estimate of working expenses was based on the usual cost of maintenance and repairs on a double track railway for the whole year. Without any especial effort to economize, the Ship Railway might be worked for $50,000 per annum, which would, of course, permit of the same profits with very much less tonnage. A regular daily line of steamers between St. John and Charlottetown over the line of Ship Railway would contribute largely to the business expected. The Chignecto Steamship Company has been formed in London, with a capital of £60,000, for this purpose; the untoward financial crisis so far has prevented this object from being consummated, but it is steadily kept in view.

The tolls to be charged on the Ship Railway must be sanctioned by the Governor-General in Council before being levied and collected by the Company.

The estimated average rate of fifty cents per ton is therefore only suggested as the probable rate that the Government would be inclined to sanction for the freight carried, for it is, in fact, very similar to the charges prevalent on the Welland Canal, which have been levied by the Government itself. The proposed rates, which, although they amount in the average to half a dollar a ton, will scarcely be felt when levied on the bushel or barrel by the shipper, who is accustomed to the high freights levied by the foreign steam lines running through the Straits of Canso to Boston. At this rate one dollar will be saved on all freight going round to St. John by water, and more than that by rail. The freight from St. John to Baie Verte being $2.50 per ton, while that to the head of the Bay of Fundy is one dollar per ton, there is a difference of $1.50 per ton, and deducting 50 cents per ton for the transport across the Isthmus, there is one dollar saved in the freight, not to count the saving of time and insurance.

The charges on freight cargoes would be at the same rate, no matter by what description of vessel carried, but the rates on the hull would probably be required to be on a sliding scale according to the size of the vessel, the highest rate being on the smallest vessels, because a small-sized vessel would occupy the railway as long as a large sized one, and the revenue otherwise obtainable from small vessels would not bring a profit to the Company. The estimated proposed average rate of 12½ cents per ton would be a fair rate to charge on hulls as compared with that on Canals where the cost of towage is considered; the latter being done on the Ship Railway by locomotives and on the Canals by steam tug-boats.

Respecting the time to be saved and the safety of vessels on the Ship Railway, no less than twenty-four prominent firms of shipowners in London and Liverpool, having experience of the coast of Nova Scotia, have certified that a saving of ten days would generally be made by sailing vessels clearing from ports on the Gulf, and making for St. John, Portland and Boston, by using the Ship Railway, and so avoiding the weathering of Cape North and Cape Canso, as by present route. They have certified also that loaded vessels would not be injured on the Railway, if supported on a cradle such as is used on all marine slips.

The most prominent naval architects of the day, Sir E. J. Reed, the late Sir William Pearce, Sir Nathaniel Barnaby, and Mr. William John, all certify to there being no danger to the ship nor cargo during transportation from sea to sea.

Mr. Bindon B. Stoney, the authority on "strains," says, "A ship resembles a tubular structure, more or less rectangular in section, underneath which the points of support are continually moving, so that when the waves are high and far apart the deck and bottom of the vessel are alternately extended and compressed, in the same way that the flanges of a continuous girder are, near the points of inflection, when traversed by a passing train." No such strain as this is possible on the Ship Railway.

There is reason to believe, therefore, that the Ship Railway, when completed, will be an undoubted success in every way, and become the pioneer of many works of like character.

In conclusion, the author would allude to the assiduous care and attention bestowed on this work by his colleagues, Sir John Fowler and Sir Benjamin Baker, the engineers who designed and carried to a successful completion the equally novel enterprise of the Forth Bridge. Without their powerful aid and co-operation the work could hardly have reached its present advanced state of progress. Should it be the success we anticipate Mr. Meiggs also, who undertook to raise the capital in England, as well as to contract for the execution of all the works, will be entitled to a principal share of the credit which should attach to the inauguration of a new and economic system of transportation for the benefit alike of Canada and the whole world.