foot (3,000 pounds per lineal foot on each track) on anchor arm only?—A. Stress sheet of anchor arm for 6,000 pounds per lineal foot of bridge attached herewith. (Exhibit No. 111.)

The Commission, having for the time being concluded the inquiry in New York, Philadelphia and Phœnixville, returned to Montreal. A second visit was paid to Quebec on November 28, for the purpose of re-examining Mr. Hoare and pursuing other investigations.

RE-EXAMINATION OF MR. E. A. HOARE, AT QUEBEC, NOVEMBER 29, 1907.

Q. Why did you use the Phœnix Bridge Company's design in 1898?—A. Previous to 1898 several picture drawings were voluntarily sent by various engineers desiring to show the merits of their designs. Amongst the number was a study by the Phœnix Bridge Company. At that date, having to prepare a plan to submit to the Railway Committee of the Privy Council to obtain their decision upon the least clearance and width of channel for navigation, I applied the outline for the superstructure of the Phœnix Bridge Company's design to my plan, it being considered at the time the most suitable design submitted.

Q. What instructions were given to Mr. Cooper when he was requested to report upon the various tenders? If these were written, please file copies?—A. Written instructions were given (copy of the same attached herewith, Exhibit 112).

Q. Was any sum mentioned to Mr. Cooper which the bridge must not exceed in cost, and if so what was it?—A. No.

Q. Was Mr. Cooper required to limit the cost of the bridge to any amount, or was the question of cost left entirely to his judgment?—A. The question was left entirely to his own judgment.

Q. Did the weight of the bridge exceed your expectations, and by how much?—A. The approximate weight of the bridge as estimated by the Phœnix Bridge Company amount to 29,700 tons, the actual weight is about 38,000 tons. I fully expected that the original figures would be exceeded by the time all details were designed.

Q. Was Mr. Cooper advised of the terms of the contract of June 19, 1903, and in what manner? Was he furnished a copy of the contract, and if so when?—A. I cannot state definitely if Mr. Cooper was advised of the terms of the contract of June 19, 1903, directly by the company. The secretary states that he did not furnish Mr. Cooper with a copy of the contract.

Q. Mr. Deans has stated that final arrangements were made with the Phœnix Company by the Quebec Bridge Company on February 22, 1904, although the contract was signed June 19, 1903. What was the reason for the delay and what was the final arrangement made February 22, 1904?—A. Although the contract was passed in June, 1903, its execution was forcibly delayed by other arrangements then under way with the government, the passing of legislation and financial arrangements, which were concluded 28th January, 1904. Letters were then exchanged in February between the two companies giving effect to the contract (copies of these letters are attached herewith. (Exhibit 113-A, 113-B, 113-C, 113-D and 113-E.)

Q. Did you find Mr. Cooper accessible and available at all times during the construction of the bridge?—A. He was accessible and available, but only at his office in New York during the design and building of the superstructure.

Q. State exactly the full scope of Mr. Cooper's duties as consulting engineer?—A. Mr. Cooper's duties, in a general way, as consulting engineer for the Quebec Bridge Company and as understood by them, are as under :

To revise the specifications when he thought necessary. To examine all stress diagrams and plans for the structure submitted by the Phœnix Bridge Co., to approve or modify the same from time to time when, as in his opinion, he considered it necessary to obtain efficiency under the powers delegated to him. Receive reports on vital and technical questions affecting the details of construction and uncertainties as to quality of metal tested, for his decision thereon. Also to be available for consultation with the Phœnix Bridge Company and the Quebec Bridge Company at any time on any question arising out of the design or construction of the bridge. Also to visit the work in progress from time to time, and finally pass upon it.

Q. File a statement showing all the payments made to Mr. Cooper by the Quebec Bridge Company?—A. See statement attached herewith. (Exhibit No. 114.)

Q. Did Mr. Cooper ever ask for any inspectors other than those who were appointed and who acted?—A. No. He was entirely satisfied with the inspectors appointed, as shown in his correspondence. He never asked for any other inspectors.

Q. Did Mr. Cooper ever ask for assistance to be given him in his office for the purpose of assisting him in checking plans or for other work?—A. No.

Q. Had Mr. Cooper authority to order expenditures on account of the Quebec Bridge Company for special tests or for engaging assistants? At whose expense were the eye-bar tests made?—A. Mr. Cooper had no written authority to order expenditures for special tests, but he could, as consulting engineer, have ordered any tests to be made that he thought necessary and upon his request any assistants would have been allowed at any time. As assistant inspectors were required from time to time Mr. Edwards applied to me direct and I authorized him to engage all the assistants he required upon terms which he considered fair.

The eye-bar tests were made at the expense of the Quebec Bridge Company, and clause No. 135 of the original specification provides that the 'contractor shall make at his own expense, under the direction of the engineer or his inspector such other tests of full sized members or details similar to those used for the work, as the engineer may prescribe.'

Q. Did Mr. Cooper at any time during the erection of the bridge stop the work, and how was this done? Please file copies of any letters or telegrams connected with this incident, and give your explanation?—A. In June, 1903, Mr. Cooper telegraphed me not to allow posts CIP to be erected until top was made level. Copy of telegram attached herewith. (Exhibit No. 115.) This was on account of the bearing of the top section of the post not being quite uniform. The report of the defects was exaggerated and the work was immediately corrected according to Mr. Cooper's instructions, which were to make sure of a minimum bearing of ⅔ of the total area.

Q. Did you receive any communication from Mr. Cooper between August 27 and August 30, 1907?—A. No.

Q. Please explain how the staff of inspectors was appointed and organized?—A. Mr. Cooper agreed to assist in that organization and appointed the chief inspector himself, and it was understood betwen us, and adhered to, that the chief inspector at the Phœnix works was to personally report at Mr. Cooper's office in New York at least once a month, and oftener if necessary, upon anything of special occurrence, result of tests, &c., and take direct and final orders from him. Mr. Cooper suggested, and I agreed with him, that it would be advisable to endeavour to obtain qualified men in Canada. I spent some time making inquiries, but found that all the qualified men were engaged. One or two doubtful applicants, I requested to communicate with Mr. Cooper direct. Finally, as I could not secure qualified men, I asked Mr. Cooper to nominate the chief inspector, which he did. The chief inspector having had some 20 years' experience, was always in touch with men of his class, and whenever extra inspectors were required for mills and shops he applied to me for authority to engage them upon their own terms, which were agreed to without exception, and they all proved to be very efficient men, thorough and conscientious in their duties. From detail reports received and from my own visits to the works at Phœnixville and mills at

which steel was rolled, as frequent as distance would allow, I am able to testify to the above facts.

Respecting the erection inspection, Mr. McLure was recommended to Mr. Cooper for the chief field appointment. He appointed him under certain conditions, to work under Mr. Edwards, the chief inspector at the shops, until he was required for erection. Knowing that it was important that Mr. McLure should remain at the Phœnix shops as long as possible to master the work outlined by Mr. Cooper, I charged Mr. Kinloch (an experienced bridge erector appointed by me), being already on the spot, to attend to the mechanical part of the work; starting with the inspection of the metal as it arrived at the storage yard; it was never the intention to permanently substitute Mr. Kinloch for Mr. McLure, but as Mr. Kinloch was competent to inspect alone on the start—I thought that for the time Mr. McLure was better employed in Phœnixville—and as soon as the field office was ready I sent for Mr. McLure. The laying of the lower chords in the false work was well advanced at that time. The instrumental work for the false work foundations and construction was attended to by engineers under my own supervision, using plans with figured data; the chords being set to fixed levels, were never changed after Mr. McLure arrived. He, however, arrived in plenty of time to supervise the checking of the position of the main pier pedestals.

Mr. Cooper had no right to state that he thought Kinloch and myself did not understand the operations at that time, being without positive knowledge of the facts, and to incorrectly assign that reason for sending for Mr. McLure at that late date. Mr. Cooper, moreover, could not have been aware that many of the important features submitted to him throughout the whole work of erection were due to Mr. Kinloch's searching inspection.

Q. Why did not you, as chief engineer of the Quebec Bridge Company, certify to the plans and other drawings before they were forwarded to the Department of Railways and Canals?—A. To make a thorough check of such a mass of plans would have taken a very long time after they were received, and caused unnecessary delay, and which I considered an unnecessary operation, knowing that these plans were most thoroughly checked by experts before they reached my office, and knowing, at the same time, that they would receive further examination on reaching the Department of Railways and Canals.

Q. What responsibility had you as chief engineer of the Quebec Bridge Company in connection with the final specifications and plans?—A. I had no responsibility in connection with the final specifications and plans. Full power was delegated to Mr. Cooper, by the order in council dated August 15, 1903, to modify the original specification and to regulate the detail parts of the structure to obtain the best efficiency, final approval to be given by the chief engineer of the Department of Railways and Canals.

Q. Were you immediately responsible for the inspection of construction both in the shops and field?—A. It was a joint responsibility divided between the consulting engineer and chief engineer, but I deferred to Mr. Cooper's judgment. My former statements with regard to the inspectors will explain this.

Q. Please state what your annual remuneration has been since your connection with the Quebec Bridge Company?—A. From November 1, 1900, $400 per month, until the completion of the bridge and railway connections and terminals. From September 5, 1905, voluntarily raised by the company to $6,000 per annum. For three years previous to the first date, $150 per month.

Q. During this period were you under salary for any other company or individuals, if so, please give full details?—A. For about two years I have had charge of the viaduct over the Cap Rouge valley, on the Transcontinental Railway, which did not require any more attention than the construction of the Quebec Bridge and Railway Company's railway approaches under my charge, work on which during that time, was temporarily suspended. This did not interfere with my work in connection with the bridge.

Q. What salary did Mr. McLure and Mr. Kinloch receive?—A. Mr. McLure

received $1,800 per year and travelling expenses, and Mr. Kinloch received $1,200 per year and travelling expenses.

Q. Were you accessible and available at all times during the construction of the bridge or did your other duties interfere with this condition; especially, could the inspectors at the bridge have communicated with you promptly on the discovery of the deflection in chord A-9-L on August 27?—A. I was accessible and available at short notice at all times during the erection of the bridge, except when en route to and from Phœnixville. My other duties did not interfere in any manner whatever. The inspectors could have communicated with me promptly on the discovery of the deflection in chord A-9-L on the 27th August.

Q. Did you consider throughout the whole of the work that the approval of the plans by the Department of Railways and Canals was a condition precedent to any operation in connection with the fabrication of the bridge?—A. Yes.

Q. Why did you permit the fabrication of any part of the bridge before the approval of the plans by the Department of Railways and Canals?—A. To my knowledge there was no fabrication of any part of the bridge before the approval of the plans by the Department of Railways and Canals, but the chief inspector at Phœnixville informed me that the Phœnix Bridge Company had the consent of the consulting engineer to roll a limited quantity of metal for the sections that he had approved, entirely at the risk of the Phœnix Bridge Company. I understood at the time that the consulting engineer had agreed to this proceeding on account of the pressure in the mills to avoid delay in the fabrication of the metal required for immediate erection, to make sure of the delivery of the parts required for the season's erection. I protested against this proceeding, but was assured that the completed detail plans would be in my hands for submission to the Department of Railways and Canals before fabrication. Knowing that Mr. Cooper had given his consent to the rolling of a limited quantity of metal, subject to the Phœnix Bridge Company's risk, I requested Mr. Edwards, the chief inspector, to omit the metal rolled ahead of certified plans in his monthly returns to me.

Q. Why did you not wire Mr. Cooper on August 27, when the deflection in chord A-9-L was discovered?—A. When the deflection in chord A-9-L was reported to me on the evening of August 27, after conversation with the inspectors, and from their description, I did not consider that there was any immediate danger to be apprehended, and considered that there was time for Mr. McLure to go to New York and Phœnixville the next day with sketches to make personal explanation of the same, in order that there might be no misunderstanding. Full reports having been mailed the same day, a telegram at that late hour would not convey the information nor reach its destination without some delay, as telegraph operators were on strike at the time, and besides that, I requested Mr. McLure to make sure that his information was complete, and that a thorough inspection of the other members of the bridge should be made the first thing in the morning, in order to be thoroughly informed of all conditions before he left. I, however, wired both Mr. Cooper and the Phœnix Bridge Company next morning that Mr. McLure had left to give full explanation with reference to the deflected chord previously reported by mail.

Q. Why did you not stop work on the bridge on August 28, pending Mr. Cooper's decision, and with the information you had in regard to the condition of some of the compression members?—A. I did not stop the work on August 28 for the following reasons: I did not consider the conditions warranted such action, particularly as the Quebec Bridge Company's inspectors and the Phœnix Bridge Company's engineer and foreman disagreed upon the origin of the deflection. The latter showed no signs of uneasiness and were anxious to continue the work, as they had made a special effort to collect a large force of bridge men. As I understood it, the majority of the men were engaged removing the large traveller and riveting and they would add very little extra load until expected instructions were received from the consulting engineer upon Mr. McLure's arrival. My confidence was strengthened by the knowl-

edge that very careful work had been performed by expert designers who had been entrusted with the calculations and preparation of the plans of the bridge, and that at the time the chord was not strained over ¾ the maximum provided for and that a mistake was impossible under such conditions; and it was also reported to me that the ribs had a full bearing at the splices.

Q. In your opinion, could the bridge have been made temporarily safe in some such manner as has been suggested by Mr. Cooper?—A. No.

Q. Did you discuss the advisability of staying the lower chords, and if so with whom did you have this discussion, when was it, what were the methods proposed and what was the decision, and why did you reach this decision?—A. The Phœnix Bridge Company officials and myself did discuss the advisability of staying the chord in question. Several methods were proposed, and when it was known that the work could not be completed before a message from Mr. Cooper could be received, it was decided to abandon the idea and await telegraphic instructions from Mr. Cooper, which were expected upon Mr. McLure's arrival, but never received. From his silence after Mr. McLure's arrival, I concluded that he considered the situation to be void of danger. If he thought otherwise a telegram to me could have been made the basis of an order to stop the work, as he did in June last year for a matter of very much less importance. The confidence that we all had in the general conditions existing at the time, and in the men in charge of the designs, and my knowledge that the work had been subject to so many methods of checking, and with members in the bridge still to be stressed a considerable amount to reach the maximum, for the time being obliterated any impressions of danger being possible, and no doubt he himself was not impressed with any sense of immediate danger.

Q. Please explain the contradiction in your letter of September 2, 1907, to Mr. Cooper to the statements contained in your letter of August 28 to him?—A. With reference to these two letters. On my arrival from the bridge late in the evening, in my anxiety to convey to Mr. Cooper by the same evening's mail a full description of the chord and to keep him informed of what had happened since Mr. McLure left, I dictated a letter hurriedly and did not read it over before signing it. In my haste I did not state exactly what I intended with reference to the continuance of the work. Afterwards I noticed my misstatements and corrected them in a second letter, and this letter correctly states the facts.

Q. Have you any further evidence to offer the Commission?—A. Referring to Mr. Cooper's answer to the question, 'Did you at any date ask to be relieved of your duties and for what reasons? If you made such a request, at whose instance was it withdrawn?' Mr. Cooper's conversation with Mr. Parent and Mr. Deans suggesting relief from his duties and stating that he could not go to Quebec was unknown to me.

Referring to Mr. Cooper's reply to the question as to proper time being allowed for preparation and study of plans, Mr. Cooper never complained about that. Besides he was the chief and could have refused to approve plans if he thought that sufficient time was not allowed for their study, verification and correction.

Referring to Mr. Cooper's reply to the question, 'What organization existed for the checking of the strain sheets and detail plans prepared by the Phœnix Bridge Company?' Mr. Cooper made his own proposal for remuneration to cover all services, which were agreed to by the company and acknowledged by him as being correct. He never before complained that duties were imposed upon him improperly, and to my knowledge he was satisfied with the staff and refused to concur in the appointment of an engineer suggested by the government of Canada.

Referring to Mr. Cooper's reply to the question, 'Was the local staff at Quebec employed by the Quebec Bridge Company and the Phœnix Bridge Company to your satisfaction, and did you consider it fully competent to handle the work?' Mr. Cooper had sufficient interest in the work to have ascertained at an early date the class of men conducting the erection, and if he did not consider the staff sufficient he could have informed the company. The Phœnix Bridge Company always had engineers

on the work, and in addition frequent visits were made by other engineers from Phœnixville to examine the work in progress.

Referring to Mr. Cooper's reply to the question relating to the qualification of engineers employed by the Quebec Bridge Company or Phœnix Bridge Company, &c., Mr. Cooper nominated a man of his own choice to represent him on the erection, to work under his own special instructions, to keep him in touch with the work, and to my personal knowledge his duties were thoroughly and most conscientiously performed and all instructions strictly followed. Mr. Cooper expresed his satisfaction with that arrangement, and if he had any doubts as to the efficiency of other members of the local staff, I am surprised that he did not make his views known to me. My general duties for the Quebec Bridge and Railway Company were not known to Mr. Cooper, and possibly he did not know that I kept in close touch with every detail of the work performed in the shops and mills as well as in the field; also followed the progress of work between the Phœnix bridge engineers' office and Mr. Cooper, to know how matters were progressing without interfering with the special duties of the consulting and designing engineers.

Referring to Mr. Cooper's reply to the question, 'Was it the practice of the Quebec Bridge Company's staff to refer all difficulties to you, and if so what were the duties of the chief engineer?' although Mr. Cooper may have performed some of the duties incumbent upon a chief engineer, he did not know, as I previously stated, the general duties I had to perform for the company. Mr. Cooper never asked for any staff of assistants or any allowance for the same.

With reference to Mr. Cooper's reply to the question 'Who authorized the commencement of the erection of the suspended span before the large traveller was taken down? was it understood that this was to be done and did this procedure have your approval?' Mr. McLure's reports and photographs to him in New York showed that the big traveller was not entirely removed before the accident. I regret that Mr. Cooper did not notify me of this understanding about entire removal of the big traveller, as I would have insisted upon his instructions being carried out. The proper channel for conveyance of any instructions for important and prompt action is through the company's engineer at Quebec.

Mr. KINLOCH, re-examination.

Q. What employee of the Phœnix Bridge Company was particularly responsible for the bolting up of the joints during erection?—A. I understood that it was the duty of Mr. Birks to see that this was properly done.

Q. To your knowledge were the blue print instructions concerning the bolting up of joints fully complied with?—A. I am certain that they were fully complied with at all points except on the bottom cover plates of the lower chord. As it was essential to remove these plates and to keep them off for a period of probably ten days while the riveting of the joints was in progress, I did not consider it necessary to make a close inspection of this bolting and am not prepared to saw how fully it was done.

Q. Were the bolts inspected for tightness or changed during the interval between erection and riveting?—A. All holes in the inner ribs of the lower chords were filled at erection with the largest bolts that could be put in and these were not changed again until the riveting gang reached the joint. As the joints closed the bolts in the outer ribs became loose and were generally replaced by larger bolts, but this was not done on many joints of the lower chord.

Q. How often were the joints inspected to see how the bolts were acting and whose duty was it to make these inspections—A. The joints were examined every time the traveller was moved forward by the inspectors of the Quebec Bridge Company and by the engineers of the Phœnix Bridge Company until each joint had taken its full bearing. These inspections were part of the general examination of the structure—

following each traveller's movement, and the bolting of the joints was observed and any change of bolts that was noticed to be needed was ordered. The representatives of the two companies worked together in these examinations.

Q. Are you positive that the bolting on erection was always in excess of the office requirements?—A. Yes.

Q. Were §-inch bolts used to any large extent in the lower chord joints?—A. No, I do not think that §-inch bolts were used in more than two joints in the anchor arm and in two joints in the cantilever arm and then only in the rows of holes near the top of bottom splice plates, this being determined by the setting of the camber openings.

Q. Were drift pins used in the lower chord points?—A. In the top cover plates of all joints the majority of the holes connecting with the two centre ribs of each chord were filled with drift pins, the remainder being filled with bolts, the reason for the use of the drift pins being the difficulty of tightening up bolts in these holes, because of the narrow space between the two inner ribs. As the joints closed, the drift pins were driven up from time to time and the bolts between the cover plate and the two outer ribs were changed whenever a larger sized bolt could be entered.

Q. Do you consider drift pins to be an efficient temporary connection for bridge work?—A. If the drift pins are long enough to get a full bearing on all the connecting plates, I consider that 50 per cent drift pins properly distributed may be used in tension joints with advantage. I am not in favour of using drift pins in compression joints but their use is sometimes necessary as in this case. The objection to drift pins is that having no heads or nuts they cannot prevent the joint plates from buckling up when under compressive stress.

Q. What was the longest time that any bottom cover plate was off?—A. The plate between chords 7-L and 8-L cantilever arm was off from about the first of August, 1907, until the day of the wreck.

Q. Did you observe any joints in the lower chord in which all four webs were not bearing equally when the joint was closed?—A. I have already given evidence concerning the mismatching of adjoining chords for line. When the chords were first set I noticed in several cases that one rib would show on top an opening of perhaps ½ inch when the other three were in contact. At the time of erection the openings at the bottom of the ribs could not be seen on account of the bottom cover plate. No rivetting was permitted on the joints until the four ribs at the bottom and the tops of the two outer ribs were in absolute contact. We could not test the tops of the two inner ribs because the upper cover plate was never removed after it had once been put in place. I am of opinion that the openings that I saw at first at the joints were closed up by the compression of the metal in the longer ribs.

Q. Did you ever observe openings in rib more than at a joint?—A. I have seen two openings, both of which were on the centre ribs, in one joint when the outer ribs were in contact.

Q. Do you remember any joints in the structure which did not close as expected?—A. The joints on both sides between chords 9 and 10 and also between chords 5 and 6 on the anchor arm were very slow in closing, and did not finally reach the proper position for riveting until after August 1, 1907. Some joints on T-5 and T-50 anchor and cantilever arms never reached their final position. There were also several longitudinal and lateral bracings near the main post that had not been got into position and riveted at the time the bridge fell.

Q. Please describe the movements that you think took place when the bridge was falling?—A. The initial failure, I think, occurred in both lower chords No. 9 anchor arm simultaneously and in the latticed portion of the chords, but not in the same way in both chords. No. 9-L, which had previously been observed to be bent, deflected slowly and transferred some of its load to 9-R, until that chord burst with a sudden fracture accompanied by the loud report testified to by some witnesses. The sudden and complete collapse of 9-R whilst 9-L was slowly yielding accounts for

the slight swing of the cantilever arm down stream and for the tendency of the upper portions of the anchor arm to fall in the same direction. At the moment of collapse the thrust of the cantilever arm forced the feet of the main posts off the pedestals and the shoes of the main posts were the first part of the structure to strike the ground. Whilst they were in the air the extremities of the stub chord on the cantilever arm struck the inside coping of the main pier a glancing blow. When the shoes struck the ground that part of C-P-6 above the patten plates failed, and simultaneously the horizontal strut connecting the two shoes was destroyed. The transverse diagonal bracing between the two posts at the bottom remained intact for an instant and almost the entire weight of the main posts and of the top chord was concentrated upon it, causing the bracing to act as a toggle and to force the shoes and the feet of the main post out sideways. This is shown by the holes made in the ground. This action threw the bottom portions of the centre post out of the vertical and permitted the feet of the P-4 posts with the broken ends of A-8 attached to them to pass inside the centre posts, some part of P-4-L striking C-P-6-L heavily as it fell. During the fall chords 10-R and L cantilever arm, which had probably broken loose when the stub chords struck the pier, rested for a moment on top of the pedestals, and were then partially suspended and thrown over on their sides, as they now lie on top of the pier, by the wreckage of S-P-5 and of the pieces connected to it. Chords 9 of the cantilever arm did not strike the pier before they reached the ground, although they now lie with their ends just against the face of the masonry, which is slightly marked. Chord 9-R of the cantilever arm is lying in the water with its two inner ribs practically straight and its two outer ribs buckled back in a V-shaped loop about 18 or 20 inches long at a point about 20 feet from the shop splice, the ends being parallel to the inner ribs. Chord 9-L is buckled at about 15 feet from the field splice in all four ribs to a shape similar to that shown by A-1-R, but with a smaller deflection.

Q. Please relate the occurrences following your discovery of the bent chord on August 28th?—A. Immediately after discovering the bend I brought the matter to the attention of Mr. Yenser and Mr. Birks, and with them re-examined both chord A-9-L and several other lower chord members. We did not know what to make of the matter and then went up to our office and arranged with Mr. McLure to have the deflections of the suspicious chords measured—this measurement which was made by Birks, McLure and myself showed the extent of the deflections; and their cause, and their ultimate result immediately became a matter of very active discussion. Mr. Birks expressed himself definitely as being of opinion that there was no danger and endeavoured to persuade me that the bend had always been in the chord. Mr. Yenser and I were uneasy, and considered the matter serious, and finally suggested that McLure and Birks should go to New York and Phœnixville for advice. It was considered that the matter could not be satisfactorily explained by telegraph or telephone and no one of us expected immediate disaster. Mr. Birks and Mr. McLure did not welcome our suggestion saying that they would only be laughed at on arrival and it was finally agreed to refer the matter of sending to headquarters to Mr. Hoare, who decided in favour of our suggestion. Mr. Hoare visited the bridge on the Wednesday and spent most of the day there. He appeared very anxious that I should abandon my position of being positively convinced that the bend had occurred since the erection of the cantilever arm was completed, and argued both this and some possible methods of strengthening the chords by bracing several times with me. I was somewhat excited and much annoyed at the unwillingness of all the engineers to accept my statement of facts and on both Wednesday and Thursday avoided further discussion of the matter as much as possible. It was understood that McLure would immediately wire me if Mr. Cooper took a serious view of the situation, but this he failed to do. Mr. Birks, however, told me on the morning of the 29th instant that he had been advised by 'phone from Phœnixville that they had a record which showed that the bends had been in the

cord before it was shipped from Phœnixville and that he had just advised Mr. Hoare by telephone at the request of Mr. Deans to that effect.

Q. Did you find that the officials of the Phœnix Bridge Company were anxious to get such assistance and advice from the local staff of the Quebec Bridge Company as they could or were they somewhat impatient of criticism?—A. In matters of details I found that they valued my opinion, but in general they claimed that their plans of erection were fully worked out, and stated that they would permit no interference with them except by the chief engineer personally.

Q. Do you consider that the supervision over and control of the operations of the Phœnix Bridge Company on the work were closer and more exacting than the similar supervision that has been exercised on other large bridges upon which you have been employed as an inspector?—A. The control of this work differed from that of any other upon which I have been employed in this respect, that every question between the inspectors and the contractors was referred to New York and Phœnixville for settlement, whereas in my previous experience the power to settle most questions was vested either in the inspectors or in a resident engineer who was always on the work.

Q. It has been stated by witnesses that general foreman Yenser cared only to rush up steel as fast as possible—what is your observation?—A. Yenser was a hustler, and like every other erector liked to get up as many tons of metal in a month as he could, but I do not recall that he ever took any serious risks in doing so, and in fact I was informed by Mr. Milliken that the inspection of Mr. Birks was especially provided so that the Phœnix Bridge Company might get the full advantage of Mr. Yenser's energies without anything being done contrary to the wishes of its engineering department. I consider that Mr. Birks' inspection was carried out with singular thoroughness and good judgment.

Q. Have you made the investigation of the appearance of the lower chord joints mentioned in your previous evidence?—A. I have examined them but could detect nothing to indicate that the ends of the ribs were unevenly stressed in the fall by reason of the original camber openings.

On December 3 a member of the Commission again visited New York to further examine Mr. Cooper, returning on December 8.

ROYAL COMMISSION, QUEBEC BRIDGE INQUIRY.

I, Theodore Cooper, consulting engineer, of the city of New York, in the state of New York, one of the United States of America, make oath and say:

1. That I attended before the Board of Royal Commissioners appointed under the Great Seal of Canada to enquire into the causes of the collapse of the Quebec bridge, on Wednesday, Thursday and Friday, the 3rd, 4th and 5th days of December, 1907.

2. That the annexed 28 pages contain my present testimony, and that the answers to the questions are true.

Sworn before me in the said City of New York, this 7th day of December, 1907, by the said Theodore Cooper, who is personally known to me.

Mr. COOPER'S testimony.

Q. When the various plans and tenders were submitted to you for report, what instructions were you given by the Quebec Bridge Company, by whom and in what form?—A. Mr. Hoare's letter of March 13, 1899, states that certain plans which he enumerates, had been sent to me by express. He adds, 'I will send later copies of tenders and conditions submitted with each. In the meantime, will you kindly inves-

tigate the merits of the cantilever plans and the Union Bridge Company suspension plans until you hear again about two other suspension designs.' That covers the substance of that letter, which is quite long. In his second letter of March 19 he speaks of the non-necessity of examining two of the suspension plans as the conditions of the Dominion Bridge Company's design were impossible. Then there is also the letter of March 21, 1899. On March 23 I had not yet received the plans, and on that day he sends me a telegram, 'Plans should reach you this evening. Transportation delayed by snow.' I did not receive the plans for some days afterwards. On April 4, Mr. Hoare telegraphed that he would be in my office. The effect of all this correspondence is that I was free to take up the plans and determine what I thought was the best plan; there were no special instructions favouring any one plan or in any way directing or guiding me in any one direction. I considered then, as the impression on my mind now is, that I was absolutely free to make a report on the plan I considered the best. Mr. Hoare was the only person who gave me any information, or you might say instructions, and the instructions were more in the direction of not considering certain plans, because they were incomplete or imperfect or had been withdrawn. The Pencoyd Company withdrew their plan and the Dominion Bridge Company practically withdrew their suspension bridge plan on account of the impossibility of getting any sub tenders for the wire work; so that left the matter practically between the three cantilever designs, two of which were identical, those of the Dominion Bridge Company and the Keystone Company, there apparently being some understanding between them to have the same plan and divide the contract in some way or other; so that really there were only two competitive plans that fully complied with the requirements of the specifications and tenders, those of the Keystone Bridge Company and the Phœnix Bridge Company. The Keystone Company's weights were higher and their bid was also higher. The Phœnix design was a far better design, in the form of the design and its general arrangement, the arrangement of the railroad system was better, and it had the advantage of being a lower price. I would state here that all the tenders were in the form of a lump sum, but they gave a schedule of rates and prices which were to be used for estimates for progress estimates.

Q. In your former evidence you referred to limitations that existed at that time as to the amount of funds apparently estimated for construction. What information had you as to the amount of money available, and by whom was this information transmitted to you, and were you instructed that the expenditure should not exceed any certain sum and if so what was this amount?—A. During the early progress of the work it was an open secret that the Quebec Bridge Company had but a small amount of money in sight. When the contract was let to the Phœnix Bridge Company in 1903, and I was preparing these specifications which were the ones on which the structure was afterwards constructed I received, on June 15, 1903, the following telegram from Mr. Hoare: 'Will your specifications reduce Phœnix weight in their contract draft?' I replied by telegram 'Don't know Phœnix contract weight. New specifications will make slight reduction over old specification for the present span.'

I then received another telegram from Mr. Hoare, dated June 16th, as follows: 'Trusses, towers and floor beams 29,300 net tons.' That same day I wrote to Mr. Hoare saying in part 'I know nothing as to the contract draft or what they now propose. If they have given an estimated weight I wish you would send it to me. Also it would be a guide to me if I knew whether the proposal is for a lump sum price or for a pound price. Also whether 'the powers that be' desire to keep down as close as possible to the original estimates or are willing to go higher if the bridge can be bettered. I am only aiming to get all parts harmoniously strong and not have some parts weaker relatively than others.'

From that time on, during all the formative part of the work, I was repeatedly told by Mr. Deans, Mr. Szlapka and Mr. Hoare personally at various times of the desire that Mr. Hoare had that the weights in the contract should not be exceeded.

Even Mr. Edwards mentioned at different times that Mr. Hoare was showing great anxiety—I do not know whether by letters to him or simply by letters to the Phœnix Bridge Company—that the weight estimated should not be exceeded. At a later date, or practically for the last two years there has been no such indication, but the strength and size and dimensions of the work were all determined and formed during this early stage when the impression was on my mind through these different sources that the original weight must not be exceeded. The point governing my mind in preparing a new specification, as I have stated in my previous testimony, was to get a better bridge for the purposes of transportation than was called for under the original specifications. While I felt that I had no right to involve the Quebec Bridge Company in greater expenditures than they anticipated I aimed to get a bridge which would be substantial, economical and better than the one that was originally proposed.

Q. In making your decision between the competitive tenders, did you consider it to the then interest of the Quebec Bridge Company to recommend the acceptance of the lowest tender that would give a safe and satisfactory structure?—A. I certainly did.

Q. Would you under any circumstances have recommended the acceptance of plans which would not in your opinion have given a safe and satisfactory structure?—A. No, I would not.

Q. Were your representations to the Quebec Bridge Company's representatives sufficiently definite and emphatic with regard to your desire to be relieved of responsibility as to draw forth any protest on their part, and if so was there any repetition of your desire. Or did the matter drop on your part, and did you continue without further protest as consulting engineer?—A. I do not know that I could say anything fuller than I did in my previous testimony. I notice that that testimony is confirmed by Mr. Deans in his evidence. As a matter of fact, I did continue as consulting engineer, although my condition of health has not improved in the meantime.

Q. We understand that the original agreement was that you should spend five days per month at the bridge site, and that you requested to be relieved of this obligation. Were you thus relieved by the Quebec Bridge Company, and if so, how was it arranged?—A. This understanding is not correct. I have here my original memoranda made at the time of the first interview with Mr. Parent, Mr. Hoare and Mr. Barthe, and my offer to them was to act as consulting engineer at $7,500 if I was not called on to be more than five days out of New York in one month. That proviso of not being more than five days out of New York per month is one that I have been compelled to make for the last twenty-five years in all my agreements to act as consulting engineer. Experience has shown me that parties out of New York do not value the time of a consulting engineer as of any importance, and when called to a distant point for consultation on work for which I was acting as consulting engineer I found great waste of time; the directors would not think it important to meet at the time stated, they would postpone the meeting for a week and think it my duty, being their consulting engineer, to await their convenience. This compelled me in all my agreements as consulting engineer during the last twenty or twenty-five years to put in a clause limiting the number of days that any corporation could command my time. This does not mean that they could not have all the time that was needed for their work, but it was intended to limit them so that they would promptly give attention to business upon making an appointment. That was the bearing of this proviso as to the five days out of New York. Several times during my visits to Quebec I have found this clause a protection. I have left three or four days before a meeting of the board which was postponed, my good friends assuming that I would enjoy that spare time at Quebec, forgetting that I had other business of importance to devote my time to. It was never intended to be interpreted that I must spend five days in every month out of New York, although that was the interpretation put upon it by Mr. Barthe at the time of the presentation of my first bill, that I had not been five days in Quebec. I immediately protested that that clause had no such meaning. I will state that in all my experience as a civil engineer I have never had to apply this

restriction, nor have I ever limited the number of days devoted to any piece of work; but nevertheless it has been a safeguard.

Q. Do you assume the full responsibility for the change from a 1,600 feet to an 1,800 feet span?—A. I assume the full responsibility for the change to an 1,800 feet span.

Q. From your observation, are you of opinion that the preliminary studies and surveys in the neighbourhood of the bridge site were sufficiently thorough, considering the magnitude of the undertaking?—A. The profile furnished by the chief engineer, which accompanied the plans, showed a gentle slope of the bottom extending out a certain distance and then a steeper slope towards the centre of the river. The piers for the 1,600 foot span were placed on or near the crest of the steeper slope. This position of such important piers, appeared to me, with the slight knowledge that I could obtain in regard to the character of the bottom and the tendency of the river as fraught with danger. The sinking of the piers at this point also necessitated a far greater depth of foundation and an execution during the short season of the Canadian summer. Impressed with these facts and also with the fact that the cost of piers further in shore would be materially less, I recommended in my supplementary report that consideration be given to the question of increasing this span from 1,600 feet to some greater length. I was authorized later to make a report upon the question of increasing the span from 1,600 feet to 1,800 feet. I found that the saving in cost of the piers, assuming the computations given by the chief engineer for the two caissons to be correct, was not much exceeded by the increased cost of the superstructure for the additional length. The experience obtained in sinking the piers now existing to depths far less than would have been needed if the 1,600 foot span had been retained I think will satisfy anybody acquainted with the work that the change was an absolute necessity. The founding of the present piers exhausted the full season during each summer of the construction. A greater depth would have been almost impracticable as it would have been impossible to maintain air pressure for the piers further out and every one versed in foundation work will recognize the risk of leaving uncompleted piers, sunk by pneumatic process, without the sustaining effect of the pneumatic pressure, which the running ice would have rendered it impossible to convey to these piers. The preliminary studies and surveys in the neighbourhood of the bridge site were very slight compared to the importance of the undertaking. There were no profiles taken, until a later date, at any other point across the river except upon the centre line of the proposed structure. The knowledge of the river bottom, 500 feet above or below the bridge, was a matter merely of conjecture. When founding the pier on the south shore, having no knowledge of the local conditions, of the regime of the St. Lawrence river, I required that additional profiles should be taken at 500 feet and 1,000 feet above the bridge and I unearthed at that later, 1902, a map of the Canadian Hydrographic Survey taken at this point in 1894. At this same time Dr. Ami of the Canadian Geological Survey was in Quebec and I got him personally interested in the borings and excavations being made, and finally succeeded in getting him officially instructed to make a report upon the geological conditions of the material on which the piers were founded.

Q. Do you assume the full responsibility for the change in the specifications, and for the selected unit stresses?—A. I assume the full responsibility for the changes in the specifications and for the selected unit stresses.

Q. What were your reasons for adopting the unit stresses specified? Please state the data upon which you founded your conclusions?—A. First, as stated before, I desired to get a better bridge without increasing the estimated weight and for that purpose I lowered the wind strains, increased the train loads and changed the formula for the determination of the unit strains. I took up the investigation of the original Phœnix design for the 1,600 feet span, examined into the sizes of the members and the unit strains employed in preparing this design, such strains being made and proportioned according to the original Quebec bridge specifications. Looking at the

figures I find under cantilever arm, lower chord, that the end panel at the tower contains 740 square inches and was being worked to a unit strain of 21,100 lbs. Similarly in the anchor arm the end panel at the tower was being worked to a unit strain of 21,100 lbs., the fourth panel from the tower, anchor arm, to 20,580 lbs. As my studies proceeded I tested the dimensions of these members under the new requirements by an assumption of using as high as 24,000 lbs. for the dead load, and found that my design instead of 21,100 lbs would have 21,400 lbs. In another case where they had 21,800 lbs. I would have 21,200 lbs. In another case where they had 21,520 lbs. I would have 21,200 lbs. That was my first study to find out whether the new bridge was going to be of proportionately greater weight than the original plan, and I found that I was going to use no higher unit strains than had been used in the original first design.

I then took up the report of the Forth Bridge, which I had read before, to refresh my memory, and I found that Messrs. Baker and Fowler, the engineers of that structure, had adopted 10 tons, or 22,400 lbs. for the constant or dead load and $6\frac{2}{3}$ tons, or 14,933 lbs. for the changeable or living load. While it is not definitely stated the impression left by reading the reports is that these strains were employed in the design of the Forth Bridge, and that the working strain is about 20,000 lbs. on the Forth Bridge and that aimed at for the Quebec bridge was 21,000 lbs. This I considered as a fair comparison for the reason that the Forth Bridge, as far as any evidence has been presented, was constructed without any regard to the camber requirements, without any regard to any such delicacy of measurement of length of members, as we endeavoured to obtain in the ordinary bridge construction in America. I therefore felt satisfied that the strains I had adopted for the Quebec bridge were undoubtedly within the strains that were employed for the Forth Bridge.

My experience of many years in the study and examination of existing structures in the United States on many of our railroads where structures were vastly overstrained from the increasing train loads (not infrequently double those originally designed) gave me great confidence in the use of high unit strains when the loads are definite and clear. In other words, I have no hesitation in believing and expressing my faith that two-thirds of the elastic limit of the material, for a positively known load, is a safe strain. But there is no case in the design of the Quebec bridge where any such strain as two-thirds of the elastic limit could have been expected. While a limitation was placed in the specification to restrict the strain to 24,000 lbs. for an increase of the specified live load of 50 per cent, this load is an absolute impossibility on any railroad in the United States, except where they are carying pig iron one way and ores the other. It must be borne in mind that the strains on the Quebec bridge were determined for heavy train loading upon both tracks. I do not believe that the actual train loads which would cross the Quebec bridge would ever equal, certainly they would not exceed, the requirements of my specifications nor do I think that the working strains under practical train loads, would ever exceed 21,000 lbs.

Q. Did the unit stresses used in the specifications exceed the then accepted practice in bridge construction?—A. Certainly, but this was an exceptional bridge of exceptional length, and high strains were justified because the greater weight was that due to the weight of the structure itself, and any small uncertainty in regard to the live load would be comparatively a minor factor.

Q. Would the actual unit stress in the anchor arm in the completed bridge have been unprecedented in bridge building?—A. Yes, I believe so, with the exception of the Forth bridge, the only bridge to which it can be at all comparable.

Q. Were the specified unit stresses exceeded in the anchor arm, and, if so, why were they permitted and approved by you?—A. The specified strains in the anchor arm were exceeded by reason of the weight of the structure exceeding that originally given me by the Phœnix Bridge Company as the weight of the bridge. Before this increased weight of structure was discovered the anchor arm was practically built and erected. When I was able to sum up the shipping weights of the different members of the anchor arm and obtain the weight of the anchor arm as a whole, I found

it exceeded the original estimated weight. There was no means of changing or correcting this work. I made an estimate of the increased strain due to this increased weight and found it to be about 7 per cent. In conference with Mr. Szlapka at a later time he approximately confirmed my calculations in regard to the percentage of increased load and increased unit strain. Realizing that there was no remedy and that this 7 per cent was not a fatal increase, I did say to Mr. Szlapka, in effect, that we would have to submit to it.

Q. To what extent were the unit stresses increased in the anchor arm over the specified stresses?—A. When I had only the increased weight of the anchor arm for the purpose of my estimate, I estimated, as I stated, that the increased unit would be about 7 per cent. Examination of the final and total weight of the bridge as we now have it, leads me to believe that the unit strains in the anchor arm, when the bridge was completed, would not be more than about 10 per cent, the specified unit strains.

Q. Did the representatives of the Phœnix Bridge Company object either formally or informally to the increase of the main span or to the alteration of the specifications?—A. In no manner whatsoever did they indicate or express any objection to the lengthening of the span or to the alteration of the specifications.

Q. When were you first advised that the actual weights of the bridge would materially over-run those assumed in the computations, and what was the stage of the work at this time?—A. The first positive evidence that I had of the increased weight beyond the estimate was Mr. Edwards' report of the raw material of February 1, 1906, which he gave me for the two anchor arms and centre posts as 36,200,208. Practically the anchor span, tower and two panels of the cantilever arm were in place.

Q. Did you take any action after receipt of this information?—A. As I stated in a previous reply, I made an estimate of the increased strains due to this increased weight of the anchor arm, which I stated I found to be about 7 per cent. At a later date I took up with Mr. Szlapka the discussion of this increased weight. About that same date, February, 1906, Mr. Hoare applied to Szlapka, according to Mr. Szlapka's own statement to me for a new estimate of weights for the completed bridge. I took up at the same time the question of a new estimate and made a new estimate, taking the weights of the new anchor arm as the basis for the new weights, and completed this estimate. At the same time I instructed Mr. McLure, who was then at Phœnixville, to take up the same question in connection with Mr. Szlapka's assistants and report to me the result of his investigations. At a later date, which I have not recorded, but a month or two thereafter, Mr. McLure reported his figures for the work complete, excepting the suspended span, which he stated neither he nor Mr. Szlapka had yet completed. The figures compared very closely with the estimate I had obtained, which was about 65,000,000 lbs. of metal for everything, excluding the suspended span. Mr. McLure stated at that time that as near as he could make out the probable estimate as so far determined at Phœnixville, would place the weight of the suspended span at about 6,000,000 lbs. I told him that while I was not thoroughly satisfied, because the data was not yet sufficient, my approximate estimate was that it would be fully 8,000,000 lbs. I requested a copy of Mr. Szlapka's estimate, but have never obtained it. During that summer, in conference with Mr. Szlapka, I requested that he would make out a new strain sheet to suit the new dead load as obtained from the estimates so that we could determine the exact increase of unit strain upon the different individual members. I never received any such correction. When the last panels of the cantilever arm were presented for approval, appreciating that the weight of the suspended span would affect these special panels much more than any other portion of the bridge, and it was important that they should be proportioned for this increased weight of the suspended span, which to me at that time was yet unknown, I wrote Mr. Szlapka as follows:—

'September 29, 1906.

'The approval of the last panels of the cantilever arm require more consideration

than you have allowed me. Have you changed the strain sheet for the increased weight of the suspended span ?'

I am under the impression—I am depending upon my memory and may be in error—that he reported to me that he had increased those last panels for the new weight of the suspended span. That is my impression, that they were proportioned for the new weight.

Q. In your computations did you assume the dead load to be uniformly distributed or did you determine the probable concentration at the various joints in the trusses ?—A. In computing the dead load strains I was furnished by Mr. Szlapka with a diagram dated May 12, 1904, which gave the dead load concentrations for the anchor and cantilever arms, Quebec bridge. These dead load concentrations vary at every point. I asked Mr. Szlapka when this was presented to me, whether it was carefully and properly estimated. He stated that he had had his best men to carefully estimate the weight at each point and that this was a correct arrangement of the final weights to the best of his belief. As I had no other means of determining these weights, the plans not being yet submitted to me, I assumed them to be correct and used them in determining my strains. I did, however, check these weights in the following manner: I added together all the concentrated loadings, deducted the allowances for floor and timber which he states here especially, and found that the resultant weight was abundant to cover the assumed estimated weight of the structure.

Q. In your computations did you include erection stresses and did you fully satisfy yourself that all members were properly designed to carry these erection stresses as well as those arising from the specification loadings ?—A. Yes, with the loads presented to me by the Phœnix Bridge Company as covering the weight of their traveller. While I did not verify each individual erection strain, I checked them sufficiently to be convinced that they were correct for the assumed loads.

Q. You have stated that the bridge might have been saved by using one hundred dollars' worth of timber and bolts. Would you please explain how this could have been done and would you desire to amplify your former statements on this point ?—A. In my former testimony I stated that after Mr. McLure had left my office on the day of the disaster I did prepare a rough sketch which I showed Mr. Berger, of the method I would suggest to the Phœnix Bridge Company for protecting and strengthening this chord in case they proposed no better method. This sketch consisted of a rectangle composed of the two opposite chords, the two transverse struts connecting the ends of these chords and the two lateral braces diagonally across this rectangle. I drew from the centre of the crossing of the two lateral braces an additional horizontal strut extending to he centre of the chord and explained that I would put in a stiffening strut at that point connected properly to the chord, thus shortening its length as a column in its weak direction to one-half of its former length; that then we could add diagonal plates, or if safe to remove any of the lattice bars put on additional plates until we obtained a chord permanently satisfactory. I also added that if the chord was showing weakness from any mistake in design, we could strengthen all the chords throughout the bridge in the same manner, by introducing these intermediate transverse struts and thus ensure their abundant strength.

When I stated that the bridge could have been saved by the use of $100 worth of timber and bolts, I had in my mind to insert in the place of these transverse struts just mentioned a timber strut formed of about four 12 x 12's about 30 feet long, properly spaced apart, so as to make a wooden strut perfectly capable of resisting one hundred tons, which I estimated was the theoretical force to be resisted at the centre of this chord, bent as shown. Whether this would cost $100, more or less, is a matter of very small importance.

Q. Referring to your previous statements that the bridge could have been made permanently perfectly safe and efficient for its intended purpose, will you please explain what is in your mind and how you would suggest that this might have been effected ?—A. I think I have explained that in my previous answer in regard to insert-

ing permanent struts to divide the chords in half and reduce their compressive length and adding additional plates or diaphragms between the ribs of the chord if, on examination, it was found necessary.

Q. Did you consider at noon on August 29 that the collapse of the bridge was imminent?—A. I did not think at that time that without additional loading the collapse was so imminent that a remedy could not be applied; but I was not aware at that time that they were adding new material and had been for the previous day.

Q. Will you please say why when you telegraphed the Phœnix Bridge Company at noon on August 29, you did not telegraph also to the chief engineer of the Quebec Bridge Company? We understand that on a previous occasion you stopped work on the bridge by adopting this course?—A. During the half hour that I had this matter under consideration I felt that prompt action was needed to stop any more loading and to promptly protect the chord from further deflection. Learning from Mr. McLure that there was no one upon the work but the foreman, realizing that it might be very slow reaching Mr. Hoare, as he might be at his home, his office, the bridge or some other place, I decided that the shortest and quickest method of reaching the bridge was through the Phœnix Bridge Company, who, I knew, had direct wire and telephonic communication with their office at the bridge. On the previous occasion when I stopped work on the bridge by communicating with the chief engineer of the Quebec Bridge Company there was no emergency before me.

Q. You have referred to the position and condition of the big traveller as not having been reported to you. Will you be good enough to refer to your photographs and correspondence and reconsider this matter? It would appear that information with regard to the location and condition of the big traveller was in your possession prior to August 29?—A. I have refreshed my memory by reference to my photographs and correspondence.

On August 17, Mr. McLure reports:—

'The work of removing the large traveller is progressing and the tip of the top overhang has been lowered this week. The removal of weight from this traveller, however, does not nearly keep pace with the additions to the suspended span.'

On August 24, Mr. McLure reports:—

'The top forward overhang is now entirely removed from the big traveller, two engines are taken off and the lower forward overhang removed.'

I therefore was under the impression that they were continuously dismantling the large traveller. I did not give special attention to the fact that the photographs still showed some portion of the big traveller in position, because I had supposed from the understanding we had with the Phœnix Bridge Company and Mr. McLure's report that they were dismantling the traveller as fast as possible.

Q. Were the reports of shop work and field work at any time of such a nature that you considered it necessary to stop the work or to place more competent men to represent you, and, if so, what action did you take?—A. In the first place I must protest against the idea that any of the employees of the Quebec Bridge Company represented me. That all action by them was referred to me is true and in the interest of the work I endeavoured to get the best results possible. I did reprimand Mr. Edwards very severely once or twice and I stated to him, after a repetition of some of the bad work in boring the chords that his duty was not solely to discover errors, but to prevent them; that I did not expect an inspector to merely sit down and verify work after it had been made wrong and report to me, but I expected him to know that the work was placed in the tool in the correct manner and that the tool was the proper tool to do the work required. He stated that it was a very difficult thing to do in the Phœnix Iron Company manufactory, that the workmen and the foremen resented any instructions or interference by the inspector and took the stand that the inspector's business was simply to inspect the work after it was completed and turned over to him. I told him this was not satisfactory and I wanted him to represent to the Phœnix Bridge Company that I demanded the right for the inspector to verify the setting of the work

and its being placed properly in the tool. He stated that there was the same objection in the Phœnix Iron Company against the interference in that manner of the inspector for the Phœnix Bridge Company. At a later date, errors still being continued, I told Mr. Edwards in my office that I would remove him and replace him if it had not been that the work was so far advanced that I felt that we had not time to break in a new inspector.

In reference to the field work I felt that Mr. McLure was doing his duty to the best of his ability and I had no reason to complain in regard to him.

Q. Were you aware that the lower chords of the anchor arm were fabricated before the weights of the suspended spans and the cantilever arms were closely computed and that the stress sheet for the anchor arm used in the design was therefore incorrect?—A. The exact weight of the suspended span and cantilever arm were not computed closely until the late dates mentioned in my previous answers, and I was not aware that the estimated weights were less than the actual weights until the work was too far advanced to make any corrections for the new stress sheet.

Q. Why did you not stop the progress of fabrication until reliable sheets were prepared?—A. For the reasons stated above.

Q. Please furnish references to the records of all full sized column tests of which you have knowledge?—A. To answer this question properly it would be necessary for me to refresh myself on all the engineering literature of the last thirty years. There will be found in the publications of the American Society of Civil Engineers a great amount of data in regard to column tests made upon full sized members. Further information will be found in the reports of tests on metals by the United States government. Some very interesting and important tests will be found in the report of Mr. Bouscaren, of the Cincinnati Southern Railroad many years ago of the earlier tests made on practical sized bridge columns. It would be impossible for me to go into this matter further; it would be simply a matter of going through the libraries and hunting up the literature.

Q. Was the design of any of the compression members tested in accordance with clause 49, Cooper's 1901 specifications and found to be satisfactory?—A. No. There is no machine or method existing by which any such tests could be made.

Q. Why were no such tests made—who had the authority to order the making of such tests and who would have had to bear the expense of them—who bore the expense of the full size tension tests?—A. The answer to the preceding question applies also to this. In regard to the expense of such tests the ordinary specification requirements state that where such tests prove the member or the detail to be satisfactory the expense is to be borne by the Quebec Bridge Company, but if the tests should prove unsatisfactory the expense is to be borne by the contractor. The Quebec Bridge Company bore the expense of all full size tests which were satisfactory with an allowance for the scrap value of the material. The Quebec Bridge Company were the only parties who had authority to order such tests and they would have had to bear the expense and it is even questionable whether for such expensive tests they could compel the contractor to perform them under the ordinary specification requirements.

Q. Did you ever request that tests in accordance with paragraph 49 should be made on compression members?—A. No.

Q. Do you consider that the requirements of paragraph 95, Cooper's specifications, 1901, influenced the design of the lower chord members and resulted in the selection of the section finally adopted in preference to anything like a box section?—A. I do not know if this clause of the specification had any influence upon the design for the lower chord members. The form of the lower chord members in general was determined by two factors, first, the desirability of a form that would not hold water and which could be always thoroughly inspected and painted, and secondly, requirements of the details necessary for the different joints in order to connect the web members with the chords and to enable spliced plates to be introduced of sufficient value. This last factor undoubtedly exerted a large influence in the general form of section selected.

Q. State clearly the substance of any communications made to you by representa-

tives of the Phœnix Bridge Company concerning the design of the lower chord members and of any discussions concerning this design?—A. I do not recall the substance of any discussion in regard to the design of the lower chord members, excepting that at one of Mr. Szlapka's visits to my office, when they were desirous of having me visit the Phœnix works to see a chord which had been especially prepared for my inspection, —after stating to Mr. Szlapka that I did not intend to go over, that that was not my method of inspection, that I preferred to see work that was not specially prepared for my inspection and did not intend to waste the time to go over and examine it,—I asked him in regard to the same and he spoke of it in high terms, made no criticism in regard to any part of it, but he said, partly laughing: 'Mr. David Reeves thinks the lattice bars should be heavier.' Mr. Szlapka made no criticism of the lattice bars, left me under the impression that he was perfectly satisfied with them and I simply made a remark to the effect that I supposed Mr. Reeves would be very glad to increase the tonnage. But no technical man connected with the Phœnix Bridge Company ever made any criticism to me, nor do I remember any suggestions referring to any changes in the form of the chords.

Q. Have you any statements to make which have not been already covered in your replies?—A. I would like to make a few observations in correction of the testimony that you have submitted to me as obtained at Phœnixville. Mr. Norris states that I wanted young men just out of college for inspectors, without any practical experience. That is not correct. I never had any such idea; I distinctly stated to every one with whom I came in contact that I desired at the shops technically educated young men with bridge experience. Mr. Deans in his testimony implies that it was my business to direct how errors should be remedied. I did suggest in my letter to him, as it was reported to me that they could not straighten a curved chord by the use of a jack, on account of scarcity of room, that by the use of long bolts the chord could be pulled into form. I declined to take the position of saying how errors of this character should be corrected, but did reserve the right to approve or disapprove the method proposed by the contractor.

He also states, in reference to the discussion between Mr. McLure and Mr. Milliken, that it was work which demanded prompt attention, and yet they had neglected it for several weeks until I drew Mr. Szlapka's attention in my office to the necessity of applying a remedy.

In the testimony of Mr. Scheidl and Mr. Szlapka the claim is made that it was always their intention to limit the thickness of the eye bars to two inches and that they endeavoured to keep the slopes down to four inches. My answer to this is to file with you a diagram (Exhibit 116) of the arrangement of the top chord submitted to me, shown on their sheet 'W,' dated May 20, 1904. This sheet 'W' showed slopes approximating seven inches and bars up to 2½ inches in thickness.

This was the original plan submitted to me for approval for the top chord of the anchor arm and was rejected by me.

They submitted another sheet or sketch—I am not positive which, it is not on record in my office—in the early part of July, 1904, which also contained bars 2½ inches thick. This plan was also rejected by me.

They finally submitted about July 27, 1904, a sheet which I found approvable. It is true that this last design of theirs did not follow the plan sent by me to them about July 1. They had done what I had suggested in my letter at that time, taken advantage of the distribution I had shown, but had improved and bettered it, maintaining the requirements that I distinctly stated at that time I aimed at, that no bars over 2 inches thick should be used anywhere except in the first or second panel and that no slopes over 4 inches should be allowed except in the first two panels and that the bars of these panels with slopes greater than 4 inches must be bored in the machine in the same position as they were to be placed in the chord.

Mr. Szlapka also speaks in condemnation of a suggestion that I made in regard to taking up the movement of the suspended span under the action of a suddenly stopped train. In explanation of this I would state that the Phœnix Bridge Company

submitted a plan by which the suspended span was fixed at one cantilever arm and free to move at the other extremity. This, at a temperature range of 150 degrees, which is the usual allowance for expansion, would have necessitated an expansion joint at one point of 24 inches. I rejected this proposal and stated that this extension should be so arranged that one-half of it only should occur at each end of the suspended span, and I felt that this amount of expansion could be provided for by a special device, but I had grave doubts whether any such expansion as 24 inches could be made safe for railroad traffic. Mr. Szlapka differed from me and brought up the subject of the swinging of the suspended span under the action of a train. I made a hasty sketch showing that by a leaf friction method, using the guard rails and a few additional timbers, this motion could be easily provided for without interfering with the natural extension of the trusses. This was suggested merely as a method indicative of how this trouble could be provided for. Later on Mr. Szlapka and I discussed the making of a similar device in metal to accomplish this purpose. In addition to my objection to having an expansion joint as great as 24 inches at one point in the track which I considered a matter of absolute danger, this amount of motion necessitated the swinging of the suspender through an arc of 24 inches, an amount of motion that could not have taken place about the suspending pin without producing excessive and dangerous bendings in the suspending members. I pointed out to Mr. Szlapka that with a special device in the form of pin hole and pin 12 inches of motion could take place without sliding frictions or producing undue bending strains in the suspending member.

Q. We would like you to supplement, if you can, your reply to the last question in your previously given evidence ?—A. You ask me whether I consider that the engineering data at our disposal are sufficient to enable engineers to design members similar to those in the lower chord with safety and economy. I do. While I do not mean to deny the desirability of far greater knowledge and study experimentally of our compression members, I feel that the faults in the existing chords as shown by the results of the disaster, do indicate in what manner these chords can be made, as I believe, effective and capable of doing the work they were intended to do. I believe that if the webs of the existing chords had had greater strength at the tops and bottoms, or, in other words, larger and wider angles, and if a horizontal web at the middle of these chords had been inserted their full length, over splices and all, this web would have given these chords abundant transverse stiffness in the horizontal direction, with the present latticing alone, and at the same time would have allowed access to all parts of said chord for inspection and painting. The introduction of this intermediate web would also have stiffened and protected, to a far greater extent, the splices during their critical period. I do not mean to suggest this form of chord at the best or as the only form; this suggestion is simply indicative of how I believe these cords could have been made abundantly strong and capable of standing the expected strains.

I, Bernt Berger, engineer, of the City of New York, in the State of New York, one of the United States of America, make oath and say :

1. That I attended before the Board of Royal Commissioners appointed under the Great Seal of Canada to inquire into the causes of the collapse of the Quebec bridge, on Wednesday, Thursday, and Friday, the third, fourth and fifth days of December, 1907.

2. That the annexed five pages contain my testimony and that the answers to the questions are true.

Sworn before me in the said city of New York, this fifth day of December, 1907, by the said Bernt Berger.

Mr. BERNT BERGER'S testimony.

Q. What was your position during the period of design and construction of the Quebec Bridge?—A. Assistant engineer to Mr. Theodore Cooper.

Q. How long have you been associated with Mr. Cooper?—A. For twenty-one years.

Q. Did you assist Mr. Cooper in the examination of the designs submitted with tenders in 1899, and to what extent?—A. Yes. As Mr. Cooper's assistant I examined strain sheets and proposed portions of members for the cantilever designs submitted by the Phœnix Bridge Co. and the Keystone Bridge Co. Also of the floor system for the Phœnix Bridge Co's suspension bridge design and made calculations for the studies of the substructive plans of all designs. All sufficiently thoroughly to arrive at definite results.

Q. Were you familiar with the various amendments made in the original specification?—A. Yes.

Q. Was the structure designed in accordance with the amended specification?—A. Yes, with the exception that the limit of 24,000 lbs per sq. inch on the chords for the assumed live load increased by 50 per cent was exceeded in a few cases, as follows:

Anchor	arm,	lower chord,	6—24,400	lbs per square inch
"	"		7—25,300	" "
"	"		8—25,460	" "
"	"		9—25,270	" "
"	"		10—25,270	" "

Q. What did you do in connection with the handling of strain sheets and what strain sheets did you check—please give details in chronological order, and did these all agree with specifications?—A. I checked the strain sheet and proportion of members of the suspended span. For the anchor arm and the cantilever arm I only checked the sections given for the members to see that they were sufficient for the strains under the specifications. To my knowledge Mr. Cooper checked these strain sheets himself.

Q. When the stress sheet for anchor arm was finally approved and construction on it had begun, were the stress sheets for the cantilever arm and suspended span in your hands, and if not where were they?—A. The stress sheet of the suspended span was approved by Mr. Cooper on March 29, 1904, also a general plan of the suspended span, showing details in a general way.

The strain sheet of the anchor arm was approved on June 30, 1904. Details of the anchor arm were examined and approved from June 1904 to Feb. 1905.

The strain sheet of the cantilever arm was approved on May 25, 1905.

Q. Was the data in your hands when the anchor arm was checked, sufficiently close to allow of the work being built correctly in accordance with the specifications?—A. I did not check the strain sheet of the anchor arm, as stated above, but am aware, as Mr. Cooper's assistant, that the data were sufficiently close.

Q. Did the weights of cantilever arm and suspended span overrun the assumed weight in designing the anchor arm?—A. Yes. This I knew from Mr. Cooper, as I had not myself tabulated the shipping weights. It was discovered long after the checking of the strain sheets.

Q. How did this difference affect unit stresses in the anchor arm and to what extent?—A. The unit stresses in the anchor arm would be increased by an increase in the weight of the cantilever arm and the suspended span, but I have made no calculations of the amount of increase.

Q. Were the unit stresses in anchor arm increased beyond the requirements of the specifications, and to what extent?—A. I have made no calculations to enable me to answer this question.

Q. What checking of details did you make?—A. I examined all detail plans of

the whole structure, except the preliminary details of a part of the floor system of the bridge, the latter plans having been received in Mr. Cooper's office when I was away on a vacation in the fall of 1903. Also excepting the packing of the eyebar chords, which Mr. Cooper attended to himself.

Q. Did you find errors in the plans, and if so, what were they and what action did you take??—A. In a general way some errors were found in the number and spacing of rivets, in net sections of riveted tension members, in number of rivets for splices and joints, in mismatching of connections, length of batten plates, and in the unnecessary use of turned bolts where rivets could be used. But the plans were very carefully worked out and the number and importance of the errors were much smaller on this work than I have usually seen in bridge work. I reported all errors I found to Mr. Cooper for action by him.

Q. Were all errors remedied on drawings before final approval ?—A. Generally, yes. It did happen that plans were approved with a note that approval was contingent on correction of some draftsman's clerical error.

Q. Did Mr. Cooper discuss with you generally on matters concerning the bridge? A. Mr. Cooper talked over a great many things with me during the progress of the work.

Q. Did Mr. Cooper discuss the details of compression members with you, particularly the lower chords and their latticing, and if so give particulars ?—A. No.

Q. Did you comment in any way on the design of the lower chords at the time, or did you fully examine their design?—A. I fully examined the details of the lower chords, but made no comment except as to web splices of the centre ribs.

Q. Did you visit the bridge during the erection?—A. I did, in August, 1906, but only as a matter of personal interest, in no way sent by Mr. Cooper to look after the work.

Q. Was the work proceeding to your satisfaction ?—A. As stated under question 18, I did not visit the bridge to look after the work.

Q. Did you inspect the fabricated material in the yards, and have you any comments to make upon the quality of the work ?—A. I visited the Phœnix Bridge Co's. works during the manufacture of the bridge material, but did not go there to inspect fabricated material, only as a matter of interest to myself.

Q. Would you say that the quality of workmanship was equal to that called for by the specifications ?—A. I had nothing to do with the inspection of the workmanship.

Further evidence was obtained from Messrs. Hoare and Kinloch.

Re-examination of Mr. E. A. HOARE, January 4, 1908.

Answers to questions asked by Mr. HOLGATE.

Q. Did the Quebec Bridge Company accept the tender of the Phœnix Bridge Company of March, 1899 ?—A. The tender was not accepted specifically, as the company was not in a position to formally accept any tender, but from Mr. Cooper's report, the selection of contractors was made, though the Phœnix Bridge Company were not notified of this in writing, but were given to understand the exact position of the Quebec Bridge Company, and also were made aware of the fact that Mr. Cooper favoured their design.

Q. Why was a price-per-pound contract entered into instead of a lump sum price?—A. It was impossible to execute a lump sum contract for the following reasons: The time limit of the proposals expired before the company was in a position to order any of the work to proceed and it was also necessary to have the option of ordering the work ahead in sections at different periods, and as the labour and metal markets would be subject to change at these periods and the work would spread

over a long period the unit price would be affected to the extent of those changes at the time each section of the work was ordered ahead, there being no complete plans and the span not being decided. Under the circumstances a lump sum agreement was impracticable, especially as the change of channel span and the fact that the drawings were not complete, rendered it impossible to make a sufficiently accurate estimate for a lump sum contract at that time. Although the proposals were on a lump sum basis this was for comparison only and for selection of general design. A unit basis in this case also prevented charges for extra quantities which would certainly have arisen out of a lump sum agreement owing to the complications that would be sure to arise. The fixed unit prices were applied to the actual weight of metal erected so there was no room for differences, or for one party to the contract taking advantage of the other.

Q. Were the prices tendered by any other parties less per pound than those tendered by the Phœnix Bridge Co. and what were these figures?—A. Yes, but unit prices were not considered. The Keystone Co's unit prices were lower, but the tenders were compared on the lump sum basis only. I have not the details of these figures of unit prices.

Q. In view of the fact that another contractor tendered at lower prices per pound, why were not new tenders asked for before letting the contract to the Phœnix Bridge Co., the weight being an unknown element?—A. Although one of the tenders showed lower unit prices, when it was compared with the Phœnix Bridge Co's plans and tenders in all essentials it was shown by Mr. Cooper that the latter was the most economical and satisfactory in every respect. They could not be used again for open competition; an adjustment of price, as far as it was affected by the cost of labor and raw metal in connection with these plans, under the circumstances, was the most satisfactory and expeditious method to adopt. The time that it would have taken to obtain new designs would have been too long, and it is doubtful if a second competition could have been obtained after the Phœnix Bridge Co's. plans had been accepted. No bridge construction company would have incurred the expense of new competitive design in view of the above facts. New tenders were not asked because our company had no plans of their own design to submit for competition, to prepare such plans would have taken about two years with a large staff of engineers especially qualified for this particular work, which would have taken some time to organize, and the result might not in the end have been as satisfactory as that obtained from the well organized and thoroughly trained permanent staff of bridge engineers employed by the Phœnix Bridge Co. Had the company been in the position of being able to accept the tender of March 1, 1899, and order the work ahead then, that is, had they had the money available for that purpose, they could have accepted the Phœnix Bridge Co's tender and have had the bridge completed for the lump sum price stated in that tender. This is technically the position of the two companies as at March 1, 1899, but subsequent events whereby specifications were amended and span changed would have upset any contract if it had been made previous to these important changes.

Q. Was there any weight specified which the bridge should not exceed?—A. No.

Q. Were the tenders received on March 1, 1899, compared as far as cost was concerned on the lump sum total only?—A. Yes.

Q. Were these tenders all lump sum tenders?—A. Yes, the tenders did not all coincide exactly with circulars issued. The consulting engineer, however, obtained all necessary particulars and explanations of each tender and afterwards analysed and reduced them all to the same basis for comparison, finally reporting in favour of the Phœnix Bridge Company's plans and tender, the plans being the best bridge and the price the lowest.

Q. Had the lower unit prices of the Keystone Bridge Company been adopted, would the bridge have cost less?—A. Had the Keystone figures of unit prices been applied to the Phœnix design the cost of the bridge would have been very much less, but the board was impressed by Mr. Cooper's favourable report of the Phœnix Bridge

Company's design and decided to follow Mr. Cooper's report, especially at that time as the Phœnix tender was a lump sum. When the contract for the superstructure was awarded to the Phœnix Company on April 12, 1900, it was on a unit price basis, as the matter of design was of first consideration, a lump sum agreement being impracticable for reasons above given, and a contract had to be concluded at an early date; and though the span was not at that date formally decided on, yet it was expected that Mr. Cooper would be favourable to the change from 1600 to 1800 feet, so that the weights figured on originally by the Phœnix company, as for a 1,600 feet span, would not agree with those for the 1,800 feet span, so there was no way except getting further lump sum tenders or making an agreement on the unit basis, and the latter course was followed, the board feeling that they were making the best possible arrangement at that time owing to all the existing conditions.

Q. Please let us have copies of the minutes of the Board of Directors, duly certified by the secretary relating to tenders and contracts between April, 1899, and April, 1900?—A. I herewith file with you the minutes of the nine meetings at which these matters were discussed. (Exhibit No. 117.)

Re-examination of Mr. E. R. KINLOCH.

Mr. Kinloch's answer to question asked by Mr. Holgate, January 4, 1908.

Q. Please read the evidence given by Alexander Beauvais as to the riveting of lower chord splices 9-10 R. and L. anchor arm, and state if this agrees with the facts as you know them, or if it differs, please give details of such points of difference?—A. On page 455 Beauvais does not state clearly what riveting was going on on the anchor arm at the time of the collapse; there were two gangs of riveters working at this time, one on 9-10 L, one on 5-6 R.

On page 456 he is mistaken as to the amount of riveting already done at the beginning of the season 1907. There had been some rivets driven in the towershell, in the shoes and on the floor system, but there had ben no riveting done on the trusses.

On page 460. In regard to the bolting of the Montreal joint I would say there were quite a few more open holes due to the addition of the repair splice plate, but the joint was more than 60 per cent bolted.

On pages 462 and 463 and referring to $\frac{7}{8}$ bolts. This refers to the two inner ribs and was on account of the camber opening. As the bridge would take its final position the holes would become better. The reason the bolts were not changed was that it would be necessary to remove the top or bottom plate to do so. I do not agree with Mr. Beauvais as to the number of $\frac{7}{8}$ bolts; am positive there were more than 22 to 25; also some $\frac{3}{4}$ bolts, the rest of the holes being filled with $\frac{7}{8}$ bolts; we always used the largest size we could get in on every joint. Mr. McLure's notes will give the camber opening at the time of first bolting up.

On page 466. It was not the case that 15 rivets were driven in the side splice plates inside ribs, but that all but 15 rivets were driven.

On page 479 and 480. Speaking of the level bracing, this refers to the lower longitudinal strut in panel 9, and was purposely left loose as per erection instructions.

In regard to Mr. Beauvais' statement about the bolting being loose, I would say no fitting gang ever pulls the work up tight enough for riveting, and no experienced riveting gang would trust any previous fitting. It is customary in heavy work of this kind for the riveters to carry a short piece of pipe which they fit over the handle of their wrench to get additional leverage.

The riveting on the anchor arm was practically completed. In regard to the trusses, all of the bottom chord was riveted except 5-6-R and L, and 9-10 L and 10-11 R and L. The bottom laterals were all riveted except the lower ends of the lateral in panel 10. All of the rest of the trusses were completely riveted. The floor system was about 50 per cent riveted. The top laterals, transverse struts, bottom struts were

fully riveted. All the longitudinal struts were riveted except the lower strut in panel 9, which was loose at one end. Diagonal T-50-5 had one joint on each still bolted. The present condition of the joint between 9 and 10 shows the ends of the ribs of both chords in good condition and in about the same distance between the ribs transversely as before. The top cover plate is attached to chord 9 and the temporary angle is in place on the bottom, showing there has been no transverse distortion. The outside west rib of chord 9 and the outside west rib of chord 10 are about 8 inches apart, the side splice plates are attached to chord 10 rib, the bolts having sheared on chord 9 rib. The west centre rib of chord 9 and the west centre rib of chord 10 are about 2 inches apart, the splice plate is riveted full and is broken square at the joint. The east centre rib chord 9 and east centre rib chord 10 are almost abutting. The splice plate is riveted full, except about 15 holes. The plate is not broken at the joint but bent. The east rib of chords 9 and 10 are abutting, and the side splice plates are attached to both chords. Taken as a whole the condition is exactly what would have to happen upon the deflection of the centre of chord 9-L towards Quebec. There is no indication of any initial failure at any place, and the only way in which I can see that it might have contributed a share to the failure would be from the fact that it did not close up like the rest of the chords, but was very slow in coming to its proper position; this may have caused the top part of the chord to have carried more than its proportion of the load even though the bottom of the ribs were in perfect contact. I have looked the chords carefully over with this idea in mind, but can find no marks that will show that any one part of the chord ends received more compression than another, but this condition of unequal bearing might have existed and yet show no marks on the end sections.

CORRESPONDENCE ORDERED TO BE INCLUDED IN EVIDENCE.

MONTREAL, January 10, 1908.

Honourable S. N. PARENT,
Ottawa, Ont.

DEAR MR. PARENT,—I would like you to state what you considered to be the real duties of Mr. Hoare and Mr. Cooper, and what you as president of the Quebec Bridge Company expected from each.

Mr. Cooper was only the consulting engineer, while Mr. Hoare was the chief engineer, yet we find Mr. Cooper performed many duties which should belong to the chief engineer. What was the reason for this, and was the board aware of what was going on?

Had Mr. Hoare as chief engineer full control of the work, and the carrying out of the contract with the Phœnix Bridge Company?

Who would be responsible for permitting the contractors to act contrary to the contract, keeping in mind that Mr. Cooper was never given a copy of the contract and never saw it nor was he advised of its terms, so it is clear that it was not Mr. Cooper?

Did the board at any time authorize any one to vary the terms of the contract with the Phœnix Bridge Company, and if so what were these variations, or did the board at any time vary the contract?

Had the Department of Railways and Canals a copy of the Phœnix Bridge Company's contract ?

Was the contract with the Phœnix Bridge Company of June 19, 1903, intended to be carried out as signed and whose duty was it to see that this was done ?

Did you consider prior to 1903 and subsequently that Mr. Hoare was competent to act as chief engineer and carry out the duties and responsibilities that attach to that position, or did you consider the position of chief engineer merely a nominal one with the responsibility elsewhere, and if so on whom was this responsibility, and what was the understanding of the Board of Directors on this question ?

I would be glad if you would carefully read the above, and let me have your reply at the earliest possible date.

Sincerely yours,

H. HOLGATE.

THE COMMISSIONERS OF THE TRANSCONTINENTAL RAILWAY, OTTAWA.

OFFICE OF THE CHAIRMAN, January 11, 1908.

DEAR MR. HOLGATE,—Your letter of yesterday's date is received and I readily comply with the request it contains that I give a reply to the various questions asked therein.

While Mr. Hoare had the title of chief engineer and Mr. Cooper that merely of consulting engineer, still we considered the latter as being in fact chief engineer of the enterprise. At the time the services of Mr. Cooper were secured, he would not undertake this work unless given full control over it not only in the preparation of the plans, but also during the execution of the work. Evidence of this was given in 1906, if I remember correctly, when he telegraphed Mr. Hoare enjoining him not to accept certain pieces of material from the Phœnix Bridge Company, as must appear in the documents now before your Commission. Further proof of this is given by the fact that Mr. Hoare, although being chief engineer in name, after conferring with Mr. Birks over certain matters, did not wish to assume the responsibility of taking a decision himself and sent Mr. McClure to Mr. Cooper in New York to lay the question before him. What further confirms the view which we were holding on this point, i.e., that Mr. Cooper had absolute control of the work, is the fact that when Mr. McClure went to see him on the mission just referred to, which was on the day of the accident, instead of sending advice direct to Mr. Hoare, as would have been the proper course if the latter had been the one in authority, he Mr. Cooper despatched Mr. McClure to Phœnixville with instructions to the Phœnix Bridge Company not to put any more metal on the structure until further advice. Therefore although bearing the title of chief engineer because he had started as such with the Quebec Bridge Company, Mr. Hoare was not really in authority when it came to the general direction and control of the enterprise, these duties being left to the consulting engineer, Mr. Cooper, at his own request as already stated.

For my part, as president of the Quebec Bridge Company and knowing the arrangements made with Mr. Cooper, I always considered that the latter and not Mr. Hoare as having full control of the work, though nominally only consulting engineer, and the carrying out of the contract with the Phœnix Bridge Company for the structure. Another fact shows Mr. Cooper's stand on this point. When the government was considering the advisability of appointing Mr. Nichols, who was considered to be an experienced bridge engineer, in order to supervise more closely the execution of the work, Mr. Cooper strongly opposed the proposal on the ground that he would not leave to any other man the responsibility of the work, and that if the government should persist in that course he would resign, and that he was satisfied to have Mr. Hoare send him reports from time to time on the state of the work

With regard to the contracts, I am not prepared to say that Mr. Cooper was never made acquainted with the terms of the same, since he saw fit to modify the first contract for the structure by changing the length of the span from 1,600 feet to 1,800, and in the second place as he had the specifications, which formed the basis and the essential part of the contract, for his guidance while the work was going on.

The documents in your hands will show the few changes which may have been made in the plans, and in the specifications. As far as I can remember, they were made by Mr. Cooper. The board relied entirely upon Mr. Cooper for the proper execution of the work. He had stated his own terms as regards salary, which were accepted. This appears on record.

To the best of my memory, the Department of Railways and Canals had a copy of the Phœnix Bridge Company's contract.

The contract speaks for itself and should answer the questions you ask regarding its carrying out.

Coming to your last question, I have answered it to some extent in the first part of this letter. While Mr. Hoare was considered a competent man to look after the work entrusted to him under these conditions, everybody was aware, at the same time, that he did not possess the experience and special qualifications of a specialist in this branch of engineering which would permit of entrusting to him the responsibility of an undertaking of this magnitude. It was for this reason that the government, realizing the importance of such expert direction, wanted to appoint a specialist on bridge engineering with the result already mentioned, as Mr. Cooper did not think that he could relinquish some of the responsibility for this enterprise on any one else. In view of this, as I understood it, Mr. Hoare was there more especially for the general supervision of the work, and, in particular, to report to Mr. Cooper from time to time as to the progress of the work and discuss with him any questions that might arise offering some difficulty.

Trusting this will cover the scope of your questions fully enough, I remain,

Yours sincerely,

S. N. PARENT,
Pres. Quebec Bridge and Railway Co.

HENRY HOLGATE, C. E.,
Prest. Royal Commission,
Quebec Bridge Inquiry.
Montreal, Que.

MONTREAL, January 3, 1908.

JOHN STERLING DEANS, Esq.,
Chief Engineer, Phœnix Bridge Co.,
Phœnixville, Pa.

DEAR MR. DEANS,—Will you please inform me in what form was your tender of March 1, 1899, accepted by the Quebec Bridge Company. If verbal, give me the particulars, and if written let me have copies of letters.

I urgently require this information, so please let me hear as quickly as possible.

Sincerely yours,

H. HOLGATE,

THE PHŒNIX BRIDGE COMPANY.

PHILADELPHIA, PHŒNIXVILLE, NEW YORK, CHICAGO, BOSTON, LONDON, ENG.

PHŒNIXVILLE, PA., Jan. 6, 1908.

Refd. to... .. ..
Noted.. .. ..
Recd. Jan. 23, 1908.
Answd.. .. ..
File No... ... ...

HENRY HOLGATE, Esq.,
Chairman Royal Commission,
Montreal, Canada.

DEAR MR. HOLGATE,—In reply to your letter January 3, I hand you herewith copy of letter of Hon. S. N. Parent, President Quebec Bridge and Railway Company, dated August 23, 1899, which is the first formal acceptance of our proposition of March 1, 1899.

Yours truly,

JNO. STERLING DEANS,
Chief Engineer.

P.S.—I just understand from Mr. David Reeves that you have a copy of this letter.—J.S.D.

THE QUEBEC BRIDGE COMPANY.

QUEBEC, August 23, 1899.

JOHN STERLING DEANS,
Chief Engineer Phœnix Bridge Co.

DEAR SIR,—Referring to yours of this day, I beg to state that this company is ready to enter into a contract with your company, for the superstructure of our proposed bridge, subject to the modifications in the specifications either decreasing or increasing or any other that may have to be made in size, depths and locations of the piers and their caissons; provided you accept in payment your share of the amount of $1,500,000 in subsidies or their equivalent and the difference in bonds given in trust as collateral security, face value and interest on same, at their redemption on conditions to be agreed upon, but at any rate the company will decide before the bridge is open for traffic to redeem the said bonds at face value or surrender them to the contractors; this company binding themselves to transfer you your proportionate share of any further subsidies or guarantees of interest that they may receive towards the construction of the said bridge. We will furnish by an early mail a statement showing the position of the company, its available subsidies and prospects as to resources and earning powers. If your company accepts the above conditions, we on the other hand will accept the conditions stated in your letter of this day, that we may order the work from you at any time within two years, providing at the time the work is ordered to proceed either party to the contract may request the prices for plain structural metal revised, to agree with the ruling prices of metal at that time and provided also that you give us to-day the price of your metal on which you have based your tender. This option is open for fifteen days from this date.

Yours truly,

S. N. PARENT,
Pres. Q. B. Co.

I, P. L. Szlapka, designing engineer of the Phœnix Bridge Company, Phœnixville, Pennsylvania, U.S.A., do hereby solemnly and sincerely declare that the document annexed hereto and marked Exhibit 'A' and numbered pages 1 to 4 is a portion of the evidence taken by the Royal Commission of Inquiry into the collapse of the Quebec Bridge and is to the best of my knowledge and belief true, and I make this solemn declaration conscientiously believing the same to be true and by virtue of the Statutory Declaration Act, 1885.

(Sgd.) P. L. SZLAPKA.

Declared and subscribed at the British Consulate, Philadelphia, this twenty-second day of January, one thousand nine hundred and eight.

Before me
(Sgd.) WILFRID POWELL,
[SEAL.] *H. B. M.'s Consul.*

This is the exhibit marked 'A' and numbered pages one to four referred to in the affidavit of P. L. Szlapka, designing engineer of the Phœnix Bridge Company of Phœnixville, Pennsylvania, U.S.A., sworn before me this twenty-second day of January, one thousand nine hundred and eight.

WILFRID POWELL,
H. B. M.'s Consul.

British Consulate, Philadelphia.
[SEAL.]

EXHIBIT 'A.'

1. State your method of computing the latticing in the lower chords and illustrate it by making the calculation for chord 9 anchor arm. State clearly the unit stresses used in each part of the design of that chord, and give the authority for the use of those stresses.

2. Did you make separate calculations for the latticing in each chord, or if not what did you do?

3. Did you apply the same method to the lattices of all compression members?

4. Mention what records of tests upon columns were familiar to you at the date when the general form of the compression members for the Quebec bridge was decided upon?

5. State what dead loads were used in the calculation of the stresses with which the members were finally designed, and how the dead load was divided between the various panel points.

6 Give your reasons for assuming ½-inch deflection in webs of chord for designing latticing.

7. Did you in your calculation of latticing consider the compression in the lattice angles due to the general compression in webs of chord?

8. Why did you assume C=36000, which is the constant for square ended columns instead of 18000, the constant for pin ended columns—values as given on page 88 Phœnix Iron Company's pocket book of 1906.

9. What investigations with regard to the design of lattice compression members did you make before deciding upon the adoption of the method given in Johnson's Modern Framed Structures.

Mr. SZLAPKA'S testimony.

1. With a maximum permissible unit stress of 24,000 lbs. as specified by Mr. Cooper, and with a lateral deflection of ½ inch as per No. 6 below, the following method was used in calculating the size of the lattices for the lower chord, this being

evolved from the discussion in 'Johnston's Modern Framed Structures,' the only authority to my knowledge which deals with this problem.

For anchor arm lower chord section (9) having an area of 780 square inches.
P=24,000 lbs. x 780"=18,720,000 lbs.
S=lateral deflection=½".
Moment M=9,360,000-inch lbs.
W transverse force at centre of chord to produce moment M.
L length of chord (9) 684".
$\frac{WL}{4}$=9,360,000-inch lbs. and therefore
$\frac{W}{2}$=about 27,400 lbs. and
L=stress in each of the four lattice.
L= $\frac{27,400 \times 1 \cdot 4}{4}$ about = + 9,600.

The Quebec Bridge Company's specifications, as amended by Mr. Cooper, specified a shearing unit stress on rivets equal to three-quarters of the unit stress on the member or in this case equal to ¾ x 24,000, 18,000 lbs., therefore two ⅞ single shear rivets, having a value of 21,600 lbs. were used to carry the above stress of about 9,600 lbs. in each lattice; the strength of the latter was made equal to the two ¾-inch rivets, only the horizontal leg of the angle being considered as acting.

2. The calculation of lattices was made only for the heaviest chord sections; the same size lattices were used for the entire lower chord, to secure uniformity of work and to guard against probable errors, if several sizes of lattices were used.

3. Yes.

4. Tests on small columns as given in the United States government 'test of material,' and as described and discussed in the current engineering papers, were known to me at the time of designing the large compression members of the Quebec bridge.

5. See attached blue print.

6. From the two equations (derived from the beam and from the compression formulæ).

$$T = \frac{MD}{21} = \frac{PSD}{21}$$

and also:

$$L_1 = \frac{PL'}{cI}$$

we obtain:

$$\frac{SD}{2} = \frac{L'}{c} \text{ or } S = \frac{2L'}{cD} = \frac{2 \times 684 \times 684}{36000 \times 68} = 0.38''$$

which was increased to ½-inch to simplify calculations.

7. Yes, in a general way.

8. Mr. Cooper's special specifications for compression members of the Quebec bridge required no reduction of unit stresses by any compression formula for lengths less than fifty times the least radius of gyration, or in other words members not exceeding that length were to be considered short columns. The chords being continuous, i.e., having no pin bearings, were considered fixed between panel points, and therefore the constant (c) in the compression formula was used equal to 36,000 lbs., as given on page 88 of Phœnix Iron Company's pocket book of 1906, Johnson's Modern Framed Structures, &c.

9. In the study of the question and for the purpose of designing the lattice compression members I consulted over one hundred modern standard specifications drawn

by engineers of railroad companies and by consulting engineers. I examined all the latest American engineering books, including Johnson's Modern Framed Structures, treating the theory of compression members; two standard German books upon the same subject, the current American engineering literature, some of the current German and English engineering papers, and all other authorities that were available to me.

The only discussion that I found upon the subject was in Johnson's Modern Framed Structures.

THE QUEBEC BRIDGE AND RAILWAY COMPANY,
QUEBEC, January 31, 1908.

HENRY HOLGATE, Esq., C.E.,
c/o. Ross & Holgate, Montreal.

DEAR SIR,—In reply to yours of the 29th instant, addressed to the president, I am instructed to inclose a sworn statement of the money received from the shareholders of the company in payment for stock issued, and also the amount of stock issued to each shareholder.

Hoping the whole will be found satisfactory, I remain,

Respectfully yours,

ULRIC BARTHE,
Secretary.

LIST OF SHAREHOLDERS OF THE QUEBEC BRIDGE AND RAILWAY CO.

10. Holders of first stock subscribed prior to 19th October, 1903 (as it appears to date 31st January, 1908, in the stock ledger of the company)—$63,700.

	Number of Shares	Amount paid up.
Allard, J. B. E.	¼	$ 25 00
Amyot, Joseph	2	200 00
Amyot, G. E.	½	50 00
Amyot, G. E.	3¾	375 00
Anctil, Joseph	¼	25 00
Asselin, N. H.	¼	25 00
Audette, Dlle Albertine	1	100 00
Audette, Dlle H.	1	100 00
Audette, Dlle L.	1	100 00
Audette, Dlle R. M.	1	100 00
Audette, L. Gustave	4¼	425 00
Audette, Rodolphe	53	5,300 00
Baillargeon, Mme. G. A.	1	100 00
Beau, Dlle R. J.	¼	25 00
Bedard, E.	1¼	125 00
Bedard, J. B. & Frere	½	50 00
Bedard, Jos. E.	1¼	125 00
Bedard, L. O. (Succ.)	½	50 00

LIST OF SHAREHOLDERS—*Continued.*

	Number of Shares paid up.	Amount.
Beemer, H. J. (by notorial deed transferred to Senator P. A. Choquette)	35	3,500 00
Belanger, A.	¼	25 00
Belzil, Ls. G.	¼	25 00
Berlinguet, F. X.	2	200 00
Bilodeau, I.	1¼	125 00
Blais, Wilbrod	1¼	125 00
Boswell, V.	47	4,700 00
Boulanges, Dame A. A.	1	100 00
Breakey, John	29	2,900 00
Burn, Henriette D.	3	300 00
Cantin, I. D.	¼	25 00
Cantin, V.	¼	25 00
Carrel, Frank	¼	25 00
Casgrain, Edm.	2½	250 00
Chabot, L. G.	¼	25 00
Chateauvert, Geo.	¼	25 00
Chateauvert, V.	1	100 00
Chauveau, Alex. J.	1¼	125 00
Choquette, Hon. P. A.	½	50 00
Clement, F. X. M.	¼	25 00
Cloutier, Ephrem (Succ.)	1¼	125 00
Consigny, N.	½	50 00
Côté, Achille	¼	25 00
Côté, Edouard	¼	25 00
Côté, Joseph	¼	25 00
Côté, J. B.	¼	25 00
Côté, P. J.	1¼	125 00
Crepault, Z. (Succ.)	2½	250 00
Darveau, Geo.	2½	250 00
Delage, Cyrille F.	1¼	125 00
Demers, L. J. (Succ.)	1¼	125 00
Derome, H.	¾	75 00
Dery, Arthur	¼	25 00
De St. Georges, H. Q.	¼	25 00
Dobell, Mrs. E. F.	28	2,800 00
Dorvall, Eugène	¼	25 00
Doyle, Wm.	¾	75 00
Drolet, Arthur	1	100 00
Drolet, D. E.	1¼	125 00
Drouin, Napoléon	2½	250 00
Dumoulin, P. B. (in trust)	5¾	575 00
Dupuis, A. B.	2½	250 00
Duquet, Cyrille	¼	25 00
Dussault, Nap. (Succ.)	¼	25 00
Faguy, Lepinay & Frere	2½	250 00
Faguy, Revd. F. X.	¼	25 00
Fortier, F. G.	1	100 00
Fortier, Nazaire	2½	250 00
Fournier, Auguste	2½	250 00

LIST OF SHAREHOLDERS—*Continued.*

	Number of Shares paid up.	Amount.
Garneau, Hon. N.	47¾	4,775 00
Gauthier & Frere (Cie)	5	500 00
Gauvreau, F. E.	¼	25 00
Gignac, J. H.	1¼	125 00
Girard, A.	2¼	225 00
Guay, J. F.	¼	25 00
Guerard, Malvina P.	¼	25 00
Hamel, Dr. A. C.	1	100 00
Huot, Emmanuel (Succ.)	¼	25 00
Jacot, Emile (Succ.)	¼	25 00
Jacques, Oct.	1¼	125 00
Kirouac, F. (Succ.)	5	500 00
Lafrance, C. J. L.	½	50 00
Laliberte, Edmond	1¼	125 00
Laliberte, J. B.	25	2,500 00
Langlais, J. A. (Succ.)	¼	25 00
Larochelle, J. H.	2½	250 00
Lavoie, Napcléon	35½	3,550 00
Leclerc & Roy	½	50 00
Legere, J. B. D.	¼	25 00
Lemieux, J. F.	¼	25 00
Lemieux, Mrs. E. S.	¼	25 00
Lemieux, N. & Fils	2½	250 00
LeMoine, G.	47	4,700 00
Letellier, A. (Succ.)	1¼	125 00
Letellier, Mme. S.	1	100 00
Levasseur, Nazaire	¼	25 00
Madden, Geo.	1¼	125 00
Magnan, C. J.	¼	25 00
Malouin, Hon. Albert	½	50 00
Marcoux, L. C.	1¼	125 00
Marois, F. X.	¼	25 00
Marsh, Wm. A.	2½	250 00
Martineau, J. E.	2½	250 00
Matte, J. S.	¾	75 00
McCall, Shehyn & Co.	2½	250 00
McWilliam, Wm.	½	50 00
Michaud, Ben.	½	50 00
Migner, Thomas	¼	25 00
Moisan, J. A.	¼	25 00
Moisan, L. A.	¼	25 00
Morin, L. D.	¼	25 00
Morisset, C. L. A.	¼	25 00
Morrissette, J. B.	2½	250 00
Myrand & Pouliot	½	50 00
Noel, J. M.	½	50 00
Noreau, Charles	¼	25 00
Pampalon, T. (Succ.)	¼	25 00
Paquet, Cie Ltée	30½	3,050 00
Paradis, Etienne	2½	250 00

LIST OF SHAREHOLDERS—*Continued.*

	Number of Shares paid up.	Amount.
Paradis, V. E.	1¼	125 00
Parent, Alexis	½	50 00
Parent, Chs. A.	2½	250 00
Parent, François	1¼	125 00
Parent, Geo.	6¼	625 00
Parent, J. Alberic	3	300 00
Parent, P. I.	½	50 00
Parent, Hon. S. N.	45	4,500 00
Pettigrew, Charles	½	50 00
Picard, Joseph	¼	25 00
Picard, O. (Succ.)	1¼	125 00
Picard, S.	¼	25 00
Pichette, Elz. (Succ.)	¼	25 00
Powell, C. S.	¼	25 00
Price, H. M	48	4,800 00
Proulx, Mme. R. A.	1	100 00
Rhodes, Wm. (Estate)	1	100 00
Robitaille, Hon. A.	1¼	125 00
Rouleau, Revd. T. G.	¼	25 00
Roumilhac, Edouard	¼	25 00
Ross, John T.	2½	250 00
St. Pierre, Ernest	2½	250 00
Samson, Joseph	1½	150 00
Savard, Elzear	2	200 00
Savoie, F. T.	½	50 00
Scott, B. A.	2½	250 00
Scott, J. G.	2½	250 00
Syndicat de Quebec	2½	250 00
Tanguay, Geo.	1¼	125 00
Tanguay, G. E.	2	200 00
Turcotte, J. B. O.	¼	25 00
Turcotte, Nazaire & Cie.	2½	250 00
Turgeon, P. L.	1¼	125 00
Villeneuve, L. O.	¼	25 00
Voyer, Jean (Succ.)	¼	25 00
Walsh, John E.	¼	25 00
Total	637	$63,700 00

Old grant from government, province of Quebec	$1,681 69
Forfeited payments	204 01
Capital stock account as per ledger	$ 65,585 70

SESSIONAL PAPER No. 154

LIST OF SHAREHOLDERS OF THE QUEBEC BRIDGE AND RAILWAY CO.

20. Holders of additional stock subscribed as mentioned in Statute III., Edward VII., chapter 54. (As it appears to date, 31st January, 1908, in the stock ledger of the company), $200,000.

	Number of Shares paid up.	Amount.
Allan, Hugh A.	250	$25,000 00
Audette, R.	4	400 00
Boswell, V.	3	300 00
Breakey, J.	2	200 00
Davis, M. P.	949	94,900 00
Fortier, F. G.	1	100 00
Garneau, Hon. N.	3	300 00
Hays, Chas. M. (in trust)	250	25,000 00
Laliberte, J. B.	2	200 00
Lavoie, N.	4	400 00
LeMoine, G.	3	300 00
Parent, Hon. S. N.	25	2,500 00
Price, H. M.	4	400 00
Quebec Central Railway	174	17,400 00
Sharples, Hon. J.	276	27,600 00
Walsh, J. H.	50	5,000 00
	2,000	$200,000 00

I, J. Henri Paquet, Treasurer of the Quebec Bridge and Railway Company, do solemnly declare that all names appearing on the above list as shareholders of the company are correct according to the stock ledger; that all such shareholders have fully paid up their stock; that no allotment of stock was allowed to any of the shareholders; and that some directors have purchased some of the above stock out of the money voted them as attendance fees by the shareholders at the annual general meetings.

J. H. PAQUET,
Treasurer.

SWORN before me at Quebec, in the Province of Quebec, this 31st day of January, 1908.

J. A. PARADIS,
Com. Sup. Court, District of Quebec.

CORRESPONDENCE ORDERED TO BE INCLUDED AS EVIDENCE—FURTHER QUESTIONS SUBMITTED TO MR. KINLOCH, AND HIS WRITTEN ANSWERS THERETO.

Q. Did the field joint of lower chord A-9-L in panel 9 show any indication of being butted more tightly on the west side than on the east side, or *vice versa*, when ready for riveting up?—A. Joint of lower chord in left truss panel 9 was riveted early in June, 1907. All ribs of 9-L and 8-L butted tight. I can remember no facts that would lead me to believe any one rib was butted tighter than another.

Q. Were there any difficulties in the way of making this examination? How did you make it?—A. The bottom plate was removed and the examination was made from the bottom; first, by trying to insert a very thin piece of steel between the abutting web plates; second, by looking up between the two inner ribs and making as close an examination as possible from the top. 1st. By making as close an examination as possible and trying to enter a thin piece of steel at the top of the vertical leg of the top flange angle of the chord just above the outside side splice plate of the outside ribs of chords only. No satisfactory examination could be made of the top of the centre ribs and if all the other points were butted perfectly we assumed that the two centre ribs must necessarily be butting also at the top.

Q. Give what information you can in this respect in the case of any other field joints in lower chords?—A. When the chords of the anchor arm were set on the camber blocks and for some time after, there was some difference in the distance between the different ribs. I believe a record will be found of this matter in Mr. McLure's notes.

Q. At the request of Mr. Hoare, Mr. Birks examined chord 9-L, anchor arm, and the field splices connecting it to the adjoining chords on August 28th and subsequently reported some results of his examination to the Phœnix Bridge Company by letter. Did you accompany him on this examination?—A. No, but I met him just after he had finished making it and at his request I went down on to the chord and examined the field splice between chords 8-L and 9-L, he remaining at track level immediately above me and conversing with me during my examination.

Q. Did you agree that the deflection of 1½ inches at field splice shown on Mr. Birks' sketch existed and in what way was it measured. Do you consider that this deflection was present at the joint when it was riveted up in June, 1907?—A. We agreed at the time that there was an apparent deflection of about one-half inch at the field splice, and I do not know why Mr. Birks reported 1½ inches. Neither he nor I had any appliances for measuring the deflection, and it was estimated by sighting along the edge of the outside upper angle from about the second point of lattice attachment on chord 9-L. The estimates at best were of very uncertain value. I am confident that the joint was straight to all intents and purposes when it was riveted up, and am not prepared to say now that the deflection that seemed to me to exist on August 28th may not have been caused by the absence of any definite and well-marked line from which to measure. I noted on August 28th particularly that the lines of rivets in the upper cover plate were straight, that the rivets showed no sign of shear and that the edge of the cover plate matched the edge of the flange angles of the outside ribs on both sides throughout its length.

EXHIBITS

ORDERED TO BE PRINTED

AND

CHRONOLOGICAL INDEX

(PAGE 448)

TO

PRINTED CORRESPONDENCE RELATING TO THE BRIDGE

INDEX OF EXHIBITS.

1. Statutes and By-laws of Quebec Bridge Company.
2. Approval by Railway Committee of general plan showing location of piers at Chaudiere site.
3. General plan approved in 2.
4. Minute of Board of Quebec Bridge Company relating to the calling for tenders.
5. Approval by Deputy Minister of Specifications on which tenders were called for.
6. Circular letter calling for tenders.
7. Specification for a suspension bridge.
8. Tender received from the Phœnix Bridge Company.
9. Report of Mr. Theodore Cooper on tenders for substructure and superstructure. *(Printed.)*
10. Resolution of Board of Quebec Bridge Company to send Mr. Cooper's report, tenders and plans to the Prime Minister.
11. Report from Mr. Theodore Copper on modifications. *(Printed.)*
12. Subsidy agreement and specifications.
13-14. Contracts for the two approach spans between Quebec and Phœnix Companies.
15. Resolution of Board of Quebec Company approving 13 and 14.
16. Contract (19 June, 1903) between the companies for construction of superstructure.
17. Order-in-Council (21 July, 1902) authorizing Mr. Cooper to modify plans and specifications.
18. Order in Council (15 August, 1903) with respect to powers and duties of Chief Engineer. *(Printed.)*
19. Copies of all annual reports of Quebec Bridge Company.
20. Resolutions of Board of Directors defining position of Mr. Cooper.
21. Copy of specifications attached to contract and copy of amendments to specifications afterwards inserted.
22. Letter from Mr. Hoare to Mr. Holgate defining duties of inspectors.
23. Correspondence between Quebec Bridge Company and Mr. Cooper.
24. List of employees Phœnix Bridge Company on south side.
25. Sketch plan showing position of objects and witnesses with relation to bridge.

26. White print of Bridge.
27. Sketches made by Mr. Haley to illustrate his evidence.
28. Reports of tests, submitted by Mr. Hoare.
29. Photograph.
30. Book of plans produced by Mr. Milliken.
31. Book of plans produced by Mr. Milliken.
32. Plan showing state of progress on August 29.
33. A, B, C, folios of plans of bridge and strain sheets put in by Mr. Hoare.
33. D Index to approved plans.
34. Two books of photographs (Mr. Cudworth.)
35. Photographs (Mr. Kinloch.)
36. Agreement, province of Quebec and Quebec Bridge Company.
37. Agreement, City of Quebec and Quebec Bridge Co.
38. Record of errors found in the field (Mr. McLure) small book.
39 Record of unfinished work (Mr. McLure) (book).
40. Sketch of 'crimp' (24 inch pin.)
41. Anchor and Cantilever Arm chord sections.
42. Progress estimates and reports (Mr. Hoare).
43. Field Engineering Reports.
44. Blue print, positions top chord panel points before and after the accident.
45. Same as 44 *re* bottom chord.
46. Positions panel points east truss of anchor arm.
47. Same as 46 west truss anchor arm.
48. Measurements for horizontal movement between anchor pier and main pier.
49. Position of pedestals on main pier before and after accident.
50 Elevations of two bench marks on face of main pier.
51. Telegrams from Mr. Hoare and Mr. Deans and sketch showing bend in chord A 9-L.
53. Mr. Hoare's Diary.
54. Blue print showing location of lower chords in wreck, and description.
55. Memorandum showing deflections under wind stress.
56 Anemometer records.
57. Sketch by Mr. Kinloch showing space blocking at chord A 4-L.
58. Letters from Mr. Birks and Mr. Yenser to Mr. Deans.
59. Letter from Mr. Deans to Mr. Yenser.

60. Blue print note book entitled: 'Notes for erecting Quebec Bridge,' and blue print notes covering erection of main traveller actually used by Mr. Birks, erection engineer.

61. Statement of condition of riveting on August 29.

62. Sketch showing method used in measuring between anchor pier and main pier south anchor arm, September 17th, 1907; plan showing location of 24-inch pins, September 27, 1905; photograph showing progress of erection at close of season 1908.

63. Letter of Mr. Douglas *re* suggested amendments, and other documents.

64. Copy of Guarantee Agreements, October 19, 1903 (3 Edward 7, Cap. 54.)

65. Letter of Mr. Schreiber to Mr. Fielding, August 12, 1903, *re* modifications of specifications.

66. Copy of Railway Department's instructions to Mr. Tomney, inspector at Phœnixville, August 4, 1904.

67. Notes by Mr. Douglas on large span bridges and proposed changes in specification.

69. Copy of Telegram, August 29th, 1907--Theodore Cooper to Phœnix Bridge Company.

70. Correspondence from Mr. Cooper's letter-books. (*Printed.*)

71. Correspondence from Mr. Cooper's letter-books. (*Printed.*)

72. Correspondence from Mr. Cooper's letter-books. (*Printed.*)

73. Correspondence from Mr. Cooper's letter-books. (*Printed.*)

74. Correspondence from Phœnix Bridge Company's letter-books. (*Printed.*)

75. Correspondence from Phœnix Bridge Company's letter-books. (*Printed.*)

76. Correspondence from Phœnix Bridge Company's letter-books (*Printed.*)

77. Correspondence from Phœnix Bridge Comp y's letter-books. (*Printed.*)

78. Correspondence from Phœnix Bridge Comp ay's letter-books. (*Printed.*)

79. Correspondence from Phœnix Bridge Company's letter-books. (*Printed.*)

80. Correspondence from Phœnix Bridge Company's letter-books. (*Printed.*)

81. Correspondence from Phœnix Bridge Company's letter-books. (*Printed.*)

82. Correspondence from Phœnix Bridge Company's letter-books. (*Printed.*)

83. Correspondence from Phœnix Bridge Company's letter-books. (*Printed.*)

84. Inspector Edwards' Report, 'Shop Errors.'

85. Tension tests of built-up members. (Blue print.)

86. Eye-bar tests.

87. Letter from Mr. Parent to Phœnix Bridge Company, August 23, 1899, tendering contract.

88. General outline plan Phœnix Bridge Company, November 30, 1897.

89. General outline plan Phœnix Bridge Company, November 30, 1897.

90. Daily record of Inspection Phœnix Bridge Company.

91. Record of Field corrections.
92. Statement weight removed and added Cantilever Arm in 1907.
93. Reports, condition of joints November 6, and August 29, 1907.
94. Preliminary plan No. 1.
95. Preliminary plan No. 2.
96. Plan submitted with 1,600 feet tender in 1899.
97. Stress diagrams for 1,600 feet design.
98 and 109. Strain sheets for detail design.
99. Copy of Quebec Bridge Company's specification (same as 11.)
100. Copy of modifications in specifications. (Same as 18.)
101 and 102. Mr. Cooper's specifications for workmanship.
103. Dead load concentrations Anchor Arm.
104. Stress sheet showing dead leads from actual shipping weights.
105. Stress sheet showing stresses immediately before accident.
105. A diagram showing camber movements.
106. Mr. Szlapka's personal diary.
107. Sketches of travellers.
108. Erection stresses due to large travellers.
109. Same as 98.
110. Mr. Cooper's packing of Anchor Arm top chord bars.
111. Stress sheet of Anchor Arm for 6,000 lbs. per lin. ft.
112. Instructions to Mr. Cooper to report on tenders. (*Printed.*)
113. Numbered letters giving effect to contract.
114. Statement of all payments to Mr. Cooper, Quebec Bridge Company. (*Printed.*)
115. Telegrem from Mr. Cooper *re* C.P.I.
116. Sheet 'W,' May 20, 1904, Phœnix Bridge Company, top chord packing.
117. Minutes of Meetings, Quebec Bridge Company Board.
118. Original of Mr. Szlapka's concluding evidence.
119. Copy of letters patent, Phœnix Bridge Company.
120. Original letter of Mr. Barthe with list of shareholders Quebec Bridge Company.
121. Mr. Cooper's Report on change of span, May 1, 1900.
122. Mr. Ami's Report on geology of foundations. (*Printed.*)
123. Balance sheet Quebec Bridge Company, 1907, and list of directors.
124. Photos of wreck taken by Mr. Francis. (*Printed.*)
125. List of plans of bridge with important dates. (*Printed.*)
126. Photographs of details and erection methods. (Appendix 10.) (*Printed.*)
127. Photographs of details and erection methods. (Appendix 10.) (*Printed.*)
128. Meteorological Records, Quebec.
129. Copies of correspondence relating to bent chords.

EXHIBIT No. 9.

THEODORE COOPER,
CONSULTING ENGINEER,
35 BROADWAY, NEW YORK.

REPORT UPON THE COMPETITIVE PLANS AND PROPOSALS FOR THE CONSTRUCTION OF THE QUEBEC BRIDGE.

The following plans with the accompanying proposals have been submitted to me for examination and report as to their relative merits and values, viz:—

Two plans by the Dominion Bridge Company of Montreal, one for a cantilever bridge with a channel span of 1,600 feet, and one for a stiffened suspension bridge with a channel span of 2,000 feet.

One plan by the Keystone Bridge Company of Pittsburg, for a cantilever bridge with a channel span of 1,600 feet (being identical with the plan proposed by the Dominion Bridge Company.)

Two plans by the Phœnix Bridge Company of Phœnixville, Pa.; one for a cantilever bridge with a channel span of 1,600 feet, and one for a stiffened suspension bridge with a channel span of 1,800 feet.

One plan by the Union Bridge Company of New York, for a stiffened suspension bridge with a channel span of 1,800 feet.

Making in all three different suspension bridge designs and two different cantilever bridge designs.

GENERAL DESCRIPTION OF PLANS.

1st. Suspension Bridges.

Dominion Bridge Company's plan, Channel span 2,000 feet.—This plan, prepared by the Pencoyd Bridge Company of Philadelphia, is a suspension bridge with continuous stiffening trusses extending from tower to tower, this portion of the cables only carrying any load. These stiffening trusses are riveted lattice girders, 70 feet in depth. The cables dip 1/10th of the span, or 200 feet. The towers are carried on sixteen cylindrical piers, eight to each tower. There are four cables, carried at the tops of the towers on movable saddles. Both anchorages are supposed to be in natural rock, and have tunnels for drainage and for access to inspect and care for the exposed metal. The spans between the shores and towers are entirely independent of the cables. The plan is accompanied by strain sheets and detail drawings.

Phœnix Bridge Company's plan, Channel span 1,800 feet.—This plan prepared by Mr. G. Lindenthal, C.E., is a suspension bridge stiffened by trussing the cables. Both the end and middle spans are loaded, so the cables carry the whole load from shore to shore; all the spans are similarly stiffened. The stiffening trusses have the cables for the upper members and the lower members are rigid chords of plates and angles. The vertical members are also rigid, but the diagonals are all adjustable wire ropes. All parts are positively connected by means of pins, the cables even being formed of wire links connected together at the panel points by pins. The whole truss thus formed is supported on pins at the tops of the towers. The towers are formed of two legs, each resting on a separate cylindrical pier 30 feet in diameter at the top. The tower pivots at the bottom on a large pin. The bridge has a buckle-plate floor which serves as a part of the wind truss. There is a toggle device at each tower which is intended to

maintain the continuity of the wind truss from shore to shore and still permit changes of length by contraction or expansion from temperature. The anchorages are supposed to be in natural rock, and after being placed, to be completely imbedded in concrete. This plan is accompanied by strain sheets and carefully worked out details, illustrating the essential features of the design.

Union Bridge Company's plan, Channel span 1,800 feet.—This plan is for a suspension bridge stiffened by trusses hinged at the ends and at the centre of the middle span, which is the only part of the structure carried by the cables; the backstays carrying no load. There are four cables and two hinged stiffening trusses. Each tower is carried on four cylindrical piers, 19 feet in diameter at the top. At the level of the roadways there extend from the towers horizontal outriggers, about the ends of which the wind cables are stretched. The structure between the shores and the towers is composed of independent viaduct spans. The plan submitted is merely a skeleton without other dimensions than the lengths of the spans and the elevations of the masonry piers. Copies of the plans of the proposed Hudson river bridge are submitted to indicate the character of the end and central hinges and other details. The plan is not accompanied by any strain sheets, sizes of parts nor any foundation plans.

2nd. Cantilever Bridges.

Keystone Bridge Company's plan, Channel span 1,600 feet.—This plan provides for two rivers arms each 550 feet long, two anchor arms each 500 feet long and a suspended centre span of 500 feet, making the channel span 1,600 feet, and the total length between anchorages 2,600 feet. The trusses are spaced 71 feet apart, centre to centre. The suspended span is 90 feet in depth and has parallel chords. The cantilever arms are 250 feet deep at the towers; the top chords sloping each way on straight lines. The floor beams are partially carried by suspenders to overhead transverse girders. The plans are accompanied by strain sheets and plans of foundations. The foundation plans are by the Engineering Contract Company of New York.

Dominion Bridge Company's plan.—This plan is identically the same as that of the Keystone Bridge Company. The foundation plans are by W. Davis & Sons of Canada.

Phœnix Bridge Company's plan, Channel span 1,600 feet.—This plan has two river arms each 500 feet long, two anchor arms each 500 feet long and a suspended centre span of 600 feet, making a channel span of 1,600 feet and a total length between anchorages of 2,600 feet. The trusses are spaced 67 feet centre to centre. The suspended span is 84 feet in depth at the ends and 120 feet at the centre, with a curved top chord, the cantilever arms are 295½ feet deep at the towers, the top chords descending in each direction on curved lines. The plans are accompanied by strain sheets and plans of foundations. The foundation plans are by the Engineering Contract Company of New York and are similar to those accompanying the proposal of the Keystone Bridge Company.

CONSIDERATION OF THE PLANS AND PROPOSALS.

After a preliminary examination and study of the several plans I made appointments with the designers of each plan (except the Pencoyd Bridge Company) and discussed with each their own design and its special features. On account of the high tender accompanying the suspension bridge plan prepared by the Pencoyd Bridge Company and the qualification made by the Dominion Bridge Company in reference to the construction of the cables, I did not consider it necessary to make any special examination of this plan.

The plan of the Union Bridge Company is indefinite and incomplete in that it

does not give the sizes of parts or proper data to determine the relative value of the design. It is not in accordance with the specifications, as it is proposed to use a higher grade of wire and of structural steel than is called for by the specifications and to strain these materials 40 to 50 per cent higher than is specified. The saving of metal by this means does not indicate any merit due to the plan and if it is permissible for one competitor to make such changes in the requirements of the specifications, fairness to the others would require that they be allowed the same privilege. The use of four cylinders for the foundation of each tower does not appear desirable in a river like the St. Lawrence, with its heavy and severe ice conditions.

The suspension bridge plan submitted by the Phœnix Bridge Company has been worked out much more thoroughly than the other suspension bridge designs. The lines of the structure are very pleasing, giving a combined effect of grace and strength. The catenary curves of the cables are not crossed or broken by the stiffening trusses. The design appears from an ordinary examination to be in accordance with the requirements of the specifications. Actual verification of the strain sheets would be difficult and require much time. A stiffening truss of the kind here proposed could not be used successfully for bridges formed with continuous wire cables, as the connections of the various members of the truss would have to be made through the frictional grip of cable bands, which would not be trustworthy. The success of such a truss depends therefore upon the use of wire links for the cables and a positive connection of all the members by means of pins. That such links can be made is undoubted, but their successful and economic manufacture has yet to be developed. The accessibility of these links for inspection at any time and the possibility, should it be necessary, of removing and replacing a link, gives this form of cable many advantages over the solid bound continuous wire cables.

CANTILEVER PLANS.

The preliminary examination of the several plans submitted led me to believe that the cantilever designs were probably the most favourable ones, in consideration of their lower tenders. They were therefore much more critically considered, not only to determine whether they were in compliance with the specifications, but also to obtain their relative values. It was then found that the two superstructure plans, viz., the Keystone and the Phœnix plans, were not proportionate for the carrying capacity. Through some misunderstanding of the specifications, the Keystone plan was proportioned for a live load two thousand pounds more per running foot of bridge than any of the other plans. In order, therefore, that this plan might be placed on a fair basis of comparison with the others, I requested the Keystone Bridge Company to correct their strain sheets and to make the corresponding change in their tender. This correction has been made and filed with the secretary of the Quebec Bridge Company and a copy has been furnished me. I have made an independent estimate of this correction, closely confirming the figures given by the Keystone Bridge Company.

Both the Keystone and the Phœnix plans of cantilever superstructure are in accordance with the specifications and are acceptable designs. The greater depth of the Phœnix design and the curving of the top members of the cantilever arms give this plan a more pleasing effect than is produced by the lower depth and straight chords of the Keystone plan. The method of carrying the floor in the Phœnix design, viz., directly to the trusses without intermediate supports, is more satisfactory than the one adopted in the Keystone plan; it also appears to be more economical, not only in weight of metal, but in saving four feet in the length of the piers. The Phœnix plan contains eye-bars of 16-inch widths, a size exceeding any heretofore made. While there is no question of the possibility of making bars of this size, it is not certain that such bars would give the desired strength and other physical qualities. There would be no difficulty, however, in substituting other forms if found desirable.

FOUNDATIONS AND PIERS FOR THE CANTILEVER PLANS.

The Engineering Contract Company furnishes similar plans for the caissons and piers for both the Keystone and Phœnix designs. The main or channel piers are alike in all of their dimensions except in the length of the piers and caissons, which are four feet longer in the Keystone plan, owing to the greater width between the trusses of this plan than in the Phœnix plan.

The piers are 24 feet wide under the coping and batter 1 in 12. The caissons are 49 feet wide for the north pier and 51 feet for the south pier; they are respectively 153 and 155 feet long for the Keystone plan and four feet shorter on the Phœnix plan.

The two Keystone piers and caissons have a total contents of 55,755 cubic yards, with a bearing area on the bottom of 15,400 square feet and exert upon the bottom an average pressure of 6.74 gross tons per square foot if allowance is made for the buoyancy of the water, or 8.5 tons if the buoyancy is neglected.

The two Phœnix piers and caissons have a total contents of 54,090 cubic yards, with a bearing area on the bottom of 15,000 square feet and exert upon the bottom an average pressure of 6.47 gross tons per square foot if allowance is made for the buoyancy of the water, or 8.22 tons if the buoyancy is neglected.

The anchorage piers and the masonry of the approaches are alike in all manners, except where necessary differences are required by the lengths of the approach spans and extra width of the Keystone plan.

In order to make these two plans, namely, the Keystone and the Phœnix, fairly comparable they should be modified so that the bearing pressures upon the bottom should be the same per square foot. Assuming the bearing pressure of 6.47 tons of the Phœnix plan as a reference, we must increase the contents of the Keystone piers about 1,300 cubic yards, making their total contents 57,055 cubic yards. This is due to the greater weight of the Keystone superstructure, even after the correction is made in its weight by changing the assumed live load.

In the above I have taken the plans with wooden caissons, as these have the most base area and are therefore the best plans.

W. Davis & Sons furnish plans for the piers and foundations for the superstructure of the Dominion Bridge Company.

The channel piers are 25 feet wide under the coping and batters 1 in 12. The bottom of the caisson is 57.5 feet wide by 156 feet long. The piers have a total contents of 58,685 cubic yards, with a bearing area of 17,887 square feet and exert upon the bottom a pressure of 5.89 gross tons per square foot if allowance is made for the buoyancy of the water, or 7.53 tons if the buoyancy is neglected.

The plans for the anchorages and approach piers differ in shape and class of masonry from those shown on the plans of the other bidders.

Messrs. Davis & Sons claim that these plans were prepared to meet the views of the Pencoyd Bridge Company, and that they hastily had to adapt the plans for the Dominion superstructure upon the Pencoyd Company declining to put in a tender. They also claim that they provided through courses of granite at the request of the Pencoyd Company and also carried their granite facing some ten feet lower than the other bidders. They therefore claim that in reducing their piers to a fair comparison with the others they should be allowed to reduce their piers to the same loads and pressures as the other bidders, and also change their unit prices to the same classes of masonry.

Considering these claims, under the circumstances, to be proper, I requested them to modify their plans and proposals on the following basis:—

To make their channel piers 24 feet under the coping; to proportionate the piers to the same loads and bearing pressures as the Phœnix plan, which I have used as the reference; and to omit the extra granite in their first plan, and to modify their tender accordingly.

They have accordingly furnished modified plans and proposals. The channel piers have a total contents of 52,400 cubic yards, with a bearing area of 14,500 square feet

and exert upon the bottom a pressure of 6.50 gross tons per square foot if the buoyancy of the water is allowed for, or 8.35 tons if the buoyancy is not considered.

They estimate the quantities of masonry in the abutments much higher than the other bidders, and also give it a higher unit value on account of the rock excavation necessary to secure a good foundation. From the information given me as to the character of the ground, I think Messrs. Davis & Sons are nearer correct than the other bids.

Omitting the abutments from both bids, the total prices for all the other piers and anchorages upon the basis of the Phœnix superstructure are as follows:—

Engineering Contract Company	$1,113,857
Wm. Davis & Sons	1,144,090

The unit prices of these two bidders, while differing, are fair competitive prices.

As the plans for the piers and foundations furnished by the above bidders are only general in character and may, or rather I should say, will need modifications to adapt them to local conditions, which may affect the relative values of the two plans, I make no recommendation in favour of either party.

RELATIVE MERIT AND VALUE OF THE PLANS AND PROPOSALS.

First.—The suspension bridge plan of the Dominion Bridge Company may be dismissed from further consideration by the relatively high tender, and also from the incompleteness of the proposal, due to the qualification made in reference to the construction of the cables.

Second.—The suspension bridge plan of the Union Bridge Company is excluded from further consideration by the indefiniteness and incompleteness of the tender, and also because the plan is not in accordance with the specifications.

Third.—The suspension bridge plan of the Phœnix Bridge Company is excluded from the fact that the tender is $600,000 higher than the tender of the same company for its cantilever plan.

Cantilever Plans.

As each of the companies submitting cantilever plans assume that separate contracts will be made for the substructure and for the superstructure, the Quebec Bridge Company should have the right to select the most favourable superstructure plan and the most favourable substructure plan independently. The proposals for the superstructure will therefore be considered separately.

Fourth.—Relative value of the proposals of the Dominion and Keystone Bridge Companies for the same superstructure plans.

The revised tenders of these companies, exclusive of all custom duties, are as follows:—

Dominion Bridge Company	$2,590,000
Keystone Bridge Company	2,402,500
In favour of Keystone Bridge Company	$187,500

The proposal of the Keystone Bridge Company is therefore the most favourable of these two companies. Each, however, state in their tenders that they have mutually agreed to a division of the work in case either of them obtained the contract.

Fifth.—Relative values of the proposals of the Keystone and Phœnix Bridge Companies.

The proposal of the Keystone Bridge Company for their superstructure plan is	$2,402,500	
Extra cost of masonry required by the greater width of their plan	6,999	
Total	$2,409,499	$2,439,499
The proposal of the Phœnix Bridge Company as originally made was	2,414,612	
Correction for lighterage, May 8	24,000	
Total	$2,438,612	$2,438,612
Balance in favour of Phœnix Bridge Company		$ 887
If we also consider the extra 1,300 cubic yards of masonry to be added to the Keystone piers to equalize the bearing pressures, we should have additionally in favour of the Phœnix Bridge Company 1,300 cubic yards at $17.40		22,620
Total in favour of Phœnix plan		$ 23,507

DUTIES.

The superstructure of the Keystone Bridge Company weighs 27,400 gross tons and they estimate the customs duties to be $639,149, or at the average rate of $23.33 per ton.

The superstructure of the Phœnix Bridge Company weighs 22,956 gross tons and they estimate the duty on metal work constructed in the United States at $22 per ton.

Assuming the lower of these figures for the duty by the ton or $22, for the purpose of comparison, we find that the excess of duties for the Keystone plan would be 4,444 tons at $22, $97,768.

CONCLUSION.

From the facts and considerations as stated above I find the cantilever superstructure plan of the Phœnix Bridge Company an exceedingly creditable plan from the point of view of its general proportions, outlines and its constructive features.

I also find that it is designed in accordance with your specifications.

The tender accompanying this plan is the lowest in price and is the most favourable as to the prospective duties upon the materials to be used in its construction.

I therefore hereby conclude and report that the cantilever superstructure plan of the Phœnix Bridge Company is the 'best and cheapest' plan and proposal of those submitted to me for examination and report.

I likewise report that the general plans and proposals for the substructure made by the Engineering Contract Company and by Messrs. Davis & Sons are both satisfactory and at favourable terms.

Very respectfully submitted.

THEODORE COOPER,
Consulting Engineer.

June 23, 1899.

The following table gives the estimated quantities of materials in the several proposed plans:—

Plan.	Steel. — Gross tons.	Cables. — Gross tons.	Timber. — Million.	Masonry. — Cubic yards.
Union Bridge Co.	14,286	3,125	1·6	23,700
Lindenthal	18,334	5,564	0·757	39,738
Pencoyd, Dominion	21,070	7,143	1·5	32,454
Phœnix Cantilever	22,956	.....	1·547	69,400
Keystone "	27,400	.....	1·4815	71,731
Dominion "	27,400	.....	1·5	71,834

SUPPLEMENTARY REPORT.

The previous report upon the several plans and proposals for the construction of the proposed Quebec bridge has been based upon the plans and papers submitted by each competitor.

Any plan or proposal accepted by the Quebec Bridge Company will undoubtedly need more or less modification, either in the line of bettering its general appearance or to adapt it to any new conditions which may be developed by a more extended study and examination of the river bottom and other circumstances.

The approach spans and other comparatively minor features will need careful study and consideration, after the special general plan has been selected.

While the data shown upon the river profile were sufficient for the purpose of obtaining comparative proposals, they are not sufficient to locate exactly the final position of the piers or to determine the proper proportions of the supporting caissons.

Before proceeding with the channel piers, the character of the material of the river bottom upon which the stability of the piers will depend, should be determined with greater certainty than can be done by a few isolated borings.

For any depths exceeding those to which it is proposed to sink these channel piers, the additional cost, risks, and uncertainties increase very rapidly. It is imperative, therefore that it be known beforehand that the material upon which the caissons are to rest and get their support is suitable for the loads to be imposed upon it by such an important structure.

While it is probable that this material is a post-glacial deposit, well solidified by ages and permanent in character, I consider it important to ascertain this by a fuller examination by means of boring and trial shafts sunk into this material.

The expense of such an examination would be very small compared to the possible cost of changes made after the work is in progress.

It may also be found desirable to investigate the possibilities of further economies in the construction of both piers and superstructure.

I would suggest therefore that provision be made in the superstructure contract for any modifications that may be made by your engineers, either in changing the length of the spans, within reasonable limits, in modifying the carrying capacity of the structure or in increasing or decreasing the quantities of the materials. It might also be desirable to ask the successful competitor to state what reductions, if any, could be made in the tender by certain modifications of the specifications.

In like manner provision should be made for any modifications made by your engineers in the size, depths or locations of the piers and their caissons.

Very respectfully submitted,

THEODORE COOPER,
Consulting Engineer.

June 23, 1899.

EXHIBIT No. 11.

THEODORE COOPER,
CONSULTING ENGINEER,
35 BROADWAY, NEW YORK, May 1, 1900.

HON. S. N. PARENT,
President, Quebec Bridge Company,
Quebec, Canada.

DEAR SIR,—In compliance with your request, I have taken up the examination of such modifications in the accepted plan for the Quebec bridge as were suggested by me in my report of last June.

The most important of these modifications, and the one requiring immediate attention, relates to the most desirable length to be selected for the channel span. The law, as well as the conditions of the river channel, require that this span must not be less than sixteen hundred feet. Would a greater span than sixteen hundred feet be more favourable is the question to be answered.

The piers, as located for the span of this length (1,600 feet), require foundations from 90 to 95 feet below ordinary high water.

They will stand in water from 30 to 40 feet deep, where they will be subject to the full ice effects of this river. Piers capable of performing the proper resistance to the conditions of the location have been designed and their cost established by competitive bids.

As the river bottom rises rapidly towards the shore on each side of the river, it is readily seen that the foundation conditions and also the ice effects are greatly improved by lengthening the channel span. Necessarily, however, the cost of the metal superstructure will be increased by using a longer span.

While in my report upon the competitive plans I suggested the desirability of investigating this question of a greater span, it could not be done at that time for want of time and also because a proper investigation required that one of the competitive plans, yet unselected, should be used in the consideration.

Now that you have selected the desirable plan a comparison can be made upon the basis of a greater length of channel span.

After a careful consideration of all the conditions by your chief engineer, Mr. E. A. Hoare, and myself, it was decided that an 1,800-foot channel span was most desirable if the expense was not too great.

I have therefore made an estimate for the change from a 1,600 to ar 1,800-foot channel span, with the following results:—

The saving in cost of the piers and other masonry will be about $400,000.

The additional cost of the superstructure, upon a liberal estimate, would be about $600,000.

But modifications can be made in the plans, which, in my opinion, are desirable and justifiable, and which in no manner reduce the carrying capacity of the structure or render it incapable of fully performing all its duties satisfactorily, which would reduce the above increase of cost to about $450,000.

From either point of view, whether the increased cost of making the change in the span be $50,000 or $200,000, I consider the change justifiable for the following reasons:—

First. The construction of the larger and deeper piers of the 1,600-foot span will require at least one more year than those for the 1,800-foot span.

Second. The contingencies of the construction of the deeper piers in the deeper water, where they might possibly be subject, in their incomplete condition, to the heavy ice floes of the main channel, would be far greater than for the piers further inshore.

Third. The effect upon any future financing by reducing the time of construction and minimizing the real and imaginary contingencies.

I would, therefore, recommend that a channel span of 1,800 feet be adopted, and the contractors for the superstructure be directed to prepare plans accordingly.

Very respectfully, your obedient servant,

THEODORE COOPER.

EXHIBIT No. 18.

Copy No. 100816.

EXTRACT *from a Report of a Committee of the Honourable the Privy Council, approved by His Excellency on the 15th August, 1903.*

On a memorandum dated 13th August, 1903, from the Minister of Railways and Canals, representing that by an Order in Council of the 21st July, 1903, authority was given, in accordance with a suggestion made by the Chief Engineer of the Department of Railways and Canals, for the employment of a competent bridge engineer to examine from time to time detail drawings of the superstructure of the bridge across the River St. Lawrence near Quebec, now in course of construction, in view of certain modifications suggested by the consulting engineer of the bridge company; the said plans to be submitted, for final acceptance, to the chief engineer of the Department of Railways and Canals.

The minister further represents that the chief engineer has this day reported, stating that, as the result of the personal interview had with the company's consulting engineer, he would advise that, provided the efficiency of the structure be fully maintained up to that defined in the original specifications attached to the company's contract, the new loadings proposed by their consulting engineer be accepted; all detail parts of the structure to be, however, as efficient for their particular function as the main members for theirs, the efficiency of all such details to be determined by the principles governing the best modern practice, and by the experience gained through actual test; all plans to be submitted to the chief engineer, and until his approval has been given, not to be adopted for the work.

The minister recommends that authority be given for following the course so advised by the chief engineer, the Order in Council of the 21st July last to be modified accordingly.

The committee submit the same for approval.

JOHN J. McGEE,
Clerk of the Privy Council.

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1897, July 7	Deans	Hoare	Visit to Bridge, &c	75-A.
1897, Nov. 8	Deans	Hoare	Plans, &c	75-D.
1897, Nov. 30	Deans	Hoare	Plans with straight chord	75-C.
1898, Dec. 12	Barthe	Deans	Extension of time for tenders	80-F.
189-, Jan. 29	Hoare	Deans	Preliminary arrangements	80-E.
189-, March 2	Hoare	Deans	Last tender received	80-G.
1899, April 14	Deans	Hoare	Conference, *re* plans	75-D.
1899, April 19	Deans	Hoare	Conference, *re* plans	75-F.
1899, Sept. 14	Deans	Parent	Banking	75-G.
1899, Nov. 28	Deans	Parent	Banking	74-H.
1900, Feb. 2	Deans	Hoare	Mr. Burbank's visit	75-I.
1900, April 21	Barthe	Deans	Approval of agreement	75-J.
1900, Sept. 11	Hoare	Deans	Maximum uplift	80-K.
1900, (?) Dec. 7	Hoare	Deans	Visit of Mr. Barthe to Phœnixville	80-L.
1901, Feb. 4	Deans	Hoare	Trial diagrams	74-A.
1901, Feb. 25	Deans	Hoare	Subsidies	74-B.
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1901, June 17	Deans	Hoare	Starting the work, &c	81-N.
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1901, Aug. 23	Deans	Barthe	Estimates, &c	74-H.
1901, Oct. 29	Deans	Cooper	Eye-bars, approach spans	74-K.
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*1902, Jan. 20	Deans	Cooper	Information to public	70-A.
—— March 31	Hoare	Deans	Conference in New York	80-J.
*1902, April 2	Hoare	Cooper	Finances	70-B.
*1902, June 5	Hoare	Cooper	Progress and finances	70-C.
*1902, Oct. 3	Hoare	Cooper	Visit to Quebec	70-D.
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*1903, May 22	Deans	Cooper	Specifications	70-G.
1903, May 22	Deans	Cooper	Ottawa visit	74-S.
*1903, May 26	Szlapka	Cooper	Specifications, &c	70-F.
*1903, May 28	Deans	Cooper	Specification changes	70-E.
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*1903, June 2	Cooper	Hoare	General letter	73-A.
*1903, June 4	Deans	Cooper	Revised specifications	70-H.
1903, June 12	Hoare	Deans	Cooper's amended specifications and attitude of department	80-O.
1903, June 15	Deans	Hoare	Revised specifications	74-N.
*1903, June 16	Cooper	Hoare	Weight, &c	73-B.
*1903, June 16	Szlapka	Hoare	Changes in specifications	73-B2.
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*1903, July 18	Fitzpatrick	Parent	Order in Council	73-C.
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*1903, July 30	Szlapka	Cooper	Floor plan	74-A.
*1903, July	Schreiber	Cooper	Modifications in specifications	70-K.
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*1903, Aug. 1	Deans	Cooper	Order in Council	70-M.
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1903, Aug. 4	Cooper	Hoare	Trouble over approval plans	80-P2.
190-, Aug. 19	Hoare	Deans	"Mr. S.," &c	80-R.
*1903, Sept. 5	Deans	Cooper	Visit to Ottawa	70-N.

*From Mr. Cooper's letter-books.

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1903, Sept. 26	Deans	Cooper	Floor beam, &c	74-Y.
*1903, Oct. 23	Szlapka	Cooper	Floor system, &c	71-B.
*1904, Feb. 19	Szlapka	Cooper	Stress diagram, &c	71-D.
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1904, Sept. 8	Deans	Hoare	Specifications	74-JJ.
1904, Sept. 12	Szlapka	Hoare	Calculations of anchor arm	74-KK.
1904, Sept. 14	Hoare	Szlapka	Stress sheets	80-T.
1904, Sept. 19	Deans	Hoare	Stress sheets	74-LL.
1904, Sept. 19	Hoare	Deans	Bottom chords panel 2, anchor arm	80-U.
1904, Oct. 8	Deans	Hoare	Government approval	74-NN.
*1904, Oct. 17	Szlapka	Cooper	Top lateral stresses	71-L.
*1904, Dec. 2	Edwards	Cooper	Shop errors	71-M.
1904, Dec. 3	Deans	Hoare	Printed specifications	74-OO.
*1904, Dec. 12	Edwards	Cooper	Weights, anchor arm	71-N.
*1905, Jan. 19	Edwards	Cooper	Eyebar tests, &c	71-O.
1905, Jan. 26	Cooper	P. B. Co	Eyebar test	80-A.
*1905, Jan. 28	Cooper	Edwards	Eyebars	73-F.
1905, Jan. 28	Cooper	P. B. Co	Eyebar tests	80 B.
1905, Jan. 31			Memorandum Cooper interview	74-RR.
1905, Jan. 31	Deans	Cooper	Eyebars	74-RR.
1905, Feb. 2			Memorandum Cooper interview	74-SS.
*1905, Feb. 15	Cooper	Edwards	Eyebars	73-G.
1905, Feb. 22	Deans	Norris	Eyebar tests	74-TT.
*1905, March 8	Hoare	Cooper	Inspection	71-P.
*1905, March 11	Edwards	Cooper	Weighing	71-Q.
*1905, March 25	Deans	Cooper	*Re* McLure	71-R.
*1905, March 31	Hoare	Cooper	*Re* McLure	71-S.
*1905, May 18	Hoare	Edwards	Rolling material	71-T.
1905, May 18		Edwards	Rolling of material ahead of time	80-V.
1905, June 15	Hoare	Q. B. Co	Calculations	80-W.
*1905, July 7	Hoare	Cooper	*Re* cheque	71-U.
1905, July 8	Deans	Hudson	Damaged chord	76-A.
*1905, July 11	Szlapka	Cooper	Stress diagram	71-V.
*1905, July 12	Deans	Cooper	Chord sections 9	71-W.
1905, July 13	Hoare	Deans	Chord A 9L	81-I.
1905, July 14	C. W. Hudson	Q. B. Co	Repair of chord A 9L	81-J.
*1905, July 17	Hoare	Cooper	Shell plates, &c	71-X.
1905, July 21	Deans	Hoare	Splicing angles of chord 9	81-K.
1905, July 21	Deans	Hudson	Chords 7, 8 and 9	76-C.
1905, July 21	Deans	Hoare	Splicing angles	76-B.
1905, July 22	Cooper	Deans	Inspection	80-C.
*1905, July 29	Deans	Cooper	Field inspection	71-W.
*1905, Aug. 11	Szlapka	Cooper	Eyebars, &c	71-Z.
*1905, Aug. 12	Szlapka	Cooper	Drawings	73-H.

*From Mr. Cooper's letter books.

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Date.	From	To	Subject.	Exhibit No.
*1905, Aug. 16	Deans	Cooper	Inspection, &c	71-AA.
1905, Aug. 18	P. B. Co	Milliken	Connection plates, &c	76-H.
1905, Aug. 19	Deans	Parent	Storage yard connection	76-I.
*1905, Aug. 21	Hoare	Cooper	*Re* Mr. McLure	71-BB.
1905, Aug. 30	Shoemaker	P. B. Co	Birks and McLure on work	61-L.
1905, Oct. 24	Hoare	Deans	Riveting	76-J.
1905, Oct. 25	Deans	Hoare	Riveting	76-J.
1905, Oct. 25	Deans	Hoare	Riveting	76-K.
1905, Nov. 22	Milliken	Deans	Close of season	76-L.
1905, Nov. 24	Deans	Parent	North approach	76-N.
1905, Dec. 26	Deans	Hoare	Viaduct, &c	76-P.
*1906, Feb. 1	Szlapka	Cooper	Struts	72-A.
*1906, Feb. 10	Hoare	Cooper	Weight, estimate	72-B.
1906, Feb. 10	Hoare	D. Reeves	Material	76-S.
*1906, Feb. 17	Szlapka	Cooper	Chord 8 R	72-C.
1906, Feb. 17	Szlapka	Cooper	Error in chord	76-T.
*1906, Feb. 19	Cooper	Szlapka	Chord 8 R, &c	73-E.
1906, Feb. 19	Cooper	Szlapka	Errors in chords	80-D.
*1906, Feb. 26	Edwards	Cooper	Eyebars, &c	72-D.
1906, March 25	Hoare	D. Reeves	Weight of metal	76-U.
1906, April 14	Deans	Parent	Approval of agreement	75-K.
1906, April 28	Deans	Parent	Viaduct	76-V.
1906, May 9	Deans	Hoare	Painting	76-Y.
1906, June 1	Deans	Milliken	Working platform	76-W.
*1906, June 2	Edwards	Cooper	Trip to Boston	72-E.
1906, June 8	Deans	Milliken	Riveting, &c	76-X.
1906, June 8	Deans	Milliken	Drillings, &c	76-X.
1906, July 3	Deans	Hoare	Painting	77-A.
1906, July 9	Deans	Hoare	Progress and travellers	77-B.
1906, July 9	Hoare	Deans	Future of bridge, terminal railways, finances, &c.	80-X.
1906, Aug. 9	Hoare	Milliken	Paint	80-Y.
1906, Aug. 20	Deans	Milliken	Field corrections	77-C.
1906, Aug. 22	Deans	Milliken	Steel bents	77-D.
1906, Aug. 23	Deans	Hoare	C.P.R. viaduct—monthly estimates	77-E.
1906, Aug. 23	Szlapka	Cooper	Travellers	77-F.
1906, Aug. 29	Deans	Hoare	Ca[illegible]ouge viaduct	77-G.
*1906, Sept. 15	Deans	Cooper	Revised stress sheet	72-F.
1906, Sept. 20	Deans	Milliken	Blocking anchor arm	77-H.
1906, Sept. 21	Deans	Milliken	Joint bolting	77-I.
1906, Sept. 29	Deans	Milliken	Blocking falsework	77-J.
1906, Oct. 3	Milliken	Deans	Blocking falsework	77-K.
1906, Oct. 4	Milliken	P. B. Co	Camber plates	77-L.
1906, Oct. 6	Deans	Milliken	"U.P.-3" and packing	77-N.
1906, Oct. 4	P. B. Co	Milliken	Camber plates	77-L.
1906, Oct. 8	Deans	Milliken	Relations with Mr. McLure	77-N.
*1906, Oct. 16	Szlapka	Cooper	End post	72-G.
1906, Oct. 16	P. B. Co	Milliken	Falsework	77-O.
1906, Oct. 19	Yenser	P.B.Co	Report on progress of w[illegible]	82-A.
1906, Oct 20	Hoare	Deans	Removal of falsework without notice	80-Z.
1906, Oct. 22	Deans	McLure	Supplying information	77-P.
1906, Nov. 7	Deans	Yenser	Progress	77-R.
1906, Nov. 7	Deans	Yenser	Falsework	77-R.
1906, Nov. 8	Yenser	P. B. Co	Falsework	77-S.
1906, Nov. 8	P. B. Co	Yenser	Falsework	77-S.
1906, Nov. 4	Deans	Hoare	Visit to Phœnixville	74-V.
1906, Nov. 12	Yenser	P. B. Co	Wind	77-T.
1906, Nov. 14			Statement by Deans and Milliken, *re* interview with Hoare	77-U.
*1906, Nov. 16	Szlapka	Cooper	Shop drawings	72-H.
*1906, Nov. 26	Edwards	Cooper	Error in pin hole	72-I.
1906, Nov. 26	Milliken	Deans	Season's work	77-W.
1906, Dec. 27	Szlapka	Cooper	Transmitting drawings	77-Y.
1907, Jan. 18	Deans	Hoare	Storage cost	78-A.
*1907, Feb. 13	Szlapka	Cooper	Stress sheet, susp. span	72-J.
1907, March 6	Deans	Hoare	Weight of bridge	78-B.
1907, March 18	Deans	Hoare	Last drawing	78-D.
1907, March 18	Deans	Cooper	Last drawing	78-C.
1907, March 19	Deans	Hoare	Starting work, &c	78-E.

*From Mr. Cooper's letter books.

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1907, March 20	Hoare	Deans	Completion of office work	81-A.
*1907, March 21	Wright	Szlapka	Rivets in centre web	72-K.
1907, April 3	Deans	Norris	Injured chord	78-F.
*1907, April 6	Edwards	Cooper	Post, section, &c.	73-I.
1907, April 20	Deans	Milliken	Starting on work	78-G.
1907, April 30	Deans	McLure	Replying to letter April 28	78-I.
1907, May 4	Deans	Milliken	Field riveting	78-J.
1907, May 7	Szlapka	Cooper	Return of drawings	72-L.
1907, May 9	Deans	Hoare	Prints for approval	78-K.
1907, May 20	Deans	McLure	Riveting instructions	78-L.
1907, May 20	Hoare	Deans	Plans for Dept.	78-M.
1907, May 21	Hoare	Deans	Complaints of engineers at Ottawa	81-B.
*1907, May 21	Deans	Cooper	Drawings	72-M.
1907, May 24	Deans	Hoare	Estimates, approval of plans, &c.	78-O.
1907, May 27	Hoare	Deans	Delay in forwarding plans for approval	81-C.
1907, May 31	Deans	Milliken	Painting	78-P.
1907, May 31	Deans	Parent	North approach	78-Q.
1907, June 14	Hoare	Deans	Payments due	81-Q.
1907, June 15	Deans	Yenser	Sagging bottom laterals	78-S.
1907, July 3	Deans	Parent	North approach	78-V.
1907, July 6	Deans	Milliken	North approach	78-W.
1907, July 12	Deans	Yenser	Driving pins, deflect., cant. arm, &c	78-Y.
1907, July 24	Deans	Yenser	Live load and specifications	79-A.
1907, July 26	Deans	Yenser	Bad holes	79-B.
1907, July 26	Yenser	P. B. Co.	Report on work	82-B.
1907, Aug. 6	Birks	P. B. Co.	Splice between chords 7 L and 8 L	81-D.
1907, Aug. 8	Deans	Parent	Storage	79-C.
1907, Aug. 8	P. B. Co.	Milliken	Splicing 7 and 8	79-E.
1907, Aug. 8	Cooper	P. B. Co	Splicing 7 and 8	79-F.
1907, Aug. 9	Deans	Cooper	Chord joint	79-G.
1907, Aug. 9	Deans	Milliken	General letter	79-H.
*1907, Aug 9	Cooper	Deans	Repairs to chord	73-J.
1907, Aug. 10	Deans	Cooper	Splicing 7 and 8	79-I.
1907, Aug. 12	Deans	Cooper	Splicing 7 and 8	79-J.
*1907, Aug. 13	Cooper	McLure	Bend in 7-8 L	73-K.
1907, Aug. 14	Deans	Yenser	Splicing 7 and 8	79-K.
1907, Aug. 14	Deans	Cooper	Splicing 7 and 8	79-L.
1907, Aug. 16	Deans	Yenser	Riveting diagonals	79-M
1907, Aug. 16	Birks	P. B. Co	Splice 7 L and 8 L	81-E.
1907, Aug. 20	Deans	Cooper	Splice 7 and 8	79-N.
*1907, Aug. 21	Cooper	Deans	Bend 7-8 L	73-L.
1907, Aug. 23	Deans	Cooper	Splice 7 and 8	79-O.
1907, Aug. 24	Yenser	P. B. Co	Report on work	82-D.
1907, Aug. 24	Yenser	P. B. Co	Daily force account	82-F.
1907, Aug. 24	Deans	Norris	Material for north side	79-P.
1907, Aug. 24	Yenser	P. B. Co	Report on work	82-C.
	Yenser	P. B. Co	Weight on end cantilever arm, Aug. 24, 1907	82-E.
1907, Aug. 26	Deans	Yenser	Office and field figures	79-Q.
*1907, Aug. 26	Cooper	Deans	Bent ribs	73-M.
1907, Aug. 27	Deans	Cooper	Splice 7 and 8	79-R.
1907, Aug. 27	Birks	P. B. Co	Chords 9 L anchor arm and 8 and 9 R cant. arm	81-F.
1907, Aug. 28	Hoare	P. B. Co	McLure's call *re* chord	79-S.
1907, Aug. 28	Birks	P. B. Co	Chord 9 AA	81-G.
1907, Aug. 29	Deans	Hoare	Chords in condition they left Phœnixville	79-T.
1907, Aug. 29	Cooper	P. B. Co	Add no more load	79-U.
1907, Aug. 29	Yenser	P. B. Co	Report on work	82-G.
1907, Aug. 29	Birks	P. B. Co	Chord 9 AA	81-H.
1907, Aug. 29	Yenser	P. B. Co	Weight on end cant. arm, Aug. 29	82-Y.
1907, Aug. 29	Yenser	P. B. Co	Daily force account	82-J.
1907, Aug. 29	Yenser	P. B. Co	Report on work	82-H.
1907, Aug. 29	Weitnight	P. B. Co	Report on collapse	79-Z.
1907, Aug. 30	Berger	Hoare	Chord 7-8 L	73-N.
*1907, Aug. 31	Cooper	Hoare	Letter of sympathy	73-O.
*1907, Sept. 2	P. B. Co.	F. T. Davis	Preserving blue prints	79-BB.
1907, Sept. 14	Connard	Deans	Original specifications, &c.	79-DD.
1907, Sept. 16	Deans	Connard	Asking for print of general plan	79-CC.

*From Mr. Cooper's letter books.

INDEX OF EXHIBITS, 70 TO 83—*Continued.*

Date.	From	To	Subject.	Exhibit No.
1907, Sept. 26.	Hoare	Szlapka	Calculations of strains	81-M.
1907, Sept. 26.	Hoare	Szlapka	Revised strain calculations	79-GG.
1907, Sept. 27.	P. B. Co.	Hoare	Blue prints of calculations	79-HH.
*1907, Oct. 4.	Berger	Schneider	Wind strains	73-P.

*From Mr. Cooper's letter books.

EXHIBIT No. 70a.

(Letterhead of Phœnix Bridge Co.)

PHŒNIXVILLE, PA., Jan. 20, 1902.

THEO. COOPER, Esq.,
Consulting Engineer,
35 Broadway, New York, N.Y.

DEAR MR. COOPER,—I have your letter of January 18 in connection with giving out information concerning Quebec bridge. I discussed this matter with Mr. Hoare soon after our last interview on this subject, and he stated he thought it would be wise to defer publishing any matter. We expect some definite and clear action in connection with the main structure during March or April, and until this is taken and all features definitely fixed and decided upon, I think it might be wise not to give out any information to the public, and this appears to be Mr. Hoare's feelings in the matter. We have been so frequently pressed regarding this matter that we have promised to give all of the engineering papers the information at the same time. I have not been in New York since the annual meeting, but shall stop in your office the next time I am in the city.

With kind regards,

Yours truly,

JOHN STERLING DEANS,
Chief Engineer.

EXHIBIT No. 70b.

(Letterhead of Quebec Bridge Co.)
(Private.)

QUEBEC, April 12, 1902.

DEAR MR. COOPER,—I called at your office on Thursday afternoon on my return from Phœnixville. You had gone home about half an hour previously. As I had nothing in view to fill up another day, I left the same evening for home. Mr. Parent came to New York, but left again the same day with his family. He hadn't very good news for future progress, and I am afraid our intentions will be checked for a while. There can't be any move in connection with new work this year on account of de-

ferred finances. We have only enough to scratch through this year's work and only with Davis' help in taking scrip. I have told Davis that he can take reasonable time about his plan studies as there will be nothing ordered for some time. I said not before end of year at earliest, all depending upon success of terminal scheme. The above is private. If I had seen you again I could have explained the scheme which has been deferred. I saw a 15" x 2" bar tested which failed in the body, about 29,000 lbs. elastic limit and nearly 56,000 lbs. ult., being the fourth satisfactory test. In haste.

Yours truly,

E. A. HOARE.

EXHIBIT No. 70c.

(Letterhead of Quebec Bridge Co.)
(Personal.)

QUEBEC, June 5, 1902.

DEAR MR. COOPER,—I will send a few hasty lines before going up the river to thank you for yor letter of the 2nd inst. and inclosure. I was at the point of writing when your letter came, but was called off for something else. Mr. Davis' work is progressing. The second caisson is at site, but not quite lined. We are loading with concrete and levelling bottom at low tide under air pressure. I am afraid there will be a halt this fall as our programme failed to mature. I hope, however, it may be revived next winter in time for some arrangements for the following year. Until then I am afraid we shall be stranded for money. Everything has been scratched together and transferred to Mr. Davis, which will only contribute a portion. He has to carry a portion on his own shoulders. When your account comes in I will try same† source to procure engineering funds as soon as possible, if you don't mind a little delay in meantime. The present available funds will be absorbed locally in a couple of months or so. When anything of importance occurs you will hear from me.

Yours truly,

E. A. HOARE.

† Some.

EXHIBIT No. 70d.

Telegram.

QUEBEC, QUE., Oct. 3, 1902.

THEODORE COOPER,
35 Broadway, New York.

Could you be here next Thursday to meet Mr. Schreiber. Preparations for winter demand decision for final depth not later than then.

E. A. HOARE.

EXHIBIT No. 70e.

(Letterhead Phœnix Bridge Co.)

PHŒNIXVILLE, PA., May 28, 1903.

THEO. COOPER, Esq.,
Consulting Engineer, Quebec Bridge Co.,
35 Broadway, New York, N.Y.

DEAR SIR,—We were very sorry to learn by Mr. Berger's letter of May 25th that the grip had hold of you, and trust by this time you have been able to knock it off.

Mr. Szlapka has carefully examined the proposed revised specifications as to loads and strains Quebec bridge and same is returned herewith, with several notes in red, which we believe you will add as agreeing with original understanding.

We would further suggest that the last clause, under the head of 'Future increase or railroad live load,' be added immediately after the live load clauses and before the wind clause.

As you will undoubtedly appreciate, it will be necessary for you to explain to Mr. Hoare how the live load proposed in these specifications will easily take care of any possible increase in live load without overstraining the material. I know personally that Mr. Hoare and his people feel that the bridge should be designed to provide for a considerably heavier load than originally intended.

It has occurred to us that it might be well to add, after the second paragraph in live load clause, the following:—'This loading being equivalent to Engine E-40 with train load of 4,000 lbs. per lineal foot on one track and Engine E-40 with train load of 2,000 lbs. per lineal foot on other track.' We simply make this to you as a suggestion, that parties examining specifications may have it directly before them that ample provision is made for heavy loading.

We notice you omit to add that the workmanship and material is to be in accordance with 'Cooper's specifications.' Please add this clause.

Knowing the people in Canada are very anxious to have the matter settled, we understand you will forward to Mr. Hoare at once these revised specifications. Kindly send a copy to us.

Yours truly,

JOHN STERLING DEANS,
Chief Engineer.

EXHIBIT No. 70f.

(Letterhead Phœnix Bridge Co.)

PHŒNIXVILLE, PA., May 20, 1903.

THEO. COOPER, Esq.,
Consulting Engineer,
New York, N.Y.

DEAR SIR,—We return herewith, by registered mail, your proposed specifications for loading and unit stresses, main span, Quebec bridge. I wish to make the following remarks in reference to these specifications:—

1st. I assume that only one engine E-40 will be used on each railroad track.

2nd. I find that the proposed 48,000 lbs. on two axles 10 ft. centre to centre on trolley stringers produce larger bending moment in centre than the 40,000 lbs. on two axles 7 ft. apart centre to centre originally used.

3rd. E-33 on each railroad track to be used for chords and main diagonals for the suspended span ,is equivalent to 4,200 lbs. per lin. ft. on one track and almost 2,000 lbs. per lin. ft. on the second track.

4th. I tried formula proposed for main members and find in each case there will be a slight saving of material and that the unit stresses come within the limit of about ⅞ths of the elastic limit for live and dead load stresses.

5th. On page 2 of your specifications there should be added the same remark as on page 3, written *by you in pencil* and marked by me with red *asterisk*.

6th. I examined the values of the permissible unit stresses for reversed strains, and I find in some cases there are slight errors, as indicated by me in red.

After you have these specifications rewritten and printed complete, I would be glad once more to have the opportunity of looking over them before they are sent to Canada for adoption.

P.S.—I have retained a copy of your papers.

Yours respectfully,

PHŒNIX BRIDGE CO.,
Per P. L. SZLAPKA.

EXHIBIT No. 70g.

(Letterhead of Phœnix Bridge Co.)

PHŒNIXVILLE, PA., May 22nd, 1903.

THEO. COOPER, C.E.,
35 Broadway, New York, N.Y.

DEAR MR. COOPER,—I returned from Ottawa yesterday, and you will be pleased to learn there is every evidence to believe that the programme as outlined by Mr. Parent in your office recently will be carried out.

I was requested by the Ottawa officials to urge upon you to act as promptly as possible in the matter of completing the specifications and to forward same to Mr. Hoare without delay. There is urgent necessity of their taking prompt action. Will you kindly write Mr. Hoare when he may expect to receive copy of the revised specifications.

I will stop to see you the next time I am in New York, which will undoubtedly be within a few days, and give you more details.

JNO. STERLING DEANS,
Chief Engineer.

EXHIBIT No. 70h.

(Letterhead of Phœnix Bridge Co.)

PHŒNIXVILLE, PA., June 4, 1903.

THEO. COOPER, Esq., C.E.,
Consulting Engineer,
35 Broadway, New York, N.Y.

DEAR MR. COOPER,—I acknowledge receipt by your letter of June 3rd copy of revised specifications Quebec bridge, which you sent to Mr. Hoare on June 2nd. I

thank you for the copy and hope we will soon hear that these specifications have been approved by the government.

Hoping you are entirely recovered from your recent attack of grip, I remain,

Yours truly,

JNO. STERLING DEANS,

EXHIBIT No. 70i.

(Letterhead of the Quebec Bridge Co.)

Private.

QUEBEC, July 1st, 1903.

DEAR MR COOPER,—I enclose copy of letter which Mr. Parent approved of and signed and which I handed to Mr. Fitspatrick (our representative member) yesterday in Ottawa. We showed it to Mr. Schreiber who approved of it and requested Mr. Fitzpatrick to obtain the consent of the Minister of Railways and Canals to proposals therein. I expect that this part of the programme will be closed this week. Regarding your specification, to-day being a holiday, I was unable to get Mr. S. to take it up with me, as Douglas was absent for a few days, and Mr. S. wished to see him in regard to it before committing himself. He said, however, that I may expect a letter in a day or two , probably putting questions for your explanation. Mr. S. said he would go to see you if he wasn't so tied up attending committees. I think the hitch, if any, will be on the method of loading and straining metal to ⅔ of elastic limit, which may require explanation direct. I do not think that financing will be as easy as supposed in these quarters. The government have not yet decided on any guarantee, but, from what I can gather here and there, it will not cover the whole required by the company. In such a case we don't want to be loaded with greater outlay than necessary. At the same time the future usefulness and permanency of the bridge for all possible traffic must not be sacrificed on account of temporary financial conditions. Therefore, if you have satisfied the above by your specifications I would suggest clinging to your proposals and overcome criticism by discussion such as we had at your office the other day. It might also be well for you to satisfy Mr. S. that when strain diagrams are being prepared you may find it necessary to increase where special conditions require it and that the present specification provides for maximum results when properly handled and that you require plenty of scope to work out satisfactory details and not be tied down to unreasonable conditions, thereby impairing your usefulness as consulting engineer. I spoke to him on these lines, hoping that it may have a little impression before Douglas returns. I found a message from Phœnixville this morning urging an agreement as they were at a standstill and could not proceed as Deans promised the premier when here six weeks ago. Is there anything they can do in the meantime in preparation of any kind, for I fear we shall take a week longer to arrive at conclusions. Please excuse a hurried random letter to catch mail.

E. A. HOARE.

SESSIONAL PAPER No. 154

EXHIBIT No. 70j.

(Letterhead of the Quebec Bridge Co.)

QUEBEC, 29th June, 1903.

The Hon. CHARLES FITZPATRICK,
Minister of Justice, Ottawa.

DEAR MR. FITZPATRICK,—Mr. Hoare has been to New York to confer with Mr. Cooper, the consulting engineer of the Quebec Bridge Company, and the chief engineer of the Phœnix Bridge Company upon the arrangement of certain matters which will govern the rate of progress of work on the bridge. In that regard, the preparation of the general drawings, and those required for the shops at Phœnixville, is a very stupendous affair, requiring expert supervision and a large staff of special draughtsmen at work for many months before details are ready for the workshops. It is absolutely imperative that the continuous flow of the working drawings to the shops shall not at any time be interrupted, as the slightest delay will most assuredly lose a season's erection. If the usual course of submitting plans to the Department of Railways and Canals (which may work very well in ordinary cases), is followed, delays will certainly occur, and in order to avoid anything of the kind, I urgently ask you to have an arrangement made by which all specifications and designs signed by Mr. Theodore Cooper be accepted by the government. Mr. Schreiber would, I should think, be pleased to have such an arrangement made whereby work could be compressed and simplified and responsibility taken by such an experienced bridge engineer as Mr. Cooper, who has been specially engaged for that purpose.

Yours truly,

S. N. PARENT,
President.

EXHIBIT No. 70k.

(Letterhead of Dept. of Rys. & Canals, Ottawa.)

OTTAWA, July, 1903.

DEAR SIR,—I have received from Mr. E. A. Hoare two memoranda made by you in respect of the plans of the superstructure of the Quebec bridge, suggesting certain modifications which you consider desirable.

Inasmuch as the contract for this structure contains an express specification by which I am bound, I am unable, as matters stand, to sanction any deviation from it.

I am, however, strongly impressed with the expediency, in order not to hinder the progress of the work of manufacture, of permitting you certain latitude in the preparation of the detail plans, even to the extent of adopting (with my own concurrence) such modifications as may appear proper, and, holding this view, I have asked that authority be given me by order in council which will enable me to act in that direction. Nothing can, of course, be done until such order is passed, but on receipt of it I will communicate with you immediately.

Faithfully yours,

COLLINGWOOD SCHREIBER,
Chief Engineer.

THEODORE COOPER, Esq.,
Consulting Engineer,
35 Broadway, New York City, U.S.A.

EXHIBIT No. 70l.

(Letterhead of Phœnix Bridge Co.)

PHŒNIXVILLE, PA., July 31, 1903.

THEODORE COOPER, Esq.,
Consulting Engineer,
35 Broadway, New York, N.Y.

DEAR MR. COOPER,—To say that I was surprised by the contents of your letter of July 30th is putting it mildly. I am trying to reach Mr. Hoare by 'phone. In addition, I have wired him and have also written a strong letter expressing my feeling in the matter.

The suggested action by Mr. Schreiber would place the business in a much worse condition than it was originally in. The 'order in council' was taken solely to save time and to have your approval of our details final and binding on the government—it simply being necessary to have Mr. Sschreiber's signature as a matter of form. It has certainly proven to be a thankless task so far in trying to save the Quebec Bridge Company a large amount of money without in the least affecting the efficiency of the structure.

We, of course, agree with you that we are at a standstill until this matter is settled, as certainly the matter of a new engineer is an uncertain quantity at present.

I cannot but believe that a trip to Quebec by yourself and myself would tend to clear the situation.

Yours truly,

JNO. STERLING DEANS,
Chief Engineer.

EXHIBIT No. 70m.

(Letterhead of Phœnix Bridge Co.)

PHŒNIXVILLE, PA., August 1, 1903.

Mr. THEO. COOPER, C.E.,
35 Broadway, New York, N.Y.

DEAR MR. COOPER,—I talked with Mr. Hoare over the 'phone yesterday (the service was not very satisfactory), and also wired him two long messages, and have received his reply stating that 'he will take up the question with parties at Ottawa and that we should go ahead, and if anything turns up to cause *trouble, tell Cooper to let me know at once.*' I have written him again and urged him to stop entirely this proposed plan, and explaining that the sole purpose of the order in council was to give you the final authority to settle all details, the government approval being a mere formality, and in this way save time which was so valuable. I personally think it would have been much better to have had Douglas, as originally proposed, rather than to have the present plan carried out; but we must insist upon having the whole matter stopped.

Yours truly,

JNO. STERLING DEANS,
Chief Engineer.

EXHIBIT No. 70n.

(Letterhead of Phœnix Bridge Co.)

PHŒNIXVILLE, PA., Sept. 5, 1903.

THEO. COOPER, Esq.
Consulting Engineer,
Cooper's Plains, Steuben Co., N.Y.

DEAR MR. COOPER,—I was pleased to learn by your letter of Sept. 2nd that you had found it possible to take a rest, and trust you will be greatly benefited by the change. We will follow your directions should anything of importance come up in connection with Quebec during your absence.

I was called to Quebec and Ottawa by a telegram from Mr. Parent on Tuesday last to meet government officials and satisfy them as to the reasonableness of the cost of our portion of the structure. Mr. Davis was present to make the same statement in connection with his part of the work. It was evident that the government were making final arrangements to bring a Bill before parliament covering guarantee of bonds to complete the work. I believe this action will be taken within a short time.

Yours truly,
JNO. STERLING DEANS,
Chief Engineer.

EXHIBIT No. 70o.

(Letterhead of Quebec Bridge Co.)

QUEBEC, May 5, 1904.

THEO. COOPER, Esq.,
35 Broadway, New York City.

DEAR SIR,—Mr. Johnson and a friend of mine, who is inspecting work for me in Montreal, have recommended a Mr. John Rankin, now engaged as inspector on the Trent canal, as a competent mill and shop inspector for our work. Both Johnson and Griffiths state that he has had considerable experience in both kind of works and is very reliable, and has been educated as an engineer, I believe, at McGill College. I have asked Mr. Rankin to write to you direct, stating his experiences from the start, in order that you may judge of his capabilities. If you think him a desirable man, I can negotiate with him and get him probably within two weeks. Another man named W. S. Walls has also been recommended to me by the same gentlemen, they state that Walls has had a little more experience than Rankin. He was shop superintendent of the Elmira Bridge Co., also the Lackawanna Steel Co. He was engaged for some time by the Pittsburg Testing Laboratory and also by the late George S. Morrison. Rankin is a Canadian-born subject and Walls an American. I have inquired about others, but the majority that apply are totally unfit for our work. Deans says he must have inspectors at Phœnixville by the 15th instant in order to spend a little preliminary time to become acquainted with their works and the shop drawings, etc. Would like to hear from you on this subject at your earliest convenience, also to have the letters in hand in reference to matters discussed in New York the last time I was there. I may as well inclose for your perusal a letter from Mr. Rolph, making an application to the Canadian Inspection Company for a position as inspector metal work. You might let me know if you think this man would be worth trying as a junior. I know I can get him if he is suitable.

Yours truly,
E. A. HOARE.

EXHIBIT No. 70p.

(Letterhead of Quebec Bridge Co.) QUEBEC, May 20, 1904.

THEODORE COOPER, Esq.,
Consulting Engineer,
45 Broadway, New York.

DEAR SIR,—I have received your letter of the 16th stating that you have engaged Mr. Edwards as inspector at Phœnixville. I haven't had an opportunity to get confirmation by the Board but I am satisfied that it will be all right. I received a letter from Mr. C. Deans to know if there would be an opportunity to get a part of this inspection as compensation for lost labour in figuring on the original contract bids with Phœnix Company. I suppose you have arranged for checking shop drawing weights in the manner already attended to or in some similar way. Consequently the only way to fit in Deans (if at all) would be some distant mill inspection, say a limited quantity that may be rushed in the future at some distance from Phœnixville, which might not interfere with the latter organization. I mention this in case of unforeseen rush. If you think Rankine efficient for the future, when required, you can let me know. I imagine, however, that he will require an answer in a month, or not much later.

Yours truly,

E. A. HOARE.

EXHIBIT No. 70q.

(Letterhead of Quebec Bridge Co.)

QUEBEC, July 21, 1904.

THEODORE COOPER, Esq.,
Consulting Engineer,
45 Broadway, New York City.

DEAR SIR,—The Department of Railways and Canals are going to send a resident inspector to Phœnixville to follow our inspector's work and keep track of all metal out of Canada in such a manner that when paid for, it can be claimed at any time by this company and the government. At the same time I imagine that the weight of metal will be checked by the government man in the manner previously mentioned. If it is arranged that the government man and Mr. Edwards can satisfactorily do this, there is no use of troubling you about it, as you probably have all the work you desire in hand. I will let you know later the actual arrangements made.

I was sorry to hear that you were called away to attend your brother's funeral.

With best regards,
Yours truly,

E. A. HOARE.

EXHIBIT No. 70r.

August 1, 1904.

Mr. E. T. MORRIS,
Inspector, the Phœnix Bridge Co.,
Phœnixville, Pa.

DEAR SIR,—James River Viaduct, Richmond, Atlantic Coast Line—I have just learned of carelessness in not following out the full and very explicit instructions given

on the drawings. These must be carried out to the letter. We must insist upon this and if there is to be any modifications from these instructions, it must be given from this office. The proper time to have made the corrections on these girders was when they were first sent out of shop and not wait until time arrives for them to be riveted together. I believe you now understand exactly what is to be done, and will see that girders are made in strict accordance with the drawings.

Quebec.—I believe you have been told verbally about the importance of the inspection of the Quebec bridge material, not alone the material for the bridge proper, but particularly the material for the falsework and traveller. This must have the same careful inspection as permanent work and particularly as to the material and workmanship about the joints.

Yours truly,

JOHN STERLING DEANS,
Chief Engineer.

EXHIBIT No. 71a.

(Letterhead of Phœnix Co.)

PHŒNIXVILLE, PA., July 30, 1903.

THEO. COOPER, Esq.,
Consulting Engineer,
35 Broadway, New York, N.Y.

DEAR SIR,—We send you in duplicate preliminary floor plan for the St. Lawrence river bridge at Quebec. This plan shows the floor arranged with a future sidewalk on the main span and on the approach spans, as well as the cross section of floor with sidewalk temporarily omitted.

We made several changes, as compared with the Quebec Bridge Company's specifications. We increased the 3-inch planking on the roadway to 4 inches; spaced the 8 x 12 railway ties 14 inches instead of 12 inches, and we omitted the two outside railway guard timbers 8 x 9 inches, which appear to be unnecessary having inner steel guard rails.

The centre posts over the main piers being 5 feet wide over-all and some of the diagonals packing out also about 5 feet, the future sidewalk has to be 5 feet clear outside of these dimensions.

The depth of the roadway stringers and the electric stringers is not yet decided upon until this floor plan is approved by you. We will then figure the exact dead weight of the wooden floor and proceed to the design of the steel floor.

Please return one plan with your approval and oblige.

Yours truly,

THE PHŒNIX BRIDGE CO.,
Per P. L. SZLAPKA.

EXHIBIT No. 71b.

(Letterhead of Quebec Bridge Co.)

PHŒNIXVILLE, PA., October 23, 1903.

THEO. COOPER, Esq.,
Consulting Engineer,
New York, N.Y.

DEAR SIR,—Under separate inclosure we send you five blue prints of drawing 'A' showing wooden floor system, main bridge, St. Lawrence river crossing. Kindly return

four of the sheets with your approval as far as the wooden portion of the cross-section is concerned.

We also send you two sheets showing general layout of the main bridge and especially showing the character of the curve of the upper chord of the suspended span. From this you will notice that this curve produced comes about 2 feet above the second panel point from the main pier. Kindly retain these prints for your office use.

Yours truly,

THE PHŒNIX BRIDGE CO.,
Per P. L. SZLAPKA.

EXHIBIT No. 71c.

POTTSTOWN, May 17, 1904.

THEODORE COOPER, C.E.,
Consulting Engineer, Quebec Bridge Co.,
New York.

DEAR SIR,—Beg to acknowledge receipt of your favour of the 16th inst., directing me to proceed to Phœnixville and to report to the Phœnix Bridge Company as inspector for the Quebec Bridge Company.

I thank you for kindly assigning me to this work, and assure you I will use my best endeavours to prove your confidence has not been misplaced. I note what you say regarding salary, and if this is agreeable to the chief engineer it will be so to me.

Would report that I called at the office of the Phœnix Bridge Company to-day as per your request, and was informed by their Mr. Deans that they expect to order material for the anchorage shell early next week.

I will be notified when this is done, and also be furnished with the necessary drawings and bills of material. I will keep track of the work now from this time on, and give prompt attention to any inspection which may arise. I remain,

Yours very truly,

E. L. EDWARDS.

EXHIBIT No. 71d.

(Letterhead of the Phœnix Bridge Company.)

PHŒNIXVILLE, PA., February 19, 1904.

THEO. COOPER, Esq.,
Consulting Engineer,
New York, N.Y.

DEAR SIR,—We send you herewith in duplicate stress diagram and general detail drawing of the 675-foot suspended span, Quebec bridge, and also our calculations in detail for same. With these calculations in hand the checking of our figures will be very much simplified.

While our general plan shows the principal features of the details to be used,

these details naturally may be subject to further changes when the final shop drawings for this span are made.

For erection purposes the upper chord sections are spliced in the field ahead of the panel points, while the panel splices will be shop riveted.

For the same reason the eyebars at the intersection with the sub-panels are attached to two separate pins by means of a special link.

Our plan shows the lower chord stiff throughout, although it may be found later on more convenient for erection to make the two centre panels of eyebars.

As noted on our plan, the details of the end portals, of the end floor beams, of the end stringers and the arrangement for transferring the lateral stresses from the suspended span into the cantilever, will be furnished later.

If you find it necessary to discuss any of our details in person, the writer will be glad to call at your office any day you may name. Kindly return one print with your approval, and oblige,

Yours truly,

THE PHŒNIX BRIDGE CO.,
Per P. L. SZLAPKA.

P.S.—Our detailed calculations are for your office use and need not be returned.

EXHIBIT No. 71e.

(Telegram.)
Dated Quebec, Que., 27

Received at
NEW YORK, April 27, 1904.

THEODORE COOPER,
35 Broadway, New York.

Think I can find in a few days satisfactory men for all inspection purposes.

E. A. HOARE.

EXHIBIT No. 71f.

(Letterhead of the Phœnix Bridge Company.)

PHŒNIXVILLE, May 3, 1904.

THEO. COOPER, Esq.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—We send you to-day six sets each of drawings T, U and V, being general detailed drawings of the anchor bent, Quebec bridge. Kindly affix your signature to these drawings and return same, so that we may forward them to Mr. Hoare for government's approval.

Yours truly,

JNO. STERLING DEANS, C.E.E.,
Chief Engineer.

EXHIBIT No. 71g.

(Letterhead of the Phœnix Bridge Company.)

PHŒNIXVILLE, May 26, 1904.

THEO. COOPER, Esq.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—We send you herewith in duplicate more complete drawings, sheets T, U and V, which may be necessary to you in checking our shop drawings No. 1 and No. 2, being eyebars, pins and pilots for the anchor bents, which plans we also send you herewith in duplicate.

The anchor eyebars are made of different lengths, owing to the fact that they are differently inclined from the bottom end pin towards the upper end pin, and also owing to the fact that the present anchor bars projecting 6 feet above the anchor piers are at slightly different elevations, as given to us by Mr. Hoare.

We understand, as already mentioned by you, it will not be necessary for us to bend the eyebars at their heads, owing to the slightly larger amount of slanting than generally specified.

We expect to send to you the bracing in the anchor bent on Saturday and the legs not later than Wednesday next.

Kindly return to us the two sheets of eyebars, pins, &c., at your earliest convenience, as we wish to make a start of rolling material in the mills, and in this way satisfy the Dominion government that the actual construction of the bridge in the shops has begun.

Yours truly,

THE PHŒNIX BRIDGE COMPANY,
Per P. L. SZLAPKA.

EXHIBIT No. 71h.

(Letterhead of the Phœnix Bridge Company.)

PHŒNIXVILLE, PA., May 26, 1904.

THEO. COOPER, ESQ.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—We send you herewith in duplicate:—

Calculations of pins in anchor bents.
Calculation of anchor tower.
Calculation of twin floor beam over anchor bent.
Complete stress sheet of anchor arm with the exception of end portal, intermediate sway bracing and bracing and trussed floor beams between centre posts.

These calculations show every position of live load used in obtaining maximum stresses. They also show the several cases of wind pressures on page 4—so that with all secants, tangents, &c., given, you will be enabled to make very rapid progress in checking our calculations.

As soon as you are through with these calculations and you wish any features of the calculations explained, corrected, or supplemented, the writer will be glad to call at your office.

Your truly,

THE PHŒNIX BRIDGE CO.
P. L. SZLAPKA.

EXHIBIT No. 71i.

(Letterhead of the Phœnix Bridge Company.)

PHŒNIXVILLE, PA., June 7, 1904.

THEO COOPER, ESQ.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—We send you in duplicate, additional sheets showing bending moments on pins of anchor arm, Quebec bridge, namely: Sheet 31 to 38, inclusive, and 44 to 46, inclusive.

In the course of two or three days we will send you the missing sheets for pins for post P-4 and centre post.

We would be greatly obliged to you, if Mr. Berger could see his way of checking the lower part of the main tower and return to us one of our plans approved, not later than next Friday—as our shops are greatly in need of this material.

Yours truly,
THE PHŒNIX BRIDGE CO.,
Per P. L. SZLAPKA.

EXHIBIT No. 71j.

(Letterhead of the Phœnix Bridge Company.)

PHŒNIXVILLE, PA., July 1, 1904.

THEO COOPER, ESQ.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—To eliminate the additional compressive stresses on the lower chord of the anchor arm, due to the bending under its own weight, we propose to move the centre line of the pins ½-inch below the centre of gravity of the chord. Kindly advise if you agree with us in this matter and oblige,

Yours truly,
THE PHŒNIX BRIDGE CO.,
Per P. L. SZLAPKA.

EXHIBIT No. 71k.

(Letterhead of the Phœnix Bridge Company.)

PHŒNIXVILLE, PA., July 28, 1904.

THEO. COOPER, ESQ.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—We send herewith for your examination and approval in duplicate:—
Drawing No. 1 C. O. 616, 617.
Drawing No. 1 C. O. 606, 607.
Drawing No. 12 C. O. 616, 617.

The end bottom chord plan was previously approved by you and we send you this plan owing to the fact that small changes were added and you requested us to send another set of drawings as finally arranged.

Kindly return one of each with your approval, and oblige.

Yours truly,

THE PHŒNIX BRIDGE CO.,
Per P. L. SZLAPKA.

EXHIBIT No. 711.

(Letterhead of the Phœnix Bridge Company.)

PHŒNIXVILLE, PA., October 17, 1904.

THEO. COOPER, Esq.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—We have your letter of October 14, referring to additional stresses caused in the top laterals by their weight, in addition to the wind stresses. We considered this point, but finding that the dead load stresses are less than 10 per cent of the wind stresses, we did not provide any additional section. Your standard specifications permit this assumption. The unit stresses—20,000 lbs. per sq. in. being less than the maximum permissible stress of 24,000 lbs. for all combined stresses, would be an additional reason for not providing any additional section, or any additional rivets for the dead load stresses. Kindly advise us again on this point, and oblige,

Yours truly,

THE PHŒNIX BRIDGE CO.,
Per P. L. SZLAPKA.

EXHIBIT No. 71m.

PHŒNIXVILLE, December 2, 1904.

List of errors of account made by the shop in the construction of posts and chords for the anchor arms of Quebec bridge:—

FOUR END BOTTOM CHORDS.—In consequence of the one end of these chords being faced $\frac{1}{32}$" out of square the connection holes for floor beams and which had been drilled from template were from $\frac{1}{8}$" to $\frac{5}{16}$" (maximum) out of their correct position in relation to the vertical line shown on drawing 7 C O 606-607.

Remedy.—The connection holes in end angles of end floorbeams were drilled to correspond with the holes in the chords. This shifting of holes in floor beams from the position as originally intended left at the top hole at least $\frac{1}{2}$" metal from side of hole to edge of angles and more material proportionately as the holes approached to the bottom of the floor beam.

No. 2 BOTTOM CHORDS.—On chords A-2-R and A-2-L (S. anchor arm) and A-2-R (N. angle arm) 14" pin holes were bored $\frac{1}{8}$-inch too low.

Remedy.—Bottom sections of post P 1 bored to correspond with pin holes in above chords.

No. 3 Bottom Chord S. Anchor Arm.—Chord A-3-L (S. anchor arm) $\frac{1}{16}$" short from centre of pin hole to faced end (short end, so-called.)

Remedy.—Abutting No. 4 chord lengthened by the amount this chord (A-3-L) was short.

Upper Section of Post P 1.—This section mark AUPR (N. anchor arm) was not set straight in the boring mill and in consequence this section was bored $\frac{1}{16}$" on one side longer than the other.

Remedy.—Pin hole was re-bored for 12$\frac{1}{8}$" pin, and connecting eyebars will be bored to correspond with this pin hole.

Hanger A T O L, South Anchor Arm.—This hanger did not 'true up' on two ribs in boring the upper 12" pin hole. Ribs were re-bored to 12$\frac{1}{8}$" and after bushing re-bored for 12" pin. Bushing $\frac{1}{16}$" thick (finished) and secured with four dowels—$\frac{3}{4}$" x 1$\frac{1}{4}$".

E. L. EDWARDS.

EXHIBIT No. 71n.

Phœnixville, December 12, 1904.

Theodore Cooper, C.E.
Consulting Engineer on Quebec Bridge and Railway Company.
New York.

Dear Sir,—I beg to send you herewith a memorandum showing the weights of some parts shipped within the past few weeks for the south anchor arm of Quebec bridge. Duplicates of these parts have been stored here for use on the north anchor arm.

Would report that the shop work is progressing steadily. The boring of 15" eye bars for panel D is now under way, in fact about 25 bars are completed. We pinned eight of these (picked out indiscriminately) and results were very satisfactory. In my inspection of 15" eyebars found two bars 15" x 2"—51'—3$\frac{21}{32}$" (c to c) mark A-D-2 which were $\frac{5}{64}$" too long. These bars have been put aside for the present. Chord A-6-L for south anchor arm we found $\frac{1}{16}$" short (at short end). Abutting No. 7 chord will be lengthened by this amount. I presume that this will meet your approval.

The forging of 15" eyebars has been improving very much lately and decidedly better than some of those which you saw at the eyebar plant on the occasion of your last visit here.

Yours very respectfully,

E. L. EDWARDS.

P.S.—No 15" eyebars will be shipped till Mr. Szlapka has arranged with you in reference to further full sized tests. He expects to see you this week, I believe.

EXHIBIT No. 71o.

Phœnixville, January 19, 1905.

Theodore Cooper, C.E.,
Consulting Engineer of the Quebec Bridge and Railway Company,
New York.

Dear Sir,—Enclosed please find reports of two tests made on one 15" x 1$\frac{15}{16}$" eye-bar. You will note that the elastic limit in both tests are rather low and in the case

of No. 20 the ultimate strength is 55000. I would therefore respectfully refer these tests for your consideration.

I would report the rejection of one pin (in addition to three previous ones) intended for anchor arms. This pin had fine seams running throughout its length.

No. 9 chord (A-9-L) for N. anchor arm we found the pin hole $\frac{1}{32}$" larger than the pin instead of $\frac{31}{64}$" allowed. Chords A-9-L and A-9-R for south anchor arm we find $\frac{1}{16}$" short from pin hole to end (long end). This occurs on one side of these chords only. the outside dimensions (from c of hole to end) are O.K. in both cases. The chords referred to will not be accepted by us till I have conferred with you later.

Yours very respectfully,

E. L. EDWARDS.

EXHIBIT No. 71p.

(Letterhead of the Quebec Bridge and Railway Company.)

QUEBEC, March 8, 1905.

THEODORE COOPER, Esq.,
Consulting Engineer,
New York, N.Y.

DEAR SIR,—I received a letter from Mr. Edwards regarding the inspector I mentioned to you the other day. I asked Mr. Edwards to see you with reference to this man's capacity to assist at Phœnixville, to become acquainted with the mechanical features of the work at the shops, and finally to be transferred to the field during the summer season. It is not easy to judge of a man by correspondence, but if you saw Mr. Edwards and the applicant you would soon decide whether he was capable, and if not we can look for others.

I received a letter from Kinloch this morning. He is the man I employed on the approach spans and whom I found to be very capable mechanically, and he has had previous experience in shop as well as field work. Kinloch would make a good second field inspector, as I don't think he has technical knowledge to qualify him for first place. I expect we will require more than one inspector in the field after getting fairly started.

Yours truly,

E. A. HOARE.

EXHIBIT No. 71q.

POTTSTOWN, March 11, 1905.

THEODORE COOPER, C.E.,
Consulting Engineer for the Quebec Bridge Company,
New York.

DEAR SIR,—On the occasion of Mr. Hoare's recent visit to Phœnixville he expressed the wish to have the weighing witnessed of as much material as possible. As every minute of our time is occupied, he stated that another man could attend to this and assist with clerical work and other duty.

I told Mr. Hoare that in case neither you nor he had any one in view, I knew of a man whom I thought would be suitable. Mr. Hoare writes me that after consulta-

tion with you it was decided to have some one assist at Phœnixville for a while and later take up erection. The man I had in mind is a young man of about 24 years of age. His experience has been purely practical, having spent four years with shipbuilding concerns and three years in the inspection of material at mills and bridge shops. While such a man could be used to advantage in assisting at the shops, his experience is probably not sufficient for such important work as inspector on erection.

From a conversation I had with you on the subject last fall you stated that you would prefer some young man who had experience in figuring strains. Just at present I do not know of a man who would be entirely suitable, but I would, if you wish, inquire and report to you. It is possible that Prof. Marburg, of University of Pa., and whom I know quite well, could recommend such a man as you desire.

I am, yours very truly,

E. L. EDWARDS.

EXHIBIT No. 71r.

(Letterhead of the Phœnixville Bridge Company.)

PHŒNIXVILLE, PA., March 25, 1905.

Mr. THEODORE COOPER,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—This letter will be handed you by Mr. N. R. McLure. Since I have talked with Mr. McLure, I feel he has had just the experience which you desire for a man to be your representative Quebec field inspector.

Yours truly,

JNO. STERLING DEANS,
Chief Engineer.

EXHIBIT No. 71s.

(Letterhead of Quebec Bridge Co.)

QUEBEC, March 31, 1904.

THEODORE COOPER, Esq.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—I have your letter of the 28th, stating that you have engaged Mr. N. R. McClure, late bridge inspector for the N. Y. O. and W. Ry., to go to Phœnixville as assistant inspector to prepare for the position of inspector of erection at Quebec, &c., &c.

On Wednesday I wired Mr. Edwards stating that if no arrangements had been made for an inspector I had some capable men in view to select from, residents of Montreal, who had previously held positions at a distance and were just about returning home. The man that you have selected, however, may be quite as capable.

Yours truly,

E. A. HOARE.

EXHIBIT No. 71t.

(Letterhead of Quebec Bridge Co.)

QUEBEC, May 18, 1905.

E. L. EDWARDS, Esq.,
Inspector,
c/o. Phœnix Bridge Co., Phœnixville, Pa.

DEAR SIR,—Answering your letter of May 5, respecting rolling of material ahead of plans approved, &c., for cantilever arms and suspended span, particulars of which I mentioned to you when in Phœnixville last week, will you please see Mr. Cooper with Mr. Deans or with Mr. Szlapka, so as to come to an understanding as to the class and quantity of metal that can be rolled, inspected and accepted for monthly progress estimates. The understanding with me is that Mr. Deans or Mr. Szlapka is to get the necessary plans approved by Mr. Cooper before he can sign any more estimates for work outside of anchor arms, towers and a limited quantity of plate metal agreed to for cantilever arms, and not to deliver metal for the cantilever arms or suspended span before the time required to prepare it for delivery in time for erection at the specified periods. Besides that Mr. Deans is to furnish me with plans ahead of any material ordered, to be approved by the Chief Engineer of the Department of Railways and Canals of Canada.

The above must be complied with before any more material is estimated, outside of the anchor arms, towers and floor system.

See Mr. Cooper, that you may get instructions before the end of this month.

Yours truly,

(Unsigned.)

EXHIBIT No. 71u.

(Letterhead of Quebec Bridge Company.)

QUEBEC, July 7, 1905.

THEODORE COOPER, Esq.,
Consulting Engineer,
35 Broadway, New York City.

DEAR MR. COOPER,—Replying to your letter received this morning, I reminded the accountant a week ago to send your cheque. Upon inquiry this morning, however, I find that it has not been sent. He will mail it to-day and provide for the draft discounts, which I stated to you would be refunded. In future he will send half yearly, as requested.

Sorry to hear that you are not up to the mark. Hope to see you soon.

Yours truly,

E. A. HOARE.

P.S.—No permanent metal erected yet.

EXHIBIT No. 71v.

(Letterhead of Phœnix Bridge Co.)

PHŒNIXVILLE, July 11, 1905.

THEO. COOPER, Esq.,
Consulting Engineer,
New York, N.Y.

DEAR SIR,—We send you herewith two additional copies of stress diagram for cantilever arms, St. Lawrence river bridge.

Kindly notice that, as you requested, we increased the sections of diagonals T-4 and T-40 and vertical post P-4. We also corrected erection wind stresses on subposts S.P. 3, S.P. 4 and S.P. 5.

We send you also in duplicate page 11a, showing sections required for the several truss members on the assumption, that the entire wind stresses are used in combination with live and dead load. The said wind stresses being calculated for wind blowing either on the suspended span only, or on the cantilever arm only.

Please increase on your pages 9 and 10 the sections of diagonals T-4, T-40 and post P-4.

The corrected erection wind stresses, namely, 78,000 lbs. for S. P. 3, 450,000 for S.P. 4, 469,000 for S.P. 5 are to be used only in combination with positive erection stresses on the above members for traveller standing in its extreme position.

The negative erection stresses for these three members are obtained, of course, with the traveller standing *in their panels*, for which position the wind stresses are insignificent.

We hope with these corrections and explanation the stress sheets will be entirely satisfactory to you and will be finally accepted.

Yours truly,

THE PHŒNIX BRIDGE COMPANY.
Per P. L. SZLAPKA.

EXHIBIT No. 71w.

(Letterhead of Phœnix Bridge Co.)

PHŒNIXVILLE, PA., July 12, 1905.

THEODORE COOPER, Esq.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—We send you herewith in duplicate chord section 9, for cantilever arms, St. Lawrence river bridge. This is the first drawing sent for your approval of the cantilever arm and we expect to send you additional drawings from now on. Kindly return one with your approval and oblige.

Yours truly,

JNO. STERLING DEANS,
Chief Engineer.

EXHIBIT No. 71x.

(Letterhead of Quebec Bridge Company.)

QUEBEC, July 17, 1905.

THEODORE COOPER, Esq.,
Consulting Engineer,
35 Broadway, New York City.

DEAR SIR,—In a few days we expect to commence placing the shell plates on the south anchor pier. I have on the work an experienced bridge inspector, who proved to be very satisfactory on the other work. McLure will not be needed here just now. Will advise later.

A chord member marked A-9-L met with an accident which caused the bending of lattice angles and cracked two legs of flange angles. I have thoroughly examined the whole piece and found nothing else wrong. Repairs can be made here, and I requested Phœnix Bridge Company to show you the points on the plan and get your approval before doing anything.

Your truly,

E. A. HOARE.

EXHIBIT No. 71y.

(Letterhead of Phœnix Bridge Co.)

PHŒNIXVILLE, PA., July 24, 1905.

Mr. THEODORE COOPER,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR MR. COOPER,—I have your letter of July 22, in connection with field inspection. I will certainly stop in to see you the next time I am in New York, and I expect to be over this week.

Mr. Milliken writes me that Mr. Hoare has been expecting to make us a visit, and I trust he may come down before the first of the month, so that between us we may get this matter in satisfactory shape. If Mr. Hoare does not come down, I think it will be necessary for me to see him on other matters at a very early date, in which case I will take up the question of inspection with him, but only after seeing you.

Yours truly,

JNO. STERLING DEANS.

EXHIBIT No. 71z.

(Letterhead of Phœnix Bridge Company.)

PHŒNIXVILLE, PA., August 11, 1905.

THEO. COOPER, Esq.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—Answering your letter of August 4, referring to bars and shop drawings of cantilever arm, Quebec bridge, we beg to state that we will be glad to substi-

tute 12" bars for 15" bars for diagonals T 1 and T 10 if the additional thickness of these bars permits this change, without encroaching on the clear width of the bridge.

We have sent you corrected diagrams of the cantilever arm showing the modified normal lengths and the camber lengths, which no doubt you will find correct.

We thank you for calling our attention to an error in wind strain in upper chord section F, namely, giving stress as 1,056,000 instead of 456,000, which error was made by reading wind stress on cantilever arm as 110,000 instead of 710,000, the 7 being very indistinct in the original.

Yours truly,

PHŒNIX BRIDGE COMPANY,
Per P. L. SZLAPKA.

EXHIBIT No. 71aa.

(Letterhead of Phœnix Bridge Company.)

PHŒNIXVILLE, August 16, 1905.

THEO. COOPER, Esq.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR MR. COOPER,—As Mr. Hoare has not been down since I last saw you, I have arranged to go to Quebec to-morrow, and one of the first things I will take up will be the matter of inspection, and you will hear from me promptly, certainly not later than early next week.

The last report from Mr. Milliken, which was this morning, he had ten lower chord sections in place—he placed four chord sections in one day—traveller handled the sections, as Milliken put it, 'as easily as ordinary rigging handled an eyebar.' We should be raising trusses in about ten days.

Yours truly,

JNO. STERLING DEANS,
Chief Engineer.

EXHIBIT No. 71bb.

(Letterhead of Quebec Bridge Company.)

QUEBEC, August 21, 1905.

THEODORE COOPER, Esq.,
Consulting Engineer,
35 Broadway, New York City.

DEAR SIR,—The work is about in shape now to need the services of Mr. McLure here. The field office for his and Mr. Kinloch's accommodations will be ready by the time he reaches here. Besides certain work that he will have to perform for this office and records required by the Dominion government, &c., please instruct Mr. McLure what special work you require him to do on your account. I have told him to come here for about three months, and afterwards go to your office or elsewhere to compute the weights of metal from shop drawings to check the same which have been made by he Phœnix Bridge Company. I will send Mr. Kinloch into the Phœnix machine shop for the winter, as, besides having had large experience in bridge erection, he is a first class shop man.

Yours truly,

E. A. HOARE.

EXHIBIT No. 72a.

(Letterhead of the Phœnix Bridge Company.)

PHŒNIXVILLE, PA., February 1, 1906.

THEO. COOPER, Esq.,
Consulting Engineer,
New York, N.Y.

DEAR SIR,—Answering your letter of January 23rd, referring to our drawing 76-C.O. 621-622, showing top strut at post 'P-3,' we beg to state that we are not quite as yet ready to say we have sinned.

The 4 angles 4" x 4" forming the strut are supported by latticing at alternate points, so that at a section through the centre of a panel only two angles are not supported, while the other two are cut at their panel points.

It is also not necessary to assume for unsupported distance of the 4" x 4" angles the panel lengths, there being at the latter plates 9" x ⅝" x 16" long, so that the actual unsupported distance may be taken between the end rivets, thus shortening the panel lengths by 12".

We have also to consider that the seeming overstraining of the struts takes place only at the 4 truss panel points next to the main pier or about 350 feet from the end of the cantilever arm.

At this great length of the truss exposed to the high wind pressure it would appear reasonable to use higher wind stresses for the struts than at the end of the cantilever arm.

In other words, using a formula: $22500\text{-}100\frac{1}{r}$ we find the sections provided for the struts satisfactory.

Since the corresponding *4 struts* in the anchor arm have been made with sections based on the same calculations as the cantilever arm, we think that no just criticism can be made if the struts are left as at present designed.

We also beg to add that the material for the struts in question is rolled.

Hoping that our explanation of the reasons for the details of the struts as shown on our plans will be found satisfactory by you, we remain,

Yours very truly,

THE PHŒNIX BRIDGE CO.,
Per P. L. SZLAPKA.

EXHIBIT No. 72b.

(Letterhead of the Phœnix Bridge Company.)

QUEBEC, February 10, 1906.

THEODORE COOPER, Esq., C.E.,
Consulting Engineer,
35 Broadway, New York, N.Y.

DEAR SIR,—I have written to Mr. Reeves stating that on account of a possible reorganization for the completion of the Quebec bridge we may be hurriedly called upon for final figures to complete the structure ready for traffic.

Omitting the end span, the figures given me for the larger structure—upon which we have based all calculations—are for total weight of 29,736 tons, which at the time I stated looked insufficient. I have already returned for payment about 29,000 tons which do not include suspended span and considerable of the cantilever arms, showing that the total weight has been underestimated.

Under the circumstances will you kindly check the revised Phœnix figures which I have asked for.

From current returns of work done to date I do not think the total weight will be far short of 35,000 tons.

Yours truly,

E. A. HOARE.

EXHIBIT No. 72c.

(Letterhead Phœnix Bridge Co.)

PHŒNIXVILLE, PA., February 17, 1906.

THEO. COOPER, ESQ.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—As reported to you by Mr. Edwards, chord 8R on cantilever arm was faced at long end 7/64" out of square, so that while one rib is of the exact length, the other three are short—the outer rib being short 7/64".

There are two methods of correcting this error—

1st. We might reface the chord, so that the end will be square and the long section will be 7/64" short. This method would cause bending on the hanger to the amount of 7/64", as the stringers in this panel are fixed at both sides. The end of the cantilever arm would drop about ¼", owing to the short panel

2nd. We might reface the chord, making the section say ¼" short and replace this material by a filler securely doweled to each rib and to the exact shape of each rib. This would preserve the panel of the exact length.

I am inclined to believe that the second method is preferable, and if you agree with me I will permit the shops to proceed with this method of correction. Please advise us as early as possible as the shops are anxious to finally complete the chord.

Yours truly,

THE PHŒNIX BRIDGE CO.,
Per P. L. SZLAPKA.

EXHIBIT No. 72d.

(Letterhead Phœnix Bridge Co.)

PHŒNIXVILLE, PA., February 26, 1906.

THEO. COOPER, C.E.,
Consulting Engineer of the Quebec Bridge Co.,
New York.

DEAR SIR,—Your letter of the 24th instant has been received and carefully noted. I have infomed Mr. Szlapka of the conditions under which you will accept the 19 eyebars in question. The understanding being that ten bars (5 for each struss) will be applied on the south cantilever arm and nine on the north arm. These 19 bars to have some distinguishing mark so they can be easily picked out and distributed as you have directed. I have shown Mr. McLure your letter, so that he understands the situation.

Regarding shop errors, would say that it is very disheartening to us to come across so many lately, and I certainly agree with you that a repetition of errors should be stopped. This is just what we are endeavouring to do, but appear to be up against a pretty tough proposition at present, but believe we will get better results before long. I am certainly working to this end. Mr. Norris stated some time ago that we had given closer attention to our work than any job that had ever gone through their shops. We have endeavoured to do this at least, knowing the importance of the work.

In reference to the new estimate of weights, Mr. Szlapka will have this prepared, and before being submitted to you will be checked over by Mr. McLure. Mr. McLure has the weight (actual) of south anchor arm and centre posts and bracing, and will commence figuring from lists and drawings the weight of members on the cantilever arm. When this is finished he will compare with Mr. Szlapka, who now has the estimated (from drawings) weights of the members of the cantilever arm from centre post to post P 2.

I am, yours very respectfully,

E. L. EDWARDS.

P.S.—In regard to weight of suspended span, Mr. McLure says he will have to get at this approximately.

EXHIBIT No. 72e.

(Letterhead, Theodore Cooper, Consulting Engineer, 35 Broadway.)

NEW YORK, June 2, 1906.

THEODORE COOPER, C.E.,
New York.

DEAR SIR,—Mr. Berger informs me you will not be at your office to-day. I blame myself for not advising you that I would be here to-day, but as I have never missed you in the past the possibility of not seeing you to-day did not occur to me.

With Mr. Hoare's permission, I will be away from Phœnixville next week on a trip with my family to Boston. I will stop to see you on my way back. May I ask you to kindly sign the May estimate and send to Mr. Hoare.

In reference to estimate, would say that under 'Total to date' the amount 54,261,279 includes all the raw material for anchor and cantilever arms, with the exception of about 1,000 tons of eyebars and plates for cantilever arm.

The amount of manufactured material under 'Trusses and bracing,' and which is 47,708,669, includes all material for north and south anchor arms, excepting two (2) pedestals, and for the cantilever arm (excepting panel 1) all chords, posts 4 and two sections of posts (Nos. 3 and 2). Hangers, all except two now under way. Most all bracing is included, also about 500 eyebars for the south cantilever arm and 300 for the north cantilever arm.

Regarding floor beams and stringers, there is practically no change since last month, viz., all are completed in the shop for the cantilever arm excepting those for panel 1.

Nothing ordered yet for the suspended span.

Mr. Hoare has not asked to have the estimate at Quebec at any particular time, so that if sent on the 4th no doubt this will be agreeable to him.

I am, yours very respectfully,

E. L. EDWARDS.

EXHIBIT NO 72f.

(Letterhead, Phœnix Bridge Co.)

PHŒNIXVILLE, PA., September 15, 1906.

THEO. COOPER, Esq.,
Consulting Engineer,
45 Broadway, New York.

DEAR SIR,—Replying to the latter part of your letter of September 13, revised stress sheet will be sent to you as soon as prints can be made.

Yours truly,

JNO. DEANS,
Chief Engineer.

EXHIBIT No. 72g.

(Letterhead, Phœnix Bridge Co.)

PHŒNIXVILLE, PA., October 16, 1906.

THEO. COOPER, Esq.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—We send you herewith our calculations of the end post of the suspended span, Quebec bridge. Our drawing for this end post, as sent you, is deficient in one respect, that is, the latticing on the post below the lower transverse strut is not distinctly shown, as consisting each of two angles 4" x 3" x 8½ lbs. per foot, thus securing double shear rivets. Above the lower transverse strut, where the shear is considerable less, single angle lattices and single shear rivets are sufficient. These lattices were figured on the assumption that the transverse shear on each post consisting of 128,000 lbs. is resisted half by the cover plate and half by the lattice system. The combined unit stress on the extreme fibre of the post due to live load, dead load and wind is less than 20,000 lbs., which is certainly a very low value. The material for the post is all rolled and delivered at shop. We hope our design of the post will be satisfactory to you.

Yours truly,

THE PHŒNIX BRIDGE COMPANY,

No. 700 $\left(\frac{337.5'}{28.125'}\right)\frac{1}{2} = 228.000$ per post.

Per P. L. SZLAPKA.

EXHIBIT No. 72h.

(Letterhead Phœnix Bridge Co.)

PHŒNIXVILLE, PA., November 16, 1906.

THEO. COOPER, Esq.,
Consulting Engineer,
New York, N.Y.

DEAR SIR,—We send you in duplicate several shop drawings for your examination and approval, including more complete plan showing adjustment arrangement during

connection of suspended span. These drawings complete all the shop drawings of the cantilever arm. Kindly return the print with your approval.

We have already started on the shop drawings of the suspended span, which being simpler than either the anchor or cantilever drawings will require less time and consequently will reach your office in quicker succession.

Yours truly,

THE PHŒNIX BRIDGE CO.,
Per P. L. SZLAPKA.

EXHIBIT No. 72i.

PHŒNIXVILLE, PA., November 26, 1906.

THEODORE COOPER, C.E.,
Consulting Engineer for the Quebec Bridge Co.,
New York.

DEAR SIR,—In reference to post EPR (for north side of the suspended span) which had the 12 1/16" pin hole bored on a skew and which I reported to you on my last visit to your office, would say this post has now been re-bored to 12¾". Pin holes in chords 1 will also be bored 12¾" when these chords are made. A special 12 1/16" pin has been ordered. It is my understanding this is done with your approval.

Yours very respectfully,

E. L. EDWARDS.

EXHIBIT No. 72j.

(Letterhead of Phœnix Bridge Co.)

PHŒNIXVILLE, PA., February 13, 1907.

THEO. COOPER, Esq.,
Consulting Engineer,
New York, N.Y.

DEAR SIR,—We send you herewith in duplicate stress sheet of the suspended span of Quebec bridge refigured for an increased dead load amounting to 14,500 lbs. per lin. ft. of bridge. The sizes of some of the truss members were increased to correspond to this increased dead load.

Yours truly,

THE PHŒNIX BRIDGE CO.,
Per P. L. SZLAPKA.

EXHIBIT No. 72k.

(Letterhead of the Phœnix Iron Works.)

PHŒNIXVILLE, PA., March 21, 1907.

MR. P. L. SZLAPKA,
Phœnix Birdge Co.

DEAR SIR,—In answer to your letter of the 19th, referring to bottom chords, Quebec bridge, I have gone into this very thoroughly and find that we cannot drive rivets in centre web. We have no machine to do this with, it is not possible to design a machine to drive these rivets satisfactorily. I do not think there is such a machine in the market.

These holes are drilled to size, and there should be no difficulty in having a turned bolt made a driving fit, as the bolts can be driven from outside of chord by inserting a long bar through rivet hole on outside web. Hoping this will be satisfactory.

Yours truly,

R. W. WRIGHT.

EXHIBIT No. 721.

(Letterhead of the Phœnix Bridge Co.)

PHŒNIXVILLE, PA., May 7, 1907.

THEO. COOPER, Esq.,
Consulting Engineer,
New York, N.Y.

DEAR SIR,—We send you herewith seven (7) blue prints of all drawings marked 'II' on our list herewith; you have in your office seven (7) copies of all drawings marked 'I' on our list.

Kindly return all these drawing 'I' and 'II' with your signature at your earliest convenience. These drawings cover the entire cantilever arm, and as many parts of the suspended span as will be erected by the large traveller.

Respectfully yours,

Per P. L. SZLAPKA.

EXHIBIT No. 72m.

(Ltterhead of the Phœnix Bridge Co.)

PHŒNIXVILLE, PA., May 21, 1907.

THEODORE COOPER, Esq.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—Referring to your advice to our New York office that you could not find drawings 13, 14, 72 of CO-621, 622—we are sending you seven prints of each drawing by mail to-day and would appreciate it greatly if you would sign and return them to us promptly. Mr. Hoare for some reason is very anxious to have certified copies of all drawings.

Yours truly,

JNO. DEANS,
Chief Engineer.

EXHIBIT No. 73a.

June 2, 1903.

DEAR MR. HOARE.—I have been laid up two weeks with grippe, and have not been able to do any work. I am much better, but still quite weak. Szlapka was here yesterday, and we cleared away some misunderstandings of each others' view as conveyed by writing. I send you the modifications of the specification as to material and workmanship, &c. Deans wanted me to specify according to my own specifications, but I thought this might be misunderstood. I did not understand that this was important at present.

I hope for the present at least my presence up there will not be required, as I am not in shape yet to go from home. Only come to the office for a short time even yet.

Hoping I have made my explanations of the specifications clear so that Schreiber will be satisfied.

I remain, yours very truly,

THEODORE COOPER.

P.S.—Of course, if it is thought best to make bridge still stronger, all right, but I have assumed that it was not desired to increase cost beyond estimate already made.

T. C.

EXHIBIT No. 73b.

June 16, 1903.

MY DEAR MR. HOARE,—I have answered the best I can your telegram of 15th

While it was my object in drafting the new specifications to get the best arrangement without materially reducing the weight, and a positive answer as to whether it will be reduced could only be determined by the actual strain sheets, I am inclined to think there will be for the 1,800-foot span a less weight than if proportioned under the old specifications. I know nothing as to the Pœnix contract draft or what they now propose. If they have given an estimated weight, I wish you would send it to me. Also it would be a guide if I knew whether the proposal is for a lump sum price or for a pound price; also whether 'the powers that be' desire to keep down as close as possible to the original estimates or are willing to go higher if the bridge can be bettered. I am only aiming to get all parts harmoniously strong and not have some parts weaker relatively than others.

Yours very truly,

THEODORE COOPER.

I am picking up strength, but am not good for much yet.

(Letterhead of the Phœnix Bridge Co.)

PHŒNIXVILLE, PA., 1903.

Mr. E. A. HOARE,
Chief Engineer, Quebec Bridge Co.,
Quebec, Canada.

DEAR SIR,—At the request of Mr. Deans, I send you herewith a sheet showing general comparison of your specifications of September 1, 1898, with specifications as now proposed by Mr. Cooper.

I took several actual instances to show what the exact figures would be as determined by either specifications.

The compression formulæ appear to be almost identical as shown for $^1/_r$ equal 60 and for $^1/_r$ equal 90.

As regards the wind pressure the values per lineal foot used by Mr. Cooper are equivalent to pressures per square foot proposed in your specifications.

With figures given I hope you will be able to see that the difference between the two specifications is very immaterial.

Where the new specifications give smaller sections than your specifications, it will be found during actual final computations, that owing to the magnitude of the structure and consequently the very large dead-load as compared with the live-load, the unit stresses selected are fully justified.

Yours truly,

P. L. SZLAPKA.

EXHIBIT No. 73c.

OTTAWA, July 18, 1903.

DEAR MR. PARENT,—The order in council was passed this morning giving Cooper the necessary authority to act as required by Hoare.

Yours sincerely,

C. FITZPATRICK.

EXHIBIT No. 73d.

August 6, 1904.

PHŒNIXVILLE BRIDGE COMPANY,
Phœnixville, Pa.

MY DEAR MR. SZLAPKA,—I have tested the proportions of the members of the anchor arm under the following maximum loading for my personal satisfaction, viz.:

Dead plus 1·5 live plus 25 lbs. of wind (½ of your wind strain) and find that the only members exceeding 24,000 in tension or 24,000—$100^1/_r$ for compression are:

The lower chord which has +26,500 and is all right, and

Towers L which should have 108 □

" $\overline{B}$ " " " 99 □ to come within the above conditions.

This is such a slight matter, I request, for the sentiment of the thing, that you change those last two members to the above sections if it does not inconvenience anything.

Yours very truly,

THEODORE COOPER.

EXHIBIT No. 73e.

February 19, 1906.

P. L. SZLAPKA, Esq.,
Phœnixville Bridge Company,
Phœnixville, Pa.

DEAR SIR,—In reply to yours of 17th inst., I regret very much these errors.

The only remedy for the chord 8-R seems to be the second method you propose. The dowels should be of such a character to insure the plates from being loosened or damaged.

For that centre cap, where all the pin holes have been bored too large, I see no satisfactory remedy but enlarged pins. The pin plates, to my surprise, have 20 per cent more pin pressure than the eyebars (should not have been so) and with the large holes will make this the weakest joint in structure, much to my regret. T-50, also have reversed strains, and the joints should be tight ones instead of being so free as now made.

Yours very truly,

THEODORE COOPER.

EXHIBIT No. 73f.

January 28, 1905.

Mr. E. L. EDWARDS,
Inspector for Quebec Bridge,
Phœnixville, Pa.

DEAR SIR,—You are hereby directed to accept no more eyebars for the Quebec bridge until further orders.

The present form of heads in use on these eyebars has been shown to be incapable of sustaining the working loads to be used, and a radical change in these heads is demanded. A long series of tests will be needed to solve this question.

As the change in the form and size of the head will affect the length of bars required, the company should stop further rolling of these bars.

You will please furnish the Bridge Company with a copy of this order.

Yours truly,

THEODORE COOPER,
Consulting Engineer, Quebec Bridge Co.

EXHIBIT No. 73g.

February 15, 1905.

E. L. EDWARDS, Esq.,
Inspector, Quebec Bridge,
Phœnixville, Pa.

DEAR SIR,—I have consented to the continuation of making eyebars for the anchor arms, but desire that the heads, as far as the lengths ordered will permit, be made at least 34 inches diameter, or with an excess of 47 per cent.

You can take up the inspection of these bars. No bars are to be accepted for the cantilever arm till further orders. Please inform the Phœnix Bridge Company of these orders.

Yours very truly,

THEODORE COOPER,
Consulting Engineer, Quebec Bridge Co.

EXHIBIT No. 73h.

(Letterhead Phœnix Bridge Co.)

PHŒNIXVILLE, Pa., August 12, 1905.

THEODORE COOPER, ESQ.,
Consulting Engineer,
45 Broadway, New York, N.Y.

DEAR SIR,—We send you to-day in duplicate shop drawing of upper section sub-post S. P. 5, and also shop drawings of side struts.

Please notice that the section of the sub-post is increased owing to the manner in which theseveral truss members be placed in position during erection.

We find that this sub-post receives its stress during erction of 1,200,000 pounds for which we provided 74·7 sq. in., using formula $p=27-112^{1}/_{r}$

Hoping you will return with your approval,

Yours truly,

The PHOENIX BRIDGE COMPANY,
Per P. L. SZLAPKA.

EXHIBIT No. 73i.

PHŒNIXVILLE, April 6, 1907.

THEODORE COOPER, C. E.,
Consulting Engineer for the Quebec Bridge Co.,
New York.

DEAR SIR.—Beg to acknowledge receipt of your favour of April 5, in reference to post sections C. P1 (R. and L.) C. O. 613.

These post sections I believe are satisfactory in every other respect, but we will make another inspection of them before shipment, as they have laid around the yard for quite a long time.

In reference to chord 10 LCO 622 which had been injured here in handling, would report that the ribs have now been straightened to our satisfaction. It was deemed best by the shop to heat some of the angles slightly at two points where outstanding legs were bent a little. After all work was done we examined the angles and ribs with magnifying glass and discovered no cracks. We have therefore accepted the chord as per your instructions.

Yours truly,

E. L. EDWARDS,

EXHIBIT No. 73j.

August 9, 1907.

JOHN STERLING DEANS, Esq.,
Chief Engineer, Phœnix Bridge Co.,
Phœnixville, Pa.

DEAR SIR.—Your telegram regarding chord joint at hand. The method proposed as sketched by Mr. McLure is not satisfactory as I telegraphed yesterday. These bent

webs can be pulled back by use of about 15 to 20 one inch bolts (in one and one sixteenth holes) threaded at both ends for nuts, passing from the outer to the inner bent webs. The outer straight web being stayed in some manner against its bending.

If the bent webs, after being pulled into line, tend to go back when released from the bolts, stays must be introduced to hold them in position. Possibly it may be necessary to permanently rivet in some of these one inch bolts.

Please let me know what method you propose to use.

It is a mystery to me how both these webs happened to be bent at one point and why it was not discovered sooner.

Yours truly,

THEDORE COOPER,

EXHIBIT No. 73k.

August 13, 1907.

N. R. McLURE, Esq., Insp. for
erection Quebec Bridge,
New Liverpool, P. Q., Can.

DEAR SIR,—Mr. Deans writes me that only one rib at joint 7 and 8 L is bent and that there is a full and complete bearing. That the bend was no doubt put in the chord in the shop before facing.

I have asked him to instruct his resident engineer to join with you in making an exact report, with dimensions, of the condition of this joint; with amount of bearing and if it is a square bearing or askew.

In reference to the splicing of T5 and T50 mentioned in your letter of 10th, I do not care to interfere with the regular programme as I have not followed the various actions of the loadings at different stages. Without going into it carefully, I think there will be more compression at these points, with more of the suspended span in place.

Please report promptly respecting joints 7 and 8 L with all the facts,

Yours truly,

THEODORE COOPER,

EXHIBIT No. 73l.

August 21, 1907.

JOHN STERLING DEANS, Esq.,
Chief Engineer, Phœnix Bridge Co.,
Phœnixville, Pa.

DEAR SIR,—I received copy of sketch of joint 7 and 8 L a few days ago.

I wrote Mr. McLure last week telling him none of the theories as to how this bending occurred were logical. That my theory was a blow on this rib after the two sections were in contact and that it probably was done in moving those suspended beams used in covering. To examine carefully to see if he could find any evidence of this. He has not yet reported. He did report a similar bend at L 8 and 9 west truss in same rib but of less amount.

I still believe this bend can be partly removed by use of long bolts with threads

at each end, outer rib being properly stiffened to prevent its bending. If it can be pulled nearer straight stays or bolts must be provided to hold it against future movement.

I cannot consent to let it go without further action, as the rivets in the cover splices would not satisfy the requirements to my mind.

Yours very truly,

THEODORE COOPER.

EXHIBIT No. 73m.

August 26, 1907.

JOHN STERLING DEANS, Esq.,
Chief Engineer, Phœnix Bridge Company,
Phœnixville, Pa.

DEAR SIR,—Mr. McLure reports he can find no evidence of the bent ribs having been hit, and does not think they could have been struck. This only makes the mystery the deeper, for I do not see how otherwise the ribs could have been bent.

When convenient I would like to discuss with Mr. Szlapka the best means of getting these ribs into safe condition to do their proper work.

Yours truly,

THEODORE COOPER.

EXHIBIT No. 73n.

August 31, 1907.

E. A. HOARE, Esq.,
Chief Engineer, Quebec Bridge Co.,
Quebec, Canada.

DEAR SIR,—Mr. Cooper has directed me to send to you the enclosed copies of letters and telegrams in regard to condition of chord joint 7-L and 8-L, south cantilever arm, Quebec bridge, etc., that all evidence in Mr. Cooper's possession will be in your hands, this in connection with Mr. McLure's letters, copies of which are in his possession.

Mr. Cooper takes the trouble very seriously, and is not in condition to write.

Yours very truly,

BERNT BERGER,
Asst. to Mr. Cooper.

EXHIBIT No. 73o.

Sept. 2, 1907.

MY DEAR MR. HOARE,—If I were a well man I feel it would be my duty to be with you, accepting all the responsibility of my position. But I know I should be of no use if there, as I could not stand the physical test.

I believe I can be of more use by staying here and keeping what strength is left me. There is nothing to be hidden in my position. Regardless of how it may affect me or my reputation, you shall have every assistance and any record or knowledge I have.

In my own depression I have not forgotten that sympathy is due to you all. May we get the truth regardless of whom it may affect. The cause of mankind is greater than any individual.

Yours sincerely,

THEODORE COOPER.

This is the first letter I have been able to write to any one.

EXHIBIT No. 73p.

Mr. C. SCHNEIDER, Oct. 4, 1907.
Consulting Engineer,
Pennsylvania Building,
Philadelphia, Pa.

DEAR SIR,—Mr. Cooper has directed me to inform you that in addition to the instructions as to the wind strains laid down in Mr. Cooper's modifications of the load and strain specification for the Quebec bridge, he ordered, in a letter to Mr. P. L. Szlapka, of the Phœnix Bridge Company, dated June 13th, 1905, that for the cantilever arms the full wind on the suspended span should be considered, as a tornado might strike over this area.

Also, Mr. Cooper has made a note on his first copy of the modifications of strain and load specifications that he had directed that 1,600 lbs. of snow per foot of bridge should be used.

Yours very truly,

BERNT BERGER.

EXHIBIT No. 74a.

E. A. HOARE, Esq., Feb. 4, 1901.
Chief Engineer, Quebec Bridge Co.,
Quebec, Canada.

DEAR SIR,—I acknowledge receipt of your favour of Jan. 31st, giving us final elevation of viaduct piers, length of approach spans, etc., for your bridge, and we will arrange our diagrams and details accordingly. We hope to get off to you, either to-day or to-morrow, copies of these trial diagrams and estimates as you request, so that you can fix final units.

Yours truly,

JNO. STERLING DEANS,
Chief Engineer.

EXHIBIT No. 74b.

(Personal.) Feb. 25, 1901.

DEAR MR. HOARE,—In checking over the proposed form of formal contract for the main structure at Quebec, we find some little trouble in meeting the wishes of your people and the requirements thrown around payments of subsidies. In work of this

magnitude it is not only usual, but necessary, to have arrangements made for *progress monthly* estimates, as we have outlined in our proposed form of agreement. Will you kindly advise me the present status of all subsidies, whether they are all operative and whether payments have been made for substructure under any or all of them; and if so, how and when these payments were made. Were they made on materials at quarry or at site, simply delivered or actually in place? Information of this kind will assist us. Please write me promptly, and oblige,

Yours,

JNO. STERLING DEANS.

Mr. E. A. HOARE,
Quebec, Canada.

EXHIBIT No. 74c.

March 26, 1901.

(Personal.)

E. A. HOARE, Esq.,
Chief Engineer, Quebec Bridge Co.,
Quebec, Canada.

DEAR MR. HOARE,—I have your personal letter of March 22nd. Mr. Szlapka tells me that only yesterday, while working over the second or third plan for the short approach spans, he was discussing with one of his assistants the advisability of making these approach spans in one length as probably the most satisfactory solution, and we are therefore very glad to receive your letter on the same subject. Mr. Szlapka will prepare now a complete design and close estimate for making these approach spans in one length and will send same to you as soon as possible. It will of course, take a few days, and you will then have all the figures before you to come to a conclusion.

Yours truly,

JNO. STERLING DEANS,
Chief Engineer.

EXHIBIT No. 74e.

(Personal.)

May 11, 1901.

Mr. E. A. HOARE, Chief Engineer,
Quebec Bridge Company
Quebec, Canada.

DEAR MR. HOARE,—Mr. Szlaptka returned home yesterday and I was pleased to receive his report that he had agreed fully with you as to the length of both approaches and has all the necessary information to prepare stress sheets to submit to you for the government's approval. This will be done promptly and when these stress sheets are returned we understand that we are to prepare shop drawings and send same to Mr. Cooper for approval.

Mr. Szlaptka also reports that the caisson for the first main pier is rapidly nearing a stage when it will be launched and placed in position. In this connection I believe

you will agree with me that the work is of such magnitude and of such importance as to make it absolutely necessary that all parts of the work should be passed upon by an independent engineer of acknowledged great ability. This should be done without questioning the ability and the conscientiousness of the contractor and his engineers, which are in this instance conceited. We expect therefore that you will have all details of construction of the foundation work, both the caisson, pier and its final depth of foundation, all passed upon by your consulting engineer, Mr. Theo. Cooper, and I would thank you to send me plans of the caisson and pier as soon as they are approved by him. I do not think it is necessary to indicate to you the great importance of this latter, and as the caisson is nearing completion, if it has not already been attended to, it should be done at once.

Will you kindly let me hear from you on the subject and oblige,

Yours truly,

JNO. STERLING DEANS,
Chief Engineer.

EXHIBIT No. 74g.

August 9, 1901.

(Personal.)

E. A. HORE, Esq., Chief Engineer,
Quebec Bridge Company,
Quebec, Canada.

Dear Mr. HOARE,—I have your letter of August 6 and am now trying to arrange to be in Quebec next Wednesday or Thursday, August 14th or 15th, and will remain until Saturday evening or Sunday evening.

I can see you on Thursday and Friday and Mr. Parent on Saturday.

While I do not specially care to take up the question of formal articles of agreement with Mr. Parent on this trip, I have prepared a revised copy to agree with the alterations suggested at our interview at the Waldorf last January and I beg to inclose you a copy, thinking you might wish to look it over and discuss same with me during my present trip. I also enclose extracts from three of our late important contracts, indicating the manner in which progress estimates are prepared. The case of the 'Brooklyn Bridge' and the contract with the 'United States Government at Rock Island' are particularly in line with present contract.

I am making trip at this time particularly to ascertain in detail how we are to prepare our estimates and how we are to be paid for the approach spans which we are just about constructing. If you can secure any information on this line in advance, it will probably give me more time to devote to other matters.

I am taking our Mr. Schenck with me, who will make the necessary sketches for preparing a perspective view of the completed bridge. We will wish to go out directly to the bride site, the day we arrive, to look over the Quebc side of the structure.

I am very sorry to learn of the illness of your daughter and trust she is much better. Hoping to see you soon and in good health,

I remain,
Yours truly,

JNO. STERLING DEANS,
Chief Engineer.

EXHIBIT No. 74h.

August 23, 1901.

Mr. ULRIC BARTHE,
Secy. Quebec Bridge Company,
Quebec, Canada.

MY DEAR SIR,—At my last visit to Quebec and in the limited time which could be given me by your president, the Hon. S. M. Parent from his usually crowded time, I was advised that we should prepare our estimates for the approach spans we are constructing, the same as was done in the case of the anchorage metal, and further that we would be paid in the same manner through checks of Mr. M. P. Davis. Under this arrangement there will become due us on or about November 15, 1901, for the erection of one approach about $50,000, and as the south approach span cannot be erected during the present season, there will be due on or before January 15, 1902, for the delivery of the metal work of this approach span at site about $32,500. I send this understanding to you direct that you may verify same and also write us should there be any action to be taken on our part different from that outlined above.

Yours truly,

JNO. STERLING DEANS,
Chief Engineer.

EXHIBIT No. 74p.

October 22, 1902.

Mr. A. E. HOARE,
Quebec, Canada.

DEAR MR. HOARE,—Mr. Tretter has returned from Quebec and reports that foundation of south river pier has been passed upon by government engineer and consulting engineer, and pronounced satisfactory, and that pier is now being sealed up and completed. This must be a great relief to you and Mr. Davis as well as all others interested in this great enterprise. I have instructed our treasurer, Mr. Davis, to send bill for the north approach span at this time, thinking you would wish to place the amount in this month's estimate—thereby dividing the total amount which will be due us on completion of both approaches. We will arrange to complete both this season as that appears to be the better plan. Please write me at your convenience.

Yours truly,

JNO. STERLING DEANS.

EXHIBIT No. 74q.

December 1, 1902.

E. A. HOARE, Esq., Chief Engineer,
Quebec Bridge Company,
Quebec, Canada.

DEAR SIR,—Replying to your letter of Nov. 6, asking a 'reasonably close estimate for talking finances,' of the several items to complete your Quebec Bridge, these prices to be what we 'think will prevail during the present winter.'

Growing out of the necessities of construction and particularly of the requirements in the field work, it will be impossible to divide the work and order same ahead, in as many items as you suggest, and I have therefore divided the work into three principal items, and even this division will be disturbed somewhat, as a very considerable portion of the cantilever arms must be erected at the same time as the anchor arms in order to make the anchor arms self-supporting. I can, however, discuss this matter more in detail with you, when you come to New York with Mr. Parent.

Item No. 1—

2 anchor arms.
2 towers on main piers.
2 towers on anchor piers.
Floor for anchor arms.

29,742,000 lbs. Price.....$1,475,900
Wooden floor for this item, including railing, screens bolts, etc..... 51,732

Total.....$1,527,632

Item No. 2—

2 cantilever arms.
Floor for same.

22,780,000 lbs.....$1,126,400
Wooden floor for this item, including railing, screens, bolts, etc..... 40,500

Total.....$1,166,900

Item No. 3.—

Suspended span.
Floor for same.

7,335,000 lbs. Price.....$ 359,190
Wooden floor for this item, including railing, screens, bolts, &c..... 24,300

Total.....$ 383,490

NOTE.

Void: See letter Jan. 20, 1903.—D.

December 1, 1902.

E. A. HOARE, Esq.,
Chief Engineer.

In item No. 1, under the item of wooden floor, etc., we have included the wooden floor, etc., of the approach spans, as it would be necessary to put these floors in at the same time the anchor arm floors are put in place.

As far as change in price is concerned, there is nothing in sight in our particular business which would indicate that there will be any change in prices within the next year or eighteen months—this is about as far as one can see ahead; certainly they will not be lower; unless there is some great financial disturbance which cannot be foreseen. General business, and particularly the railways, are prosperous, as indicated by their increased earnings, beyond any previous record.

As far as I can learn from those best informed, everyone looks to next year as a year which will show, if anything, increased prosperity and business, and this is my own opinion.

As I have frequently expressed to you, it seems to me there is no time so well suited to launch a large enterprise as a time of activity, with business on a sound basis and a prospect of a continuance of these conditions. It is true that possibly your company might be called upon to pay slightly increased price for metal at such times, but this would be much more than offset by the ease in making your financial arrangements.

On the present basis, this increase in price of metal is only some $150,000 above the original figures. The remaining portion of increase in total price is due to the fact that we are now providing two sidewalks over the entire bridge at your request, and this appears to us to be a wise conclusion; and further, we are using the increased loads you mentioned in arriving at the sections of the floor system. These items of sidewalks and specifications increase the original estimate about 10 per cent.

One hesitates necessarily to discuss the future and I do not wish to be a party to mislead you or the people you represent in any way, but I firmly believe that nothing but a financial crash, which no one can foresee, and of which we have no evidence whatever at present, can affect the great prosperity now existing for at least eighteen months.

Yours truly,

JNO. STERLING DEANS,
Chief Engineer.

P.S.—Please advise me early whether you will wish to discuss this matter with me in New York or in Philadelphia and time when you expect to reach either place. I am often away, as you know, and should have this information as long in advance as possible. I trust we will see you soon.

J. S. D.

EXHIBIT No. 74r.

May 20, 1903.

THEO. COOPER, ESQ.,
Consulting Engineer,
New York, N.Y.

DEAR SIR,—We return herewith, by registered mail, your proposed specifications for loading and unit stresses, main span Quebec bridge.

I wish to make the following remarks in reference to these specifications.

1st. I assume that only one engine E—40 will be used on each railway track.

2nd. I find that the proposed 48,000 lbs. on two axles 10 ft. centre to centre on trolley stringers produce larger bending moment in centre than the 40,000 lbs. on two axles 7 ft. apart centre to centre originally used.

3rd. E-33 on each railroad track to be used for chords and main diagonals for the suspended span, is equivalent to 4,200 lbs. per lin. ft. on one track and almost 2,000 lbs. per lin. ft. on the second track.

4th. I tried formulæ proposed for main members and find in each case there will be a slight saving of material and that the unit stresses come within the limit of about ⅓ of the elastic limit for live and dead load stresses.

5th. On page two of your specifications there should be added the same remark as on page 3 written *by you in pencil* and marked by me with red *asterisk*.

6th. I examined the values of the permissible unit stresses for reversed strains and I find in some cases there are slight errors, as indicated by me in red.

EXHIBIT No. 73a.

June 2, 1903.

DEAR MR. HOARE.—I have been laid up two weeks with grippe, and have not been able to do any work. I am much better, but still quite weak. Szlapka was here yesterday, and we cleared away some misunderstandings of each others' view as conveyed by writing. I send you the modifications of the specification as to material and workmanship, &c. Deans wanted me to specify according to my own specifications, but I thought this might be misunderstood. I did not understand that this was important at present.

I hope for the present at least my presence up there will not be required, as I am not in shape yet to go from home. Only come to the office for a short time even yet.

Hoping I have made my explanations of the specifications clear so that Schreiber will be satisfied.

I remain, yours very truly,

THEODORE COOPER.

P.S.—Of course, if it is thought best to make bridge still stronger, all right, but I have assumed that it was not desired to increase cost beyond estimate already made.

T. C.

EXHIBIT No. 73b.

June 16, 1903.

MY DEAR MR. HOARE,—I have answered the best I can your telegram of 15th

While it was my object in drafting the new specifications to get the best arrangement without materially reducing the weight, and a positive answer as to whether it will be reduced could only be determined by the actual strain sheets, I am inclined to think there will be for the 1,800-foot span a less weight than if proportioned under the old specifications. I know nothing as to the Pœnix contract draft or what they now propose. If they have given an estimated weight, I wish you would send it to me. Also it would be a guide if I knew whether the proposal is for a lump sum price or for a pound price; also whether 'the powers that be' desire to keep down as close as possible to the original estimates or are willing to go higher if the bridge can be bettered. I am only aiming to get all parts harmoniously strong and not have some parts weaker relatively than others.

Yours very truly,

THEODORE COOPER.

I am picking up strength, but am not good for much yet.

(Letterhead of the Phœnix Bridge Co.)

PHŒNIXVILLE, PA., 1903.

Mr. E. A. HOARE,
Chief Engineer, Quebec Bridge Co.,
Quebec, Canada.

DEAR SIR,—At the request of Mr. Deans, I send you herewith a sheet showing general comparison of your specifications of September 1, 1898, with specifications as now proposed by Mr. Cooper.

I took several actual instances to show what the exact figures would be as determined by either specifications.

The compression formulæ appear to be almost identical as shown for $^1/_r$ equal 60 and for $^1/_r$ equal 90.

As regards the wind pressure the values per lineal foot used by Mr. Cooper are equivalent to pressures per square foot proposed in your specifications.

With figures given I hope you will be able to see that the difference between the two specifications is very immaterial.

Where the new specifications give smaller sections than your specifications, it will be found during actual final computations, that owing to the magnitude of the structure and consequently the very large dead-load as compared with the live-load, the unit stresses selected are fully justified.

Yours truly,

P. L. SZLAPKA.

EXHIBIT No. 73c.

OTTAWA, July 18, 1903.

DEAR MR. PARENT,—The order in council was passed this morning giving Cooper the necessary authority to act as required by Hoare.

Yours sincerely,

C. FITZPATRICK.

EXHIBIT No. 73d.

August 6, 1904.

PHŒNIXVILLE BRIDGE COMPANY,
Phœnixville, Pa.

MY DEAR MR. SZLAPKA,—I have tested the proportions of the members of the anchor arm under the following maximum loading for my personal satisfaction, viz.:

Dead plus 1·5 live plus 25 lbs. of wind (½ of your wind strain) and find that the only members exceeding 24,000 in tension or 24,000—$100^1/_r$ for compression are:

The lower chord which has +26,500 and is all right, and

Towers L which should have 108 □

" B " " " 99 □ to come within the above conditions.

This is such a slight matter, I request, for the sentiment of the thing, that you change those last two members to the above sections if it does not inconvenience anything.

Yours very truly,

THEODORE COOPER.

EXHIBIT No. 73e.

February 19, 1906.

P. L. SZLAPKA, Esq.,
Phœnixville Bridge Company,
Phœnixville, Pa.

DEAR SIR,—In reply to yours of 17th inst., I regret very much these errors.

The only remedy for the chord 8-R seems to be the second method you propose. The dowels should be of such a character to insure the plates from being loosened or damaged.

For that centre cap, where all the pin holes have been bored too large, I see no satisfactory remedy but enlarged pins. The pin plates, to my surprise, have 20 per cent more pin pressure than the eyebars (should not have been so) and with the large holes will make this the weakest joint in structure, much to my regret. T-50, also have reversed strains, and the joints should be tight ones instead of being so free as now made.

Yours very truly,
THEODORE COOPER.

EXHIBIT No. 73f.

January 28, 1905.

Mr. E. L. EDWARDS,
Inspector for Quebec Bridge,
Phœnixville, Pa.

DEAR SIR,—You are hereby directed to accept no more eyebars for the Quebec bridge until further orders.

The present form of heads in use on these eyebars has been shown to be incapable of sustaining the working loads to be used, and a radical change in these heads is demanded. A long series of tests will be needed to solve this question.

As the change in the form and size of the head will affect the length of bars required, the company should stop further rolling of these bars.

You will please furnish the Bridge Company with a copy of this order.

Yours truly,
THEODORE COOPER,
Consulting Engineer, Quebec Bridge Co.

EXHIBIT No. 73g.

February 15, 1905.

E. L. EDWARDS, Esq.,
Inspector, Quebec Bridge,
Phœnixville, Pa.

DEAR SIR,—I have consented to the continuation of making eyebars for the anchor arms, but desire that the heads, as far as the lengths ordered will permit, be made at least 34 inches diameter, or with an excess of 47 per cent.

You can take up the inspection of these bars. No bars are to be accepted for the cantilever arm till further orders. Please inform the Phœnix Bridge Company of these orders.

Yours very truly,
THEODORE COOPER,
Consulting Engineer, Quebec Bridge Co.