Mr. McLURE.—Just as it suits you. That will be the shortest way, I think. You want the condition of the erection at the time I made an inspection of the chord and found it straight. As nearly as I remember the date was August 15. At that time I have recorded as being erected on that day the bottom chord sections of the suspended span B-R and L of sub-diagonals S-P-2-R and L. These chords were connected by pinning diagonal eye-bars T-2-P and L to the hangers T-O-O. That was on the third panel of the suspended span. The main post of the small traveller then would be over post P-1 of the suspended span and I should say the panel was approximately half erected—panel 3.

Prof. KERRY.—The traveller was sitting on the second panel?

Mr. McLURE.—Yes. The tip of the top forward overhang only had been removed.

Commission took recess.

## AFTERNOON SESSION—TWELFTH DAY.

The Commission resumed at 2 p.m.

Mr. HOARE put in monthly progress estimates from June, 1904, to July, 1907, accompanied by progress diagrams (filed and marked Exhibit No. 42).

Mr. McLURE, recalled.

Prof. KERRY.—You were familiar with the instructions issued by the Phœnix Bridge Company in regard to erection, Mr. McLure?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—And in all except very minor detail those instructions were absolutely followed?

Mr. McLURE.—Yes.

Prof. KERRY.—In particular were the instructions in regard to the opening at the joints between the several chords of the lower chord followed exactly?

Mr. McLURE.—They could not follow any instructions in regard to the openings. They had to make their own openings. You could not make the openings anything you wanted to.

Prof. KERRY.—Not setting the place originally?

Mr. McLURE.—You could on the anchor arm. On the anchor arm the opening centres are set to a certain elevation. On the cantilever arm the opening in the chord would be made at a certain point and you could not change that if you wanted to.

Prof. KERRY.—You mean that the length of the members absolutely fixed that opening?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—And as it worked out the openings were as anticipated?

Mr. McLURE.—The openings agreed fairly well with what was supposed.

Prof. KERRY.—What do you mean by fairly well?

Mr. McLURE.—They were not always exactly what was indicated on the drawing.

Prof. KERRY.—How much would they vary?

Mr. McLURE.—An eighth of an inch.

Prof. KERRY.—I think you told us that you were not present at the time that the lower chord of the anchor arm was laid?

Mr. McLURE.—No, sir.

Prof. KERRY.—So that you could give us no positive evidence in regard to those openings?

Mr. McLURE.—I know what they were after I got there.

Prof. KERRY.—Was it possible to examine them?

Mr. McLURE.—Yes.

Prof. KERRY.—And they were in accordance with the blue print instructions?

Mr. McLURE.—I do not remember whether they were or not. My impression is they were.

Prof. KERRY.—They were sufficiently in accordance that you had no ground for taking any exception?

Mr. McLURE.—Yes.

Prof. KERRY.—What opportunity had you to observe these openings during the building out of the cantilever arm?

Mr. McLURE.—The observations we made on the outstanding legs of the top and bottom flange angles of the two outside ribs.

Prof. KERRY.—They were regularly measured?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—How often was that done?

Mr. McLURE.—Every time the traveller was moved, or in other words, every time a panel of the cantilever arm was completed.

Prof. KERRY.—Do you have a record of these movements?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—(to Mr. Deans).—Will these also be recorded on that general diagram you showed us, Mr. Deans?

Mr. DEANS.—No, they will not be recorded on that, but there are other reports including these openings you have referred to now.

Prof. KERRY.—In Mr. Yenser's file?

Mr. DEANS.—Mr. Cudworth said that he made a set of those that will be filed.

Mr. McLURE.—I have them here.

Prof. KERRY.—Have you got them in shape to file?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—You better put them in as an exhibit, please. (Diagrams produced.)

Mr. HOLGATE.—How do you describe these, Mr. McLure?

Mr. McLURE.—Diagrams showing changes in openings of bottom chord splice. (Put in and market Exhibit No. 43.)

Prof. KERRY.—In general the closing up of these so-called camber openings was regular and satisfactory?

Mr. McLURE.—Yes, sir, it was in general.

Prof. KERRY.—We asked Mr. Milliken at the time he was giving his evidence for a diagram showing the exact condition of the riveting at the time of the failure. Has that yet been prepared, do you know?

Mr. McLURE.—No, I have not heard Mr. Milliken say anything about it yet.

Mr. DEANS.—I do not think that has been prepared as yet, but we will see that it is prepared. He will have to confer with Mr. Kinloch about that.

Prof. KERRY.—The riveting of the main connections, Mr. McLure, was dependent on the closing up of the joints?

Mr. McLURE.—Riveting of the splices?

Prof. KERRY.—Yes?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—Was there any material delay between the time that a splice was ready for riveting and the time the riveting was actually done?

Mr. McLURE.—I do not know that you would call it delay. None of them were riveted until they got ready to rivet them whether they were closed or not.

Prof. KERRY.—You had no reason to make any complaint as to the force of riveters actually at work on the bridge?

Mr. McLURE.—None at all.

Prof. KERRY.—It was all that the Quebec Bridge Company desired in that respect?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—Have you any record of the removal of the false work from under the anchor arm—the dates?

Mr. McLURE.—I have a separate record. It would be included in my diary, or my correspondence with Mr. Cooper, stating the condition at each time that a report was made.

Prof. KERRY.—As I remember the previous evidence, no false work was removed until the anchor arm was entirely free from it.

Mr. McLURE.—There were definite instructions issued from Phœnixville regarding the removal of false works, and as I remember Mr. Cooper knew of those instructions and approved of them.

Prof. KERRY.—These instructions were regularly and closely followed?

Mr. McLURE.—Yes, sir, I think they were right to the letter.

Prof. KERRY.—So that the record of instructions from the Phœnixville office will fully cover the removal of the false work?

Mr. McLURE.—I think it was not removed quite as soon as it could have been according to those instructions; that is some parts were left under a little longer than they need to have been according to the instructions.

Prof. KERRY.—Had you any chance to, or did you observe any relation between the movements of the cantilever forward and the closing of the joints along on the chord?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—Was there a definite and observable relation or was it little marked?

Mr. McLURE.—There was a uniform movement forward of the top of the main post, and at the same time apparently there was a closing of the joints of the anchor arm.

Prof. KERRY.—Was that to such an extent that you could fairly predict when the cantilever moved forward what the result of your measurements would be?

Mr. McLURE.—Not as regards each particular splice. When the cantilever arm was pretty well out on the main pier you could count on finding much smaller openings in the anchor arm joints each time the traveller was moved than you could count on at the top of the centre post each time the traveller was moved as compared with the previous measurement.

Prof. KERRY.—The moving of the parts under the altered stress due to the advance of the traveller, that would be almost immediate, Mr. McLure?

Mr. McL[illegible]—No, sir.

Prof. Ker[illegible] did not take any length of time to settle into position?

Mr. McL[illegible]ould say it would take at least twenty-four hours.

Prof. Kerr[illegible] usually made measurements how long after the traveller was moved?

Mr. McLure[illegible]ally not until the next day; I gave it time to work out through the truss.

Prof. Kerr[illegible]s would get their set before you made your measurement?

Mr. McL[illegible]Yes.

Prof. Ker[illegible]; what time d[illegible]rection did the upper chord commence to come into play?

Mr. McLURE.[illegible]the third panel of the south cantilever arm.

Prof. KERRY.—[illegible]came on it of course it would be in every panel——

Mr. McLURE.—Right s[illegible]through to the end of the anchor arm.

Prof. KERRY.—And you found that the several bars were acting together?

Mr. McLURE.—Yes, I found that right straight through the work.

Prof. KERRY.—That is to say they were so accurately made that when the stress came on a composite member all parts commenced to act immediately.

Mr. McLURE.—All parts seemed to act together.

Prof. GALBRAITH.—How did you test that?

Mr. McLURE.—By kicking them.

Prof. GALBRAITH.—By sound?

Mr. McLURE.—Not by sound, by motion.

Prof. GALBRAITH.—In your discussion with Mr. Birks previous to the last movement of the traveller, did he express any definite opinion?

Mr. McLURE.—I do not know that he expressed a definite opinion, but he gave me the impression that he did not think it would make much difference whether the traveller was moved or not.

Mr. STUART.—I think Mr. McLure shared that view himself?

Prof. KERRY.—Mr. McLure stated that this morning. (To Mr. McLure): To what extent, when you were going through these figures yourself, Mr. McLure, did you consider the very peculiar action of a post member in the way of the stress? You were considering the deflection of a heavy compression member. You estimated the increase of the stress due to the movement forward of the cantilever arm. Did you make any other calculations?

Mr. McLURE.—We would figure the stress in the latticing, due to the eccentricity that we measured in that chord.

Prof. KERRY.—In the ordinary chord member, normal and straight, did you have occasion to examine the latticing at all? Not in any special chord, but in any one of the chords that was under full strain?

Mr. McLURE.—No, I think not.

Prof. KERRY.—You are not in a position to say whether the latticed members, particularly the 'X' members, would be very tight or not, under very heavy strain?

Mr. McLURE.—On an ordinary chord?

Prof. KERRY.—An ordinary chord, yes?

Mr. McLURE.—No, sir.

Prof. KERRY.—In the case of the chords you examined, what was the condition of these bars?

Mr. McLURE.—They were absolutely straight, there were no loose rivets with one exception, and upon rapping a few of them they gave forth a kind of singing sound, like a wire under tight strain.

Prof. KERRY.—In other words, you thought they were under heavy strain?

Mr. McLURE.—They seemed to be working; how heavy you could not tell.

Prof. KERRY.—And what was your calculation directed to find out? You speak about calculating the stress in the latticing due to the deflection; did you consider that latticed member as a truss that was deflected down a matter of two inches in that length?

Mr. McLURE.—Yes, we made the assumption that the deflection was a maximum through all the ribs, that the latticing acted as a truss with freedom to move the joints, and that the ribs had no stiffness in themselves.

Prof. GALBRAITH.—You calculated as if the whole chord was bent into a circle?

Mr. McLURE.—No.

Prof. GALBRAITH.—And calculated the shearing force taken up by the latticing?

Mr. McLURE.—Yes. I think we found the latticing was strained considerably under one-half the elastic limit. I do not remember the figures exactly according to our assumptions.

Prof. KERRY.—You would assume in that calculation that the normal chord member had no stress in the latticing at all?

Mr. McLURE.—No initial stress.

Prof. KERRY.—No initial stress of any kind? You would have calculated those stresses in the lacing or latticing simply from the elongation of the members necessary to give a circular form?

Mr. McLURE.—Yes.

Prof. KERRY.—That was practically all that you had to go on?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—Did you include in that calculation the fact that the length along the chord in the rib between the two ends of the lattice bar had been materially decreased by the shortening of the member?

Mr. McLURE.—By the shortening due to strain?

Prof. KERRY.—Due to the compression of the member?

Mr. McLURE.—Compressive stress, no.

Prof. KERRY.—Normally it would appear that with a member perfectly straight on account of that compression the latticing would not be under strain, it might even be under a slight compression strain?

Mr. McLURE.—Due to the shortening of the member. That shortening was about three-eighths of an inch in the whole length of the chord under its full strain. Of course it was only receiving about two-thirds, therefore it would not be that much.

Prof. KERRY.—That theoretical consideration was not covered?

Mr. McLURE.—It was not entered into.

Prof. KERRY.—And did you make any effort to apply the various theories of post flexure to the conditions existing?

Mr. McLURE.—From which the different column formulæ were derived?

Prof. KERRY.—Yes?

Mr. McLURE.—No, sir, that did not enter into this, because the cross sections were such that we did not have to use a column formula to reduce the stress.

Prof. GALBRAITH.—You say you found by hammering the lacing that it was under high tension? How did you compare the sound of the diagonal latticed members at the places where the bulge was greatest? We will say the centre of the post and the diagonal lattice members at the end, did you compare the sound of those two members?

Mr. McLURE.—No, I did not. Mr. Kinloch did the hammering, and as I remember it, he hammered half a dozen all in the same neighbourhood.

Prof. KERRY (to Mr. Kinloch).—Was there any difference in the sound of a diagonal member near the middle of the chord and near the end of the chord?

Mr. KINLOCH.—There was some slight difference, yes.

Prof. KERRY.—Which way?

Mr. KINLOCH.—I do not remember now; they all sounded high.

Prof. KERRY.—You could not distinguish to say which was lowest and which was highest?

Mr. KINLOCH.—I do not remember now.

Prof. KERRY.—In general, the condition of the latticing on the different chords was entirely satisfactory?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—You assumed in your calculations that you were dealing with what is technically known as a short column all the time?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—And you did not realize that the moment the member showed an appreciable deflection it showed that it was not a short column?

Mr. McLURE.—I am not convinced of that yet.

Prof. KERRY.—You are not convinced of that yet?

Mr. McLURE.—No, sir.

Prof. KERRY.—Have you any other information you would like to add, Mr. McLure, anything that you think would be of assistance to the Commission in drawing its attention to the cause of failure, the cause and the locality?

Mr. McLURE.—I do not think of anything just now.

Prof. KERRY.—You are satisfied by the measurements you have taken both before and since the accident that the cause of the failure lies entirely in the steel work?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—That the foundations are in perfect condition and have not moved to an appreciable extent?

Mr. MCLURE.—They have got copings chipped off, otherwise they are in perfect condition.

Prof. KERRY.—And without any appreciable shift?

Mr. MCLURE.—Yes, sir, the main pier seems to have risen a little bit.

Prof. KERRY.—I shall ask you further questions on that when Mr. Cudworth submits the diagrams and measurements. On a strictly technical point, would the appearance of those columns and the flexure in the columns as you looked at them, particularly in the neighbourhood of the joints, suggest that the columns had free ends or fixed ends?

Mr. MCLURE.—Which one, the cantilever arm or the anchor arm?

Prof. KERRY.—Both?

Mr. MCLURE.—I think the anchor arm chord from appearances would give the impression of a column with free ends; the cantilever arm chords look more like a column deflected with fixed ends. (This answer is modified by a subsequent answer.)

Prof. KERRY.—That is to say, in the case of the anchor arm the fracture apparently extended right down the whole splice?

Mr. MCLURE.—Yes.

Prof. KERRY.—But on the cantilever arm?

Mr. MCLURE.—It seemed to run out.

Prof. KERRY.—It ran out to the edge of the cover plate?

Mr. MCLURE.—Yes.

Mr. STUART.—You might ask him how he accounts for that?

Prof. KERRY.—Can you advance any reason or suggest any reason for the difference of apparent action in the two cases?

Mr. MCLURE.—I do not know why there should be any difference in the action; no, the splices are almost identical.

Prof. KERRY.—And they were not fully riveted up in either case, were they?

Mr. MCLURE.—Yes, the anchor arm chord was fully riveted at one end and the other end ran into the next panel. It was not riveted, so that the deflection that I had in mind was in that part of the No. 9 anchor arm chord lying south of the T-5-Z hanger.

Prof. GALBRAITH.—The splice was on the other side?

Mr. MCLURE.—One splice, the splice that was not riveted.

Prof. GALBRAITH.—You mean the splice that was really at the other end of the chord?

Mr. MCLURE.—Yes.

Prof. KERRY.—In the other case, on the cantilever arm?

Mr. MCLURE.—On the cantilever arm, the splice between 10 and 9 was riveted, and I think between 9 and 8 fully riveted; between 8 and 7 was being riveted.

Prof. KERRY.—In the plans filed under No. 43, showing the openings at the chord joints, what was the accuracy of measurement, to what unit were they measured?

Mr. MCLURE.—One sixty-fourth of an inch either way; that is a possible total variation of $\frac{1}{32}$ of an inch.

Prof. KERRY.—The possible error in the figures as given there you would place at $\frac{1}{32}$ of an inch?

Mr. MCLURE.—Yes, sir.

Prof. KERRY.—Do you know if any of those joints were found to be open to that extent when the cover plates were removed?

Mr. MCLURE.—The cover plates were never removed until the joints were tight.

Prof. KERRY.—How would you know they were tight if the measurements were not closer than $\frac{1}{32}$ of an inch?

Mr. MCLURE.—I stuck a $\frac{1}{64}$ inch plate in them if they were open; if you could not get it in they were tight.

Prof. KERRY.—Could you get into the joint?

Mr. McLURE.—You could get to the outstanding edge of the flange angles.

Prof. KERRY.—The lower flange angles?

Mr. McLURE.—Lower or upper, as the case might be.

Prof. KERRY.—And the entire end of the chord member was cut to a true plane?

Mr. McLURE.—Yes, faced off on a rotary machine.

Prof. GALBRAITH (after a conversation with Mr. McLure).—I think Mr. McLure might say: 'On reconsideration of my answer respecting the free endedness or otherwise of the columns, I am inclined to think that since I have had an opportunity of observing the bend only from batten plate to batten plate the chord as a whole could not be necessarily considered free-ended at the end next post T-5-Z hanger.' That is what you mean, is it not?

Mr. McLURE.—Yes.

Prof. KERRY.—Under the direction of the Commission, Mr. McLure, you have made certain surveys of the wreck, have you not?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—Have plans from those surveys been prepared?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—Are they ready for deposit?

Mr. McLURE.—Yes. Do you want everything, levels and lines?

Prof. KERRY.—Just make a deposit of each one and we will say what it is.

(Document produced, filed and marked Exhibit No. 44.)

Prof. KERRY.—Exhibit 44 was submitted to show the positions of the top chord panel points in plan before and after the accident, the positions after the accident being indicated by full circles.

(Document produced, filed and marked Exhibit No. 45.)

Prof. KERRY.—Exhibit 45 shows similar information concerning the bottom chord panel points and the positions before and after the accident are marked by the same method.

(Document produced filed and marked Exhibit No. 46.)

Prof. KERRY.—Exhibit 46 shows the positions in side elevation of the panel points of both the upper and the lower chord of the east truss of the anchor arm before and after the accident, the elevations of the panel points after the accident not being accurately fixed.

(Document produced, filed and marked Exhibit 47.)

Prof. KERRY.—Exhibit No. 47 gives the same information with regard to the west truss of the anchor arm.

(Document produced, filed and marked Exhibit No. 48.)

Prof. KERRY.—Exhibit No. 48 shows the results of measurements made to determine whether any horizontal movement had taken place between the anchor pier and the main pier on the south side.

(Document produced, filed and marked Exhibit 49.)

Prof. KERRY.—Exhibit 49 shows the position before and after the accident of the pedestals on the main pier.

(Document produced, filed and marked Exhibit No. 50.)

Prof. KERRY.—Exhibit 50 shows the elevations determined at various dates of two bench marks on the face of the main pier.

Prof. KERRY.—How many of the elevations given in exhibit 50 were determined by yourself, Mr. McLure?

Mr. McLURE.—I had a hand in all of them.

Prof. KERRY.—You assisted in all of them?

Mr. McLURE.—Yes, I think.

Prof. KERRY.—And the one especially marked with your initials?

Mr. McLURE.—I took as a check.

Prof. KERRY.—A special check measurement that you made independently.

Mr. MCLURE.—Yes.

Prof. KERRY.—Now, you might state any observations of interest that you made on the wreck, Mr. McLure, any points that you observed which you think bear directly on the cause of the disaster, or would indicate the position of the first break. You assisted, I believe, at the taking of the photographs that were submitted yesterday by Mr. Kinloch and in the identification of the parts both on the ground and on some of the photographs?

Mr. MCLURE.—Yes.

Prof. KERRY.—And to the best of your knowledge those are perfectly correct?

Mr. MCLURE.—Yes, with the exception of the corrections Mr. Kinloch made yesterday.

Prof. KERRY.—That has been made on the photograph.

Mr. HOLGATE.—Yes.

Mr. MCLURE.—Not on the negative; I made it on your copy.

Prof. KERRY.—Would you tell the results of your observations?

Mr. MCLURE.—The tension members all seemed to be in pretty good shape, only one eye-bar broken as far as I could see.

Prof. KERRY.—Was there anything in the tension members to indicate that they fell before the general fall?

Mr. MCLURE.—No, nothing to indicate that they would fall; also nothing to indicate that they had been in any way over-strained except during the fall. The details of all the connections, both pin and riveted, as far as I have observed, are, with one or two exceptions, in as good condition now as before the accident. These exceptions are minor points in a few ears in the pin connection, and in general the connections are intact.

Prof. KERRY.—You have noticed nothing in those connections to indicate a failure previous to the collapse?

Mr. MCLURE.—No, sir. The condition of the transverse bracing, of course, is pretty bad, pretty well smashed up, also the lateral system and the floor system, although there are certain panels in the floor system that seem to have escaped without much damage. In the main compression members is noticed the greatest damage due to the fall. In the vertical posts there is evidence in almost every case of almost complete destruction of certain parts, particularly in the body of the member. In the bottom chords there is also evidence of destruction in numerous places. I guess that about covers all of them.

Prof. KERRY.—You arranged to submit an additional plan showing the position of the floor beams? We understand that the floor beams in every case in the anchor arm were riveted before the accident took place?

Mr. MCLURE.—Yes, sir.

Prof. KERRY.—You were to submit a plan showing the position of the floor beams before and after the accident, determining on the ground the position of the two ends of each floor beam, or in one or two cases where the floor beam was badly bent, possibly to determine the two ends and the centre.

Mr. MCLURE.—In the case of the truss floor beam to take the ends of the top chord on which the stringers rested?

Prof. KERRY.—Yes. What we particularly wish to determine from that is to see if we can make out how those floor beams fell. It is fair to assume, I think, that the the floor beam remained connected with the post until the post struck the ground.

Mr. MCLURE.—I think probably you will find most of them lying right between their connections now. I can find that out definitely.

Prof. KERRY.—Have you seen any members among the wreckage that you consider may have fallen previous to the general collapse?

Mr. MCLURE.—Judging from their present condition?

Prof. KERRY.—Judging entirely from their present condition?

Mr. McLURE.—The main posts look very much as though they might have fallen any time either before or during the collapse from their positions now. Judging entirely from their present conditions, I should think that any one of the vertical posts might have fallen.

Prof. KERRY.—That is to say, they are so completely broken up?

Mr. McLURE.—That they might have fallen before the collapse, yes.

Prof. KERRY.—Might have fallen at any time and you would not have been able—

Mr. McLURE.—To tell which fell first. Also chords 9-R and L of the anchor arm might have fallen before the collapse.

Prof. KERRY.—Do you think it likely that if any chords of the anchor arm fell that those chords show more indication of failure than any of the others?

Mr. McLURE.—They are more completely demolished now than any of the other chords. They either fell first, if any of the chords did, or else they got the worst treatment in the fall.

Prof. KERRY.—From your observation, Mr. McLure, is it your opinion that the failure took place in the top chord?

Mr. McLURE.—No, sir.

Prof. KERRY.—Is it your opinion that it took place in the posts?

Mr. McLURE.—I have not any opinion that is not subject to change, but at the present time it is not.

Prof. KERRY.—Is it your opinion that it took place in any of the lateral or bracing systems?

Mr. McLURE.—No, sir.

Prof. KERRY.—Then it is your opinion that the failure took place in the bottom chord?

Mr. McLURE.—Yes, sir.

Prof. KERRY.—And from the present condition of the wreckage you consider it probable that it took place, more likely than any other hypothesis that can be advanced, in chords 9-L and 9-R?

Mr. McLURE.—Yes, sir, one or the other first, I do not know which.

Mr. STUART.—Would you mind asking Mr. McLure whether there was anything which indicated that there was a failure in any part of the cantilever arm first?

Prof. KERRY.—Have you seen or heard any evidence that would indicate that the failure occurred in any part of the cantilever arm?

Mr. McLURE.—I did not see it fall.

Prof. KERRY.—You have seen nothing since the accident?

Mr. McLURE.—I have seen nothing since to indicate that there was any failure in the cantilever arm.

Prof. KERRY.—Have you heard any one who saw the bridge fall claim to have seen the failure at any point in the cantilever arm?

Mr. McLURE.—I have heard so many stories now I cannot recollect; they are all different. I do not think I have.

Prof. KERRY.—Will you read over this description, Mr. McLure? (handing witness typewritten paper). Can you say that that description which was prepared by Mr. Cudworth from the dictation of members of the Commission correctly describes the present position of chords 9-A-L and 9-A-R?

Mr. McLURE.—It describes the position of 9-A-R. It seems to describe mostly the position of the chain mark and loose rivet on 9-A-L.

Prof. KERRY.—You think it should be amplified to state the full position of 9-A-L?

Mr. McLURE.—Yes; I do not think that describes the position of 9-A-L very fully. That is a description of the mark of the chain and of the loose rivet.

Prof. KERRY.—Will you take that description, Mr. McLure, and, in conjunction with Mr. Cudworth, prepare a plan showing the piers, and showing the present position of the members and also the chord of the anchor arm?

Mr. McLURE.—Do you want all four ribs?

Prof. KERRY. I think we might say with details where any particular distortion exists.

Mr. McLURE.—Is this to be just a plan? I cannot show it in perspective very well.

Prof. KERRY.—To be accompanied with a written statement covering the points not readily intelligible by an ordinary plan. Different members are so badly twisted that short of a model I do not think you could prepare anything that would make it absolutely clear.

Mr. McLURE.—How large a piece do you want shown? There are lots of little pieces lying around there?

Prof. KERRY.—The general instruction of the Commission is to determine the cause of the wreck. Anything that does not bear on that is not worth taking.

Mr. HOLGATE.—If, in the description, you can refer to any one of those photographs definitely, in order to fix the point, it might be just as well to do it.

Mr. McLURE.—All right.

The Commission adjourned until ten a.m. Monday morning.

## THIRTEENTH DAY.

QUEBEC, P.Q., September 23 1907.

The Commission met at 10 o'clock.

E. A. HOARE, Chief Engineer, Quebec Bridge Company, recalled.

Mr. HOLGATE.—I think you were present during the giving of the evidence of Mr. Kinloch and Mr. McLure?

Mr. HOARE.—Yes, sir.

Mr. HOLGATE.—They related in chronological order certain matters that they noticed and they detailed some defects that had been noticed in the chords. Do you remember the earliest date at which these were brought to your attention?

Mr. HOARE.—Which chord was that?

Mr. HOLGATE.—Any of the chords.

Mr. HOARE.—The defects on chord 9 anchor arm and the two chords on the cantilever arm 8 and 9 were called to my attention on the 27th August, by Mr. McLure.

Mr. HOLGATE.—Do you feel sure that none of these were brought to your attention before that time?

Mr. HOARE.—No, not before.

Mr. HOLGATE.—Was any intimation given you with respect to any other part of the structure?

Mr. HOARE.—Yes, from time to time. They would refer to anything. Whenever I visited the work I would always ask the question: Is everything all right on the structure? Anything special to call my attention to? And in most cases the answer was 'no.'

Mr. HOLGATE.—Would there be anything of that nature which was reported to you which would not appear in the written reports written by Mr. McLure?

Mr. HOARE.—No, in fact everything of importance, in fact every detail is mentioned in the daily report, in fact the daily report was a description of the work done,

a complete description of the work done and included important and unimportant details.

Mr. HOLGATE.—When were daily reports made up by Mr. McLure? Take for instance, one day's work, would that report be made out on that day or on the following day?

Mr. HOARE.—I could not say the exact time he made that out; I think he made that out every evening.

Mr. HOLGATE.—What day would you receive them on?

Mr. HOARE.—I would not get them myself daily in writing; he would make my office book up from time to time; I would take it out occasionally and——

Mr. HOLGATE.—Where was that office book kept?

Mr. HOARE.—In my office in Quebec; it is an exact copy of his field book.

Mr. HOLGATE.—How was that entered up, daily?

Mr. HOARE.—It was not actually entered up daily, but the records are daily.

Mr. HOLGATE.—There might be a period of——

Mr. HOARE.—Two or three days before my book was written up.

Mr. HOLGATE.—Two or three days, so that anything that Mr. McLure might have reported in the form of diary which was written up in your office, you might not have a complete report of that until several days after?

Mr. HOARE.—Well, not in writing, but verbally. If anything happened, or anything out of the common occurred, he would confer with me, that is, if I was not at the bridge that day.

Mr. HOLGATE.—By telephone?

Mr. HOARE.—By telephone and on the work; whenever I visited the work he would discuss everything fully.

Mr. HOLGATE.—Would that mean daily communications between you and Mr. McLure?

Mr. HOARE.—Practically daily communication.

Mr. HOLGATE.—But not necessarily daily communication?

Mr. HOARE.—No, the only days when perhaps there would be no discussion would be when they were making erection preparations, that is moving the travellers, the rigging, for putting in panels ahead.

Mr. HOLGATE.—Had you a private telephone line?

Mr. HOARE.—Yes, I had a private telephone in the office and one in my house, and I hardly missed a day without calling one or other of them up and sometimes both of them up by telephone morning and evening.

Mr. HOLGATE.—When you speak of a private telephone, that is a telephone solely for your own use?

Mr. HOARE.—The telephone was in the office at the bridge.

Mr. HOLGATE.—In the Quebec Bridge Company's office?

Mr. HOARE.—No, in the Phœnix Bridge Company's office, but the Quebec Bridge Company's office at the bridge was adjoining it.

Mr. HOLGATE.—There was just one telephone, then, at the bridge?

Mr. HOARE.—Just the one telephone, yes.

Mr. HOLGATE.—Then, if anything had been observed by Mr. McLure on August 20th, you might not have known of that for some days later?

Mr. HOARE.—He would not have waited so long as that; anything that occurred on the 20th he would have notified me.

Mr. HOLGATE.—As a matter of fact, can you say when his observations of the 20th of August became known to you?

Mr. HOARE.—I have nothing on the 20th of August, I have nothing of importance noted in my book.

Mr. HOLGATE.—In whose handwriting is that diary?

Mr. HOARE.—Mr. McLure's.

Mr. HOLGATE.—Mr. McLure's own handwriting?

Mr. HOARE.—Yes.

Mr. HOLGATE.—And that was written up in your office in Quebec?

Mr. HOARE.—No, in his own, at the work.

Mr. HOLGATE.—And transferred to your office?

Mr. HOARE.—No, given to me when I went out.

Mr. HOLGATE.—And the only times you saw the diary were when you visited the work?

Mr. HOARE.—No, I always kept the diary in office for reference; I kept this diary in the Quebec office for reference from time to time as to what occurred on the work, and had it made up; I used to take it to the work now and then when I went there.

Mr. HOLGATE.—Well, then in order to keep your office diary record in agreement with Mr. McLure's diary which he kept on the work, when you visited the bridge you took your office copy to the bridge and compared it with Mr. McLure's field copy and entered up any omissions from your office copy from Mr. McLure's field copy.

Mr. HOARE.—No, I did not compare my copy with his; he would write this up for me from his.

Mr. HOLGATE.—Mr. McLure would fill it in, then?

Mr. HOARE.—He would fill these in from his field copy.

Mr. HOLGATE.—So then your office diary was made up from time to time and back dates filled in on the occasion of your various visits to the bridge?

Mr. HOARE.—Yes.

Mr. HOLGATE.—You have filed something showing your visits to the bridge?

Mr. HOARE.—I have put in something, yes.

Mr. HOLGATE.—Were you there on August 20th, Mr. Hoare?

Mr. HOARE.—I am not quite positive; I could not say right off whether I was there or not.

Mr. HOLGATE.—What have we here to show?

Mr. HOARE.—I do not think there is anything to show.

Mr. HOLGATE.—By reference to a private diary could you tell us what your movements were in regard to visiting the bridge?

Mr. HOARE.—Well, I might; I am not quite sure about that; I do not actually know every day I visited the bridge; sometimes I used to go on consecutive days and I did not enter it up; in fact, sometimes I did and sometimes I did not.

Mr. HOLGATE.—What we would like to know would be your movements in regard to the bridge work from the 20th of August forward to the 29th?

Mr. HOARE.—I am positive about the 28th, that I was there on the 28th? I can speak from memory that I was there on the 28th, all day long.

Mr. HOLGATE.—I have no doubt that you could, from consulting your own private diary, say just what your movements were in that period?

Mr. HOARE.—Possibly I could. The only day I am positive about now is the 28th. I was there all day on the 23th.

Mr. HOLGATE.—Will you give us a memorandum covering that information?

Mr. HOARE.—Yes.

Mr. HOLGATE.—Then, what was the first report of Mr. McLure's that drew your special attention in that period to the work?

Mr. HOARE.—On the 27th he showed me a sketch.

Mr. HOLGATE.—In Mr. McLure's absence from the work whose duty was it to write up that diary and keep the field notes?

Mr. HOARE.—He attended to it always.

Mr. HOLGATE.—But in his absence? We have a statement from him that he was in the hospital?

Mr. HOARE.—Well, it was not written up, he wrote it up when he came out.

Mr. HOLGATE.—Who, then, kept the notes from which he would write up that diary?

Mr. HOARE.—Mr. Kinloch would keep the account of the daily work.

Mr. HOLGATE.—Mr. Kinloch kept the notes?

Mr. HOARE.—He was supposed to keep track of everything during Mr. McLure's absence in the hospital, and when Mr. McLure was sick, I called up Mr. Kinloch, and several times during the day when I was not at the bridge myself to know if everything was going on smoothly, and if he required any assistance, and his reply was that there was nothing of special importance taking place, that they were principally engaged in the moving of travellers and rigging for the next panel.

Mr. HOLGATE.—Were you at the bridge during Mr. McLure's absence in the hospital?

Mr. HOARE.—Yes, sir; and I took every pains to ascertain from Mr. Kinloch if he required any assistance and if he would be overworked during Mr. McLure's sickness, and he—in fact he laughed at me for asking the questions.

Mr. HOLGATE.—Now, Mr. Hoare, would you please go on with what took place from the 27th of August forward?

Mr. HOARE.—Mr. McLure reported that the four ribs of chord 9-A-L showed deflections towards the axis of the bridge, and showed me a pencil sketch of it. He told me that that was reported to him, that it was discovered by Mr. Kinloch, and that as those bends had not been discovered before, he had reported the matter that day to Mr. Cooper, and that Mr. Birks had reported in the same manner to Phœnixville. He also stated that he thought it would be advisable to go to New York and describe it, as it took so long to communicate by telegram on account of delays in getting messages through; there was a strike at the time. He also stated that Mr. Yenser would not move out the traveller. My answer was that that was all right, and that he had better go to New York and Phœnixville. But before going, I wished him to check up everything—that is to take levels at the main pier, to examine the posts, and see that everything was in perfect line, and be perfectly sure that he had full information on the general condition of the bridge before leaving. In the morning of the 28th, I went out to the bridge and met Mr. McLure and Mr. Kinloch and Mr. Birks—they were together at the office.

Mr. HOLGATE.—Was Mr. Yenser present?

Mr. HOARE.—Not just at that moment; he showed up a few minutes later. I asked them if they had examined everything as requested the night before. He said everything had been examined, and everything was in perfect condition.

Mr. HOLGATE.—What did you understand he meant by that?

Mr. HOARE.—He meant that everything was in normal condition, referring to the levels of the bridge and the alignment of posts. Everything was working right with the exception of that chord and the two chords mentioned on the cantilever arm.

Mr. HOLGATE.—That is the two chords mentioned to you at that time, or some time previously?

Mr. HOARE.—No, at that time.

Prof. GALBRAITH.—Which chords?

Mr. HOARE.—Two chords on the cantilever arm on the Quebec side.

Mr. HOLGATE.—But I suppose your diary contained references to these under a previous date?

Mr. HOARE.—They are all mentioned here, 8 and 9 chords, the diary refers to them. I asked the question if any rivets or latticing had been broken on chord 9-A-L, and they stated that there was no visible damage, but that the latticing appeared to be, I think they said, slightly strained.

Mr. HOLGATE.—Do you remember who made that remark?

Mr. HOARE.—It was Mr. Kinloch, I think, made that remark. He said they sounded rather peculiar.

Mr. HOLGATE.—Can you recollect any statements made by Mr. Yenser or Mr. Birks in regard to not only that matter but anything else that took place at that time?

Mr. HOARE.—Yes; when Mr. Yenser appeared on the scene; before he appeared

I was told that the traveller had been moved that morning. I asked him why he moved it. He said he had so many men out, that he thought there was no danger in moving the traveller.

Prof. GALBRAITH.—About what o'clock was this conversation?

Mr. HOARE.—I think that was about half-past ten in the morning.

Mr. HOLGATE.—Was the impression made on your mind at the time, Mr. Hoare, by Mr. Yenser's remark, that he was free from any feeling of danger?

Mr. HOARE.—Yes; he seemed to be quite at ease over it, in the way he spoke to me, judging from his manner. And then I asked Mr. Birks, I think it was, a question if he had figured the effect of moving that small traveller on the 9-A-L chord. He stated it was approximately about 50 pounds to the square inch.

Mr. STUART.—Did he state that he had figured it? Mr. Hoare's answer does not indicate whether he had figured it. I want to know if he really said he had figured it?

Mr. HOARE.—Yes, he said he had figured it; approximately, it was 50 pounds to the square inch. I replied that that was a bagatelle, compared with the stress already on the chord.

Mr. HOLGATE.—Did you understand that his 50 pounds to the square inch was simply the additional compression strain brought on the member?

Mr. HOARE.—Brought on that chord by the moving of the traveller forward. That is what he stated to me.

Prof. GALBRAITH.—As a whole?

Mr. HOARE.—As a whole.

Mr. HOLGATE.—Was any other question discussed by you with Mr. Birks with regard to the question of strain?

Mr. HOARE.—No, I do not think so.

Mr. HOLGATE.—You do not remember that any direct reference was made to the condition brought about by any change in shape of the member?

Mr. HOARE.—No. After that discussion about the traveller having been moved, I told Mr. McLure to hurry off and catch the noon train and go to New York and see Mr. Cooper and lay the facts before him and have a full discussion and come to some decision about it, and then to go to Phœnixville and repeat the same explanations there so that there would be no misunderstanding which might arise by telephoning or telegraphing from the office.

Mr. HOLGATE.—Previous to that moment had you made a personal examination of the parts you were discussing?

Mr. HOARE.—No, I only looked down, I merely went out on the deck and partly out on one of the floor beams so I might be positive where the distortions occurred. I went out there and I did not notice anything from the place I was standing.

Mr. HOLGATE.—You could not discern the bends that these gentlemen were speaking about from the deck?

Mr. HOARE.—Not from where I was on the deck.

Mr. HOLGATE.—Then I understand that you did not go down on the chord yourself?

Mr. HOARE.—No, I did not go down, I was perfectly satisfied.

Mr. HOLGATE.—To verify their reports?

Mr. HOARE.—I was perfectly satisfied with their reports, because they had made careful measurements of the same.

Prof. GALBRAITH.—Do you know anything about the total stress on that chord that morning? You have given me increase of stress.

Mr. HOARE.—I think there was about—I had some conversation about that with Mr. Birks later in the day, and to the best of my recollection, he told me there was about three-quarters of the maximum on it.

Prof. GALBRAITH.—How much did you understand that to be?

Mr. HOARE.—I think I have a note of that somewhere. The maximum was supposed to be over 15 000,000.

Prof. GALLATIN.—I meant unit stress, or put it the other way.

Mr. HOARE.—I think there was about from 11,000,000 to 12,000,000 pounds on it that day.

Mr. HOLGATE.—Total load?

Mr. HOARE.—Total load on it that day, speaking approximately.

Mr. HOLGATE.—At any rate you cannot say positively now?

Mr. HOARE.—Cannot say positively.

Mr. HOLGATE.—And you do not know this definitely?

Mr. HOARE.—No.

Mr. HOLGATE.—And the information of that nature that you would have received would have been received from whom, Mr. McLure or Mr. Birks?

Mr. HOARE.—Mr. McLure was away, he had gone to New York. I was ascertaining these figures from Mr. Birks as he was keeping track of the effects of the erection on the members from time to time.

Mr. HOLGATE.—You gave us what you understood to be Mr. Yenser's appreciation of the conditions, Mr. Hoare?

Mr. HOARE.—Yes.

Mr. HOLGATE.—Did Mr. Birks pronounce upon the matter?

Mr. HOARE.—Yes. My general conversation with him about that chord led me to conclude that he did not consider it a dangerous matter at all. He considered that it would be necessary to take some steps to repair it, but I did not conclude from the conversation I had with him that he considered it a dangerous affair.

Mr. HOLGATE.—But he approved of Mr. McLure going to interview Mr. Cooper?

Mr. HOARE.—Well, I did not consult him at all about that.

Mr. HOLGATE.—He knew he was going?

Mr. HOARE.—He knew he was going; at least he did not know until I told him he had gone.

Mr. DAVIDSON.—I would like to suggest why should these engineers have considered repair necessary if it was not in a serious and dangerous condition?

Mr. HOLGATE.—I think the facts are clearly stated. Mr. Davidson, there is a condition described.

Mr. DAVIDSON.—Probably that is a conclusion more or less justified by the evidence so I do not insist on that.

Mr. HOLGATE.—Was any scheme of repair suggested to you, Mr. Hoare, with regard to that member or any other member?

Mr. HOARE.—Yes, on one of the chords of the cantilever arm, correspondence took place between Mr. Birks and the Phœnix Bridge Company and Mr. McLure and Mr. Cooper in reference to repairs to one of the chords on the cantilever arm. I have the correspondence about it at the office: 'Splice between chords 7 and 8 on the west truss of south contilever arm. The west centre rib was three-quarters of an inch out of line.'

Mr. HOLGATE.—To what are you referring there, to a letter?

Mr. HOARE.—No, to the daily record.

Mr. HOLGATE.—On what page is that?

Mr. HOARE.—Page 190.

Mr. HOLGATE.—Would that be what you would call a mater of repair?

Mr. HOARE.—Yes, that was a question of repair. That is, they were suggesting certain repairs at Phœnixville and to Mr. Cooper.

Mr. HOLGATE.—Repair would indicate that damage had been done. In this case had damage been done?

Mr. HOARE.—No, we did not consider that any permanent damage had been done, simply a bend, and they were discussing the question of how to straighten that chord rib and hold it in line, hold it in position. Mr. Kinloch suggested a diaphragm being put in there.

Mr. HOLGATE.—What was the date of that entry in your diary?

Mr. HOARE.—August 12.

Mr. HOLGATE.—August 12? Did you inspect this point yourself?

Mr. HOARE.—No, I did not inspect the point, but it was mentioned to me at the time, and we discussed it, and Mr. Kinloch and Mr. McLure together were speaking of a diaphragm, and asked me what I thought of it, and I said I thought it was a very good way of straightening up the chord and holding it.

Mr. HOLGATE.—Then what was done in connection with it?

Mr. HOARE.—Well, there was nothing done, it was in abeyance; it was left to Mr. Cooper and Phœnixville to come to some agreement on that detail, but they had not arrived at any decision. Mr. Cooper differed somewhat from the methods proposed, and it was still under discussion when the bridge collapsed.

Mr. HOLGATE.—Did you understand that this defect that had been discovered was one relating to the erection of the bridge, or did it affect the character of the structure?

Mr. HOARE.—Which one do you refer to?

Mr. HOLGATE.—The one you are now referring to between 7 and 8.

Mr. HOARE.—Would you repeat the question?

Question read to witness as follows: 'Did you understand that this defect had been discovered was one relating to the erection of the bridge, or did it affect the character of the structure?

Mr. HOLGATE.—In other words, was it a local or a general defect?

Mr. HOARE.—I understood it to be a local defect.

Mr. HOLGATE.—Having an effect on the general structure?

Mr. HOARE.—It looked as if the chord was straightened out it would be satisfactory.

Mr. HOLGATE.—Was that the only instance of the kind?

Mr. HOARE.—I think, as far as I can remember at the time, it is the only one of any consequence.

Mr. HOLGATE.—Did you personally investigate any other questions?

Mr. HOARE.—Yes. There was a detail in connection with the top main post, one of the details there.

Mr. HOLGATE.—Which main post do you mean, the centre post?

Mr. HOARE.—The main centre post, yes.

Mr. HOLGATE.—The right or left?

Mr. HOARE.—I do not remember now; I will have to refer to a book to find out which it was, but I remember looking over those. There was a dish in the top section. I do not remember the match mark of section, but there was a dish where the top section bore on certain brackets which was not precisely true. They called my attention to it, and also reported it in the usual way to Phœnixville and Mr. Cooper, but it turned out to be of no consequence, and the corresponding post in the shop was examined to see if that little hollow existed in that post, but they found out it was all right.

Mr. HOLGATE.—Did you correspond personally with Mr. Cooper in regard to any of these matters that were discovered on the bridge?

Mr. HOARE.—Very seldom. I corresponded in some instances, but I left that to Mr. McLure entirely.

Mr. HOLGATE.—I mean in regard to any of these instances we are now discussing?

Mr. HOARE.—No, none of these. The only communication I had with Mr. Cooper was by telegram on August 28, reading: 'Have sent McLure to see you early to-morrow morning to explain letter mailed yesterday about anchor arm chord.'

Mr. HOLGATE.—Is that a letter of yours?

Mr. HOARE.—No, it is Mr. McLure's is referred to, it is his report. I sent a similar message to the Phœnix Bridge Company reading: 'McLure will call to-morrow morning to explain Birks' letter re anchor arm chord. Will see Cooper first.'

Mr. HOLGATE.—Just resume, then, where you left off, at the point when you were talking to Mr. Yenser and Mr. Birks.

Mr. HOARE.—I did not see Mr. Yenser after he said he was satisfied, felt quite comfortable about having moved out the traveller. I do not think I had any further communication with him that day.

Mr. DAVIDSON.—I would like to know if Mr. Yenser actually said that or whether Mr. Hoare simply thought he got that impression. There is quite a difference to my mind whether Mr. Yenser said it or whether Mr. Hoare received that impression.

Mr. HOARE.—Yes, he told me most distinctly.

Mr. HOLGATE.—Can you repeat, as nearly as possible, Mr. Yenser's own words?

Mr. HOARE.—My words to him were: 'So you have decided to move the traveller out?' And he said, 'Yes, I have.' He said: 'I had a dream,' in a kind of joking way, 'I have had a dream, I think it was foolishness not to move the traveller.' He said, 'I have so many men out on the work that I wanted to employ them.' That is about all he said. As far as I remember that is substantially the conversation we had.

Mr. DAVIDSON.—Who was present at that conversation?

Mr. HOARE.—I do not know that anybody was close by. We were standing at the door outside of the office, standing outside the office in front of the door. I do not know that anybody was there at the time.

Mr. HOLGATE.—I think you did state what time that was?

Mr. HOARE.—About 10.30.

Mr. HOLGATE.—In the morning?

Mr. HOARE.—In the morning.

Mr. HOLGATE.—Of the 28th?

Mr. HOARE.—Yes.

Mr. HOLGATE.—What followed?

Mr. HOARE.—After Mr. McLure left?

Mr. HOLGATE.—At what time did he leave?

Mr. HOARE.—He took the noon train on the Grand Trunk; he took the train that leaves Lévis about one o'clock from Chaudière Curve. Then I remained at the bridge during the rest of that day, at least until about five o'clock, and I had some further conversation with Mr. Birks.

Mr. HOLGATE.—What was that?

Mr. HOARE.—The first thing I asked him to do in the evening was to go and make another examination of chord 9-A-L and see whether the deflections showed up at the south splice and extended into the batten plates, as the sketch I had from Mr. McLure just showed the deflections commencing at the batten plates. It was a matter more for my personal information.

Mr. HOLGATE.—What did he say?

Mr. HOARE.—He said, yes, that it showed slight distortions at the splice between 8 and 9.

Mr. HOLGATE.—I understand this is the report of his examination?

Mr. HOARE.—Just verbal.

Mr. HOLGATE.—That would be at what time?

Mr. HOARE.—It would be in the afternoon. I do not know the exact hour. It was during the afternoon.

Mr. HOLGATE.—This report of Mr. Birks is made after he had made a second examination at your request?

Mr. HOARE.—Yes.

Prof. GALBRAITH.—Did he see anything?

Mr. HOARE.—I said, 'Are you sure that the lattice does not show any signs of buckling?' He said, 'No, not the slightest.' I made the remark that it was rather strange it should be so.

Prof. GALBRAITH.—Did Mr. Birks say anything about the appearance of those ribs near the foot of T-5-Z? That is the division between panels 9 and 10?

Mr. HOARE.—No, he did not make any special remark about it.

Mr. HOLGATE.—Mr. Birks, I understand, reported that there was nothing visible that was wrong in the latticing?

Mr. HOARE.—He said nothing.

Mr. HOLGATE.—And you said you were surprised at that?

Mr. HOARE.—I was surprised, yes.

Mr. HOLGATE.—Had you expected it?

Mr. HOARE.—Well, from the sketch, from the distortions shown on the sketch I thought there might probably be something visible. I thought it was possible there might be something show there.

Mr. HOLGATE.—After Mr. Birks reported this to you, Mr. Hoare, what followed?

Mr. HOARE.—Then I sent for Mr. Kinloch, and asked him to go to the storage yard and see Mr. Clark and get him to refresh his memory about some repairs that were made to that chord in the storage yards during the summer of 1905, in July, I think it was, 1905, as I knew that that chord had met with an accident in the storage yard, and I had not any reference to it at the time, and I asked him to see Mr. Clark and get me a description of what took place at the time, just for present discussion. He went to the storage yard and saw Mr. Clark again about it, and we had a general review as it were of the repairs that were made. It was so long ago I had forgotten what had happened to that chord. I knew it had fallen from the grips; there was a splice plate broken and a pair of angles, speaking now from memory; they were all repaired at the time from a sketch, made at Phœnixville, which was submitted to Mr. Cooper for approval at my request, before it was sent here to be used. I simply wanted to refresh my memory at the time about those repairs.

Mr. HOLGATE.—After doing that what followed?

Mr. HOARE.—We had some conversation about the repairs being considered satisfactory.

Mr. HOLGATE.—What time of the day would that bring it up to?

Mr. HOARE.—Oh, possibly four o'clock in the afternoon.

Mr. HOLGATE.—And what happened after that?

Mr. HOARE.—I think I went to Quebec.

Mr. HOLGATE.—Did you leave any particular instructions with Mr. Kinloch before leaving?

Mr. HOARE.—No, I do not think I did.

Mr. HOLGATE.—Did you have any communication with Mr. Kinloch over the telephone after you went to Quebec that night?

Mr. HOARE.—I am not positive about that

Mr. HOLGATE.—Or with anybody at the bridge?

Mr. HOARE.—Yes, Mr. Birks called me up on the 'phone.

Mr. HOLGATE.—With reference to what?

Mr. HOARE.—With reference to that chord U-A-L.

Mr. HOLGATE.—What did he say?

Mr. HOARE.—He merely emphasized what he had already said that the chord was bent from the splice. I suppose he had been plotting it, making a sketch, and that he called me up again to state he was positive the bends occurred in the splice, and that he had thought the bends, some of them—I think he used the word 'some of them,' or to a certain extent, they were there before the chord was put in the bridge. He made some remark of that kind, I could not repeat the exact words. I said: We will just have to await the result of Mr. McLure's trip, and we will possibly get the answer to-morrow—some words of that kind; that is all the conversation that took place.

Mr. HOLGATE.—Have you anything definite to show that Mr. Birks made such a sketch as that?

Mr. HOARE.—No.

Mr. HOLGATE.—He stated over the telephone that he had made such a sketch?

Mr. HOARE.—I understood so—that he had made a sketch or notes of the different

deflections from the splice. I asked him to make a more precise examination after Mr. McLure went away.

Mr. HOLGATE.—Did Mr. Birks in that telephone conversation indicate anything of his apprehension of the nature of this trouble?

Mr. HOARE.—No, he merely stated that he thought that some of these bends occurred before the chord was placed in the bridge.

Mr. HOLGATE.—Did he indicate anything in regard to the possible effect it might have on the bridge?

Mr. HOARE.—Not at all; never referred to it.

Mr. HOLGATE.—Neither one way nor the other?

Mr. HOARE.—Neither one way nor the other. At the time I was on the bridge he did make an allusion to the fact that he did not consider it serious; it was not a serious affair—I think those are the words he used—I do not think it a serious affair.

Mr. HOLGATE.—You think he did express himself?

Mr. HOARE.—While I was on the work after Mr. McLure left.

Mr. HOLGATE.—But at a later period that day he did not?

Mr. HOARE.—No, I do not remember him referring to it at all.

Mr. HOLGATE.—Was there anything further happened on the night of the 28th?

Mr. HOARE.—No.

Mr. HOLGATE.—What were your movements on the following morning?

Mr. HOARE.—Next morning I was preparing some information—some data for the annual meeting of the directors.

Mr. HOLGATE.—Did you visit the bridge?

Mr. HOARE.—No, I did not.

Mr. HOLGATE.—Did you make further inquiry over the telephone?

Mr. HOARE.—No, I was simply expecting to hear from Phœnixville or New York.

Mr. HOLGATE.—Did the bridge call you up?

Mr. HOARE.—They did not.

Mr. HOLGATE.—In connection with the work itself, what did you do that day?

Mr. HOARE.—I did nothing at all except office work—nothing in connection with the outside work.

Mr. HOLGATE.—You received no communication from Mr. McLure?

Mr. HOARE.—No. The only communication I received that day was a telegram from Mr. Deans at Phœnixville, but that did not refer to that chord at all. It referred to the splice 7 and 8 on the west cantilever arm. I misunderstood that message; I thought it referred to chord 9-A-L, but after explanation I found it referred to the cantilever arm—to the original splice that was under discussion.

Mr. HOLGATE.—What was the telegram, Mr. Hoare?

Mr. HOARE (reading).—'Phœnixville, Pa., August 29, 1907—E. A. Hoare, chief engineer, Q. B. Company, Quebec, Que.: McLure has not reported here; the chords are in exact condition they left Phœnixville in and now have much less than maximum load. (Sgd.) John Sterling Deans.' I thought it referred to chord A-9-L, and I felt quite comfortable that day about it. I knew it could not be long before the matter would be taken up.

Mr. HOLGATE.—You might file that bunch of correspondence, Mr. Hoare.

Mr. HOARE.—There are a lot of things here that are just private notes.

Mr. HOLGATE.—That telegram, to begin with.

Mr. HOARE.—I will put all these telegrams in. Here is a sketch that Mr. McLure gave me; is that any good? This is the one first shown me when the chord was first discovered?

Prof. GALBRAITH.—What made you come to the conclusion that this telegram did not include chord A-9-L as well as the others?

Mr. HOLGATE.—I thought that referred to chord 9-A-L.

Prof. GALBRAITH.—I understood you to say that afterwards——

Mr. HOARE.—Mr. Deans explained to me afterwards that it did not refer to that chord at all.

Prof. GALBRAITH.—That is what I am asking you. It was from conversation with Mr. Deans?

Mr. HOARE.—Yes, sir. That is the only communication I had that day with New York or Phœnixville; in other words, I was awaiting the result of their conference before doing that.

(Telegrams put in and marked Exhibit No. 51.)

Mr. HOLGATE.—Then, you had no communication with the work on the 29th of August?

Mr. HOARE.—Not that I can recollect.

Mr. HOLGATE.—Up to what time?

Mr. HOARE.—Until the time of the accident.

Prof. KERRY.—There are two or three points I do not follow very clearly, Mr. Hoare. Your copy of Mr. McLure's diary was written up each time you went to the bridge?

Mr. HOARE.—Generally in that way and sometimes I would send it out by anybody going that way; that is, whenever there was an opportunity to get my book to Mr. McLure I availed myself of it.

Prof. KERRY.—Was it systematically read?

Mr. HOARE.—Yes.

Prof. KERRY.—Every time you received it back you read the entries?

Mr. HOARE.—I used to read it over—yes.

Prof. KERRY.—So that between the time that the book was posted the importance or otherwise of any event was left entirely to Mr. McLure's judgment?

Mr. HOARE.—No, I did not depend upon the book for practical purposes. The book was merely to keep a record of everything because I could not remember what took place from time to time; it was more for a book of reference than anything else. I did not depend on the book for my daily knowledge or information for what was going on at the bridge. I used to get that personally by going there, or if I could not go there at any special time, I was always in telephonic communication.

Prof. KERRY.—But that telephonic communication would be a statement only of the matters that Mr. McLure considered to be important?

Mr. HOARE.—He would repeat everything that was going on, either he or Mr. Kinloch. I would call them up at night and they would repeat the whole process during the day, whether they were moving the traveller, rigging the traveller, or what member had been placed, whether this member fitted, or whether they had to chip the plate—all the details; they explained fully over the 'phone whenever I called them up.

Prof. KERRY.—In other words they gave you every day over the 'phone the same information in detail that was covered in the diary?

Mr. HOARE.—Substantially so—not word for word, but generally speaking. For instance, there were days when I would call up and ask the question: What is going on to-day? They would say: Moving traveller, rigging traveller and so forth, and that would end it. I would say: What is going to happen, and they would say: Continue the same kind of work. Then, I did not trouble my head to ask any further questions. It was only when they were doing any special work that I would ask any questions.

Prof. KERRY.—Mr. McLure was absent from the work from the 17th to the 23rd. At what date subsequent to the 23rd was your diary written up?

Mr. HOARE.—I could not tell you; I do not remember.

Prof. KERRY.—So that there may have been a gap of as much as ten days?

Mr. HOARE.—There would not have been a gap of ten days without my having personal knowledge of the work that was going on at the bridge.

Prof. KERRY.—But without any official record?

Mr. HOARE.—I do not think it is likely that there was that length of time, but even if there was, as I said before, I did not depend upon this book for my personal knowledge. It was simply as a book of reference.

Prof. KERRY.—Then, were you in communication with the bridge on the Monday of the week of the failure?

Prof. GALBRAITH.—The 26th?

Mr. HOARE.—I am not positive. I cannot state now positively whether I was or not.

Prof. KERRY.—Can you let us know that later?

Mr. HOARE.—I think I can.

Prof. KERRY.—Then, on the Tuesday, when did the report of the deflection of the chord reach you?

Mr. HOARE.—Tuesday evening.

Prof. KERRY.—At what time?

Mr. HOARE.—It was after dinner. I do not remember the exact hour.

Prof. KERRY.—Then, practically twelve hours elapsed between the time that the deflection was discovered and the time that the report reached you?

Mr. HOARE.—I understand they discovered it that same day. There would not be that length of time.

Prof. KERRY.—We have evidence to the effect that it was discovered at nine o'clock in the morning?

Mr. HOARE.—I suppose about ten hours.

Prof. KERRY.—What was the reason for that delay?

Mr. HOARE.—I could not speak positively about that beyond the fact that Mr. McLure had to make his measurements. After Mr. Kinloch discovered the bend he called Mr. McLure's attention to it and they had to make measurements, then make their sketches and then they had to get their reports out. They had to occupy all the time before he could reach me. That should take up all the time. That would be the cause of the delay. It takes considerable time crawling along that chord and making precise measurements.

Prof. KERRY.—It was perfectly possible, for example, Mr. Hoare, to call you up at nine o'clock that morning and let you know there was trouble?

Mr. HOARE.—Yes.

Prof. KERRY.—And that was not done?

Mr. HOARE.—That was not done—no.

Prof. KERRY.—And no effort was made to call you till after dinner in the evening to advise you of it?

Mr. HOARE.—Yes, Mr. McLure called me up and said that he was coming in to see me to show me a sketch. I do not see that calling me up earlier in the day would have done any good, because after discovering the deflection necessarily they had to get the information to make a sketch to show all the points of deflection so as to be able to send it over by mail that day to New York and Phœnixville. That was a more important proceeding than coming into town to see me, because I could not have said anything—could not have done anything without having particulars of the trouble. That was the first thing to do and they pretty well consumed the whole time before they could have reached me in getting that information in good shape.

Prof. KERRY.—Do I understand, Mr. Hoare, that if that information that Mr. Kinloch gave Mr. McLure had reached you at nine o'clock in the morning you would not immediately have stopped everything and gone out on the bridge to inspect that yourself?

Mr. HOARE.—No, I should have required more information before I should have taken any action on it. That is the information I gave them in the evening.

Prof. KERRY.—I mean personal inspection, which does not depend on the action of your subordinates?

Mr. HOARE.—If it had been reported to me possibly I might have gone out; that is if they had reported to me that anything serious had presented itself I should have gone out there, but I could not have done anything without getting more particulars and that is what they were getting during the day. I would want to have something definite to work on, because little bendings of the chords of minor importance would occur occasionally from time to time and be examined by the inspectors before they went in the structure.

Prof. KERRY.—Both Mr. Kinloch and Mr. McLure testified that they were seriously disturbed by this occurrence and we understand you that they took the full responsibility of not reporting that matter for the course of an entire day?

Mr. HOARE.—Yes, they did, and I imagine they considered that it was not necessary to report it, as I said before, until they got complete data to lay before me as well as Mr. Cooper.

Prof. KERRY.—Where were you that day, Mr. Hoare?

Mr. HOARE.—In the morning I was in Quebec. I do not remember the exact time, but I was in the office preparing some data for the annual meeting.

Prof. KERRY.—That is on the morning of the 27th?

Mr. HOARE.—Yes, I was there.

Prof. KERRY.—Till what time?

Mr. HOARE.—I could not say exactly till what time, but I was within reach anyway.

Prof. KERRY.—And subsequently?

Mr. HOARE—I think I was in the office all day. Yes, I think I was in Quebec all day.

Prof. KERRY.—Can you file a definite statement with us, Mr. Hoare, covering that?

Mr. HOARE.—Yes.

Prof. KERRY.—Mr. McLure reported to you, Mr. Hoare, that the traveller would not be moved on the evening of the 27th?

Mr. HOARE.—No, he stated that Mr. Yenner said he would not move the traveller.

Prof. KERRY.—On the morning of the 28th you went out and found that the traveller had been moved?

Mr. HOARE.—Yes.

Prof. KERRY.—Did you express any opinion either in the way of approval or otherwise of the movement of that traveller?

Mr. HOARE.—Yes, after putting the question to Mr. Birks, if he knew or if he had considered the effect on chord 9-A.L, and when he stated that it was only 50 lbs. additional stress, I think I said: That does not amount to much anyway. That was all the remark I made.

Prof. KERRY.—You did not take any responsibility or give any definite instructions either to one effect or to the contrary concerning the movement of the traveller?

Mr. HOARE.—No.

Prof. KERRY.—Did you ask Mr. Birks if he included in his calculations the weight of the new panel that was to be erected?

Mr. HOARE.—No, I merely mentioned the traveller.

Prof. KERRY.—So that, it was assumed by Mr. Birks, or did you consider that it was assumed by Mr. Birks that no iron was to be erected?

Mr. HOARE.—Yes, I was under the impression that that was all they were going to do. They were working on the big traveller taking metal off. I was under the impression they were going to continue that work and just work on the small traveller getting it ready for the next panel.

Mr. HOLGATE.—Was that merely an impression or was it a definite understanding?

Mr. HOARE.—That was my belief from general conversation.

Prof. KERRY.—How large a piece of work is the getting ready of the little traveller? After the traveller is moved forward in position what further detail is there before the erection of the new panel would commence?

Mr. HOARE.—It is practically ready then; generally speaking, it is practically ready.

Prof. KERRY.—So that you reasoned that Mr. Yenser, who you knew had been uneasy, would move that traveller forward for no direct purpose and then go back and proceed to take down the big traveller?

Mr. HOARE.—Will you kindly repeat that question?

Prof. KERRY.—You reasoned that Mr. Yenser, who you knew was uneasy,——

Mr. HOARE.—I did not know; I was not under that impression at all. When I saw him in the morning he had a different opinion altogether. I thought he was not uneasy at all. He seemed to act just the reverse way. He spoke to me most confidently about it.

Prof. KERRY.—He had been an entire day before? Mr. McLure reported to you—?

Mr. HOARE.—He reported to me simply the night before that he said he would not move the traveller until he got more information on the chord, but in the morning when I spoke to him outside the office he was of a different opinion altogether; he seemed perfectly at ease.

Prof. KERRY.—Did you still consider that he moved that traveller forward without the least intention of using it?

Mr. HOARE.—I thought so. When I was there they appeared to be working on the big traveller; most of the men on the big traveller and unloading——

Prof. KERRY.—Would you consider that action under your understanding of the programme, to be the action of a perfectly reasonable man?

Mr. HOARE.—Yes, I should say so.

Prof. KERRY.—Mr. Yenser told you, we understand, Mr. Hoare, that he moved that traveller forward partially because he had more men out to work than he could conveniently employ otherwise?

Mr. HOARE.—He did not say that; he simply said: There are too many men out.

Prof. KERRY.—Your interpretation of that would be the same as mine, would it not?

Mr. HOARE.—That he wanted to employ them; that he did not want to have them idle.

Prof. KERRY.—He made no statement as to what he proposed to do with these men?

Mr. HOARE.—No, he did not say anything further.

Prof. KERRY.—After the traveller was moved out?

Mr. HOARE.—No, he did not make any further statement to me on the subject.

Prof. KERRY.—How long did it take to move the small traveller forward?

Mr. HOARE.—I could not say. It was moved before I got out in the morning.

Prof. KERRY.—That is to say it did not occupy more than two hours at the outside.

Mr. HOARE.—Three or four hours, I suppose.

Prof. KERRY.—And the officials of the Phœnix Bridge Company proceeded to add the iron to the next panel without any communication either one way or the other?

Mr. HOARE.—Yes.

Prof. KERRY.—You were not consulted in the matter?

Mr. HOARE.—No.

Prof. KERRY.—You were not advised, previous to the fall of the bridge that any iron had been put on that panel?

Mr. HOARE.—No.

Prof. KERRY.—You did not know they were working on that panel until after you heard of the fall of the bridge?

Mr. HOARE.—I knew they were working on the bridge, but I did not know whether they were putting more metal on or not. My general impression was that they were working on the big traveller, had most of their force on the big traveller, taking it down.

Prof. KERRY.—In your discussions with Mr. Birks and Mr. McLure, were you called on for any decision in regard to their action?

Mr. HOARE.—In what respect?

Prof. KERRY.—As to whether the traveller should be moved forward or whether the work should be continued.

Mr. HOARE.—The night before I was under the impression that the traveller would not be moved forward, and when I arrived next morning I found that it had been moved forward. That is all the information I had.

Prof. KERRY.—The only decision you were asked for was as to whether Mr. McLure should go to New York or not?

Mr. HOARE.—That is it. He asked me that question the day before, and I told him, yes, go the next day—to take the morning train, but that I would be at the bridge before he left.

Prof. KERRY.—Otherwise the action to be taken at this time was not referred to you at all?

Mr. HOARE.—Apart from that?

Prof. KERRY?—Yes.

Mr. HOARE.—No.

Prof. KERRY.—They simply went ahead and made their own decisions?

Mr. HOARE.—Yes.

Prof. KERRY.—In regard to this member about which there seems to have been a controversy as to whether it was bent before or after it went into place, had you any definite information in the way of the records of your inspectors?

Mr. HOARE.—If it was bent before it went into the work?

Prof. KERRY.—Yes?

Mr. HOARE.—No, none whatever.

Prof. KERRY.—Had you any reason to believe that it could have been bent before it went into the work?

Mr. HOARE.—No reason at all. The only time that chord sustained any damage was in lifting it in July, 1905, but repairs were made and they had thoroughly examined it in the yard before it was removed to the bridge and everything was found to be satisfactory.

Prof. KERRY.—Being examined by whom?

Mr. HOARE.—Mr. Hudson, myself, Mr. Kinloch and even Mr. Szlapka examined it.

Prof. KERRY.—You knew personally at the time of the discussion that the chord had gone into the bridge straight?

Mr. HOARE.—Yes, taking my inspectors' reports, they are positive when they make a statement of that kind.

Prof. KERRY.—Did you not state a minute ago that you examined that yourself?

Mr. HOARE.—At the storage yard. That was in 1905?

Prof. KERRY.—You found it straight then?

Mr. HOARE.—It was in good condition then.

Prof. KERRY.—So that you knew it went in the bridge in good condition?

Mr. HOARE.—Yes.

Prof. KERRY.—In the discussion in regard to the strains on the bridge you got Mr. Birks' opinion as to how much increase of strain there would be by the moving forward of the traveller. Did you make any calculations yourself?

Mr. HOARE.—No; Mr. McLure said about 70 lbs. Mr. McLure and Mr. Birks in their conversation said that they had approximately checked it and one made it about 70 lbs., and the other 50. It was somewhere probably between these two figures.

Prof. KERRY.—Did you direct or make any calculations considering that member as a post after it had already deflected?

Mr. HOARE.—No.

Prof. KERRY.—Supposing you saw a post under test in a testing machine and visibly deflected out of line, what would you expect to happen?

Mr. HOARE.—If I saw a post in a testing machine under severe strain?

Prof. KERRY.—Under severe strain?

Mr. HOARE.—I would expect that it would fail without some reinforcement.

Prof. KERRY.—And if you did not want that post to fail after you noted the deflection, would you permit the operator to put a pound more stress on the machine?

Mr. HOARE.—I do not think a pound would make much difference. If I was making a test of that kind I would like to put a sufficient load to test the post to destruction to obtain results.

Prof. KERRY.—Did you direct that any systematic measurements should be made of that post while it remained under suspicion and unreinforced?

Mr. HOARE.—You mean the post for testing?

Prof. KERRY.—No, I am referring to that particular chord in the bridge?

Mr. HOARE.—Will you repeat that, please?

Prof. KERRY.—Did you direct that systematic measurements of the deflection of the chord should be made while it remained under suspicion and unreinforced?

Mr. HOARE.—The measurements were made before I was aware that the chord was deflected.

Prof. KERRY.—Did you direct any further measurements to be made when you were aware that it was deflected?

Mr. HOARE.—Only to Mr. Birks on the afternoon of the 28th.

Prof. KERRY.—Did you direct Mr. Birks to make accurate measurements?

Mr. HOARE.—I asked him to make another inspection of the chord and more particularly to see whether the deflection extended beyond the outer edges of the bottom plates.

Prof. KERRY.—So that after the deflection of this member, which we may consider as a post as far as the stress is concerned, had been observed it was allowed to stand for more than forty-eight hours without any measurement being made to see whether the deflection was increasing or decreasing?

Mr. HOARE.—No, I gave no further instructions after I asked Mr. Birks to make that second examination. That was on the afternoon of the 28th. That was the last request I made about making a further examination of the chord. After that I simply awaited the results from Mr. McLure's trip, but in the meantime I did not consider that there was anything dangerous.

Mr. HOLGATE.—Your chief attention seems to have been called to this bend in 9-A-L; did it occur to you to inspector order to have inspected 9-R-A?

Mr. HOARE.—No, it never occurred to me.

Mr. HOLGATE.—Did you inspect the corresponding number of 9-A-L?

Mr. HOARE.—No.

Mr. HOLGATE.—At that time or any other time?

Mr. HOARE.—No.

Mr. HOLGATE.—Has your diary been put in as an exhibit?

Mr. HOARE.—No, I would like to keep it until you get through, because I will have to refer to it.

Mr. HOLGATE.—We had better have it as an exhibit now, because we will have to refer to it.

(Diary put in, filed and marked Exhibit No. 53.)

Mr. HOLGATE.—When tenders were originally asked for this bridge in reply to circular letter, were plans sent in with these tenders?

Mr. HOARE.—Yes, sir.

Mr. HOLGATE.—Have you got those?

Mr. HOARE.—No, they were all returned to the different bidders.

Mr. HOLGATE.—There were no copies retained by you?

Mr. HOARE.—No, there were none kept. They were all returned to Mr. Cooper and then returned to the different bidders.

Mr. HOLGATE.—Were descriptions of these bridges sent in with the tenders?

Mr. HOARE.—Yes.

Mr. HOLGATE.—Have you those?

Mr. HOARE.—I think the secretary ought to have them.

Mr. HOLGATE.—Will you please let us have the tenders and any descriptive matter that may have accompanied them?

Mr. HOARE.—I think he deposited all he has. I think he deposited the different reports and the different tenders.

Mr. HOLGATE.—What we want is a description of the work they proposed in those tenders.

Mr. HOARE.—I think all of their descriptive matter was returned to them. Take suspension bridges, for example, they had to submit specifications of the character of the work they were to employ.

Mr. HOLGATE.—I find that Mr. Barthe only deposited the figures and documents relating to the Phœnix Bridge Company. It is the other information we would like to have.

Mr. HOARE.—He would only then have the forms of tender filled up, because I am almost positive the special specifications and the plans were returned.

Mr. HOLGATE.—We would like to consult anything you have.

Mr. HOARE.—Anything we have I will produce.

Mr. HOLGATE.—If you make a search for that and show us what there is we can look over it, and if it is necessary to bring it in we will bring it in.

Mr. HOARE.—Yes, I will get all there is.

Witness retired.

The Commission took recess.

## AFTERNOON SESSION—THIRTEENTH DAY.

Commission resumed at 2 p.m.

Mr. MCLURE, recalled.

Mr. HOLGATE.—We asked you, Mr. McLure, for a sketch showing the present location of all lower chord members in the anchor arm and a description of the condition of the lower chord members. This description further was to include similar information in regard to the floor beams as at present lying on the ground. Will you produce that information?

Mr. MCLURE.—Yes, it is included in the blue print and description.

(Blue print and description produced and marked Exhibit No. 54.)

Mr. HOLGATE.—In reference to this diagram, the dotted lines indicate the original position of the lower chords and floor beams?

Mr. MCLURE.—Yes, sir.

Mr. HOLGATE.—And the solid lines indicate the present location of the floor beams and lower chords?

Mr. McLURE.—Yes, sir.

Mr. GALBRAITH.—The dotted lines indicates the centre lines of the chords?

Mr. McLURE.—The original centre lines in horizontal projection.

Mr. HOLGATE.—I understand that in the preparation of Exhibit No. 54 you were assisted by Mr. Cudworth?

Mr. McLURE.—Yes, sir.

(The witness also submitted a memorandum showing the deflection of cantilever arm under wind November 12, 1906, and November 16, 1906.)

Mr. HOLGATE.—I understand that these two were taken by yourself and Mr. Cudworth?

Mr. McLURE.—Yes, sir.

Mr. HOLGATE.—And the note dated February 3, 1907, on this same memorandum?

Mr. McLURE.—From an observation by Mr. Kinloch.

Mr. HOLGATE.—Was observed by Mr. Kinloch?

Mr. McLURE.—Yes, sir.

(Memorandum put in, filed and marked Exhibit No. 55.)

FRANK CUDWORTH, recalled.

Prof. KERRY.—Mr. Cudworth, did you assist in the surveys and office work in connection with the preparation of Exhibits 43 to 50 inclusive, and Exhibits 54 and 55?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—And those exhibits are, to the best of your information, perfectly correct?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—You also assisted in the preparation of the diagram showing the positions of the pins at different dates filed as part of Exhibit 30?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—Have you brought with you for deposit with the Commission the records of the anemometer?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—You might make deposit of those, please?

Mr. CUDWORTH.—These are the anemometer sheets for the season of 1907 up to and including August 29, the time of the accident.

(Document produced, filed and marked as Exhibit 56.)

Prof. KERRY.—At what date approximately was the cantilever arm completed, the arm itself?

Mr. CUDWORTH.—It was not entirely finished until this season.

Prof. KERRY.—Were the members all in place in 1906?

Mr. CUDWORTH.—No, sir.

Prof. KERRY.—It was during 1907 that it was finished up.

Mr. CUDWORTH.—Yes, sir, I think so. Some of the members that looked to be part of the cantilever arm are really part of the suspended span.

Prof. KERRY.—We understand that these records cover the working season of 1907?

Mr. CUDWORTH.—Not all of it, most of it.

Prof. KERRY.—If not, can you say between what dates?

Mr. CUDWORTH.—No sir, the exhibit shows for itself.

Prof. KERRY.—The records for the year 1906 are where?

Mr. CUDWORTH.—At the bridge.

Prof. KERRY.—Will you kindly arrange to let us have those for deposit, for 1906?

Mr. CUDWORTH.—Yes, sir. This covers what you asked me for the other time.

Prof. KERRY.—Will you tell us briefly, Mr. Cudworth, practically as a matter of information to the engineering profession, how those records were taken, what equipment you had?

Mr. CUDWORTH.—These wind records?

Prof. KERRY.—Yes.

Mr. CUDWORTH.—The anemometer records?

Prof. KERRY.—Can you describe the equipment technically at all. For example, there are several anemometers, or would you prefer to draw up a written statement covering that?

Mr. CUDWORTH.—I can tell you in a few words. In the first place, when the machine came, I checked it up to see if the gearing and everything about it would be correct according to the best authorities on that matter, and I measured it up and found that it was correct, that the length of arms and cups as given would correctly record with that gearing. It is automatic, it records in the office. The velocity is given by a moving vane which we had placed on top of one of the main post peaks as being an exposed position and one most apt to give true results.

Prof. GALBRAITH.—Whose manufacture is it?

Mr. CUDWORTH.—Queen & Company, Philadelphia.

Mr. STUART.—I understand it is the United States standard.

Mr. DEANS.—It is the United States standard cup wind gauge.

Mr. CUDWORTH.—It is one that has been recommended by the weather department of the United States.

Prof. GALBRAITH.—Was there any certificate accompanying the instrument?

Mr. CUDWORTH.—Not to my knowledge.

Prof. GALBRAITH.—Do you know, Mr. Deans?

Mr. DEANS.—No, but it is a guaranteed standard weather bureau cup anemometer, the United States standard, Queen Company, Philadelphia. There is no certificate accompanying it.

Mr. CUDWORTH.—It might be of interest to tell you that we compared our readings at the bridge with those at the observatory here at Quebec at different times, during high winds, and they compared very favourably.

Prof. KERRY.—The cup vane itself was set where?

Mr. CUDWORTH.—It was set on top of the Quebec main post peak, the highest point on the bridge.

Prof. GALBRAITH.—That was completed in 1905, was it not?

Mr. CUDWORTH.—Not the peaks, no sir, as I remember, they were not.

Prof. GALBRAITH.—Not the peaks, the beginning of 1906.

Mr. CUDWORTH.—Yes, I am not quite sure about that.

Prof. GALBRAITH.—Are these standards made in various sizes or is there just one size?

Mr. DEANS.—This is, I think, just one size. I could get a certificate of Queen & Company regarding that instrument.

Mr. HOLGATE.—Is it the same instrument as is used by the Weather Bureau?

Mr. DEANS.—It is the same instrument, their standard. Queen & Co. have a great reputation in the United States for instruments of that kind.

Prof. KERRY.—Then the recording drum was in the office?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—Equipped in the ordinary fashion, I presume?

Mr. CUDWORTH.—Yes, with a clock.

Prof. KERRY.—And your tests of the instrument were limited to a check measurement of its dimensions?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—And occasional comparison with the records of the Quebec observatory?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—Which were reasonably satisfactory ?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—Or entirely satisfactory. How close were they ?

Mr. CUDWORTH.—I do not remember any case where we were over 10 miles out.

Prof. KERRY.—With a maximum record of how much maximum speed ?

Mr. CUDWORTH.—I think our maximum was around 60 miles an hour.

Prof. KERRY.—The instrument, of course, went in the wreck.

Mr. CUDWORTH.—Yes, sir, I have a piece of it yet.

Prof. KERRY.—Mr. McLure submitted certain records of truss deflections, Exhibit No. 55, which you identified. How were those measurements taken, Mr. Cudworth ?

Mr. CUDWORTH.—They were taken with a transit, the instrument placed on the ground near the end of a bridge span and the back sight on a point on the railway track through the cut south of the bridge, thence to a target on the bridge itself, two panels back from the end of the cantilever arm.

Prof. KERRY.—That is to say that you had to transit the telescope each time ?

Mr. CUDWORTH.—Yes, sir.

Mr. KERRY.—Are you pretty sure of your judgments ?

Mr. CUDWORTH.—I always used the transit the same way, so there will be no question about it. I always looked at the target with the telescope direct, I had the back sight of the telescope inverted.

Prof. KERRY.—You did not check by reversing the instrument ?

Mr. CUDWORTH.—We did at the time we put the target up.

Prof. KERRY.—The target was a fixed target ?

Mr. CUDWORTH.—Yes.

Prof. KERRY.—Attached at what point ?

Mr. CUDWORTH.—On strut between the T.I. posts cantilever arm.

Prof. KERRY.—That would be 112 feet from the end of the arm, approximately.

Mr. CUDWORTH.—Yes, sir, approximately.

Prof. KERRY.—Were any measurements made other than these submitted in the record ?

Mr. CUDWORTH.—There may have been, I will not be positive.

Prof. KERRY.—But you have no record of other ?

Mr. CUDWORTH.—I would not be positive.

Prof. KERRY.—The question of the movement of the masonry, Mr. Cudworth, was one of very considerable importance. Will you tell us first what equipment you had to determine the elevations shown on Exhibit No. 50. It is a direct case of technical equipment ?

Mr. CUDWORTH.—We use a Queen Company 'Y' level, Queen Company Philadelphia style rod and the bench marks I put in myself.

Prof. KERRY.—The bench marks were what ?

Mr. CUDWORTH.—Iron imbedded in lead, in holes in the pier, in the stone.

Prof. KERRY.—You drilled the side of the pier and just set iron bench marks in with lead settings ?

Mr. CUDWORTH.—Yes, sir, with lead.

Prof. KERRY.—Do you know the delicacy of the bubble and the magnifying power of the glass ?

Mr. CUDWORTH.—I think the time we did this we had the Berger instrument, the Quebec Bridge & Railway Company's level.

Prof. KERRY.—Could you get us that information ?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—Covering both the delicacy of the bubble and the power of the instrument ?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—What would be the length of the sides taken ?

Mr. CUDWORTH.—I would prefer to get you that with other information.

Prof. KERRY.—Will you describe to us how the check measurements at the span were made ?

Mr. CUDWORTH.—The check measurements for the span were made—I used an instrument tape, using a 500 foot tape.

Prof. KERRY.—That tape was originally used in laying out the span ?

Mr. CUDWORTH.—Yes, sir, the same tape that was used in laying out the two previously.

Prof. KERRY.—So that no question of error of tape graduation would possibly come in ?

Mr. CUDWORTH.—No, sir.

Prof. KERRY.—Any further details ?

Mr. CUDWORTH.—No, I do not think of any.

Prof. KERRY.—What precautions were taken to eliminate the ordinary causes of error in tape measurement ?

Mr. CUDWORTH.—The tape was supported at intervals of about 25 feet, was cramped at one end and pulled with the number of pounds, or pulled to correspond to the number at which the tape was standard.

Prof. KERRY.—The supports were carefully levelled.

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—And the maximum distance between them was 25 feet ?

Mr. CUDWORTH.—I could not limit it to feet as I did not measure them, but roughly that is it.

Prof. KERRY.—What calculated corrections were applied to the measurements ?

Mr. CUDWORTH.—Not any. The pull was made right and the temperature happened to be nearly that at which the tape was standard so it was not necessary to apply corrections.

Prof. KERRY.—And the supports were horizontal ?

Mr. CUDWORTH.—Yes, it was measured on a horizontal line.

Prof. KERRY.—And you considered that the sag was so small it was not necessary to calculate it ?

Mr. CUDWORTH.—Yes, sir, we gave 25 more pounds pull on account of that than if the tape was supported continuously.

Prof. KERRY.—I do not follow you altogether there; was that arbitrary or the result of test ?

Mr. CUDWORTH.—In that case it was arbitrary.

Prof. KERRY.—But you decided that 25 pounds pull on the tape would compensate the shortening due to sag ?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—But without any calculation ?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—Did that condition obtain in both the original and final measurements ?

Mr. CUDWORTH.—I cannot say that it did in the former, as it was done by the Quebec Bridge Company, and I only assisted in any way I could and did not do the actual measuring.

Prof. KERRY.—Can you answer that question, Mr. McLure ?

Mr. MCLURE.—No, sir, I was not here at that time. As I understand it, though, the spring pull was not used in the first measurement.

Prof. KERRY.—How was the tape supported in the first measurement, Mr. Cudworth ?

Mr. CUDWORTH.—About the same way, by putting cleats on the wooden false work legs and they are approximately 25 feet apart. It was then measured on a horizontal line and the cleats were put on with a measure.

Prof. KERRY.—Would you feel justified in saying that the only possible instrumental error as between the two measurements would be due to differences in the pull, that the temperature was the same?

Mr. CUDWORTH.—I could not say that the temperature was the same.

Prof. KERRY.—Was there any material difference ?

Mr. CUDWORTH.—I could not say.

Prof. KERRY.—Were you not there both times ?

Mr. CUDWORTH.—Yes, sir. I could not give you the number of degrees difference.

Prof. KERRY.—Would it lie within ten or twenty degrees ?

Mr. CUDWORTH.—I do not remember that. If I was doing the work myself I would record that but I would not remember it.

Prof. KERRY.—You have a full record of the final measurement ?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—Who has the record of the original measurements, who had charge of the measuring at the time ?

Mr. CUDWORTH.—I think Mr. Lanthier, acting for Mr. Hoare.

Prof. KERRY.—Would Mr. Lanthier's measurements be on record in your office, Mr. Hoare ?

Mr. HOARE.—I think so.

Prof. KERRY.—We would be glad if you would look it up for us, please.

Mr. HOARE.—I will look them up.

Prof. KERRY.—You might submit a note covering the technical detail of that measurement, as far as you are acquainted with it.

Mr. CUDWORTH.—The previous one, the first one ?

Prof. KERRY.—The final one. If you have not the first one, you cannot submit it very well.

Mr. CUDWORTH.—No, sir. You understand of course that the two piers are not the same level, so we had to carry the measurement down with an instrument.

Prof. KERRY.—How was that line carried down ?

Mr. CUDWORTH.—With a transit.

Prof. KERRY.—A transit set on the ground ?

Mr. CUDWORTH.—A transit set on the ground at right angles to the axis of the bridge and at some distance from it.

Prof. KERRY.—How was that position first set ?

Mr. CUDWORTH.—The position of the instrument ?

Prof. KERRY.—The position for the instrument.

Mr. CUDWORTH.—It was taken by lining out the side of the pier in one place and the main pier in the other. The measurement was made from a known point on the pier to the fixed end of the tape by using a level rod projecting over the pier carrying the measurement from the tape to the rod with an instrument.

Prof. KERRY.—Was there any stride level on the transit, and was it used ?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—Can you say anything concerning the adjustment of the stride level ?

Mr. CUDWORTH.—I have been using it right along, I always watch the adjustments of it.

Prof. KERRY.—It had been regularly tested ?

Mr. CUDWORTH.—Yes, sir. I think it was reversed inside, that would correct any error of adjustment.

Prof. KERRY.—In regard to checking up the position of the truss as the work progressed, you made a measurement each time the traveller was moved forward ?

Mr. CUDWORTH.—I do not understand what you mean by measurement.

Prof. KERRY.—Were regular observations of the general positions of the truss made after each movement of the traveller ?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—You might give us a little detail in the answer ?

Mr. CUDWORTH.—They were also taken at some other times.

Prof. KERRY.—These regular observations included what ?

Mr. CUDWORTH.—They developed as the work progressed. This season they have been the elevations of the lower chord pin centres, the longitudinal inclination of the main post and observations for alignment, also the position of the end post of the anchor arm.

Prof. KERRY.—Was there a regular set that was made each tim hat you took observations ?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—Just a complete set of measurements that were to be taken and that set was taken each time?

Mr. CUDWORTH.—Do you mean that certain things were required or certain things made.

Prof. KERRY.—Was there a regular set of position observations that was made each time, and did these include all points mentioned on both trustees?

Mr. CUDWORTH.—Yes, all.

Prof. KERRY.—Was there any indication of a sidelong movement in the bridge at any time ?

Mr. CUDWORTH.—No, sir.

Prof. KERRY.—Was the equipment used the same as that described for the masonry work, the same transit and level and general methods ?

Mr. CUDWORTH.—Yes, sir, except the tape; we never used a 500-foot tape.

Prof. KERRY.—In connection with your work did you ever notice at any time any unexpected settlements in parts of the bridge or any sidelong movements?

Mr. CUDWORTH.—No, sir.

Prof. KERRY.—The records from the measurements were entirely satisfactory ?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—Now, will you tell us in your own words just what you saw at the time that the bridge fell?

Mr. CUDWORTH.—At the time the bridge fell I was at the house, about a thousand feet away and at an angle to the bridge, and my attention was first attracted by an unusual noise. I thought at that time it was a plate dropped, or hit against a column or something, and while I was turning around to look out of the door this noise continued, so I knew it was something unusual, and by the time that had passed through my mind I was looking at it.

Prof. KERRY.—How much of the bridge could you see from the door where you were ?

Mr. CUDWORTH.—Just a little more than what is shown there (producing a negative).

Prof. KERRY.—That photograph was taken from the door ?

Mr. CUDWORTH.—Taken from the yard just back of the house and perhaps 15 or 20 feet from the door. It is taken lower down, that is all.

Prof. KERRY.—What did you notice as soon as you were able to look at the bridge itself ?

Mr. CUDWORTH.—My attention was directed principally to the top of the main post and the main post peaks. I have no remembrance of seeing the traveller nor did I look at the anchor arm. I might have seen the traveller had it been there, but I do not think it was and I did not see the anchor arm, I did not look for it.

Prof. KERRY.—And what did you note with regard to the movement of the main posts?

Mr. CUDWORTH.—The main posts had three distinct motions while I saw them. I presume the sound took a second to come over there and it took me a second or a second and a half to get in position to see the bridge, so when I looked at the main posts they were falling. The first decided movement I noticed in any other direction was towards Quebec, it was falling towards the river, but the first decided thing I noticed was a motion towards Quebec and this continued for a very small space of time and then I noticed that—it is a little hard to describe this—the motion that took

my attention more then was one towards the river, and the motions in those two directions stopped and the posts went down, they just seemed to sink out of sight.

Prof. KERRY.—That would be that probably all three motions were going on at the same time.

Mr. CUDWORTH.—Yes, they were; that is why it is hard to describe them.

Prof. KERRY.—You first of all noticed the falling over of the peaks towards Quebec, as being the most prominent movement?

Mr. CUDWORTH.—Yes, it was falling both down and also slightly towards the river at the same time.

Prof. KERRY.—Then next the fall towards the river became——

Mr. CUDWORTH.—Became more noticeable.

Prof. KERRY.—Then finally the drop of the posts.

Mr. CUDWORTH.—Then it did not seem to move any way except to sink right down. My idea of the position at the time corresponds about to the position of the peaks as they are now, in the plan.

Prof. KERRY.—Could you make a guess at the length of time that elapsed from the first sound you heard until the posts had disappeared?

Mr. CUDWORTH.—I should say it would take a second for the sound to come that distance, about. It would take another second at least, if not a little more, to turn around to look at it. Then it is pretty hard to say, perhaps one and a half or two seconds that I saw the bridge.

Prof. KERRY.—The time estimate is necessarily pretty rough, but five seconds would perhaps cover the whole movement?

Mr. CUDWORTH.—Yes, sir, it certainly was not over five seconds, I think.

Mr. HOLGATE.—Mr. Cudworth, could you indicate on plan marked Exhibit No. 25 just where you were standing at the time of the collapse?

Mr. Cudworth indicated the point on the plan and marked the place with the letter X and his initials F. E. C., and, continuing, said: I saw that the peaks remained the same distance apart as they went down; they did not become separated. The parts, as I saw them, seemed to fall as a unit.

Prof. KERRY.—That is to say practically that all the upper bracing was effective in the earlier stages of the fall?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—You might take up the history of the bridge as it came to your knowledge, say, from about August 19—anything that bears upon the subject of our inquiry.

Mr. CUDWORTH.—During a considerable portion of the time on August 22, 23 and 24, I was engaged in work on the bridge in connection with the field engineering report which you have. Is that what you want?

Prof. KERRY.—Yes, and did you notice anything at that time of any account?

Mr. CUDWORTH.—No.

Prof. KERRY.—And you heard no report?

Mr. CUDWORTH.—No, sir.

Prof. KERRY.—You might just continue.

Mr. CUDWORTH.—The results which were obtained on those days compared very favourably with those previously obtained and were, in a general way, what were expected. During the 27th and 28th I was most of the time on the north shore in connection with the foundations for the wood and steel false work.

Prof. KERRY.—Isn't there a gap in your time? The 25th was Sunday, was it not?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—On the 26th were you on the north shore?

Mr. CUDWORTH.—The 27th and 28th—Tuesday and Wednesday.

Prof. KERRY.—What happened on the 26th—anything?

Mr. CUDWORTH.—I think on part of the 26th and part of the 28th and most of the 29th I was engaged in photograph work at the office on the south shore.

Prof. KERRY.—That is printing and developing?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—Did you make any personal examination of any of the members that were under discussion. You heard the discussion, I suppose?

Mr. CUDWORTH.—Yes, sir, I heard some discussion.

Prof. KERRY.—You were practically not on the south span of the bridge until when that week? Were you on the span on the 29th?

Mr. CUDWORTH.—I do not remember that I went to the front on the 29th at all —that is out to the suspended span.

Prof. KERRY.—You had not an opportunity to personally examine any of the members and you were not in any way connected with any of the measurements that were made?

Mr. CUDWORTH.—No, sir, except the measurement test on the main pier with Mr. McLure before he left for New York.

Prof. KERRY.—To test the elevation?

Mr. CUDWORTH.—Yes.

Prof. KERRY.—Did you hear anything in the way of conversation, Mr. Cudworth, that would bear very directly on the object of the enquiry?

Mr. CUDWORTH.—No, sir, I do not think so.

Prof. KERRY.—You have examined the wreckage pretty carefully since the accident?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—You might tell us generally what you noted particularly there as bearing again on the object of the enquiry?

Mr. CUDWORTH.—I do not think I have noticed anything but what was brought out by Mr. McLure in his evidence—nothing new.

Prof. KERRY.—Your observations will fully agree with those of Mr. McLure in his evidence?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—Did you ever, in the regular course of your work, make any effort to determine the, what you might call, geometrical relation between a vertical plane continuing the centre line of the bridge and the axis to the end of the pins?

Mr. CUDWORTH.—Yes, sir. We checked the 24 inch pins of the main shoes by sliding a rod through the holes in a pin.

Prof. KERRY.—Did you find it was exactly at right angles to the vertical plane I have described?

Mr. CUDWORTH.—I think we found an error of something like a sixty-fourth of an inch.

Prof. KERRY.—That was the only one that was tested?

Mr. CUDWORTH.—Both pins were tested.

Prof. KERRY.—You tested two 24 inch pins, one at the bottom of each main post?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—That error of a sixty-fourth, if that be the amount of it, will be more particularly an error in the pedestal setting, would it not?

Mr. CUDWORTH.—Did you mean whether the two planes were exactly at right angles to centre line of the bridge; did you refer to the position of the pin itself in regard to that line?

Prof. KERRY.—I meant the centre line, as to whether it was correct both in the sense of it being exactly at right angles to the centre line——

Mr. CUDWORTH.—The axis of the pin was in a plane perpendicular to the truss plane?

Prof. KERRY.—It would be horizontal?

Mr. CUDWORTH.—I could not give that to you now.

Prof. KERRY.—Have you any record on that point?

Mr. CUDWORTH.—I have a record of it.

Prof. KERRY.—You took the elevation at both ends?

Mr. CUDWORTH.—The elevation at both ends and for transverse alignment.

Prof. KERRY.—You might look that up for us, will you? Will you tell us in what order the chord sections were placed in the false work?

Mr. CUDWORTH.—They were placed in the following order: 2, 1, 3, 4, 5, 6, 7, 8, 9, 10, 11—both trusses at the same time—the corresponding chords.

Prof. KERRY.—Your test on the 24 inch pins showed it to be very closely in exact alignment; would that be a proof that all intermediate pins were also very close to true alignment?

Mr. CUDWORTH.—No, sir, it would be no proof whatever.

Prof. KERRY.—Because the chords were not bolted up?

Mr. CUDWORTH.—That is as far as the field work goes, I mean.

Prof. KERRY.—Did you examine the top chord to any extent during the progress of your observations?

Mr. CUDWORTH.—It was certainly examined for alignment.

Prof. KERRY.—For the cross alignment of the pins?

Mr. CUDWORTH.—No, sir, the member itself was, but not the pins.

Prof. KERRY.—The member itself was in what way?

Mr. CUDWORTH.—That is in taking the longitudinal inclination of the centre posts the position of the member was determined.

Prof. KERRY.—Have you any reason to believe that the axes of the pins on both chords were not accurately at right angles to the central plane of the bridge?

Mr. CUDWORTH.—No, sir, the first chord was set so that they would be in position. The first chord set was No. 2.

Prof. KERRY.—And all the subsequent members of both the upper and lower chords went in without difficulty?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—In such a form as to indicate that they were occupying their true geometrical position?

Mr. CUDWORTH.—Yes, sir.

Prof. KERRY.—Can you say off-hand, Mr. Cudworth, what the maximum sideways movement of the end of the pin has been observed to be?

Mr. CUDWORTH.—Of the pin itself with reference to the member with which it is placed or with reference——

Prof. KERRY.—To the central plane of the bridge.

Mr. CUDWORTH.—That was rather more at the time of the erection of the anchor arm than at any other time. It depended on the way the false work towers took their load on the different sides.

Prof. KERRY.—That is to say the effect of the settlement of the false work was more noticeable than the effect of any unequal settlement of the cantilever arm while it was in progress of construction?

Mr. CUDWORTH.—Yes, sir, that would express it.

Prof. KERRY.—You cannot recall what the maximum figures would be?

Mr. CUDWORTH.—No, sir, I cannot.

Prof. KERRY.—Is there a record of that?

Mr. CUDWORTH.—I think there are records of some work that was done in that connection. I will see if I can find them. The points acted differently after the cantilever arm was under erection when the members were under stress.

Mr. HOLGATE.—Is there anything you would like to say in explanation, Mr. Cudworth?

Mr. CUDWORTH.—No.

Mr. HOLGATE.—Are there any points you would like Mr. Cudworth to bring out, Mr. Deans, particularly?

Mr. DEANS.—I thought the Commission would like to know that we appreciated the necessity of being careful to show all the details in connection with the setting of

the shoes on these blue prints and to see that they were conformed with. Mr. Scheidel, who had charge of that, was here at the time of the setting of these shoes to see that it was acurately done. We assumed that if we started right there, with a careful inspection of the material in the shop, and if the borings were accurate it would proceed uniformly from that point. The setting of the shoes was all done under the supervision of Mr. Scheidel and it was all laid out on little blue prints. We thought that if we started square and level the rest of it would come out right. Mr. Cudworth remembers that.

Mr. CUDWORTH.—Yes, he was there.

Prof. GALBRAITH.—I think that is the point of the examination. You have summarized it.

Mr. DEANS.—We appreciated the importance of sending an engineer here for that purpose.

Mr. HOLGATE.—Who was the engineer in charge at that time?

Mr. DEANS.—Mr. Scheidel, who had charge of all the details.

Mr. HOLGATE.—Your resident engineer? Was that prior to Mr. Birks' time?

Mr. DEANS.—I think so, but even if Mr. Birks were here we thought it of sufficient importance to have Mr. Scheidel here because he got up the details and knew how important that was. We sent him in addition to any other men on the ground to see that the bridge was started right. Mr. Birks was here, Mr. McLure reminds me.

The witness (Mr. Cudworth) retired.

Mr. KINLOCH called.

Mr. HOLGATE.—Mr. Kinloch, there are some matters that have come to your knowledge since your last examination in regard to part of the lower chord system. You will just explain what those are?

Mr. KINLOCH.—At A-4-L chord I find that eight feet from the field splice with A-3-L there are two plates in between two outside west ribs each resting on the bottom angle of the chord ribs and inclined from the horizontal about 70 degrees. Between the two east ribs the same distance back from the field splice, A-3-L and A-4-L, I find three oak blocks with a small plate. The top of the blocks is one foot from the top of the ribs of the chord. The outside measurement on that chord from the east rib to the east centre rib on the top is 19¼ inches and on the bottom 19⅜ inches. From the west centre rib to the west rib the distance is 19¼ inches top and bottom. These measurements were taken back to back of the plates.

Mr. HOLGATE.—When was that blocking put in between the ribs and also when were those spreaders—I suppose you call them spreaders——

Mr. KINLOCH.—Spacing plates.

Mr. HOLGATE——between the west rib and the west centre rib put in?

Mr. KINLOCH.—That is beyond my knowledge. They were there when I came on the bridge. I was informed by Mr. McLure that plates were used for spacing the webs in the shop and I suppose the blocks were used for that same purpose. I have no personal knowledge of the matter.

Mr. HOLGATE.—Was that an exceptional instance or was it used in different places?

Mr. KINLOCH.—I have no definite knowledge of it having been used in any other place than between the east rib and the east centre rib of chord A-8-R of the cantilever arm, but there were other instances.

Mr. HOLGATE.—Was that to secure safety in handling during transportation?

Mr. KINLOCH.—No, sir

Mr. HOLGATE.—Do you know what it was for?

Mr. KINLOCH.—Only what I have been told, but it was not necessary for that.

Mr. HOLGATE.—In what way would that be necessary?

Mr. KINLOCH.—In assembling the four ribs together in the shop.

Mr. HOLGATE.—To ensure the spacing?

Mr. KINLOCH.—To ensure correct spacing.

Mr. HOLGATE.—Would that account for the tight wedged condition it is in now?

Mr. KINLOCH.—Probably Mr. Meeser and Mr. Edwards would give you more information on that. I could make a guess at it, but as that is done in the shop they might tell you more about it than I could.

Mr. HOLGATE.—At any rate you found it in several instances on the lower chord?

Mr. KINLOCH.—Yes.

Mr. HOLGATE.—They were left that way in the bridge?

Mr. KINLOCH.—Yes, they had not been taken out. They should be taken out when they come to clean up.

Prof. KERRY.—These oak blocks that you mentioned were in your opinion placed there before shipment from Phœnixville?

Mr. KINLOCH.—Yes.

Prof. KERRY.—If you had noted their presence what would you have thought of them?

Mr. KINLOCH.—I would have thought what I have said, that they had been used to space the work for riveting.

Prof. KERRY.—They had simply forgotten to take them out.

Mr. KINLOCH.—They were too hard probably for some one to take them out, and they let them go for the next man to take them out.

Mr. HOLGATE.—I do not quite understand how they are so tightly fixed there?

Mr. KINLOCH.—I do not know; if they built these chords on the side I suppose they used these blocks for the spacing and to take the weight while they were riveting. I am not familiar with it.

Mr. HOLGATE.—At any rate they were not in your way during the process of erection.

Mr. KINLOCH.—No, you would not know they were there until you saw them.

Mr. HOLGATE.—They were about the second lacing panel?

Mr. KINLOCH.—They were right at the tie angle.

Mr. HOLGATE.—Between the first and second lacing panel?

Mr. KINLOCH.—Yes.

Mr. STUART.—They are quite visible?

Mr. HOLGATE.—Yes.

Prof. KERRY.—Referring to your previous evidence, Mr. Kinloch, there are one or two points that we want to get cleared up. Can you give us any estimate of the period of time that elapsed between the first time that your attention was drawn to the fall of the bridge and the time that the bridge was fully down?

Mr. KINLOCH.—No, sir.

Prof. KERRY.—Can you make any guess at it?

Mr. KINLOCH.—I would not be sure within fifteen seconds or five. I would not want to say it because I would not be sure and it would not be any use to you. I do not know anything about it.

Prof. KERRY.—It was simply a very short period of time and you were unable to judge it?

Mr. KINLOCH.—Yes, sir.

Prof. KERRY.—Have you examined the ends of the different lower chord members since the accident?

Mr. KINLOCH.—Some of them I have not thoroughly, but I have examined some of them.

Prof. KERRY.—You gave the orders for the final riveting of the joints, did you not?

Mr. KINLOCH.—I let them rivet them when they were tight.

Prof. KERRY.—What method did you follow in order to determine when they were tight?

Mr. KINLOCH.—I had a little tool, a moulder's spatula. If I had not that I took the end of my knife, and if I could enter this I did not call them tight.

Prof. KERRY.—Just thrust that in between the two bottom chord angles?

Mr. KINLOCH.—No, the webs.

Prof. KERRY.—At the bottom?

Mr. KINLOCH.—Yes, sir.

Prof. KERRY.—In every case before it was riveted up you could not get the knife blade in there?

Mr. KINLOCH.—No, sir.

Prof. KERRY.—Have you noted, on the ends of the members since the fall of the bridge, anything to indicate that they were or were not in close contact?

Mr. KINLOCH.—No, sir, I am not sure of that although some of the tops and some of the bottoms opposite different chords look as if they had more strain. Whether it is due to the fall or not I cannot say.

Prof. KERRY.—That is to say that the upper side of the joint would indicate a heavier strain than the lower side?

Mr. KINLOCH.—Yes, and vice versa at different places.

Prof. KERRY.—Does that indication of an extra strain correspond to the way the gaps were left for the camber?

Mr. KINLOCH.—I have not investigated that fully to know what to say.

Prof. KERRY.—Would you mind looking into that with that in view, Mr. Kinloch, and just see what you can observe?

Mr. KINLOCH.—Yes, sir.

Prof. KERRY.—One of the witnesses referred to an incident shortly before the collapse of the bridge, to the fact that the erection stringers were sent out on to the bridge to be put in place, sent back again, then finally brought out and erected. Do you know anything of the detail of that movement?

Mr. KINLOCH.—No, sir, I do not.

Prof. KERRY.—You simply did not notice it at all?

Mr. KINLOCH.—I know the erection stringers were out there and were sent back again; that is all. What they were sent back for I do not know. I was not paying any attention to it because frequently stuff was sent back that way; they were not ready for it.

Prof. KERRY.—Do you remember about what time this took place?

Mr. KINLOCH.—No, I do not.

Prof. KERRY.—It would probably have been on the Wednesday afternoon, would it not?

Mr. KINLOCH.—I think it was on Wednesday afternoon. The probability was that it would be Wednesday afternoon and I am pretty sure now it was Wednesday afternoon.

Prof. KERRY.—Could you describe very shortly the switch connections between the two tracks on the bridge?

Mr. KINLOCH.—You go in from the yard over the east main line track?

Prof. KERRY.—When you speak about the east main line track you mean the track on the Quebec side?

Mr. KINLOCH.—Yes, sir.

Prof. KERRY.—The railway man's term deals with the direction of the traffic?

Mr. KINLOCH.—It was the track on the Quebec side and then right on about three or four feet of a parapet wall on the approach span, or right at the end of the approach span there is a switch stand.

Prof. KERRY.—That is at the south end of the approach span?

Mr. KINLOCH.—At the south end of the approach span. That throws it on the Montreal track or the Quebec track. There are two tracks that run out.

Prof. KERRY.—There is a single track in front of the office?

Mr. KINLOCH.—No, a double track. The switch was in front of the office, the point of the track was just in front of the office.

Prof. KERRY.—But there was a double track coming down from the storage yard?

Mr. KINLOCH.—No, there is one track. There is a double track, but one track was not used; it was dead at the parapet wall. It is the Montreal track.

Prof. KERRY.—That is to say there was a switch, so that a train coming from the storage yard could take either the Quebec track on the bridge or the Montreal track on the bridge.

Mr. KINLOCH.—Yes, sir, but to get on the other track you would have to go back to the storage yard,—to get on the Montreal track that was dead at the parapet wall. There was no cross-over up near the yard or the bridge.

Prof. KERRY.—So that if material was stored on the dead track it had to be thrown on the dead track at the storage yard, pushed down and let stand until required.

Mr. KINLOCH.—Yes, sir.

Prof. KERRY.—There was no cross-over anywhere on the bridge itself?

Mr. KINLOCH.—No, sir.

(Mr. Kinloch marked sketch showing blocking referred to and it was put in, filed and marked Exhibit No. 57).

Witness retired.

Mr. MEESER, re-called.

Mr. HOLGATE.—Mr. Kinloch has just described some wooden blocking and some steel plate wedging in lower chord No. 4 on the side of the cantilever arm and the sketch he has put in illustrates what he described. Could you give us the history of that and the reasons for it?

Mr. MEESER.—It is customary when they build these chords to put in a plate piece and it is milled off to the proper length to keep these chords apart until they are assembled or riveted together, and the only reason that they were there is that they put in wood so as to get the right space. When the ribs are built in most of the cases they have a piece something like that, they stand it on its end, mill it off to the proper length and the rib is laid on top of that until the lacing angles are put on and riveted. Some of these you will find in the chords to-day. That is the blocking that may have been been there. If they had not enough of these other pieces they may have used these blocks to get the required length. It is not a customary rule at all to use wood—always iron.

Mr. HOLGATE.—It would be removed prior to shipment?

Mr. MEESER.—Most always. There are two or three pieces in the Belair yard in which these are in yet.

Prof. KERRY.—Do you recollect any other instance in which wood blocking is used?

Mr. MEESER.—Yes, wood blocking is used. After the chord had been milled they would take these pieces out to use them over again and when it came to the finishing department to put the ribs in the right position they might spring one way an eighth of an inch. After they are milled they are left on their side and they put the blocks in there to hold the chord stationary in its right position until the templet is applied, the holes drilled and the top cover plate or top splice plate put on and bolted fast. But those blocks have to be taken out before the side splice plate is put on.

Prof. KERRY.—Previous to the fall of the bridge, Mr. Meeser, there was a discussion as to whether a certain chord member was considerably bent before it left the shop or not. What evidence have you bearing on a point of that kind?

Mr. MEESER.—I have no evidence but just what I have heard in conversation since I came over here. I have no evidence but what I found out since I came here. I

found out more about it here than I did there. There were two chords that they thought there was something wrong with, and that question had been taken up, I believe, or I found out since, between the Phœnixville Bridge Company and Mr. Cooper, but I did not come in contact with that.

Prof. KERRY.—Was it your business as one of the shop inspectors to see that the chords were as perfectly straight as they could reasonably be made? Suppose a chord had not been made reasonably straight, would you have a record of the fact?

Mr. MEESER.—Yes, sir, we would, but there were none of them ever went out but what they were reasonably straight. We had cut chords apart before they were milled that we did not think were straight, but none of them ever passed out as finished but what we thought were reasonably straight.

Prof. KERRY.—So that you were satisfied that every chord member that was shipped——

Mr. MEESER.—I am satisfied that every chord was straight. There may have been a rib that had some wave in it, but as a chord the chord was straight.

Prof. KERRY.—You tested those in what way?

Mr. MEESER.—With our eye.

Prof. KERRY.—You looked directly along the whole line of the chord?

Mr. MEESER.—Yes, sir.

Prof. KERRY.—And you would expect to detect a wave of what amount?

Mr. MEESER.—Well I think I could easily detect anything over half an inch, easily.

Prof. KERRY.—Did you attempt to check that up to any extent on your visit to Belair?

Mr. MEESER.—We did this afternoon.

Prof. KERRY.—What did you find?

Mr. MEESER.—We found one lying on its side was out ¾ of an inch. In those standing up we had ⅛, ¼, ⅜. Mr. Francis, Mr. Edwards and I were out to-day. The most was ¾ in one chord.

Prof. KERRY.—And you attribute that to some extent——

Mr. MEESER.—To the position it is lying in.

Prof. KERRY.—You think if that was——

Mr. MEESER.—Set up the way it goes into the bridge, I do not think you would find as much.

Prof. KERRY.—It would recover itself.

Mr. HOLGATE.—But this one was lying on its side?

Mr. MEESER.—Lying on its side.

Prof. KERRY.—Is that very noticeable to the eye?

Mr. MEESER.—Well, yes, it is now. Mr. Edwards tells me it is the one you and he measured the time you were out there and you said about ⅝.

Mr. HOLGATE.—Is the deflection due to its own weight?

Mr. MEESER.—I do not know if it is that or lying on the blocks, or what it is.

Mr. HOLGATE.—Is it carrying a load now?

Mr. MEESER.—On one end there is something on it.

Prof. KERRY.—Speaking of the lower chords, at what time in the making up of a member were the pinning holes drilled?

Mr. MEESER.—Practically the last with the exception of drilling the holes for the splice plates.

Prof. KERRY.—That is to say the member was——

Mr. MEESER.—The member was assembled, riveted and milled.

Prof. KERRY.—The shop splices riveted?

Mr. MEESER.—No, sir, all that was put in afterwards. I mean the chord was assembled, it was riveted together, the lacing angles all were put on, they were assembled, riveted, milled, laid out, and then bored.

Prof. KERRY.—The operations subsequent to boring were——

Mr. MEESER.—Sir?

Prof. KERRY.—What was done subsequent to the boring?

Mr. MEESER.—They were put up on the machine and to get the height of our holes we had a gauge and measured up for a certain distance. I have already explained the method of getting our top line. It was laid out on that and then set on the bori mill, which was all of iron on a concrete basis, and bored. After it was put in the boring mill, to be sure that it was right, the men first set it to the scribe lines and then we checked it up. Next when the holes were cut we re-checked it, at the last cut we re-checked it and after it was done checked it again.

Prof. KERRY.—When you had finished with your boring, Mr. Meeser, and your hole was cut to your satisfaction, what still remained to be done on the member?

Mr. MEESER.—The splice plate holes both on the ribs and the splice plate holes on the top and bottom of the big lateral plate were put in; that about finished the chord.

Mr. DEANS.—I think Mr. Meeser misunderstood about the splices, the shop splice was completed before boring?

Mr. MEESER.—I was speaking of the field splice, the chord was all riveted up before there was any boring, everything was completed in that line before any of those other members were touched at all.

Mr. DAVIDSON.—It has been given in evidence that Mr. Birks was strongly of the opinion that that bend which was discovered in the chord had always been in it, that is that it came from the shop in that condition. I would like to know if Mr. Meeser agrees in that position?

Mr. KERRY.—I think Mr. Meeser has already expressed himself.

Mr. DAVIDSON.—He has as a matter of fact; it is just to put the two side by side. He has already I know said they came away straight, but it is evident of course that he does not agree with the other opinion since that was his opinion.

Prof. KERRY.—It seems absolutely clear that if any crookedness existed in any one of those chords it was certainly not seen by Mr. Meeser and that he specially inspected the chords to see if anything of that sort existed.

The Commission adjourned.

## FOURTEENTH DAY.

QUEBEC, P.Q., September 24, 1907.

The Commission met this morning at 10 o'clock.

JOHN STERLING DEANS, re-called.

Mr. HOLGATE.—Mr. Deans, who designed the erection plant of the bridge?

Mr. DEANS.—Who designed the erection plan of the bridge?

Mr. HOLGATE.—Plant?

Mr. DEANS.—It was designed by both the engineering department and the erection department of the Phœnix Bridge Company.

Mr. HOLGATE.—Who particularly were the responsible men connected with that?

Mr. DEANS.—The general methods of the erection were decided upon in conference between myself, the computing department and the erection department, and then the details of this method were worked out by each of those departments. The engineering department more particularly had the designing of the main travellers and false

work. The erection department were more directly responsible for the methods in handling the material and the appliances that were necessary to do this handling.

Mr. HOLGATE.—Will you mention the names of the various gentlemen; who were those to whom you have referred?

Mr. DEANS.—The man in principal authority in the designing department or the computing department is Mr. T. L. Szlapka; under him Mr. C. W. Hudson, who had the principal charge of designing the details of the main traveller. In the erection department Mr. A. B. Milliken, superintendent of erection, in principal charge; Mr. G. A. Tretter, his assistant, and Mr. A. H. Birka, engineer of the department.

Mr. HOLGATE.—The outcome, then, of their co-operating was the plan that was used?

Mr. DEANS.—The outcome was the plan that was used in the erection of the structure.

Mr. HOLGATE.—And the final approval of that rested with yourself?

Mr. DEANS.—The final approval rested with myself.

Mr. HOLGATE.—And you did approve?

Mr. DEANS.—I approved all that they did.

Mr. HOLGATE.—Then when erection was commenced on the south shore who was your representative in chief charge on the ground?

Mr. DEANS.—Who was my representative particularly?

Mr. HOLGATE.—The Phœnix Bridge Company's representative?

Mr. DEANS.—Do you mean when we started to erect the false work?

Mr. HOLGATE.—Yes?

Mr. DEANS.—Mr. E. J. Wickizer was the general foreman in charge of the work here, working directly under Mr. A. B. Milliken, who made frequent trips to the work.

Mr. HOLGATE.—Was there a representative of the engineering department there then?

Mr. DEANS.—A representative in Mr. Cudworth who gave centres and elevations for the setting of this false work and the alignment.

Mr. HOLGATE.—Then those are the only two who were there during the erection of the false work?

Mr. DEANS.—I think so; yes, sir.

Mr. HOLGATE.—Then when did you send an erecting engineer to the work?

Mr. DEANS.—An erecting engineer was on the work during the rection of the main traveller as I remember that.

Mr. HOLGATE.—Who was that?

Mr. DEANS.—Mr. C. W. Hudson, who had the charge of designing it.

Mr. HOLGATE.—Did the designing of the main traveller necessarily involve the study of the details of erection?

Mr. DEANS.—Yes, sir.

Mr. HOLGATE.—Then it is probably from Mr. Hudson's familiarity with the design of the traveller that he was sent there?

Mr. DEANS.—He was sent there particularly because he had designed the traveller in connection with the erection department.

Mr. HOLGATE.—How long did Mr. Hudson remain there?

Mr. DEANS.—I cannot give the dates. He remained there, as I remember, until the traveller was erected and I think until they had actually handled some members to be certain that it worked properly.

Mr. HOLGATE.—Was the design of the traveller made to suit the design of the bridge or was the design of the bridge made to suit the design of the traveller?

Mr. DEANS.—The designing and detailing of the bridge was worked along at the same time as the designing and detailing of the traveller and the erection methods, and the traveller was designed to handle to the best advantage the members of the bridge as designed in detail.

Mr. HOLGATE.—In the design of the bridge did you at any period require to alter the design of any of its details in order to suit the traveller?

Mr. DEANS.—I think not after the design of the traveller was once determined upon, because the order of erection of each member of the bridge was decided upon between the man who had charge of the details and the erection department, and therefore the details as they came out would agree with this rotation of erection, and I cannot remember an instance where the traveller was altered to agree with any detail of design.

Mr. HOLGATE.—I gather then from that that the general design of the structure and of its details was made largely with a view to the facility of erection.

Mr. DEANS.—In our first study of the bridge we appreciated that the erection was probably the most important part of the construction, and the designing of the bridge was made to suit the facility of erection and the safety of the bridge during erection. That was our principal motive in the design.

Mr. HOLGATE.—In determining the important details which you referred to, Mr. Deans, who were your assistants to whom you entrusted this work?

Mr. DEANS.—Mr. P. L. Szlapka, designing engineer, Mr. Chas. Scheidal, assistant engineer in charge of detail.

Mr. HOLGATE.—And you would be guided to some extent by their opinions?

Mr. DEANS.—Only in the detailing of the members to suit the methods of erection, which had been determined upon by the erection department.

Prof. KERRY.—As we understand it, then, the idea of erection was clearly kept in view as one of the most important items in the whole bridge construction?

Mr. DEANS.—From the very beginning; yes, sir.

Prof. KERRY.—And the responsibility of that erection under yourself, or the methods of erection under yourself, and the suitability of the bridge for those methods of erection rested on three men: on Mr. Milliken, for the working plan, on Mr. Hudson for the general design of the traveller, and erection gear of that character and on Mr. Szlapka to see that the detailing fitted in with the plans prepared by the erection department.

Mr. DEANS.—And immediately under him Mr. Scheidal.

Prof. KERRY.—Immediately under him Mr. Scheidal?

Mr. DEANS.—Yes, sir.

Prof. KERRY.—Now, where would Mr. Hudson come in? He is a man we have not come across at all. To what department did he belong?

Mr. DEANS.—He was at that time the assistant engineer in the designing department immediately under Mr. Szlapka. He is now consulting engineer in New York with Prof. Merriman.

Prof. KERRY.—His would be a parallel position to Mr. Scheidal's?

Mr. DEANS.—Yes, in a different department of the company.

Prof. KERRY.—Both reported to Mr. Szlapka?

Mr. DEANS.—Yes, both reported to Mr. Szlapka.

Prof. KERRY.—One dealing with the erection plan and the other with the permanent plan?

Mr. DEANS.—Yes, that is correct.

Mr. HOLGATE.—I think you said Mr. Hudson was on the work during the commencement of the erection of the steel work?

Mr. DEANS.—As I remember he remained long enough to see the traveller handle its first heavy members.

Mr. HOLGATE.—Was it then your intention to have Mr. Hudson continue there?

Mr. DEANS.—No, it was not our intention to have Mr. Hudson continue. As soon as the part of the work he was particularly interested in in the office was completed it was the intention to take him back to Phœnixville.

Mr. HOLGATE.—Then did he return to Phœnixville?

Mr. DEANS.—He returned to Phœnixville.

Mr. HOLGATE.—Was Mr. Hudson a well qualified man to have continued in the erection of that structure?

Mr. DEANS.—As far as his ability was concerned he was a very able man, but it was not necessary for him to discuss the details of erection and work up the method of erection to such an extent as Mr. Birks did and therefore we substituted Mr. Birks for Mr. Hudson as the permanent erection engineer on the work.

Mr. HOLGATE.—Mr. Hudson, I believe, was a man older than Mr. Birks?

Mr. DEANS.—Yes, sir.

Mr. HOLGATE.—And had had a good deal of similar experience in other work?

Mr. DEANS.—Mr. Hudson had had a great deal of experience in the designing and detailing of work; he had not had any special experience in the actual erection work. I mean by that actually being with the men and in contact with erectors; he had not had that experience.

Mr. HOLGATE.—Having a competent foreman, such as Mr. Yenser has been described to be, was there further necessity for an engineer skilled in erecting on the work? We understand that Mr. Yenser was in complete charge?

Mr. DEANS.—Yes. Well, we considered in work of this magnitude it was necessary to have an engineer on the ground in addition to the foreman.

Mr. HOLGATE.—What we have in mind is, I think it is in evidence, that Mr. Birks had, previously to this work, had no field experience in erection?

Mr. DEANS.—That is not correct.

Mr. STUART.—I do not think that is in evidence?

Mr. DEANS.—He had had experience. You even asked me to get a list of the places where he had worked and I got it, at least I did have it.

Mr. HOLGATE.—Have you got a further record of Mr. Birks' erection work?

Mr. DEANS.—I conferred with Mr. Milliken and I did make it up at the time, I thought you wanted it the next day. I know he was on bridges on the Southern Railway which we were erecting, also on bridges on the Lehigh Valley and on the Reading Railway.

Mr. HOLGATE.—Of course we look upon the qualifications of Mr. Birks as a matter of rather great importance.

Mr. DEANS.—It is, very.

Mr. HOLGATE.—And we would like you to make it as clear as possible what your estimate of his qualifications is, with a statement of all the facts in connection with it, that led you to that conclusion. If you want time to prepare that statement——

Mr. DEANS.—I think I can give it to you in a very few words.

Prof. KERRY.—It would be better in the form of record?

Mr. DEANS.—All right.

Mr. HOLGATE.—We could get that from Mr. Deans at a later date. We would also like you to clearly explain your reasons for making the change from Mr. Hudson to Mr. Birks.

Mr. DEANS.—We never considered the question of leaving Mr. Hudson on the Quebec work longer than the erection of the traveller, and to be certain that it would perform its work, because Mr. Hudson in many ways, was not as well fitted to act as an erection engineer as Mr. Birks. We always had in mind that the permanent engineer on that work should be Mr. Birks. His qualifications were so pronounced that there was no question in our minds about appointing him.

Mr. HOLGATE.—Considering the magnitude of this work, was the question ever considered by you of the appointment as resident engineer of a man who had experience corresponding in some degree to this work?

Mr. DEANS.—We felt that our interests were perfectly safe in the hands of the force that we had there.

Mr. HOLGATE.—So that that question was not considered?

Mr. DEANS.—That question never entered my mind.

Mr. HOLGATE.—And so far as the Phœnix Bridge Company was concerned, you had full confidence in the men whom you placed in charge?

Mr. DEANS.—I had absolute confidence in the men in charge of that work.

Mr. HOLGATE.—And you would carry that full confidence to the extent of allowing the men there on the work to act in the case of any emergency arising?

Mr. DEANS.—I should expect them to act in the case of any emergency where they did not feel it was necessary to report the matter to the Phœnixville office.

Mr. HOLGATE.—You felt that they were competent to know when an emergency arose?

Mr. DEANS.—Yes, sir, I did.

Mr. HOLGATE. Then, Mr. Deans, was your organization composed and carried out on the assumption that emergencies would arise?

Mr. DEANS.—We expected that they might arise during the construction of that work.

Mr. HOLGATE.—And having that very thought in your mind, you reposed in your staff the confidence you have shown?

Mr. DEANS.—The staff was the best that we could possibly secure, and we had every confidence in them.

Mr. HOLGATE.—If we understand the organization correctly you even then had no man on the work who would act in an emergency or who felt himself competent to act in an emergency without consulting the office in Phœnixville?

Mr. DEANS.—I cannot see how we could have improved on that organization and taken care of an emergency any better except by moving the entire Phœnixville office to the Quebec bridge. In other words, we had a force there that we thought could act in any emergency that might arise, and in which they did not have time to report to the Phœnixville office.

Mr. HOLGATE.—Were telephone communications of frequent occurrence between the bridge and Phœnixville?

Mr. DEANS.—They were of frequent occurrence, and we took special pains with the manager of the telephone at this end and at our end to give us clear and good service between our office and the bridge, but this service was often very poor and very unsatisfactory. The managers at both ends were doing their best to improve it.

Mr. HOLGATE.—What was the first intimation that you received in connection with any trouble reported from the bridge?

Mr. DEANS.—We received daily reports from the bridge which included all matters of interest in connection with the erection. I suppose you refer to our first intimation in connection with any trouble with the chords.

Mr. HOLGATE.—Unless there was anything else?

Mr. DEANS.—There was nothing else of any moment that I remember.

Mr. HOLGATE.—Was the trouble confined to the chords?

Mr. DEANS.—The serious report which we received about chords we received on the morning of the accident.

Mr. HOLGATE.—Had there been intimations of anything of like character before?

Mr. DEANS.—The first report that we received regarding chords which have come up in the investigation here was in a letter dated August 6, which we received August 8. This referred to the fact that one of the centre ribs did not line up in the connection between 7-L and 8-L of the cantilever arm, and contained a suggestion by Mr. Birks to put in a diaphragm at this point. We received word from Mr. Cooper the same day that he had a similar report and that he did not approve of that method, and we had correspondence back and forth, the matter not being settled exactly what would be done at that joint until the day of the accident.

Mr. HOLGATE.—Then what was it decided to do at that joint?

Mr. DEANS.—Nothing was finally decided; it was not considered a matter that demanded immediate attention, and Mr. Cooper had not determined exactly the manner in which he wanted it corrected.

Mr. HOLGATE.—Do I understand, then, that Mr. Cooper disapproved of the suggestion made by, I presume, Mr. Birks?

Mr. DEANS.—Yes, he thought that there might be some better way of holding that rib than that suggested by Mr. Birks.

Mr. HOLGATE.—But up to the 29th of August he had not made up his mind?

Mr. DEANS.—No, the correspondence had not come to a conclusion between our office and the field and his representative in the field and his office.

Mr. HOLGATE.—What position did you take in the matter?

Mr. DEANS.—Mr. Cooper in his correspondence thought that possibly the chord had been bent in either handling or in erection or during transportation. We took the position that no doubt that chord was in exactly the position in which it left Phœnixville, and that it merely was necessary to bring it in line and hold it there, and we thought that Mr. Birks' suggestion was a good one.

Mr. HOLGATE.—Then do we understand that the change took place in that member after it was placed in the bridge?

Mr. DEANS.—I think not. There were a number of other cases similar to this, but not as great in deflection which Mr. Cooper had passed upon and settled himself without any reference to our office.

Mr. HOLGATE.—Previous to this?

Mr. DEANS.—Previous to this, I understand, and possibly subsequent, too.

Mr. HOLGATE.—Were they reported to you by Mr. Birks?

Mr. DEANS.—They were not reported to me by Mr. Birks.

Mr. HOLGATE.—How did you ascertain that?

Mr. DEANS.—I understand that from Mr. McLure.

Mr. HOLGATE.—Were there any other matters reported between August 8 and August 29?

Mr. DEANS.—Nothing of importance?

Mr. HOLGATE.—Until the 29th?

Mr. DEANS.—Until the 29th, in a letter written by the field here on the 27th.

Mr. HOLGATE.—Signed by Mr. Birks?

Mr. DEANS.—Signed by Mr. Yenser, inclosing a letter from Mr. Birks.

Mr. HOLGATE.—We have had information from Mr. McLure in evidence, Mr. Deans, with regard to the subject under discussion on the 27th, 28th and 29th August. Do you remember if that information conveyed by Mr. Birks is substantially the same as has been brought here by Mr. McLure with regard to the condition of the members referred to?

Mr. STUART.—We have copies of the letters.

Mr. HOLGATE.—You have handed in a copy of a letter of August 27 from Mr. Yenser, copy of a letter of August 27 from Mr. Birks, and also copy of a letter from Mr. Birks of August 28. You have the originals in Phœnixville?

Mr. DEANS.—We have the originals in Phœnixville, and these copies were made from the copy-book here.

Mr. HOLGATE.—As to Mr. Yenser's letter in which he speaks of 9-R and L, what have you to say?

Mr. DEANS.—It should be 9-R and 8-R.

Mr. HOLGATE.—You think it is simply an error?

Mr. DEANS.—An error in typewriting.

Mr. HOLGATE.—An error in typewriting?

Mr. DEANS.—His was a typewritten letter.

Mr. HOLGATE.—And Mr. Birks' references are correct in his letter?

Mr. DEANS.—Mr. Birks' references are correct.

(Letters put in, filed, and marked Exhibit No. 58.)

Mr. HOLGATE.—Do you remember what time you received the letters of August 27?

Mr. DEANS.—I think, as I remember, they were received in the usual Quebec mail about 9.20 or 9.30 on Thursday morning, August 29.

Mr. HOLGATE.—When did they come to your attention?

Mr. DEANS.—Immediately on their arrival in the office.

Mr. HOLGATE.—Can you tell us what action you took?

Mr. DEANS.—I immediately called in consultation Mr. P. L. Szlapka, the designing engineer; Mr. William H. Reeves, general superintendent of the company, and Mr. E. L. Edwards, inspector of the Quebec Bridge and Railway Company.

Mr. HOLGATE.—What was the result of the consultation?

Mr. DEANS.—The result of the consultation was that we considered that there was no immediate or possible ultimate danger in that condition, and that we should call up the field and so advise them. I had Mr. Milliken do this over the 'phone about ten o'clock or 10.30, and I heard him from the adjoining room talking to Mr. Yenser on these lines, and when he had finished talking with Mr. Yenser I told Mr. Milliken to call Mr. Birks to the 'phone so that I could talk to him, and I had a conversation with Mr. Birks on the subject.

Mr. HOLGATE.—What was that conversation with Mr. Birks?

Mr. DEANS.—I first asked Mr. Birks if he had made any further examination of the chords, sketches of which were sent in his letter of the 27th. He said: We have been watching it—we have watched it all day yesterday, and there has been no further movement in the chords. He also said that he had examined the lattice and battens, and they showed no signs of yielding, the rivets were tight, and he also said: Since writing you that letter we have made a further examination, which satisfies us that either the entire bend or the whole bend in this chord was in it at the time of erection. We found that the large splice plate which was riveted up in June has shown no signs of movement or action, either in the riveting or the plate since it was erected, and as there had been more than three million pounds added since June he felt entirely satisfied with the condition of the chord, and it was entirely safe to proceed with the erection. He said: We have moved the traveller and have gone on with the erection. I asked him if he had reported this to Mr. Hoare, and he said yes, he had and that Mr. Hoare had been there during the day in which this examination was made.

Mr. HOLGATE.—Were any further instructions given by you to Mr. Birks at that time over the telephone?

Mr. DEANS.—I simply told Mr. Birks to watch the chord, see how it behaved, that we were going to receive a visit from Mr. McLure, that he had seen Mr. Cooper in New York, and then we would decide what was to be done.

Mr. HOLGATE.—Did Mr. Birks, in that conversation, report that he had made any further measurements than those referred to in his letter?

Mr. DEANS.—I assumed that he had made a very careful examination of these chords, because he told me distinctly that there had been no movement in the chords. I assumed that he did something of that sort.

Mr. HOLGATE.—Did Mr. Birks leave any record of any further measurement that he made?

Mr. DEANS.—This letter that he wrote to us, the letter of August 28, is the letter that he referred to.

Mr. HOLGATE.—Is that the last record that Mr. Birks left in regard to these troubles?

Mr. DEANS.—It is the last record that he left regarding these chords.

Mr. HOLGATE.—Were you satisfied, Mr. Deans, with the evidence of Mr. Birks as to the condition of those members when they were placed in the structure?

Mr. DEANS.—I think that Mr. Birks' conclusions as to the condition of that chord when it was placed in the structure grew out of the fact that in all his travels over the bridge he had not noticed it, and the riveting being made in June of a very large plate and showing no signs of working since June.

Mr. HOLGATE.—You refer now to which plate?

Mr. DEANS.—The spliced plate between 8 and 9 L, anchor arm chord. He reached the conclusion that the chord had at least a considerable portion of this wave in the webs when it was erected.

Prof. GALBRAITH.—That was in June?

Mr. DEANE.—June, 1907.

Mr. HOLGATE.—In view of the evidence that we have that Mr. Kinloch, Mr. McLure, and, I think, Mr. Clark, remember the condition of that chord as it was put into the bridge and that Mr. Kinloch, Mr. McLure and Mr. Clark had communicated their knowledge to Mr. Birks, do you think, Mr. Deans, that Mr. Birks' information, as given to you, was correct?

Mr. DEANS.—I think the condition in which that splice was at the time Mr. Birks wrote that letter of August 28, and the fact that it was riveted in June and that 3,000,000 lbs. of material were added, warranted Mr. Birks in believing that he had an actual fact before him to lead him to believe that there was some bend in that chord at the time it was riveted, notwithstanding that these three men thought it was absolutely straight.

Prof. GALBRAITH.—Do you mean 3,000,000 lbs. of material added to the bridge?

Mr. DEANS.—I mean to the bridge. I think he had the right to believe that there was some bend in the chord at the time it was erected.

Prof. KERRY.—Then, as far as you know, Mr. Birks had no positive evidence in reaching his conclusion and his conclusion was based upon argument from the appearance of the chord on the date at which it was riveted.

Mr. DEANS.—Yes, his conclusion, I have no doubt, was reached due to the fact that the spliced plate was riveted at that time; that the bend of the chord extended to the splice, under the spliced plate, and that none of these rivets showed any signs of working since that splice was made, and I think he had no other absolute evidence.

Mr. HOLGATE.—Then, Mr. Deans, in discussing the subject of Mr. Yenser's letter, and of Mr. Birks' two letters with Mr. Szlapka and the others, what considerations weighed with you in deciding you to instruct Mr. Yenser and Mr. Birks as you did?

Mr. DEANS.—Mr. Szlapka took about half to three-quarters of an hour to determine the loading on that chord, and he found that the chord was receiving about three-quarters of its total load. Then, I had Mr. Edwards in to question him in regard to his notes of inspection as to how these chords left the works, and I found that in a number of instances the chords had waves in their webs, but the exact amounts he did not have in his note-book. I also had the general superintendent of the works and he remembered the same facts. We then came to the conclusion that while it was a matter that would ultimately need to be straightened up, the same as other matters, it was not a matter of any immediate serious note, and knowing at that time that we were going to have a conference with Mr. Cooper and Mr. McLure, we waited for our final action until after that. As I remember, that was what was in our minds at the time.

Mr. HOLGATE.—What was the last progress report that you had had from the field prior to the receipt of the letters you have put in—Exhibit No. 58?

Mr. DEANS.—On August 23 and 24 elevations, alignment, position of main post and end post were sent us from the field, and indicated to us that the entire structure was behaving as we expected from our figures and design, and it was so satisfactory and complete that I wrote to the foreman acknowledging the receipt of this report of August 26, three days before the accident, indicating the satisfactory condition in which this entire structure was at that time to our mind. I have the original of that letter here to hand to the Commission.

Mr. HOLGATE.—Would you read the letter and we will put it right in the evidence?

Mr. DEANS (reading):

PHŒNIXVILLE, PA., August 26, 1907.

B. A. YENSER, ESQ.,
New Liverpool, P.Q., Canada.

DEAR SIR,—Referring to your field report No. 19, we know you will be interested in learning the check figures of the office.

| The field make the elevation. | | Office. |
|---|---|---|
| Bottom of P-1, | average 19⅛" | 18⅝". |
| Foot of T-O-O, | average 25 15/16" | 24 7/16". |

There must necessarily be some discrepancy between the office figures and the actual facts existing in the field. In the single case of weight of the wooden floor, assumed by the office, at 1,500 lbs. per lin. foot for entire floor, up to and including last panel erected, is no doubt too much, and therefore it is natural that the office results should be lower than the actual figures found in the field. This all is a very satisfactory check.

Yours truly,

JNO. STERLING DEANS,
*Chief Engineer.*

P. S.—We will not need any further measurements for longitudinal position until we come to the centre post.—J. S. D.

(Letter put in, filed and marked Exhibit No. 59.)

Mr. HOLGATE.—You say that you expected Mr. McLure on the 29th. What time did he arrive at Phœnixville?

Mr. DEANS.—After our talk with Mr. Yenser and Mr. Birks over the 'phone on the morning of August 29, at about 10.30, I went to Philadelphia on the 11.09 train and returned to Phœnixville about three o'clock. Either then, or immediately thereafter, I received a message from Mr. Cooper's office advising me that Mr. McLure would be at our office at five o'clock. I then advised Mr. Szlapka, the designing engineer, and Mr. Milliken, superintendent of erection, to come into the office and await Mr. McLure's arrival. He reached there at five o'clock and reported his meeting with Mr. Cooper, and I asked him if Mr. Cooper had given him any further instructions, and he said no; he evidently wanted to look into the matter further. I asked him if he made any figures over there, and he said no, there was not time.

Prof. GALBRAITH.—If he had made any figures?

Mr. DEANS.—Any calculations.

Prof. GALBRAITH.—If Mr. Cooper had done so?

Mr. DEANS.—He said no, there was not time; he had just told him to go to Phœnixville.

Mr. HOLGATE.—Up to that point had there been any communication between Mr. Cooper and Phœnixville that day?

Mr. DEANS.—Just that message—the message that Mr. McLure has put in exactly —I have not a copy—advising us that Mr. McLure would be there.

Mr. HOLGATE.—There was no telephonic communication?

Mr. DEANS.—No telephones, no other messages and no letter.

Mr. HOLGATE.—Yes?

Mr. DEANS.—In this discussion Mr. McLure said that he had received a message from Mr. Birks advising that he had made further investigation of the chords and referring to a letter which he had written which would reach Phœnixville on Friday morning. Our discussion was stopped probably quicker than it otherwise would have been to await the receipt of that letter.

Mr. HOLGATE.—Is that letter in evidence?

Mr. DEANS.—It is dated August 28.

Mr. HOLGATE.—And it forms part of Exhibit No. 58?

Mr. DEANS.—Yes, sir. Mr. McLure left the office, I think, about half-past five, and fifteen minutes after he left we had a call from Quebec which we could not understand well, and it took Mr. Waitneight with all his efforts at this end and our efforts, through the manager of the telephone company at our end, to get any word from Quebec up to about, as I remember it, ten minutes after seven from a quarter of six. That is when we were advised of the wreck.

Prof. GALBRAITH.—From a quarter past five?

Mr. DEANS.—We had a call from Quebec about a quarter of six. It was so poor that Mr. Milliken, who went to the 'phone, could not understand what was said. Mr. Waitneight tried, and as he was not able to get the connection, I called up the manager from our end to try and get the connection, and it took till ten minutes after seven to get word, as I remember it.

Mr. HOLGATE.—In the conference after Mr. McLure arrived did you arrive at any conclusion?

Mr. DEANS.—No, sir, the discussion was not completed.

Prof. GALBRAITH.—You were expecting this letter?

Mr. DEANS.—Expecting this other letter which would contain some important information next morning.

Mr. HOLGATE.—Has there been any communication from Mr. Cooper to the Phœnix Bridge Company since the occurrence of this accident?

Mr. DEANS.—No communication whatever.

Mr. HOLGATE.—Has there been any communication at all from Mr. Cooper bearing upon these features?

Mr. DEANS.—No communication. These (referring to three bundles of blue prints) are Mr. Birks' own notes.

Mr. HOLGATE.—Will you put that in, and say in your own words what it is?

Mr. DEANS.—The small blue print note-book entitled 'Notes for erecting Quebec Bridge,' containing 77 pages, and also blue print (pages 1 to 5), being notes covering erection of main traveller, are notes covering all details of erection, and were those used by Mr. Birks, erection engineer.

Mr. HOLGATE.—Do I understand that this is the actual copy used by Mr. Birks?

Mr. DEANS.—This is the actual copy used by Mr. Birks on the work. These were the instructions issued from the Phœnixville office for erection purposes.

(Blue prints put in, filed and marked Exhibit No. 60.)

Witness retired.

Mr. MILLIKEN re-called.

Mr. HOLGATE.—We asked you, Mr. Milliken, for a statement indicating the condition of each riveted joint as it existed on August 29. Have you been able to get that?

Mr. MILLIKEN. This (producing paper) is a statement showing the condition of the field riveting up to August 29, on the anchor and cantilever arms.

Mr. HOLGATE.—And in so far as you know, it is complete?

Mr. MILLIKEN.—Yes, sir; that is prepared by Mr. Kinloch and Mr. McLure and, in so far as I know, it is complete.

Mr. HOLGATE.—You have been over it?

Mr. MILLIKEN.—Yes, sir.

Mr. HOLGATE.—And from your knowledge of the work you believe it to be correct?

Mr. MILLIKEN.—Yes, sir.

Witness retired.

Mr. McLURE recalled.

Mr. HOLGATE.—Are you familiar with the document that Mr. Milliken has just put in?

Mr. McLURE.—Yes, I made it out.

Mr. HOLGATE.—And it is correct?

Mr. McLURE.—In so far as I know it is; to the best of my knowledge, it is correct.

Mr. HOLGATE.—Is this the best information that is available at the present time on this point?

Mr. McLURE.—It is the best information that is available, unless Mr. Kinloch knows of some correction to add to that.

Witness retired.

Mr. KINLOCH recalled.

Mr. HOLGATE.—Are you familiar with the statement put in by Mr. Milliken in regard to the condition of the riveting on August 29?

Mr. KINLOCH.—Yes, sir.

Mr. HOLGATE.—Is it correct?

Mr. KINLOCH.—Yes, to the best of my knowledge.

Mr. HOLGATE.—Is there any means of getting more accurate information than this statement contains?

Mr. KINLOCH.—No, sir.

(Statement put in, filed and marked Exhibit No. 61.)

Witness retired.

Mr. MILLIKEN recalled.

Mr. HOLGATE.—Mr. Milliken, have you the information that we asked for that would indicate the position of the locomotive and the cars, the traveller and any material for erection, or any material to be erected, that was on the cantilever span on August 29?

Mr. MILLIKEN.—I have information gained from those who were at the bridge or on the bridge on August 29.

Mr. HOLGATE.—Do you believe it to be correct?

Mr. MILLIKEN.—Yes, sir.

Mr. HOLGATE.—Could you compile that and put it on a diagram so that we can understand the actual location of these weights?

Mr. MILLIKEN.—Yes, sir.

Mr. HOLGATE.—Will you do so?

Mr. MILLIKEN.—Yes, sir.

Mr. HOLGATE.—I thought it would be in time if we had that in complete form when we were discussing the matter with Mr. Szlapka.

Mr. MILLIKEN.—All right, sir, I will get it in more complete form by that time.

Mr. HOLGATE.—Are there some other matters that you want to bring up?

Mr. MILLIKEN.—Nothing except the shell that was damaged in the wreck on the Delaware and Hudson Railway.

Mr. HOLGATE.—Will you explain what the shell is?

Mr. MILLIKEN.—It is the shell or shield covering the bars on the anchor pier.

Mr. HOLGATE.—As part of the framework of the structure?

Mr. MILLIKEN.—No, sir, entirely independent.

Mr. HOLGATE.—So that the accident that you refer to could have no effect on the structure itself?

Mr. MILLIKEN.—None whatever. It is just simply a shell covering the anchor bars, and is rather an ornament to the end of the bridge.

Prof. GALBRAITH.—An architectural feature and not an engineering one?

Mr. MILLIKEN.—Yes, sir.

Prof. GALBRAITH.—You might say what the accident was.

Mr. MILLIKEN.—It was simply the bending of one or two panels of the lacing between the plates that comprised the shell.

Mr. HOLGATE.—As a matter of fact, were they repaired before it was used in the bridge?

Mr. MILLIKEN.—Yes, sir. I have some correspondence in connection with the accident to the shell, copies of which I will leave with the Commission.

Mr. HOLGATE.—Are there any other correspondence or letters you have bearing on the accident?

Mr. MILLIKEN.—No, sir.

Mr. HOLGATE.—We would like to go through that letter-book between the office and the bridge and see if there is anything there of interest, Mr. Stuart.

Mr. STUART.—We will hand it to you. I do not want to deposit it for reasons I have already explained, but if there are any letters you wish to be put in we will put them in. Mr. Deans is at the hotel, and he will hand it to you.

Witness (Mr. Milliken) retired.

Mr. CUDWORTH recalled.

Mr. HOLGATE.—We asked you for some information yesterday, Mr. Cudworth. You might just put in as Exhibit No. 62 those three papers (referring to papers produced by Mr. Cudworth), and describe what they are.

Mr. CUDWORTH.—The first sheet is a sketch showing the method used in measuring between the anchor pier and main pier south anchor arm on September 17, 1907. The next sheet is a plan showing the location of the 24-inch pins on September 27, 1905. The third is a photograph showing the progress of erection at the close of the season of 1906.

(Sketch, plan and photograph put in, filed and marked Exhibit No. 62.)

Prof. GALBRAITH.—I think you were asked to make a statement regarding the delicacy of your instruments on this work. You are going to get that?

Mr. CUDWORTH.—Yes, sir. I also put in additional wind records to be added to those already deposited and marked Exhibit No. 56.

Witness retired.

Mr. HOARE, recalled.

Mr. HOLGATE.—In going over the evidence from yourself, we thought we came across some inconsistencies, and having spoken about these matters, and having suggested to you to read your own evidence over again and that some other matters would probably appear to yourself, we would like to know what you have to say in regard to those points that were brought up, and if you would just make a statement covering any matters that may appear somewhat inconsistent in your evidence, we would be glad to have it.

Mr. HOARE.—I found on further examination that I had made certain misstatements as to dates—what I did on certain dates previous to the accident. Having referred to certain notes and having further referred to the matter, I have put the facts, which I think are quite accurate, in writing. May I read it?

Mr. HOLGATE.—Kindly read it?

Mr. HOARE (reading).—The first information of the deflection in chord A-9-L was received by me on Tuesday evening, when Mr. McLure called at my house with a sketch of chord A-9-L anchor arm.

I thought the matter important, but not serious, and gave instructions that a thorough examination of the bridge should be made—particularly all chords, posts, laterals and main pier, and to take levels to the main pier.

On Wednesday morning I went out to the bridge, and Mr. McLure and Mr. Kinloch reported that they had examined all the chords, Mr. McLure the upper ones and Mr. Kinloch the lower ones, and that none of them showed any departure from the normal except A-9-L anchor arm and 8 and 9 cantilever arm, and that no change had taken place in any of these. They further reported to me that the lacing on A-9-L was not otherwise affected than being strained, when tested with a hammer—that the posts were in perfect order and showed no sign of strain—that the diagonals were normal. I also asked if they were certain that all other chords were in line and if any lower laterals were deflected or showed signs of anything being wrong at connections with chords. Mr. Kinloch replied that he had inspected those parts, and that everything was O.K.

It was also reported to me that the levels of the bridge had been taken by Mr. Cudworth and that these levels were in exact accord with the theoretical calculations as to what their position would be when carrying its then load.

These facts satisfied me that there was no real danger, and in fact the idea of danger did not enter my head.

I thought the matter important, as possibly requiring repair, and inviting possible delay, but the idea of a possible collapse of the bridge never crossed my mind.

I have been asked to give an exact statement of my movements from Monday the 26th to Thursday the 29th of August, inclusive. After the most careful thought and examining all records which I could lay my hands upon, I find the following to be the facts:

Monday, August 26.—In office at Quebec.—Called McLure on the telephone to know what was taking place at bridge. Answer received that on account of scarcity of men there was no erection that day. In the afternoon I went to Cap Rouge.

Tuesday, August 27.—In office all day preparing for annual meeting. McLure called me on the telephone at 4.30 p.m. to say that he would see me that evening, as he had something special to discuss.

Wednesday, August 28.—I spent all day at the bridge, arriving about 10 to 10.30 a.m., leaving there at about 4.30 p.m., when it was reported to me before leaving that no change whatever had taken place in chord A-9-L nor in any part of the bridge. I felt no anxiety about the bridge.

Thursday, August 29.—I was in the office until 1 p.m. I went out to Cap Rouge and spent the afternoon there. I reached home about 6 p.m, when I heard of the fall of the bridge. During the afternoon I received the telegram from Mr. Deans that the bend in chord was of long standing, which somewhat strengthened my confidence.

Mr. STUART.—I think Mr. Hoare ought to add there that that was a misunderstanding on his part and that the chord referred to was the chord in the cantilever arm.

Mr. HOARE.—This telegram is already in evidence. I did not understand that it referred to the other chord until he came here.

In answer to Mr. Kerry respecting events that happened on the 20th of August, Mr. Kinloch called me up about 9 a.m. to say that no work was in progress on account of a man being killed, and wished me to convey the information to Mr. McLure at the hospital and tell him not to worry about getting to the work that day. Mr. Kerry asked me to especially account for what took place on the 20th, and at the time of my evidence yesterday I was rather vague about it.

Mr. HOLGATE.—You stated in evidence yesterday that you did not personally examine chord No. 9-L. Have you any explanation to account for this?

Mr. HOARE.—Having full confidence in Messrs. McLure and Kinloch, I depended entirely upon their investigation and measurements in all matters of that kind. To personally reach that chord it would be a great physical effort attended by a considerable amount of danger, unless one was in daily practice in doing that kind of work. The inspectors were there for that special purpose, and if I had to climb to look at

every detail on the bridge I might just as well have been an inspector myself and their services would not have been necessary. My work was more general in looking after the company's business and seeing that the work was being carried out according to contract and specifications and that inspectors on the work and at Phœnixville were fulfilling their various duties from time to time and giving me the necessary information required for the proper conduct of the work and for its monthly estimation for progress payments.

Mr. HOLGATE.—Were these progress payments made upon your certificate, Mr. Hoare?

Mr. HOARE.—Yes, sir.

Mr. HOLGATE.—Was there any inspection on the part of any other authority before these certificates were made payable?

Mr. HOARE.—A Mr. Tomney represented the government at Phœnixville.

Mr. HOLGATE.—Who represented the government at the Quebec bridge?

Mr. HOARE.—Mr. Johnston.

Mr. HOLGATE.—All I want to know is whether Mr. Tomney's and Mr. Johnston's certificates were required to make your certificates payable, that is the only point I want.

Mr. HOARE.—No, they did not come to me; their certificates were necessary for the Dominion government to check mine.

Mr. HOLGATE.—Their certificates were necessary for payment to the Phœnix Bridge Company?

Mr. HOARE.—Yes, sir.

Mr. HOLGATE.—That is the way you understand it?

Mr. HOARE.—All right.

The Commission adjourned to meet in Ottawa on Thursday, September 26.

## SUPPLEMENT TO MR. DEAN'S TESTIMONY.

QUEBEC, Sept. 27, 1907.

Mr. Deans, by direction of the Commission, dictated the following general description of the methods adopted in the designing and erection of the Quebec Bridge, to be considered as an addition to his sworn testimony:

*Study.*—When the construction of this bridge was first considered in detail it was soon appreciated that the erection would be by far the most important item of construction, and that upon the success of this feature of the construction the safe execution of the work would be dependent. In this connection studies were made of what had been done in the past in the erection of cantilever construction and after careful consideration it was decided that a departure from the plans pursued in previous works was necessary to ensure absolute safety. The preliminary studies and preparation of these plans engaged the labour of eight to ten engineers and draughtsmen for the greater portion of three years.

*Shop Details.*—In designing the details of the structure all connections and field details were designed to facilitate the erection and to ensure safety in this part of the work. This feature was carried out without regard to the shop cost, it being thoroughly appreciated that cost must not enter into this consideration. To this end, double pin connections were made at panel points and the riveted connections were so arranged as to make it possible to complete a panel in its entirety before proceeding to the erection of the next panel. Details were so arranged that as each panel was

completed the bracing, both upper and lower horizontal bracing and the transverse bracing could be put in complete.

*False work.*—The anchor arm span, 500 feet long, about 96 feet deep at the shore end and 315 feet deep at the main pier, being a frame with its long members, at the time of its erection materially different in length from what they would be in the finally completed structure, made it necessary to erect this anchor span as a frame broken at principal joints. To make the erection of this frame possible it was necessary to set it upon false work that would not settle appreciably under load and that would make the jacking of pin centres to fixed points easily possible. This consideration, in addition to the further consideration of avoiding all risk of accident by fire, decided us to adopt steel false work to support the metal superstructure. The only wooden false work used being the central portion, temporarily required to carry stringers and tracks for the running out of material and metal for erection. This steel false work was founded upon a grillage of three to five layers of heavy planed timbers set to exact levels by instrument. Before placing these timbers we had the foundation examined by expert foundation engineers. The care exercised in the placing of these foundations led to excellent results, no settlement of any magnitude occurring during the erection of the anchor span. Immediately under the lower chord at panel points steel blocking was placed, resting on the top of the false work, and this blocking was so designed that the panel point could easily be raised or lowered by means of jacks. The blocking was also arranged so that movement longitudinally for temperature changes, etc., might readily take place, without distorting the trusses.

*Travellers.*—The principal departure from previous practice was in the style of the traveller. In the past engineers have used what is called an inside traveller running between the trusses and resting directly upon the floor system. This style traveller prevented the complete erection of each panel including the bracing, before the traveller is moved ahead. For this very important reason the traveller used at Quebec is what is called an outside traveller, completely enveloping the entire frame work and resting upon the false work during the erection of the anchor arm and upon extended cantilevers of beams hung from lower chord pins, during the erection of the cantilever arm. This style of traveller, while much more expensive, made it possible to complete each panel in order, including all bracing, insuring absolute safety. For the erection of the suspended span a smaller traveller running upon the top chords of the span was used. This traveller also permitted the complete panel to be finished before moving ahead. The rigging of the traveller called for hoisting blocks, sheaves, shackles and engines far beyond what had been used before and actual tests of all of these features were made and all were carefully designed in our engineering office. The travellers themselves were designed and figured with the same care as the permanent structure and also received the same careful inspection in the shops and the same high grade of material was used in their construction.

*Power.*—Careful consideration was given to the power to be used and it was finally decided to adopt electric power. This reduced the risk of fire and also was considered more reliable in view of the erection running into the winter at the end of the season. The electric power was used not only for the four 125 horse-power hoists on the main traveller and the two 55 horse-power hoists on the smaller traveller, [illegible] engines used on the structure, and it was also used to run compressing, reaming, drilling, &c., eliminating the use of fire upon the entire structure with the exception of rivet-heating forges. This electric power was used more extensively in this structure than in any previous work and demonstrated its superiority over steam. The electric power was obtained from the Canadian Electric Company—it being delivered at a substation at bridge in 2,200 volt alternating current and then transformed by 175 k.w. generators to 550 volt direct current for use in motors on the structure.

*Erection appliances.*—The magnitude of the work and the size of the members, running as they did, up to 100 tons, made it impossible to use the ordinary methods

of handling, and, therefore, we designed in advance erection appliances for the handling of all members, with complete plate, angle, and pin connections with the hoisting block shackles. These appliances received not only the consideration of the erection department, but were carefully checked up by the designing department and not a single one developed any sign of weakness during the erection of the work.

*Storage yards.*—To ensure continuous erection and avoid any delays incident to wrecks in transit, &c., storage yards were established near each end of the bridge. These yards were 67 feet wide and about 1,000 long, served by two 65 horse-power electric cranes. These storage yards were capable of holding about 12,000 tons of material and also afforded sufficient room for assembling eye bars in complete panels ready for erection and also for the attachment of appliances to other members in advance of their being forwarded to the bridge.

*Erection programme.*—To eliminate as far as possible the necessity of the erection foreman using his judgment in connection with the erection, a programme was made out in the office a year or so in advance of the actual work being done and was made out by the erection department, working in conjunction with the engineering department, fixing in every detail, every operation of the traveller and the hoisting apparatus, and defining to the minutest detail how the attachments should be placed and attached, and how the material should be loaded on the cars at the storage yards. This programme also gave in detail the sets of hoisting falls which should be attached in handling each member, how each member should be raised from the car and how it should be lowered into place and connected. All of this programme was indicated in clear terms in blue prints, furnished to the general foreman, assistant foremen and engineers. These instructions covered every operation from the placing of the first member to the completion of the entire work, and it included every member on the bridge. It is a matter of the greatst interest to know that this programme was found to work perfectly and with the experience gained on the south side, very few and only minor alterations were made in connection with the work on the north side.

*Special features.*—Deflection diagrams and diagrams giving the position of all pin points, alignment, position of main and end posts were made by the field engineer and records sent to the office at Phœnixville, and to the consulting engineer, and after the moving of the traveller from panel point to panel point, during the entire work. A United States weather bureau standard wind gauge with electric registering apparatus in the office was used to keep a daily record of wind velocities. Thermometer readings were also taken and records each day. The movement of the trusses under varying degrees of temperature were also noted and recorded.

*Field organization.*—In addition to the regular field erection force which consisted of a general foreman in charge of the entire work, assistant foremen at the travellers and storage yards and in charge of riveters and false work, two engineers of special fitness for their work were kept at the bridge during the entire construction, one engineer having full charge of all instrument work and one engineer having whole charge of all matters in connection with the power assembling and handling of members, the proper attachment of all appliances, the proper bolting and riveting of all joints, including bracing. Both of these engineers were technical advisers to the general foreman. There was also a master mechanic (Mr. Samuel Oaks, who survived) on the work at all times and an electrician (Mr. Britton).

*Results.*—The first metal was placed in position on the anchor pier July 22, 1905. From that date to August 29, 1907, not a single accident of any kind occurred to the hoisting apparatus or in the handling of any material to the bridge or in erecting it in place. There were only five fatal casualties during the entire time, and each of these casualties was the result of the individual action of the man.

## FIFTEENTH DAY.

OTTAWA, Sept. 26, 1907.

The Commission met in Room 16, House of Commons, at 3 p.m.

Mr. COLLINGWOOD SCHREIBER, C.M.G., sworn.

Mr. HOLGATE.—Up to what time were you Deputy Minister and Chief Engineer of the Department of Railways and Canals?

Mr. SCHREIBER.—What time did I cease to be?

Mr. HOLGATE.—Yes.

Mr. SCHREIBER.—On the 1st July, 1905.

Mr. HOLGATE.—How long did you occupy that position up to that time?

Mr. SCHREIBER.—Since December, 1892, I think it was or 1893. It was 1892, I think.

Mr. HOLGATE.—You would be familiar with all the business that was done in connection with the Quebec bridge?

Mr. SCHREIBER.—It all passed through my hands.

Mr. HOLGATE.—We would like to have just a concise story of the connection of your department with the Quebec bridge. You could just give us that and then, at the proper places, put in any documents that will illustrate the matter. Then we can follow it through consecutively in the evidence.

Mr. SCHREIBER.—You wish to begin from the approval of the plans?

Mr. HOLGATE.—Yes, from the inception of the idea.

Mr. SCHREIBER.—The general plan of the bridge was approved by order in council of May 16, 1898. (Referring to Exhibit No. 2).

Mr. HOLGATE.—What necessitated the approval by order in council at that time, Mr. Schreiber?

Mr. SCHREIBER.—The government had granted a subsidy to the bridge of a million dollars.

Mr. HOLGATE.—Do you remember the date of the grant of the subsidy?

Mr. SCHREIBER.—No, I do not.

Mr. HOLGATE.—At any rate the granting of the subsidy then was previous to the submission of the plan for the location of the bridge?

Mr. SCHREIBER.—So far as the location is concerned, that is a matter that affects the navigation of the river and for that reason the plan would have to be approved: that is the general plan. That is one reason, and other is, as I say, in regard to the subsidy.

Mr. HOLGATE.—After the approval of the location under the order in council, what was the next matter that came up?

Mr. SCHREIBER.—Then a contract was entered into under the Subsidy Act and the work proceeded. Month by month I had it examined by an engineer to see what quantity of work had been done and the value of the work upon which the subsidy was based, and on my certificate the payments were made for subsidy.

Mr. HOLGATE.—Did the Quebec Bridge Company submit to you their general specifications?

Mr. SCHREIBER.—I think so, yes.

Mr. HOLGATE.—Was that in the same year, 1898?

Mr. SCHREIBER.—I think they submitted one in 1903—I am not sure, but I think so. They certainly did when they entered into that contract in 1898.

Mr. HOLGATE.—I have a note here that on Aug. 31, 1898, you advised the Quebec Bridge Company that their general specification was approved of?

Mr. SCHREIBER.—Yes, that is dated the 31st Aug. 1898 (referring to Exhibit No. 5). That is correct and I informed them that the specification was quite satisfactory.

Mr. HOLGATE.—Why was that approval necessary?

Mr. SCHREIBER.—So as to ensure a bridge of sufficient strength, giving the height above water, &c., and specifying the class of masonry that the abutments were to be built of, also the character of the steel of which the superstructure was to be built.

Mr. HOLGATE.—Under what general act of legislation was this approval necessary?

Mr. SCHREIBER.—All bridges at that time had to be approved by the Railway Committee of the Privy Council and now they have to be approved by the Railway Commission.

Mr. HOLGATE.—Then, these general specifications being approved, what was the next step?

Mr. SCHREIBER.—The contract was prepared and executed and the work proceeded.

Prof. KERRY.—This approval that we have here is not an approval by the Railway Committee, it is approval by the chief engineer of the department.

Mr. SCHREIBER.—I approve and recommend them.

Prof. KERRY.—What we are trying to get at is under what special legislative authority was this approval made. Why was it necessary? Was it part of the regular business of the Railway Committee of the Privy Council?

Mr. SCHREIBER.—I should say that the approval of plans is a part of the business of the Railway Committee of the Privy Council, and this approval, I think, is called for by the Act or by the contract in some way or other—by the contract, I think it is—may be it provides in the contract that it shall be approved before the work proceeds.

Mr. HOLGATE.—Who prepared the specifications that were approved?

Mr. SCHREIBER.—I understood Mr. Cooper did, and Mr. Cooper states so, I think, in a letter of his.

Mr. HOLGATE.—I refer to the specifications that are approved by your letter of Aug. 31, 1898, Mr. Schreiber?

Mr. SCHREIBER.—I do not remember who did that.

Mr. HOLGATE.—In a resolution of the board of directors of the Quebec Bridge Co., Mr. Hoare appears to have been instructed to put himself in communication with you in connection with preparing suitable specifications for the proposed Quebec bridge to be a basis for calling for tenders. Do you recollect if that was the course pursued?

Mr. SCHREIBER.—I do not remember that, but my impression is that when they advertised for tenders they asked the companies to submit their specifications and plans giving a certain basis upon which they were to work.

Mr. HOLGATE.—We would like to find out just how these specifications were arrived at and who drew them up. They were approved by the chief engineer of the Department of Railways and Canals?

Mr. SCHREIBER.—That is right.

Mr. HOLGATE.—But what specifications were they and who prepared them?

Mr. SCHREIBER.—What is the date of that? (referring to Exhibit No. 5.)

Mr. HOLGATE.—1898.

Mr. SCHREIBER.—Those must have been submitted by the company. It is quite probable that Mr. Hoare had a consultation with me about them. It is very likely.

Mr. HOLGATE.—Would you not have a record of those specifications?

Mr. SCHREIBER.—There should be. There must be one in the department.

Mr. HOLGATE.—But you cannot now say what specifications they were or who prepared them?

Mr. SCHREIBER.—I looked over some correspondence this morning and there were no specifications attached to the copy of the contract that I saw there, but the contract referred to the specifications.

Mr. HOLGATE.—What contract would that be?

Mr. SCHREIBER.—The contract of 1898, I think.

Mr. HOLGATE.—Is that the subsidy agreement?

Mr. SCHREIBER.—Yes.

Mr. HOLGATE.—That is at a later date?

Mr. SCHREIBER.—Was it? Was that the one of 1903?

Mr. HOLGATE.—Yes, we are only at 1898 now.

Prof. KERRY.—Mr. Schreiber, before the approval of this first set of specifications was given by you what investigation was made into the specifications themselves as to their soundness and to their being satisfactory for the work in contemplation?

Mr. SCHREIBER.—I am speaking from memory now, but I should judge from my usual practice that I must have been in consultation with Mr. R. C. Douglas, our bridge engineer. That is the usual practice.

Prof. KERRY.—Then their specifications would have been referred to Mr. Douglas to examine and report on?

Mr. SCHREIBER.—Yes.

Prof. KERRY.—And would have been approved by you after he had passed them as being satisfactory?

Mr. SCHREIBER.—Yes.

Mr. HOLGATE.—Then, we understand, the history of the matter was that the Quebec Bridge and Railway Company issued a circular letter inviting tenders?

Mr. SCHREIBER.—Yes.

Mr. HOLGATE.—Then that certain tenders were sent in and a period of time elapsed and the next thing we hear about in connection with the department was an agreement between the Quebec Bridge and Railway Company and the government dated November 12, 1900 (Exhibit 12). There are certain specifications attached to that contract?

Mr. SCHREIBER.—Yes, there must be a general specification.

Mr. HOLGATE.—Can you say who prepared those specifications?

Mr. SCHREIBER.—My impression is that they were prepared by the Phœnix Bridge Company; I am not sure. I forget when Mr. Cooper was appointed. Mr. Cooper was a man we relied on very much for these things and I forget when he was appointed, whether it was under the second contract, that contract for the guarantee, or whether it was——

Mr. HOLGATE.—Mr. Cooper, it appears, came into the question in May, 1900.

Mr. SCHREIBER.—It is perfectly evident that he did not prepare the 1898 one; that is sure.

Mr. HOLGATE.—No, sir, he is not connected with the matter in 1898.

Mr. SCHREIBER.—No, I really could not tell you now who did prepare those.

Mr. HOLGATE.—What was Mr. Cooper's position as you understood it?

Mr. SCHREIBER.—He was consulting engineer to the company.

Mr. HOLGATE.—To what company?

Mr. SCHREIBER.—To the Quebec Bridge and Railway Company—not to the Phœnix Bridge Company.

Mr. HOLGATE.—Did he hold any other apopintment to your knowledge in connection with the matter?

Mr. SCHREIBER.—Not that I am aware of—just consulting engineer.

Mr. HOLGATE.—Acting solely for?

Mr. SCHREIBER.—Solely for the company.

Mr. HOLGATE.—The Quebec Bridge and Railway Company?

Mr. SCHREIBER.—Yes, solely for the Quebec Bridge and Railway Company and being an engineer of very high repute, of large experience in bridge construction and known as the leading bridge engineer in the United States we relied largely on him, the interests of the bridge company and the government being really identical.

Mr. HOLGATE.—The agreement between the Quebec Bridge Company and the government being made in November had you come in contact with Mr. Cooper in connection with the matter prior to that time?

Mr. SCHREIBER.—Prior to 1898?

Mr. HOLGATE.—Prior to Nov. 12, 1900. Mr. Cooper made a report on the plans and specifications?

Mr. SCHREIBER.—No, I did not know Mr. Cooper till then. I only knew him by repute, but I had never seen him. When I say we relied on Mr. Cooper, I mean as to general things, but all detailed drawings and so forth were placed before Mr. Douglas to see whether the strains exceeded any of those in the specification so that everything went through his hands before it was passed.

Mr. HOLGATE.—Were those specifications attached to Exhibit 12, sufficient?

Mr. SCHREIBER.—I do not understand your question.

Mr. HOLGATE.—I will put it in another way. Were the specifications attached to the subsidy contract the same as those that were prepared in 1898, before referred to, and approved by your letter in Exhibit 5?

Mr. SCHREIBER.—I think so. I do not remember others.

Mr. HOLGATE.—Were they considered sufficient then for the work under contract?

Mr. SCHREIBER.—They were considered so.

Mr. HOLGATE.—Clause 2 of the subsidy agreement, Exhibit 12, stipulates that the company shall build the bridge in accordance with the general plans before mentioned and the specification for substructure and superstructure hereto annexed marked respectively 'A' and 'A-1' or with such amendments of the said plans and specifications as the Governor General in Council may from time to time approve. Were there amendments to these specifications?

Mr. SCHREIBER.—There evidently were amendments to the specifications, because I see a letter here from Mr. Cooper in which he refers to some amendments he proposes. I do not know whether you have seen that letter or not, here is a copy of it.

(Mr. Schreiber here produced a copy of a sheet in Exhibit 21, marked 21-A.)

Mr. HOLGATE.—Were there any details attached to that, Mr. Schreiber, or is that all you have in connection with that matter?

(Mr. Schreiber filed copies of a letter from Mr. R. C. Douglas, bridge engineer of the Department of Railways and Canals, criticising the amendments to these specifications proposed by Mr. Theodore Cooper. These documents were filed and marked Exhibit 63 on the understanding that they would be later further identified by sub-numbers.)

Prof KERR.—This subsidy agreement provides that the bridge was to be constructed in accordance with the specifications attached to the agreement, or with such amendments to the said plans and specifications as the Governor General in Council may from time to time approve. Do you know if any amendments to the specification were approved by the Governor General in Council?

Mr. SCHREIBER.—I am not aware of any, and I should judge by those reports of Mr. Douglas that there would not be, for I see he has reported against these proposed changes of Mr. Cooper's. There was no order in council approving of any changes but they made me responsible for that, and in consultation with Mr. Cooper if there were any changes that I approved I passed them through, but in passing through, I would pass nothing through without first putting it through the hands of our bridge engineer, Mr. R. C. Douglas.

Mr. HOLGATE.—Then have you a record of the changes in specifications that were approved by you?

Mr. SCHREIBER.—I could not see any in the correspondence I looked through to-day in the department.

Mr. HOLGATE.—In connection with that matter, you have just put in certain papers purporting to be modifications in the specifications (Exhibit 63); were they approved by you?

Mr. SCHREIBER.—I am afraid I am not able to say at this moment; nothing was approved by me that Mr. Douglas, after going through the figures, would recommend should not be approved.

Mr. HOLGATE.—Where would we ascertain whether Mr. Douglas did pass these or not?

Mr. SCHREIBER.—It ought to be in the correspondence, in letters to me, correspondence with me.

Mr. HOLGATE.—To what extent was your department then interested in having the specifications for the construction of the bridge approved, Mr. Schreiber?

Mr. SCHREIBER.—They were paying the subsidy upon this and later on they were guaranteeing the bonds of the company.

Mr. HOLGATE.—Up to that time they had not guaranteed the bonds of the company?

Mr. SCHREIBER.—No, but up to that time they were paying subsidy and they wanted to ensure having a substantial, safe structure built, and not pay out their money for nothing.

Mr. HOLGATE.—The approval of the specifications must have taken place some time or else the construction would not have been proceeded with.

Mr. SCHREIBER.—Oh, no doubt it must have been, no doubt.

Mr. HOLGATE.—In your recommendation to Council, Mr. Schreiber, of the 9th of July, 1903, you ask to be authorized to employ a competent bridge engineer?

Mr. SCHREIBER.—Yes.

Mr. HOLGATE.—To examine from time to time the detail drawings of each part of the bridge as prepared?

Mr. SCHREIBER.—Yes.

Mr. HOLGATE.—Was your recommendation followed?

Mr. SCHREIBER.—There was an order in council passed upon that recommendation authorizing that to be done.

Mr. HOLGATE.—And what was the result?

Mr. SCHREIBER.—And the department corresponded with an engineer of the name of Nichols in New York, asking what terms Mr. Nichols would make. Mr. Nichols was a man of some standing in the profession and he gave his terms, &c. In the meantime, I wrote to Mr. Cooper and I enclosed him a copy of the order in council, &c., and he replied not favouring that very much. He said it would take the responsibility off his shoulders. After that I think the matter went into the minister's hands and he wrote something. I forget now exactly what that was. However, it resulted in this, that after discussing the matter it was considered that the interests of the company and of the Dominion government were identical in every way, and therefore, having Mr. Cooper, a man whose ability was never questioned, and whose experience in connection with bridge construction has been large, it was thought better to rely upon him rather than interfere with what he might do, what advice he might give.

Mr. HOLGATE.—Then we gather, Mr. Schreiber, that you acted in accordance with that, and that really in the design Mr. Cooper for those reasons was given a free hand?

Mr. SCHREIBER.—Yes, he was.

Mr. HOLGATE.—Were you familiar with the modifications in the specifications, that Mr. Cooper made?

Mr. SCHREIBER.—No further than they came before me and I would hand them over to Mr. Douglas. I do not remember what they were now, you know, and I think Mr. Douglas reported in favour of many of them. I do not know that he did all, and then if he did not, they were not approved.

Mr. HOLGATE.—Could we find what points were disapproved by your department?

Mr. SCHREIBER.—I think by searching through the correspondence in the department that might be ascertained.

Mr. HOLGATE.—Could Mr. Douglas tell us?

Mr. SCHREIBER.—Yes, he could; yes, I think so.

Prof. KERRY.—The Order in Council of August 15, 1903, Exhibit 18, read as follows, Mr. Schreiber:—

'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 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.'

Now, that order in council of that date would seem to authorize the adoption of the new loadings proposed by Mr. Cooper and no other of his changes, and it would seem to make it necessary for all plans to be submitted to the chief engineer of the Department of Railways and Canals and to be approved by him. Was that course followed throughout?

Mr. SCHREIBER.—I think so, and as I say I approved nothing until it had gone through Mr. Douglas' hands.

Mr. HOLGATE.—Then the next change appears to be that a new contract was entered into between the Quebec Bridge Company and the government on October 19, 1903. Have you a copy of that contract here?

Mr. SCHREIBER (producing document).—That is the original.

(Document ordered to be entered as Exhibit 64, on the understanding that a copy would be put in by Mr. Schreiber.)

(Mr. Schreiber filed a copy of a letter under date of August 12, 1903, to the Hon. W. S. Fielding (Exhibit 65), acting Minister of the Department of Railways and Canals, recommending the course adopted by the government in the issue of that order in council—Exhibit 18.)

Mr. HOLGATE.—This contract (Exhibit 64) is called the guarantee agreement?

Mr. SCHREIBER.—Yes, sir.

Mr. HOLGATE.—In clause 7 of that document reference is made to the Chief Engineer of the Government Railways?

Mr. SCHREIBER.—Yes.

Mr. HOLGATE.—Who is meant by that officer?

Mr. SCHREIBER.—It is intended to mean me, but that was not my title.

Mr. HOLGATE.—Then, that is just a clerical error, is it, or a lawyer's error? Clause 12 of that agreement calls for the plans and specifications for all the works of the undertaking to be submitted to and approved by the Governor in Council before any work is constructed thereunder?

Mr. SCHREIBER.—I could find no such order this morning in looking through the papers.

Mr. HOLGATE.—Then the work was not carried out in accordance with this clause?

Mr. SCHREIBER.—I cannot tell you. I am only telling you that in the papers placed before me this morning by the department I could find no such order as that.

Prof. KERRY.—Was the question of the jurisdiction of the Board of Railway Commissioners over this structure ever discussed, Mr. Schreiber?

Mr. SCHREIBER.—I never heard it. I think, by virtue of their office, they would have something to say in regard to it.

Prof. KERRY.—My remembrance is that the Board of Railway Commissioners commenced active life about the 1st of February, 1904.

Mr. SCHREIBER.—Yes, I suppose that would be the time they took an active interest in things.

Prof. KERRY.—And the plans for the structure which has fallen would not have reached the department until probably the fall of 1904 or later?

Mr. SCHREIBER.—I am unable to say how that is. I could not find that order this morning among the papers. It may be in the department but overlooked, you know.

Prof. KERRY.—So that although the Railway Act of 1903 required the approval of the plans for all bridges of over 18 feet span, the plans for this structure really never reached the Board of Railway Commissioners?

Mr. SCHREIBER.—I could not say. They may have considered the plan.

Mr. HOLGATE.—In the guarantee agreement, Mr. Schreiber, in clause 13, I see 'the continuation of the work of constructing the said undertaking,' that is the bridge, 'shall be proceeded with as soon as the plans thereof are submitted to and approved by the Governor in Council, and such undertaking shall be completed not later than—' were those plans submitted to and approved by the Governor in Council?

Mr. SCHREIBER.—I think not, as far as I know. As I told you a few minutes ago, I could find nothing amongst the papers that were placed before me by the department this morning. I could find no such order in council there, but the original plan had been approved by the Railway Committee of the Privy Council. The Railway Commissioners superseded the Railway Committee of the Privy Council.

Mr. HOLGATE.—We find that the plans from which the structure was built are signed by the Deputy Minister and Chief Engineer of Railways and Canals?

Mr. SCHREIBER.—Yes.

Mr. HOLGATE.—Under what authority were those plans signed?

Mr. SCHREIBER.—I could not remember the law now in regard to that. I must have had some authority to do it.

Mr. HOLGATE.—Those plans were signed by yourself?

Mr. SCHREIBER.—Yes.

Mr. HOLGATE.—As Chief Engineer?

Mr. SCHREIBER.—Well, are they not signed by me as being attached to a report of mine—something of that kind? That is usually the case.

Prof. KERRY.—We understand further, Mr. Schreiber, that your approval of the plans in every case was reserved until Mr. Douglas had made his examination of those plans?

Mr. SCHREIBER.—I do not think there is any doubt about it.

Prof. KERRY.—And reported them satisfactory?

Mr. SCHREIBER.—I should say there is no doubt about it.

Prof. KERRY.—Then, as far as you know at present, Mr. Schreiber, there is no order in council authorizing you to approve the plans subsequent to the making of the guarantee agreement of October 19, 1903?

Mr. SCHREIBER.—I could find none this morning.

(Mr. Schreiber was requested to file with the Commissioners a copy of the guarantee agreement between His Majesty the King and the Quebec Bridge and Railway Company, under date of October 19, 1903—Department No. 15234.)

Mr. HOLGATE.—Then, you put certain inspectors on the work? You, I understand, had an inspector at Phœnixville? Will you let us have a copy of the instruction under which he was acting?

Mr. SCHREIBER.—Mr. C. J. Tomney was there.

(Mr. Schreiber filed a copy of the instructions issued to Mr. C. J. Tomney under date of August 4, 1904, and signed by the secretary of the Department of Railways and Canals; marked Exhibit No. 66.)

Mr. HOLGATE.—Had Mr. Tomney any other duties besides his written instructions?

Mr. SCHREIBER.—Nothing except in connection with the bridge. He had to give us a statement of every piece—every member of the bridge, where it was, what had been removed, what had been delivered at Quebec, and so forth.

Mr. HOLGATE.—Was his inspection entirely in the nature of checking material in regard to the amounts?

Mr. SCHREIBER.—That is all; checking material for payment—the monthly estimate.

Mr. HOLGATE.—He had nothing to do with inspecting the quality of work or material?

Mr. SCHREIBER.—No.

Mr. HOLGATE.—In regard to the inspection of the work done at the bridge itself, who had you?

Mr. SCHREIBER.—Mr. Cooper was really the man who looked after that. As I said before, the interests of the company and of the government were identical. He was supposed to visit it frequently.

Mr. HOLGATE.—Were Mr. Cooper's personal visits frequent enough to ensure a complete inspection?

Mr. SCHREIBER.—Well, I retired from the position in the department. I do not occupy that position in the Department of Railways and Canals now. I retired from that in 1905, so that there was scarcely anything done at that time in regard to the superstructure. I met him down there on two occasions. That is all I remember.

Mr. HOLGATE.—In other words, the work on the superstructure was practically confined to the period after which you retired from the Department of Railways and Canals?

Mr. SCHREIBER.—Yes, sir.

Mr. HOLGATE.—But during your incumbency of the Railway Department had you inspectors who did visit the work?

Mr. SCHREIBER.—Mr. Douglas was down once or twice and Mr. Johnson also visited the works, but the object of his going was more to examine the estimates shown.

Mr. HOLGATE.—Is that Mr. Johnson's business?

Mr. SCHREIBER.—Mr. Johnson's—yes, upon which we were either guaranteeing or paying a subsidy.

Mr. HOLGATE.—Would his inspection include an examination of the quality of the work or simply the quantity of it?

Mr. SCHREIBER.—Yes, he would examine the quality of it as well as the quantity as far as the substructure is concerned, and as far as anything would have been done in regard to the superstructure.

Mr. HOLGATE.—What did Mr. Douglas do?

Mr. SCHREIBER.—Mr. Douglas went down on several occasions. He was down with me twice—I am not sure—certainly once, and may have been twice, and at that time, I do not think there was anything delivered in the way of material for the superstructure. It was all substructure at that time.

Mr. HOLGATE.—You personally visited the work?

Mr. SCHREIBER.—I went down occasionally.

Mr. HOLGATE.—On several occasions?

Mr. SCHREIBER.—Yes, but only the short land spans were erected before I retired. I am not sure about it, but certainly nothing beyond that.

Mr. HOLGATE.—Is there anything that occurs to you in regard to your explanation?

Mr. SCHREIBER.—No, I do not know of anything further?

Mr. HOLGATE.—Had the Department of Railways and Canals, in so far as you know, anything to say in connection with the appointment of the engineering staff of the Quebec Bridge and Railway Company?

Mr. SCHREIBER.—Nothing as far as I know.

Mr. HOLGATE.—Considering the relations of Mr. Cooper to the Quebec Bridge and Railway Company and your opinion of Mr. Cooper's ability and the relation of the government with the Quebec Bridge and Railway Company, would you consider that Mr. Cooper would have the power or authority to amend the specifications for the work from time to time as he might consider necessary or desirable, and would those amendments be tacitly accepted by all parties concerned?

Mr. SCHREIBER.—No, I think not. They would have to be submitted to me and they would come before our bridge engineer—before the bridge engineer of the Department of Railways and Canals—before they would be accepted.

Mr. HOLGATE.—So that, unless we can find a formal acceptance of the changes or alterations made in the specifications we would have to consider them as unauthorized?

Mr. SCHREIBER.—Certainly.

Mr. HOLGATE.—And yet the structure, no doubt, has been constructed in accordance with the various amendments to the specifications that Mr. Cooper has made from time to time, and payments have been made as the work progressed. How would those payments be made unless the steps leading up to the authorization of those payments were complete?

Mr. SCHREIBER.—The payments, of course, should not be made unless everything was in order, no doubt, but the assumption would be when the certificates left my hands that they were correct, although they might be criticized afterwards or examined afterwards by the Finance Department. But they would be assumed to be correct.

Mr. E. V. JOHNSON, sworn.

Prof. KERRY.—Mr. Johnson, will you state briefly the position you have occupied in connection with the construction of the Quebec bridge and the duties that you have performed?

Mr. JOHNSON.—Well, as inspecting engineer of subsidized railways, I visited Quebec as nearly as practicable once a month for the purpose of making an estimate of the progress of the work of the Quebec Bridge and Railway Company, which included a portion of the railway and the Quebec bridge. This was to ascertain what amount of work had been done during the month and, as I say, to put in a progress estmiate for the release of the bonds.

Prof. KERRY.—Your duty, then, was to visit the work if possible once a month to inspect its progress and to make an estimate for payment of the amounts of subsidy due to the Quebec Bridge and Railway Company up to date?

Mr. JOHNSON.—Yes.

Prof. KERRY.—In those inspections, Mr. Johnson, did you make what we might term a detail engineering examination of the Quebec bridge?

Mr. JOHNSON.—No, my examination was simply to report as to how far the work had gone. I looked at the work generally and reported the condition of the bridge, as far as its extent had gone up to the date of my examination.

Prof. KERRY.—That is, the main object of your inspection was to determine the quantity of work that had been done and only roughly to say that the work was satisfactory.

Mr. JOHNSON.—Yes.

Prof. KERRY.—You did not consider it as part of your duty to study the design of the structure?

Mr. JOHNSON.—Not at all; I considered that as being settled outside of my business.

Prof. KERRY.—Outside of your department? The object of this inquiry, Mr. Johnson, is to determine the cause of the fall of the bridge. Would you, as an engi-

neer, consider that any of your observations have been close enough to enable you to give evidence that will assist the commission?

Mr. JOHNSON.—No, I think not. I simply walked over the bridge, generally up to the end of it, and took a general look over it to see what progress had been made, but I considered that all questions of that sort were settled by others who were in a better position to do it.

Prof. GALBRAITH.—You had to do with making the monthly returns of the actual weights of the pieces in the structure?

Mr. JOHNSON.—Yes.

Prof. GALBRAITH.—Have you any information as to how those weights agreed with the weights figured from the drawings upon which the stresses in the bridge were computed?

Mr. JOHNSON.—No, I have not the information on that subject.

Prof. GALBRAITH.—I believe that in the contract there was an allowance made of 2½ per cent as between the actual weights and the estimated weights. Do you know anything about the actual percentage of difference?

Mr. JOHNSON.—No, that is a matter that I never went into at all.

Mr. HOLGATE.—Who signed the certificates for payment?

Mr. JOHNSON.—The chief engineer.

Mr. HOLGATE.—Who is he?

Mr. JOHNSON.—At present, Mr. Butler, the Chief Engineer of Railways and Canals.

Mr. HOLGATE.—Those are the certificates of payment from the government to the Quebec Bridge Company?

Mr. JOHNSON.—Yes.

Mr. HOLGATE.—Those are the certificates that you had to make?

Mr. JOHNSON.—I made my report out in an estimate of the quantities and value of work done up to date to the chief engineer of the department, and on these he issued his certificate for the release of the bonds.

Mr. HOLGATE.—Then the payments made to the contractors on the bridge site were made by the Quebec Bridge and Railway Company. Had you anything to do with the certificates of their engineer?

Mr. JOHNSON.—No.

Prof. KERRY.—One question about your reports. You saw that certain members of the bridge were in place, you had to arrive at the weight of those members?

Mr. JOHNSON.—I did not arrive at the individual weights of them; I had a report from Mr. Tomney, which was always referred to me, and this gave a list of the members and the total weight of a certain class of work that was either at the shop or on Crown land, at Phœnixville, or delivered at Quebec, and also got the estimates from Mr. Hoare, giving practically the same thing, which I compared to make sure that my estimate would be correct.

Prof. KERRY.—Did Mr. Tomney in his reports of material shipped, give the weight of each individual member or the total weight?

Mr. JOHNSON.—No, he gave the number, a long list of different members with the weight of the pieces and the total weight of all that lot. It might be a million pounds or more; it was just the bulk.

Prof. GALBRAITH.—Were these weights the weights as furnished by the railway companies, or were they weights determined at Phœnixville in the bridge works?

Mr. JOHNSON.—The weights that Mr. Tomney gave to us right on the spot and he got them from the Phœnix Bridge Company.

Mr. HOLGATE.—Was the check complete and continuous, Mr. Johnson, from the shop to the bridge?

Mr. JOHNSON.—How do you mean, Mr. Chairman; do you mean en route, or by dates?

Mr. HOLGATE.—No, was the check complete from the fabrication of a member to its placing in the bridge; I mean with regard to the payment for that material?

Mr. JOHNSON.—Well, not individually, the individual pieces. There was a return made by Mr. Tomney of raw material delivered from the shops to the Phœnixville works, and to the Crown lands.

Mr. HOLGATE.—Was the check complete enough so that if an error had been made it could have been detected?

Mr. JOHNSON.—I doubt it.

Witness discharged.

The Commission adjourned.

## SIXTEENTH DAY.

OTTAWA, September 27, 1907.

The Commission met at 10 a.m.

ROBERT C. DOUGLAS sworn.

Prof. KERRY.—Your official position is?

Mr. DOUGLAS.—At the retirement of Mr. Smith, who was formerly bridge engineer, his work was given to me—in 1893, I think, some time—1893 or 1894, or something about that time. Since that time I have been bridge engineer in addition to my other duties.

Prof. KERRY.—That is bridge engineer of the Department of Railways and Canals?

Mr. DOUGLAS.—Yes.

Prof. KERRY.—And in that capacity you had some work to do in connection with the Quebec bridge?

Mr. DOUGLAS.—Some, yes—with the substructure; nothing with the superstructure except the routine part of the plans and the reports.

Prof. KERRY.—No direct connection with the structure?

Mr. DOUGLAS.—No direct connection with the superstructure in any way.

Prof. KERRY.—In Mr. Schreiber's examination yesterday it developed that practically the first step towards construction was in the preparation of the specification by the Quebec Bridge Company and its approval by the Deputy Minister of the Department of Railways and Canals. You know that specification, do you?

Mr. DOUGLAS.—I know that specification.

Prof. KERRY.—It was handed to you for examination?

Mr. DOUGLAS.—No, sir, it was not, to the best of my recollection. I will describe it if you will allow me.

Prof. KERRY.—If you please.

Mr. DOUGLAS.—As nearly as my recollection serves me, Mr. Hoare came into my office with the manuscript specification or with the specification in the galley form, and wanted me to go over it with him. He said: Mr. Schreiber said, 'Go into Douglas and go over the specification with him.'

Prof. GALBRAITH.—What year would this be?

Mr. DOUGLAS.—It was before the 1st of September, 1898. Mr. Hoare and I went over the specification. Some portions of it were founded upon a specification of mine prepared in 1896; that was the first general specification I had written for the Department of Railways and Canals. Other clauses were incorporated, due to

the larger spans of the bridge than those contemplated in the general specification. There were some things I did not agree with and Mr. Hoare would say: It does not make any difference; this specification is not for the construction of the work; it is merely for calling for tenders. That is the best of my recollection. When the contract is let there will be a new specification compiled of a different kind. That is the best of my recollection, and I do not think you will find in the file of the Quebec bridge any endorsement or any report in regard to that. I went through the specification with Mr. Hoare—that is my recollection—in my office. It was not officially referred to me.

Prof. KERRY.—We have on file here a letter from the then Deputy Minister and Chief Engineer of the Department of Railways and Canals advising the Quebec Bridge Company that the specification was approved; the approval, then, was not given on advice from you?

Mr. DOUGLAS.—No, not to the best of my recollection, except that I went over the original specification with Mr. Hoare.

Prof. KERRY.—But Mr. Hoare did not, as I understand you, modify that specification?

Mr. DOUGLAS.—I did not say that there were any modifications required. I accepted the specification in that way; that it was a specification for tenders and not for construction. That is the way I understood it. It was a specification for calling for tenders.

Prof. GALBRAITH.—You practically accepted it, having made no objection to the specification?

Mr. DOUGLAS.—I made no objection to it as a specification for calling for tenders. That is a totally different thing from a specification for construction.

Prof. KERRY.—The whole procedure was a more or less unofficial discussion between yourself and Mr. Hoare?

Mr. DOUGLAS.—Yes, an informal discussion between myself and Mr. Hoare. That is the best of my recollection; I do not remember making any report upon it. I do not think anything will be found in the papers.

Prof. KERRY.—When did the Quebec bridge matter next come to your notice?

Mr. DOUGLAS.—I was instructed by Mr. Schreiber, I think some time in the spring of 1901, to proceed to the bridge and examine into the work that had been done by the Quebec Bridge Company on the substructure. This work consisted principally of masonry in the quarry, some timber for the caissons and such other preparations for constructing the work. That was my first connection with it.

Prof. KERRY.—Will you follow along historically?

Mr. DOUGLAS.—Periodically I made inspection of the substructure and gave estimates on the substructure. I was directed, on a difficult matter in regard to the landing of the south main pier and the foundations, to proceed to Quebec and examine into the foundations, and I think I met Mr. Cooper. In the meantime, Mr. Schreiber came to Quebec, met Mr. Cooper and the foundations were settled without any reference to me or report upon it for the south main pier.

Prof. KERRY.—During this period you are speaking about, Mr. Douglas, the construction tenders were called for by the Quebec Bridge Company?

Mr. DOUGLAS.—Yes, I presume so. I know nothing about that.

Prof. KERRY.—You did not come in contact with any of that?

Mr. DOUGLAS.—No, I did not come in contact with that except by hearsay, that Mr. Cooper had endorsed the plan of the Phœnix Bridge Company and recommended their tender as the plan, and, I presume, their price, were the best. I had no connection with it because at that time the Quebec Bridge Company and the department were apart in one way. It was merely a subsidized bridge, like a dozen others that had been subsidized by the government.

Prof. KERRY.—All that was necessary for the department was to see that the work was sufficiently satisfactory to justify the payment of the subsidy?

Mr. DOUGLAS.—That the general plans were accepted and that the work was going on satisfactorily. Several bridges were going on in the same way—the Cornwall bridge; I inspected that, the bridge on the Musquodoboit river in Nova Scotia, a large bridge with pneumatic pressure, and the Interprovincial bridge over here where there were large piers and foundations. They were all subsidized bridges, and I considered the Quebec bridge a similar bridge to these others.

Prof. KERRY.—When did you next come in contact with matters concerning the superstructure of the bridge?

Mr. DOUGLAS.—The only contact I had with the superstructure, other than the routine moving around of plans in the office, was that the amendments of Mr. Cooper to the specification of 1898 were submitted to me for report. That is the only official connection, outside of the routine of the office, that I had with the Quebec bridge.

Prof. KERRY.—And that was just one set of amendments that he proposed?

Mr. DOUGLAS.—He proposed one set of amendments.

Prof. KERRY.—This only came up once?

Mr. DOUGLAS.—Well, it came up several times in this way; during the interval I made a general sort of report that was not too technical for any layman or engineer that did not know much about bridges to understand.

Prof. KERRY.—Is that a copy of your report (referring to Exhibit No. 58)?

Mr. DOUGLAS.—I have a copy here. My copy of the report is July 9, 1903.

Prof. KERRY.—That is it.

Mr. DOUGLAS.—This is the report that I made.

'OTTAWA, July 9, 1903.

'DEAR SIR,—I have the honour to submit this report upon the proposed amendments to the contract with the Quebec Bridge Company in regard to the specification of the superstructure approved and attached. The proposed changes apply to clauses 28,——

Prof. KERRY.—At that time you had the original printed specification and Mr. Cooper's proposed amendments as well?

Mr. DOUGLAS.—Yes, at that time we had. 'The proposed changes apply to clauses 28, 29, 30, 31, 32, 33, 34 and 35 of the contract specification. Under these clauses and such others as require amendment the Quebec Bridge Company should be requested to substitute the amendments in agreement with their respective numbers.'

I had no connection with Mr. Cooper; it was the Quebec Bridge Company, or Mr. Hoare, their representative.

'The diagrams of engines proposed for train loadings should be denoted as in present specification.'

That is the specification of 1898.

'No approval should be given to future increased train loadings as mentioned in preface and page 3 of proposed amendments.'

Prof. KERRY.—That is to say that you thought it would not be safe to increase the train loadings?

Mr. DOUGLAS.—Yes, as provided for by Mr. Cooper in his amendments.

Prof. KERRY.—Mr. Cooper makes the remark that the train loadings can be safely increased?

Mr. DOUGLAS.—Yes.

Prof. KERRY.—And your report is that you do not consider it safe to do that?

Mr. DOUGLAS.—No.

'In bridges of great span the dead load is of such large proportion to the combined loads it is customary to adopt greater unit stresses than in bridges of ordinary spans. In some of the bridges of large span with a uniform live load and a concentrated load for the floor system the live load for the trusses has been specified 20 per cent less. I should recommend that no greater unit stresses be permitted than 60 per cent.'

In the original draft I had 'in eye-bars and 55 per cent in built members.' I erased the '55 per cent' in built members, but that represents my opinion. My opinion is that no member should be permitted in the bridge greater than 60 per cent of tension members and 55 per cent of compression members, or built members.

'I should recommend that no greater unit stresses be permitted than 60 per cent of the elastic limit of medium steel as specified in the 'general specifications of steel bridges, 1901,' of this department.

That was the new specification which would have applied to this bridge and which had been endorsed by the department, and I did not think that the hodge-podge amendments of Mr. Cooper should be tacked on to the old specification of 1898—that there should be a defined new specification re-written,—'And that the general conditions of that specification as regards stresses of tension, compression, etc., should be followed if a change of contract is desired.' The original specification was a defined contract with the government. It is not my duty nor my office to deal with legal matters but I considered each clause of this a defined contract, and that when Mr. Cooper's changes were submitted the clause as amended should be clearly defined.

Prof. KERRY.—Let us be clear on that point, Mr. Douglas. At this time you had the original specification attached to the contract before you?

Mr. DOUGLAS.—When I first had to do with the Quebec bridge sub-structure I had forwarded to me by the law clerk, or Mr. Schreiber transmitted the subsidy agreement between Her Majesty the Queen and the Quebec Bridge Company. This contract, as I read it, governed my actions.

Prof. KERRY.—The specifications are attached to the agreement?

Mr. DOUGLAS.—They are not attached to this exactly, but the original specifications of the superstructure and the specifications of the substructure were attached to this.

Prof. KERRY.—These are the specifications of September, 1898?

Mr. DOUGLAS.—I have not a copy of the substructure one here and I do not know what the date of it is, but the superstructure is dated Sept. 1, 1908. I do not know whether the substructure is the same date or not.

Prof. KERRY.—That specification of 1898 was made part of the contract between the government and the Quebec Bridge Company?

Mr. DOUGLAS.—Yes, sir.

Prof. KERRY.—And I think you said that the specification did not meet approval and was not referred to you officially?

Mr. DOUGLAS.—To the best of my recollection except in the matter of running over the specification in my office with Mr. Hoare. That is the best of my recollection.

Prof. KERRY.—But at that time you did not regard it——

Mr. DOUGLAS.—I merely regarded that specification as a tentative specification for the sole purpose of calling for tenders.

Prof. KERRY.—And at the time that the subsidy agreement was entered into by the government the specification was not referred to you at all?

Mr. DOUGLAS.—Not that I remember.

Prof. KERRY.—Then when Mr. Cooper suggested these amendments, your intention in making this report was that the bridge should be built in accordance with the department's specification of 1901?

Mr. DOUGLAS.—Yes.

Prof. KERRY.—With certain modifications?

Mr. DOUGLAS.—With certain modifications. I may say that considering the unit stresses, design and erection of the three important parts of a large bridge of that character, and considering that the American government in several cases appointed four or five engineers to consider and determine unit stresses of unexampled magnitude, I thought that this matter was too important to be left to the judgment of Mr. Cooper.

Prof. KERRY.—There is no mention of that in your letter or in your report. In the report to Mr. Schreiber you do not seem to have suggested that procedure?

Mr. DOUGLAS.—It was subsequent to that. I had conversations with Mr. Schreiber and to the best of my recollection in a conversational manner I mentioned the question of consulting engineers. If the matter had been referred to me my intention was to have consulted engineers personally without bringing them in as consulting engineers, and with that in view I wrote to several engineers in preparation, believing that there would be some action taken on Mr. Cooper's amendment.

Prof. KERRY.—What followed the sending in of this report, Mr. Douglas?

Mr. DOUGLAS.—In so far as I was personally concerned?

Prof. KERRY.—In so far as you know?

Prof. GALBRAITH.—There is one point I am not quite clear on as to the date. Between 1898 and July 9, 1903, you made no report on the specifications?

Mr. DOUGLAS.—No sir, not to my recollection. It will be found on the file if there is.

Prof. KERRY.—As I understand it, Dr. Galbraith, there is no official report of any kind bearing on the superstructure that was made by Mr. Douglas other than the one under date of July 9, 1903. Previous to that he had taken no official action of any kind in regard to the superstructure.

Mr. DOUGLAS.—That is it. After these proposed changes I had correspondence with Mr. Hoare; that is personal correspondence, because, going around through the department would take so long, through the red tape manner you never get anything, and I had correspondence with the chief engineer of the American Bridge Company—Mr. Wolfel. That is in July, 1903. I requested Mr. Wolfel to send the stress sheet of the Monongahela bridge, which was the largest bridge in the world that had been built on what you might call the American principle or the eye bar principle. Mr. Deans, is that not the largest bridge?

Mr. DEANS.—Yes, that is the largest cantilever bridge.

Mr. DOUGLAS.—Mr. Wolfel referred my letter to Boller & Hodge, who were the engineers, and Mr. Hodge was kind enough to forward me the specification and stress sheets of the anchor arm of the Monongahela bridge. Then I had correspondence with the American Bridge Company in regard to the construction of large eye bars, July 24, 1903. Mr. Wolfel sent me their experience in the construction of what eye bars they could furnish of a large character, which were the largest that had ever been built in the world. I had my doubts about the eye bars; there had been no experiments made in regard to them except this last disaster. There has been quite an experiment made there. That is my only connection with the Quebec bridge as far as engineering or the department are concerned.

Prof. KERRY.—Then you made this report to Mr. Schreiber recommending practically that Mr. Cooper's alterations be not approved?

Mr. DOUGLAS.—Practically, of course. The general report will show that in the engineering specification of 1901 the elastic limit was 33,000 lbs. It was a defined amount; that would make 19,800 lbs. a limiting unit stress in tension members and 55 per cent of the elastic limit in compression members; that would make 18,250 lbs. a limiting stress on compression members less the general column formula. The American formula, which I do not like—the long line formula—was used and I was in favour of using the Gordon & Rankin formula.

Prof. KERRY.—At the time that you wrote this report, Mr. Douglas, you were aware that the original specifications attached to the subsidy contract were rather carelessly drawn up?

Mr. DOUGLAS.—I was aware they were not fit for the work. I wanted just one specification—the specification of the department, or the revised specification which had been drawn up by myself and which I knew was a proper report.

Prof. KERRY.—You did not make at that time any special examination of the Quebec Bridge Co's. specification without reference to Mr. Cooper's amendments at all?

Mr. DOUGLAS.—No, except it was a contract with the government.

Prof. KERRY.—You knew that had been approved and you did not consider it.

Mr. DOUGLAS.—There were about 15 or 16 amendments to the specification and my action was to get defined amendments and have another specification drawn up.

Prof. KERRY.—That would be a new specification completely setting aside the Quebec Bridge Co's. specification?

Mr. DOUGLAS.—I have this personal letter from Mr. Hoare and I will merely read portions of it.

'I have your letter of the 12th inst. I am sending you by express the original strain sheets based on specification September 1st, 1898, which you have on file.'

These were personal to my office. He sent them personally.

'The strain diagrams for present design cannot be made until the proposed changes by Cooper are adopted. The figures for the original will give the proportions for all loads; the dead load results will, however, be greater in the present bridge. Don't change the original specification. We desire Cooper's made a supplement to it for loads and unit strains. It can be attached and endorsed as such. A more simple and quicker method of dealing with it than disturbing the original. Please don't change, Cooper's column formula being more practical and rational than Gordon's in any specification.'

Prof. KERRY.—You better refer to the date of that letter.

Mr. DOUGLAS.—June 15, 1903.

Mr. HOLGATE.—From?

Mr. DOUGLAS.—Mr. Hoare.

Mr. HOLGATE.—To?

Mr. DOUGLAS.—To myself. It is merely a personal letter. They wanted the change to go in holus bolus and I could not do anything.

Prof. KERRY.—Subsequent to this report the question of the specification never came before you officially at all?

Mr. DOUGLAS.—Mr. Cooper came to Ottawa and Mr. Schreiber and Mr. Cooper settled on the changes in the specification themselves without any consultation with me.

Prof. KERRY.—Following that action detailed plans for the construction of the bridge were prepared and were sent in to the department for examination and approval?

Mr. DOUGLAS.—Yes, sir.

Prof. KERRY.—You made an examination of these plans for the department, Mr. Douglas?

Mr. DOUGLAS.—Yes, sir.

Prof. KERRY.—And in making that examination were you guided by the original specification, or by the original specification with Mr. Cooper's amendments attached?

Mr. DOUGLAS.—I was not guided by anything except Mr. Cooper's signature; practically, he was responsible for the plans.

Prof. KERRY.—But you checked the plans did you not, to see that they were in accordance with ——

Mr. DOUGLAS.—I checked them in accordance with the contract, I did not compute them.

Prof. KERRY.—But when you were checking your plans did you read Mr. Cooper's

Mr. DOUGLAS.—Oh yes, I considered Mr. Cooper's amendments, certainly.

Prof. KERRY.—As being part of the contract?

Mr. DOUGLAS.—Oh, yes, certainly, his unit stresses and his changed loading were considered in the examination of the plans.

Prof. KERRY.—Had you any official authority for doing that?

Mr. DOUGLAS.—No official authority except the official authority 'referred to Mr. Douglas' written on the sheet.

Prof. KERRY.—No, I mean official authority for considering that Mr. Cooper's amendments were part of the contract.

Mr. DOUGLAS.—No, not that I remember, except by looking through the file; no, I was not notified except by looking through the file. I found that they had probably been approved by order in council.

Prof. KERRY.—I will read over this order in council or part of it, this extract from Exhibit 18:

'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 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.'

Prof. KERRY.—Is that the order in council that you refer to?

Mr. DOUGLAS.—I do not remember ever reading it.

Prof. GALBRAITH.—What is the date of that?

Prof. KERRY.—August 15, 1903.

Mr. DOUGLAS.—My recollection is that I read Mr. Schreiber's report to the minister recommending the approval of these amendments themselves, and then written on 'C. in C.,' something like that, order in council, and that is all I know about it.

Prof. KERRY.—This is word for word the same as Mr. Schreiber's letter?

Mr. DOUGLAS.—I remember reading Mr. Schreiber's report but I do not remember the following up of the official action.

Prof. KERRY.—You might look over this (Exhibit No. 60), Mr. Douglas, and see if this is a copy of the letter from Mr. Schreiber that you read?

Mr. DOUGLAS.—No, sir, I do not think it was; it was a letter referring to Mr. Cooper as a celebrated engineer and all sorts of things.

Prof. KERRY.—We do not seem to have that letter of Mr. Schreiber's but Exhibit No. 17 contains a copy of it. Perhaps that is the letter you refer to, Mr. Douglas?

Mr. DOUGLAS.—Yes, sir, that is the copy I read, it is followed up by an order in council, so I did not bother with the order in council.

(Mr. Douglas identified the letter, a copy of which forms part of Exhibit No. 17, as the letter he saw.)

Prof. KERRY.—You concluded then, without any precise instructions, that Mr. Cooper's amendments were approved of by the department?

Mr. DOUGLAS.—No, I would assume from the letters there would be an order in council, that is an order in council approving, but as to the special reading of the order in council, I do not remember. I would see on the backing that an order in council naturally had been passed approving of the amendments.

Prof. KERRY.—The amendments had already been referred to you at that time, and you had a copy of them in your possession?

Mr. DOUGLAS.—No, sir, I had not a copy in my possession, they were in the file.

Prof. KERRY.—You returned them to the file?

Mr. DOUGLAS.—Yes, they were in the file. I did not have anything to do with them.

Prof. KERRY.—They were there, I suppose, where you could consult them at any time?

Mr. DOUGLAS.—Oh, yes.

Prof. KERRY.—In the order in council pursuant to that letter of Mr. Schreiber's, they say 'that the new loadings proposed by their consulting engineer be accepted,' and as we read that, that simply approved the increase of live loads.

Mr. DOUGLAS.—No, the amendments, there was a change of live loads. To the best of my recollection there was a change of live load on account of the increased span; it was 200 feet longer. The original live loads were for a 1,600 foot span, and changing to 1,800 feet necessitated a new condition of what is called loadings. This is a diagram I found showing Mr. Cooper's amendments as to loadings, which were quite correct.

Prof. KERRY.—What diagram is this?

Mr. DOUGLAS.—This is a copy I made to show you what it means.

Prof. KERRY.—The point I am trying to clear up is this, that the order in council seems clearly to approve the change of the live loadings; it does not seem to approve any increase in the unit stresses.

Mr. DOUGLAS.—I do not know anything about that.

Prof. KERRY.—But in a subsequent examination of the plans made by the department the increase of the unit stresses was adopted.

Mr. DOUGLAS.—Yes, the increase.

Prof. KERRY.—You used in your examination——?

Mr. DOUGLAS.—I used in my examination Mr. Cooper's amendments as those amendments were noted by the Phœnix Bridge Company on their plans. These plans bore a note, as I remember, 'according to the specifications of the Quebec Bridge Company as amended by Theodore Cooper.'

Prof. KERRY.—That was used?

Mr. DOUGLAS.—That was used in the examination of the plans.

Prof. KERRY.—For checking the plans?

Mr. DOUGLAS.—In checking them, examining them.

Prof. GALBRAITH.—Did you understand that the change in live loading was due to a change of span from 1,600 to 1,800 feet? That was your understanding, was it?

Mr. DOUGLAS.—Oh, that was my understanding essentially, yes. And it was necessary; whether that loading was advisable or was correct is a matter of opinion.

Prof. GALBRAITH.—And you approved that?

Mr. DOUGLAS.—Yes, the change of 200 feet in the length of the span necessitated a change of live load.

Prof. GALBRAITH.—That was the consideration that came in there, that was the cause?

Mr. DOUGLAS.—That was one of the causes.

Prof. KERRY.—There is a copy (Exhibit 21) of the Quebec Bridge Company's specification, of September 1, 1898, with Mr. Cooper's amendments attached to it, the amendments being dated June 2, 1903. Can you identify those papers as being copies of the specifications that were used by you in checking the plans submitted by the Quebec Bridge Company?

Mr. DOUGLAS.—I can identify the specification of 1898, but Mr. Cooper's amendments that were referred to me would be marked 'referred to Mr Douglas.' This is a copy, I presume; these are the ones certainly.

Prof. KERRY.—You might just look at them and make sure that they are.

Mr. DOUGLAS.—This appears to be the same, some of it appears to be the same but my impresion is that Mr. Cooper's amendments were in manuscript, Mr. Cooper's handwriting, what I saw or what I took note of. I took note of them, I think they are similar. If I remember rightly they were in manuscript; I do not know.

Prof. KERRY.—In your examination of the plans submitted did you use the notes that you referred to or did you use the notes found on the Phœnix Bridge Company's plans?

Mr. DOUGLAS.—I used principally the notation of the Phœnix Bridge Company's plan together with the notes I had taken of Mr. Cooper's amendments.

Prof. KERRY.—Could you say that these amendments attached to this exhibit (Exhibit 21) agree with your notes?

Mr. DOUGLAS.—I think so, practically, yes; yes, as far as that is concerned. I have the notes here.

Prof. KERRY.—We understand that these facts in this document are entirely your personal opinions and are in no way official?

Mr. DOUGLAS.—Those are merely a collection of facts for an enlarged report, a general report, an engineering report.

Prof. KERRY.—If you see fit to do so, Mr. Douglas, the Commission would be very pleased to have a copy of your own professional opinions of that date.

Mr. DOUGLAS.—That is not an opinion, that is simply a collection of facts.

Prof. KERRY.—We would be very pleased to have it?

Mr. DOUGLAS.—Very well, if you take it as it is.

(At the request of the Commission, Mr. Douglas filed some notes made by him personally during the summer of 1903 with regard to large span bridges. Document filed and ordered to be copied and marked as Exhibit No. 67.)

Mr. HOLGATE.—This was never made official use of in your department?

Mr. DOUGLAS.—No, I never made a report, the thing was settled.

Prof. KERRY.—Now, the procedure, as I understand it, was for the Quebec Bridge Company to send its plans up to the department for approval, and they would be sent to your office by the department.

Mr. DOUGLAS.—For examination; correct, sir.

Prof. KERRY.—And after you had examined them and signed them——

Mr. DOUGLAS.—Signed as examined they would go to the chief engineer for approval.

Prof. KERRY.—Will you let us know just how completely those plans were examined; what part of the plans?

Mr. DOUGLAS.—The plans were examined first for Mr. Cooper's signature, that is the principal part of it. Then they were examined to see whether they were in accordance with the specifications as attached to the contract with the Quebec Bridge Company.

Prof. KERRY.—Was the stress sheet checked over in that examination, Mr. Douglas?

Mr. DOUGLAS.—No, the stress sheet did not come in until after the plans. The plans came in before the stress sheet. There is no checking, there were no computors in the office and there is no information in the office, even if there were, to check up.

Prof. KERRY.—And some plans, Mr. Douglas, were probably officially approved by the department before the stress sheet was received?

Mr. DOUGLAS.—The first note of the plans coming in to me, the first plans came in October 3, 1903, enclosed as 'blue prints—details of floor beams and stringers "all approved by Mr. Cooper".' Mr. Hoare sends these in all approved by Mr. Cooper. Then on November 4th, the floor system of anchor arm; then for January 21st, 1904, truss floor beams of cantilever arm; on January 19, 1904, truss floor beams; on March 8th, 1904, truss floor beams, anchor arm. Then on April 8th, design of suspended span. June 18th, stress sheet anchor arm. I suppose that some of the floor beams were built before the plans were approved, for all I know.

Prof. KERRY.—June 18th, 1904, that would be the time the first stress sheet reached you?

Mr. DOUGLAS.—It came into the department, yes. That is the date I have put. The first plans came into the department on October 3, 1903. That is, the plans of the large bridge, I did not mean the approach spans. I have noted the stress sheet of the anchor arms, June 18th, 1904.

Prof. KERRY.—Then with regard to these stress sheets, Mr. Douglas, under the

system of examination, the actual stress on each member would not be checked at all in the department?

Mr. DOUGLAS.—They would not be checked in the department; they would not be checked by me, for in that way I would be holding myself responsible for all the bridges over the country.

Prof. KERRY.—You have no staff to do that?

Mr. DOUGLAS.—No, I have no staff to do that. Generally with subsidized bridges they place a contract before the department and they agree to do certain things and certain loadings and certain stresses and all that sort of thing. If they make a mistake in their plans it is their own funeral.

Prof. KERRY.—If a mistake is made in those plans the department has no machinery——

Mr. DOUGLAS.—No, only that in observing the plans if I saw anything wrong with them in the general examination—I do not simply look at them—if I should see anything wrong of course I draw attention to it.

Prof. KERRY.—Then would you proceed to determine that each member had sufficient sectional area to carry the strain shown on the stress sheet?

Mr. DOUGLAS.—No, not exactly that. I would take the stress denoted on the stress sheet and divide it up by Cooper's amendment—by the unit stress as denoted on the plan.

Prof. KERRY.—And see whether the area was——

Mr. DOUGLAS.—Whether they corresponded—not exactly as checking.

Prof. KERRY.—In each case what would you do?—take the total stress shown, divide it by the effective area of the member and see whether the unit strain was less or more?

Mr. DOUGLAS.—Was the same as endorsed on Mr. Cooper's amendments.

Prof. KERRY.—In each case, before you put your signature to the plan, you found that the plan was correct?

Mr. DOUGLAS.—Yes, the plans were correct in every way as far as my general observation as an engineer indicated. They were well drawn and the details were good. There was nothing wrong with them in any way.

Mr. HOLGATE.—As far as you know, they were complete?

Mr. DOUGLAS.—Yes.

Prof. KERRY.—You examined them from what you might call an engineer's point of view, not a computing office point of view?

Mr. DOUGLAS.—Yes.

Prof. KERRY.—You examined the detail of each of the members?

Mr. DOUGLAS.—Yes, I examined them as an engineer so as to be conversant with them if anything occurred.

Prof. GALBRAITH.—You made yourself familiar with them, and with all the connections?

Mr. DOUGLAS.—That was after the examination I made myself familiar with them. I did not go into all tie plates, splice plates and rivets and everything of that description. I looked at them as an engineer as a question of interest.

Prof. KERRY.—You know there is now considerable suspicion in regard to the efficiency of some of the lower chord members?

Mr. DOUGLAS.—Yes.

Prof KERRY.—You examined these plans from an engineering point of view and found them satisfactory?

Mr. DOUGLAS.—I thought them satisfactory as far as the specification went. If they had been built according to the calculation of 1901 they would have had to have had a cover plate upon them.

Prof. KERRY—At the time that you looked over the plan you were not at all apprehensive as to the safety of the structure?

Mr. DOUGLAS.—No, not in the slightest, except that after the fact, or before the fact, there might be some criticism.

Mr. HOLGATE.—But you made no criticism?

Mr. DOUGLAS.—I was not asked; I made an examination, that was all.

Mr. HOLGATE.—In your examination of the various specifications, Mr. Douglas, and any recommendations which you made, did you make any recommendations with regard to the fabrication of the bridge or in regard to its erection?

Mr. DOUGLAS.—My connection with the Quebec Bridge Company ceased at that report as an engineer.

Prof. KERRY.—Would it be a fair statement, Mr. Douglas, to say that for all practical purposes in connection with the actual design and construction of the bridge, Mr. Cooper could be considered as acting as engineer in charge for the department?

Mr. DOUGLAS.—I should not say that he would be exactly—not as I understood it or understand it.

Prof. KERRY.—I want to get at it, not formally, but as a matter of absolute fact. Any detail of construction that would be approved by Mr. Cooper, or any engineering question that would come up, and on which Mr. Cooper would pronounce a definite opinion would be settled in accordance with Mr. Cooper's opinion?

Mr. DOUGLAS.—I should say that is my understanding of Mr. Cooper's connection —I would not say with the government—but with the Quebec Bridge Company, because you could not get anything from the Quebec Bridge Company except from Mr. Cooper.

Prof. KERRY.—And the department practically accepted any plans that carried Mr. Cooper's signature?

Mr. DOUGLAS.—I do not know about the department. They were sent to me for examination; I examined them and then Mr. Schreiber approved them. He is the department. He takes the responsibility of approving them.

Prof. KERRY.—Mr. Schreiber told us yesterday in his evidence that it was generally understood that the interests of the government and the Quebec Bridge Company were alike, and that those interests were considered to be thoroughly taken care of by being entrusted to Mr. Cooper.

Mr. DOUGLAS.—That condition has arisen since I had anything to do with the bridge as an engineer—that is since the specification—so that I know nothing about it.

Prof. KERRY.—As far as you know, that was what you might call the general temper of the department?

Mr. DOUGLAS.—As far as I know. Everything went.

Mr. HOLGATE.—You said that in examining the plan the thing you looked for was Mr. Cooper's signature?

Mr. DOUGLAS.—Certainly. He was paid for that business, and I saw that he had his name there. I presume the department considered that Mr. Cooper was the authority, because they never referred anything to me.

Prof. KERRY.—As far as you know, Mr. Douglas, there was never any proposal on the part of the government to appoint an engineer who should be permanently resident in the vicinity of the bridge during construction?

Mr. DOUGLAS.—I do not know of any such movement. Previously on bridges on which I was acting as bridge engineer, I had my own personal inspector, and he reported to me week by week or day by day. That was the customary method. When the Cornwall bridge collapsed there was a great hubbub in the papers about the inspection of bridges, and most of the large bridges I had an inspector on.

Prof. KERRY.—In this case the usual practice of the department was not followed?

Mr. DOUGLAS.—No, I cannot say that. There was no practice about it. Sometimes on an important structure they would instruct me to look after it, but if the department were going to look after the construction of bridges all over the country they would have a pretty big contract.

Mr. HOLGATE.—In the case of the Cornwall bridge, was there a consulting engineer employed on that in the same capacity as Mr. Cooper?

Mr. DOUGLAS.—No. It was more with regard to the substructure, the pressure work and the re-enforcement of the piers and that sort of thing that I was down there.

The building of the superstructure of the Cornwall bridge was in American territory, and we had nothing to do with it.

Prof. KERRY.—We understood you to say that you had not had occasion officially to visit the bridge during the progress of the superstructure at all.

Mr. DOUGLAS.—In that connection I would correct a misapprehension of Mr. Schreiber in his evidence yesterday. He, by interjecting my name in many places, would lead you to think that I had been connected with the bridge during the whole construction I only visited the bridge during the time of the construction of the substructure. Since the commencement of the erection of the superstructure I have not visited the bridge, and I never saw it until it collapsed.

Prof KERRY.—And to the best of your knowledge, Mr. Douglas, no other officer of the department visited the bridge for the purpose of carefully inspecting the details of construction.

Mr. DOUGLAS.—I thought that perhaps Mr. Johnson was doing the work in the way it should be done. An engineer could not do it. He could not climb over the bridge; he would have to have his own inspector—a man he had confidence in. An engineer would not do any good; he would want a first-class inspector. At least I would not climb 350 feet high, or 150 feet from the ground.

Mr. HOLGATE.—Then, was the regular procedure of your department applied to the construction of the Quebec bridge?

Mr. DOUGLAS.—There was no regular procedure.

Mr. HOLGATE.—I understand that there is a regular procedure in your department in regard to the construction of subsidy bridges?

Mr. DOUGLAS.—Not in regard to inspection.

Mr. HOLGATE.—In regard to the connection of your department with subsidy bridges?

Mr. DOUGLAS.—Yes, ordinarily.

Mr. HOLGATE.—Was that regular procedure followed?

Mr. DOUGLAS.—Yes, as ordinarily.

Mr. HOLGATE.—Was there anything more than the ordinary procedure followed except that you had the assurance of the Quebec Bridge Company of their appointment of Theodore Cooper as their consulting engineer?

Mr. DOUGLAS.—That is as I understood it. I always considered that it was the regular procedure of the department in regard to a subsidized bridge. After the government came into it, I do not know anything about it.

Mr. HOLGATE.—I think that is all, unless there is anything you wish to say.

Mr. DOUGLAS.—No, I have said all I wish to say.

The Commission adjourned to meet again at the call of the Chairman.

The Royal Commission on the Quebec Bridge met in New York city, October 14, 1907, and proceeded with the examination of Mr. Theodore Cooper, consulting engineer of the Quebec Bridge Company, which lasted until October 22.

## MR. COOPER'S TESTIMONY.

Q. What were your first relations with the Quebec Bridge Company or with any of its officials and at what date?—A. About February 25, 1899, I received a communication from the Quebec Bridge Company asking if I was at liberty to take up the examination of their competitive plans. I replied in the affirmative. The next occurrence, as far as my memory goes, was upon the 23rd of March, when Mr. Parent, Mr. Hoare and Mr. Barthe, the secretary, came to New York and had a personal interview with me. They gave me a brief account of what the plans were, I having had

no previous knowledge of the same, and asked me upon what terms I would undertake the examination, and how much time it would probably require. I stated, with the slight knowledge I had of what they were describing, and assuming that they wished a relative report rather than a detailed critical report on all the numerous plans, that I thought it would require about three months' time, and I stated my fee for performing that service. They then asked me under what terms I would act as consulting engineer when the work was under construction. I stated my fee. They then asked if the inspection of the work was included in my services. I distinctly stated it was not. They then asked me to give them an estimate of what the probable cost of the inspection would be. I told them that with the slight knowledge I had of the subject my estimate would be very much in the line of a guess, but I assumed from the magnitude of the work and from what I supposed it would be, that it would probably cost from $20,000 to $25,000 for the shop inspection. I do not think they accepted any of my offers at that time, but Mr. Parent left me under the impression that the plans would be sent to me. My offer as consulting engineer was not acted upon.

Q. Previous to your engagement to report upon the competitive plans had you been consulted in any way about the project and had you seen the plans and specifications prepared by the Quebec Bridge Company?—A. No, I had no knowledge in regard to the project except what was in the technical papers stating what they proposed. I had no definite knowledge except the general knowledge that they were preparing to build a bridge at Quebec.

Q. Were the outlines of the preliminary plan prepared by the Quebec Bridge Company generally followed in the final design?—A. That question I do not thoroughly understand, but I suppose it has reference to the legal requirements which, I think, were embodied in the tracing showing the profile of the river, the distances and the legal requirement of 1,200 feet at a certain elevation above the water. That is the only preliminary plan that I know of.

Q. By whom were the details and outlines of this preliminary plan suggested?—A. I do not know.

Q. Did you consider that any change in the general type or outline of the structure was desirable and were any studies made to this end?—A. Certainly not at that time, because I had no knowledge of any type or other outline than before mentioned.

Q. At the present date and with the advantage of the several years of additional experience would you confirm your original recommendation both as to the type of the structure and as to the merits of the design submitted?—A. Yes, if under the same limitations that existed at that time as to the amount of funds apparently estimated for the construction. That is an important point, because the structure was apparently limited to the amount of funds they had in sight as far as it was impressed on me. The impression was given me that this work was to be constructed by a private corporation, that the amount of money that they expected to have was a limited amount, and the question to be decided was the possibility of building the best bridge within the financial strength of the company. The question of the best bridge was not brought up at all. So that, to answer that question a little more fully, it must be limited by that statement, but with my present knowledge I could make further recommendations.

Q. It is not an unknown practice for a bridge-building company to secure the promise of a contract from the promoters at a very early date, and in advance of the calling for competitive tenders?—A. It is a general belief that that is not an unknown practice.

Q. Have you any reason to think that any such understanding existed between the officials of the Quebec Bridge Company and the Phœnix Bridge Company previous to the final award of the contract?—A. Not to my knowledge. I was left absolutely unhampered in any manner in my report as to which I should consider the best plan and the best bridge. In no manner was there anything indicated to me that one plan should be preferred over any other or any one bid over any other.

Q. On what date did you accept appointment as consulting engineer to the Quebec Bridge Company?—A. I received a letter appointing me consulting engineer to the Quebec Bridge Company on May 6, 1900.

Q. What extent of professional responsibility was given to you in connection with this work by the Department of Railways and Canals, and how and when was this responsibility given?—A. In a supplementary report with even date of my report upon competitive plans, June 23, 1899, I stated in a general way that my examination of the competitive plans was based entirely upon the specification and data furnished me by the Quebec Bridge Company, that I thought, before the construction of the work should be undertaken, careful study should be made to see if a better bridge could not be had and whether a change of span was not desirable. On May 10, 1903, Mr. Parent informed me verbally—I think it was—that the financial affairs were in such shape that the work could now be done. I then took up again with the Phœnix Bridge Company and with the chief engineer the necessary modification of the loads and stresses to suit a bridge of this magnitude. After considerable discussion between Mr. Szlapka, the designing engineer of the Phœnix Bridge Company, myself and Mr. Hoare, it was found that nothing could be done in the way of changing the original specification except with the authority of the Deputy Minister of the Department of Railways and Canals. After considerable correspondence (which is on file) and discussion and a personal visit by myself to Ottawa, I received, on August 23, a copy of an order in council dated August 15 (Exhibit No. 18), certified by the Clerk of the Privy Council, giving me, in a general statement, the authority to make modifications from time to time in the specifications and the proposed loadings, subject to certain provisos, and 'provided the efficiency of the structure be fully maintained up to that originally defined in the original specifications attached to the company's contract' (Exhibit No. 12).

Q. 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?—A. I cannot give dates, but fully three years ago, I think—certainly over two years ago, before the work of erection had commenced at Quebec—Mr. Parent, in my office, asked me when I was going to Quebec next. I answered: 'Mr. Parent, I never expect to be able to go to Quebec again; I am under the ban of my physician, and I feel that I ought to be relieved of the responsibility which is upon me, as it is impossible for me to give it that attention that I conscientiously feel I should do.' I do not, of course, know whether Mr. Parent looked upon that as an official statement, but he protested, and said: 'Mr. Cooper, we never intend to let you go until the bridge is done; we have confidence in you and we want your services continued.' About the same time I told Mr. Deans, the chief engineer of the Phœnix Bridge Company, that I thought I should withdraw, that while I appreciated the complication that it would involve and the difficulty of their mutually selecting somebody who would be satisfactory, I would gladly withdraw from any further responsibility. He likewise protested, and said they could not submit to that; that they did not know of any one upon whom they could all mutually agree, that they felt the same confidence in and to whom they would be willing to submit an important contract like the one under execution. Realizing this difficulty, and feeling also a pride and a desire to see this great work carried through successfully, I took no further action.

Q. Was your advice asked in connection with the framing of the contract for the construction of the bridge, and if so, upon what points?—A I do not recollect in any manner having been consulted on the framing of the contract.

Q. Are you conversant with this contract?—A. I have no knowledge whatsoever in regard to this contract except what I have gathered casually and inferentially from time to time.

Q. Did you consider that the order in council of August 15, 1903 (Exhibit No. 18), gave you as consulting engineer for the Quebec Bridge Company full and absolute authority to amend the specifications and to order such alterations in the construction

plans as seemed best in your judgment?—A. Yes, under the restriction that the efficiency of the structure should not be in any way reduced from that originally proposed, and subject to the provisos previously referred to.

Q. Had your decisions to be referred for confirmation to any officials of the Quebec Bridge Company, or of the Dominion of Canada?—A. I think every change of any importance, certainly all those in the specifications, were referred to the chief engineer, Mr. Hoare, and supposedly through him to the department.

Q. Please state what alterations were made on your advice and on your authority to the original specifications attached to the contract? Were these alterations accepted by the Phœnix Bridge Company without discussion, and were they observed by it throughout the work?—A. As an experienced engineer of many years' standing, I recognized that the original specification of the Quebec Bridge Company was what I would call a 'scissored' one; that it was not drawn upon any theory by any person having the importance of this bridge structure in his mind. Although a specification for a Canadian bridge, there was no recognition of the snow weight that must at times come upon this structure. The requirements for the wind strain were those practically imposed upon the Forth Bridge against the protest of the chief engineers of that bridge, Messrs. Baker and Fowler. The train load and train requirements were not as great as I thought they should be in the present state of transportation. I saw that a large amount of the material in this bridge was going to be devoted to giving it horizontal strength against an imaginary and an impossible wind, material that could be much more favourably placed to give the bridge vertical strength under higher train loading. I therefore corrected the specifications to provide for a less wind strain than that originally required, with a greater vertical loading than that at first required. Being impressed with the necessity of restraining the weight of the structure under these new loadings and changes of loads so that it would not exceed the original estimated weight contained in the contract, I made modifications in the unit strains to be employed upon the various members, with the view of keeping the final weight within the limitations and yet obtain more harmony in the relative strength of the different parts of the structure. Previous to taking up the consideration of the new loadings, the 210 feet spans making the approaches on each side had been constructed. On examining the plans, when submitted to me, I found that the floor system was excessively heavy. I immediately wrote to Mr Hoare, the chief engineer of the Quebec Bridge Company, that I found the floor system on these 210 feet spans unnecessarily heavy, that they exceeded by 18 to 20 per cent the best requirements of the Pennsylvania Railroad and all first class railroads in the United States; that I understood that directions had been given to build these approach spans according to the official specifications of the Department of Railways and Canals of Canada. I wrote to Mr. Hoare as follows: 'While it is a matter of not much importance for these particular spans, if this is to be taken as a precedent for the main spans, it will add considerably to the weight.' I afterwards explained that for every extra pound put in the floor system from four to five pounds extra metal would be required in the trusses to carry it, and that this excessive requirement would render it impossible to build the structure within the limitation of the financial ability of the company, and that I did not consider it would in any way detract from the perfectly safe and satisfactory building of the bridge to lower the requirements to those accepted by the first class railroads throughout the United States.

Q. Were these alterations accepted by the Phœnix Bridge Company without discussion, and were they observed by it throughout the work?—A. As I believe I stated previously, these alterations made by me were discussed with the designing engineer of the Phœnix Bridge Company. This, however, was not for the purpose of getting at their wishes, but to get the benefit of the views of Mr. Szlapka, a brother bridge engineer, upon the suggestions that I was making.

Q. Please state the approximate dates upon which the following operations were commenced:—

(*a*) The preparations of the final plans in detail.
(*b*) The rolling of the necessary metal.
(*c*) The fabrication of the metal in the shops.
(*d*) The erection of the structure into position at the site.

A. Most of these questions will have to be answered by the contractor if exact dates are required. As to the preparation of the final plans in detail, I could give you the dates from the different plans if I had my office plans here, but speaking from memory I cannot. On September 15, 1903, I received the first plans, the plans for the floor system.

The rolling of the necessary metal undoubtedly commenced as soon as they got my approval of the first plans. Of course that is a presumption; the exact information can be obtained from the Bridge Company itself. While I know they started rolling the metal as soon as they could, my testimony would not be positive on that matter; I simply answer, about the latter part of September.

The information as to the fabrication of the metal in the shops would be obtained in the same way; they all followed one after the other. I do not suppose it would be three weeks after I received the plans until the shops were going on the floor system.

The erection of the bridge began on the south anchor arm on July 22, 1905.

Q. Was there ample time between the award of the contract and the beginning of the work in the mills and shops for the preparation of the construction drawings? Do you consider that sufficient time was given to the study and preparation of the drawings, and, if not, for what reasons was this time curtailed?—A. The Phœnix Bridge Company practically had the contract for the construction of this bridge several years before they commenced the preparation of the plans. I urged them at an early date to prepare their studies and plans as far as possible for the accepted 1,800 foot spans for which no plans had yet been prepared, stating that in an important work like this very cautious and very careful consideration would be required in each and every individual detail of the structure, and that this should be done before the rush of construction would come upon us. They gave this no attention, and practically made no steps towards preparing the plans until they had completed their financial arrangements and had executed their present contract as I believe dated June 19, 1903 (Exhibit No. 16). There has not been time enough given, in my opinion, to the careful study and preparation of the drawings and plans of this structure, free from the rush and push of its practical execution. As I understand it, the time stated in this contract for the completion of the work, as verbally given me by Mr. Deans at the time, is three years. I protested against that, and stated it was an absolute impossibility to construct that bridge in three years, that under the most favourable circumstances without considering any contingencies, four years at least would be needed, and in my judgment five at least should have been asked for. I told Mr. Deans at that time that this meant rush and hurry, and the impossibility of giving thoughtful and careful consideration to every step before undertaking the work in the shop. The urgency and demand of the manufacturing side of this problem here, in my opinion, outweighed and burdened the technical and thoughtful consideration of all the plans.

Q. What organization existed for the checking of the strain sheets and detail plans prepared by the Phœnix Bridge Company?—A. My own office organization absolutely.

Q. At whose expense was this organization maintained and was it sufficient for the purpose?—A. At my own expense, and it was not sufficient for the purpose considering the other duties which were imposed upon me improperly.

Q. Was this work properly part of the duties of the consulting engineer?—A. I so considered it to be.

Q. Was it found necessary to order alterations in the plans prepared by the Phœnix Bridge Company in any important particulars and, if so, what were the principal alterations made?—A. Yes, numerous and comparatively minor alterations were frequently called for when the detail plans did not fully come up to the require-

ments. The most important alteration, however, was that of the long eye-bar chord of the anchor arm. It was about the first of June, 1904, that the Phœnix Bridge Company submitted their plan and arrangements for the top chord and diagonals of the anchor arm. After careful personal examination, I declined to approve it as having violated the requirements that I had stated in a personal conference with the engineers and proprietors of the Phœnix Bridge Company I should demand. At that conference I stated that I would accept no bars exceeding two inches in thickness unless it was an absolute necessity to use a greater thickness. My experience had proved to my mind that when that thickness was exceeded satisfactory bars could not be obtained. In this plan submitted for the top chord they had used bars two and one-half inches in thickness and other prohibitory thicknesses, and they had arranged the bars at angles which were, to my mind, thoroughly unsatisfactory and I called for a new design. Mr. Szlapka came and had a personal interview and protested that it could not be made better, that he had had his best men on it for two months and he could see no change that could be made in it that would come nearer to my requirements than this plan. I stated I never would approve it and finally I was compelled personally, although it was work I had not done for twenty years, to redesign the whole system. It was a very arduous and trying work and when I was through I was thoroughly exhausted. I gave them a copy of my design and stated that it was not the best that could be done, but that it was the best that I could do, and I hoped now they would take the matter up from the point of view of the changes I had made and still further improve it in certain details which I pointed out. It was in early June that I first took up the question of this eye-bar chord. While I was working on this chord, on July 10, Mr. Szlapka brought me a new packing which I refused again to approve and it was not until July 31 that I succeeded in getting from the Phœnix Bridge Company a satisfactory chord packing in conformity with my views and requirements.

Q. Were the plans finally approved to your entire satisfaction or would you have given them further study had you been able to do so?—A. I should have been glad to have had the physical strength and the time allowed me to have given further study to many parts of this structure, but in my physical condition I have been compelled, and must accept the responsibility for the same, to rely, to some extent, upon others. I had and have implicit confidence in the honesty and ability of Mr. Szlapka, the designing engineer of the Phœnix Bridge Company, and when I was unable to give matters the careful study that it was my duty to give them, I accepted the work to some extent upon my faith in Mr. Szlapka's ability and probity.

Q. What organization was created to see that proper material was secured for the construction and that the shop work was in all particulars up to the requirements of your specifications and in accordance with your instructions?—A. There were inspectors appointed at the mills to inspect the crude material as rolled to see that it was up to the specifications and requirements. There were inspectors at the shop to inspect the mechanical work and to see that all the details complied with the approved drawings.

Q. Was this inspection properly part of the duties of the consulting engineer, and was the organization of this inspection in accordance with your advice? Were you satisfied that the inspectors appointed were, in all respects, the men best qualified for the position and if not, why and by whom were they appointed? Was your advice with regard to the local force required for inspection and charge of erection asked or did you find it necessary to offer advice on this point? Was this advice followed?—A. It was not properly the duty of the consulting engineer, and the organization was not in accordance with my advice. Long before any work of construction was started at the shops the chief engineer of the Quebec Bridge Company asked me in regard to the matter of the inspection, and I outlined the following programme, stating that the inspection of the shop work on this structure was far greater and more important than anything that we had had experience with before, that the features of the mechanical work were minor ones compared with the necessity of

watching all the technical features of the plans, and that technical engineers, if possible with shop experience, who could not only inspect this work in the mechanical requirements, but see that all the technical requirements of the plan and strain sheets were properly executed, should be employed. I expressed a desire that technical graduates should be appointed to the position of inspectors at the shops. I pointed out that after the erection work commenced we would need a highly developed class of men to take charge of that part of the work; it would be very responsible and very difficult to undertake, and that I hoped we could gradually weed out from those who were at the shop men who were competent to take charge of the inspection of the erection after it commenced. I also pointed out to the chief engineer of the Quebec Bridge Company that when this bridge was done and finally completed and turned over to the proprietors it would be necessary to have a competent body of engineers to have charge of the structure, its maintenance and general supervision, and that such men should be men who were thoroughly acquainted with the whole history of the construction, the whole theory of the work, and who would be able to know the thing as intimately as possible in order to maintain and take care of the structure properly. I stated that in view of this matter I thought it would be fair and proper that, if it were possible, these inspectors should be Canadians, graduates of Canadian institutions, because I stated that the men having charge of this work would have to live there, and they should be men of the country. I did not feel that Mr. Hoare was in sympathy with this matter, and I did not succeed in obtaining at that time the men I hoped for. At a conference at Phœnixville about the time the work was under way, the necessity of an inspector became imperative, and I stated that I was hampered, that the men's names that Mr. Hoare had sent me did not satisfy me sufficiently to have me recommend them, and that I had no real right to take up that matter. Mr. Reeves, the president of the Phœnix Bridge Company, stated at that time that Mr. Edwards, who is the present inspector, had been inspector at their shops for many years, and that they considered him a very competent man, that he was *persona grata*, and that he would recommend me to give him consideration. I had Mr. Edwards come to my office and examined into his history and found that some seventeen years before he had done some inspection for me that was satisfactory, and that he had been constantly an inspector from that time on, and I appointed him inspector at the shops, and so reported to Mr. Hoare. Later on, feeling the necessity of having some one qualified for the inspection of the erection, and failing to get any such person appointed, I heard of Mr. McLure, bridge inspector at that time on the New York, Ontario and Western Railroad. I sent for him and examined into his career. I found he was a technical graduate. I inquired into his ability to climb and his ability to express himself clearly in regard to technical matters, and I concluded that he was a desirable candidate for the position of inspector for the erection. I again took the initiative and appointed him assistant inspector at the shops, telling him what my ultimate purpose was, that if he proved himself, after a trial, competent, he should be the inspector of the erection. I sent him to the shops under instructions that while he was to give sufficient attention to the mechanical inspection to make himself thoroughly acquainted with the construction of the work, he should bear in mind that the principal duty that I wanted him to prepare himself for was that of inspecting the erection, that I wanted him to make himself thoroughly acquainted with all the strain sheets, not only of the work as it would finally be constructed, but especially the strains due to the erection; that I wanted him to be so prepared that when he went to the bridge he would know under every change daily made in the load what the effect would be upon all the members of that structure theoretically, and that it would be his duty to see that they practically met the expectation of the theory. I explained to him in a general way the camber necessity, the changes of position of the different members and the necessity of keeping careful and watchful eye on these actions and to know why these modifications were expected, and, when they did not occur, to find out why. I then privately requested Mr. Szlapka, the designing engineer of the Phœnix Bridge

Company, to give me all the aid he could in educating Mr. McLure for the position, and confidentially to give me his opinion of Mr. McLure's capacity after he had been there a sufficient time to determine it. Later on Mr. Szlapka reported that he found Mr. McLure very energetic, very active, very bright and thoroughly capable of undertaking the work that I had in view. I reported the appointment of Mr. McLure to the chief engineer of the Quebec Bridge Company (Mr. Hoare). The general impression left upon my mind after communicating with Mr. Hoare, was that he did not want Mr. McLure. He even stated that he had other men in view. The work of erection had progressed to the extent of placing nearly all the lower chord of the anchor arm upon the falsework before Mr. Hoare called for Mr. McLure's assistance. He had previously to that, I would state, forestalled my action after I had appointed Mr. McLure by notifying me that he had appointed Mr. Kinloch inspector for the erection. Without any reflection upon Mr. Kinloch—all I have heard of him has been most favourable—I knew he was not qualified to do the duty that I expected of the inspector of erection. When Mr. Hoare sent for Mr. McLure finally, they were wedging out the lower chord for camber, something that I am thoroughly satisfied neither Mr. Hoare nor Mr. Kinloch understood. I think that was the reason for calling for Mr. McLure at this late day. Knowing that Mr. Hoare had already appointed Mr. Kinloch inspector for the erection, I felt it my duty to put Mr. McLure's position clearly to Mr. Hoare, so I gave Mr. McLure a letter of instruction, and addressed him as inspector in charge of the erection, Quebec bridge. I told him to present that letter to Mr. Hoare when he went to Quebec.

Q. How often did you personally visit the shops, and by whom and in what form were instructions given to the inspectors?—A. I am sorry to say after the work commenced I visited the shops I think but three or four times. I do not know to what extent Mr. Hoare may have given the inspectors instructions; I have given them from time to time verbal and written instructions. The shop inspectors' instructions have been almost entirely verbal, except on occasions when things would come up about which I felt it necessary to write a letter to the shop inspector. He was in the habit of coming to my office at least once a month, sometimes twice, but always once a month, to bring estimates of weights of material for my examination and approval. At such times he furnished me memoranda showing what had been done, and also drew my attention to points on which he wished my advice and instruction, so that largely my advice and instructions to the inspector at the shops were verbal. As to Mr. McLure, I know not what instructions he may have received from the chief engineer of the Quebec Bridge Company, but all my instructions to him while he was on the work were in the written communications of which the Commission have full copies.

Q. Were the records from the inspectors regularly transmitted to you and to whom did they refer for instructions in case of dispute or difficulty?—A. I think that is already answered except in regard to the records. Mr. Edwards made both verbal and written reports from time to time. Mr. McLure made regular weekly reports in regard to the work of erection and, to the best of my knowledge and belief, in all cases of dispute or difficulty I was the only person from whom they received any instructions.

Q. Was the workmanship satisfactory to you, or did you find it necessary to take decided action to secure satisfactory results?—A. In many directions the workmanship was perfectly satisfactory, but I had cause to make frequent complaints of the mechanical department, especially regarding the facing of the compression members and the boring of the pin holes.

Q. Did you find it necessary to take decided action to secure satisfactory results?—A. Unfortunately I did not know the unsatisfactory results until after they were made. I did frequently and strongly express my dissatisfaction with the faults that were made, and I did also require that all such faults should be corrected to put the work into a satisfactory shape. Whether that was done I have no personal knowledge, except the reports from the Phœnix Bridge Company and the inspector. During

the erection, on June 2, 1906, Mr. McLure reported that when preparing to erect the centre posts he found the bearings of the upper parts of this post were not true and straight and sent me sketches which indicated very bad shop workmanship. I instructed him to stop the erection until this was properly corrected and remedied. He reported later that this work had been corrected in accordance with my instructions. Of course, I do not recall, and it would be perhaps unnecessary, each individual case where errors occurred. They are all on record and can be found from the files, but I could not refer to them without devoting a good deal of time to going over the records, and I do not think it would be important in the line of testimony except to show that the workmanship was not entirely satisfactory to me, especially that part that I have mentioned.

Q. Are you fully satisfied with the steel that has been supplied for this bridge and does its action both when under test and in the wreck indicate thoroughly good material?—A. I think it has been shown both under tests in the testing machine and the test of the failure, as far as I can judge by the reports of the failure, that the material is unquestionably most excellent

Q. Did the magnitude of the structure call for much better workmanship than is usual for ordinary bridges and was any effort made to secure such superior workmanship? Was the workmanship defective in any particular?—A. I most decidedly think it did demand a higher class of workmanship than that employed in ordinary bridges, and I do not think that in all matters proper efforts were made to secure such workmanship, particularly in reference to the two points I have previously mentioned, the facing of the compression members and the boring of the pin holes.

Q. Who devised the method of loading and unloading the members and all provisions for transportation, and under what supervision was this work carried on?—A. It was entirely within the hands and under the control of the Phœnix Bridge Company.

Q. Was the deformation of these members while in transit probable?—A. Yes, under careless treatment or in the case of accidents.

Q. Whose duty was it to ensure that the erection methods and appliances were suitable to the work and to organize the system of erection?—A. The Phœnix Bridge Company's. At the same time I had in a general way, but not in detail, to consider the methods they intended to employ and I believe that great care was employed by the Phœnix Bridge Company in devising an excellent method of handling the material and putting the same in place.

Q. Was the inspection of the work of erection and the taking charge of that work properly part of the duties of the consulting engineer and, if not, whose duty was it?—A. It was not the duty of the consulting engineer. It was the duty of the chief engineer and his organization, with the sole right to apply to the consulting engineer for advice upon any special problem.

Q. 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?—A. Not from my present knowledge. When discussing the necessity of technical men for the inspectors, I took the matter up with the chief engineer of the Phœnix Bridge Company and pointed out to him not only the necessity of the Quebec Bridge Company having competent men in charge of erection, but also the absolute necessity for the Phœnix Bridge Company to have an engineer on the work at all times who was fully cognizant of the details of the structure, the action of the different members under the different strains and camber movements and who would have the technical knowledge to take action if, at any time, the theoretical expectations should not be obtained, to determine why such result was not obtained and be able to direct the necessary corrections. I do not think, from my present knowledge, that the Phœnix Bridge Company did have any such engineer upon the work.

In regard to the local staff of the Quebec Bridge Company, I have no knowledge further than in reference to the chief engineer and Mr. McLure, and I feel now that on the part of the Quebec Bridge Company, Mr. McLure was the only person who had any preparation or qualifications for supervising the construction of that bridge, and I know that the time allowed him for preparation for this important duty was not

as great as should have been given him. From the reports that he has from time to time sent me, from personal intercourse with him, I feel that he did all that could be expected of him under the circumstances.

Q. By whom were its members appointed and to whom were they responsible?—I have already explained the method of the appointment of Mr. McLure, the only one in regard to whose appointment or selection I have any knowledge.

Q. By whom was this force paid?—A. I presume by the two companies, that each company paid the staff employed by it at Quebec.

Q. Please state what qualifications in the way of training, age and experience were necessary to make a man fit to have supreme local control of the erection of this bridge and whether any of the staff employed by either the Quebec Bridge Company or the Phœnix Bridge Company had these necessary qualifications?—A. For a man to be qualified, in my opinion, to have the supreme local control of the erection of a bridge as important as that under consideration, I think he should have been a thoroughly technically educated and experienced bridge engineer. I regret to say that I do not think the chief engineer of the Quebec Bridge Company had these qualifications. In reference to the local control by the Phœnix Bridge Company, as stated before, I do not think they had the quality of engineer that the circumstances demanded. In saying this I do not wish to reflect in any manner upon Mr. Birks, who sacrificed his life and who undoubtedly was a competent man in his line of experience; but I do not understand that he had the thorough training and knowledge of all the requirements of this structure necessary to fit him for the responsible position as the engineering representative of the contractor on such an important structure.

Q. Is it reasonable to expect that emergencies of grave importance may arise upon work of such character and magnitude and could the local staff of the Quebec Bridge Company be considered to be reasonably complete without including an engineer of sufficient scientific training, age and practical experience to be competent to deal with any such emergencies?—A. I have practically answered that already. I do think that emergencies of grave importance are liable to occur in the erection of such a great work and the history shows that they have occurred, and, as I stated before, I do not think that the local staff contained a man of sufficient scientific training, age and practical experience, to have met the emergencies.

Q. To what do you attribute the employment of a staff not equal in calibre to the difficulties of the undertaking, on the part both of the Quebec Bridge Company and of the Phœnix Bridge Company?—A. This is a rather difficult question for me to answer. I suppose that in the case of the Quebec Bridge Company, like all projects undertaken by men not specially acquainted with the necessities, the engineering features of any such great work, they were unable to make a proper selection. In reference to the Phœnix Bridge Company, I think it was due to the fact that the commercial branch of that company gave more consideration to the pushing and completing of the work than they did to the giving of due consideration to the practical requirements of such a great structure.

Q. Do you consider that it is a wise practice when building a bridge of novel character and unprecedented dimensions to place the design of the structure and of the methods of erection in the hands of the mechanically trained staff of a contracting company and, if not, why was this practice allowed in this case?—A. In answer to this question, it is the general practice in America to have the mechanically trained staff of contracting companies prepare the working plans. As a rule, no engineer could afford to maintain a staff of such character, and no corporation would listen to a fee that would cover any such expense.

Q. Were the methods of erection submitted to you for approval or were you in any way advised of these methods and of the character of the plant that was being provided for the erection?—A. They were submitted to me unofficially, not for my criticism, nor that they came within my authority, but for personal interest.

Q. What authority had the engineers and inspectors of the Quebec Bridge Com-

pany to order changes in these methods or to interfere with the progress of erection?—A. They had all the authority that belongs to a chief engineer and his staff, the authority that belonged to their offices.

Q. Was it fully understood that the execution of this work was at all times subject to their approval?—A. I think that is implied in the office of the chief engineer. In my instructions to Mr. McLure, as far as his authority went, he was distinctly instructed to see that no undue risks were taken, and that all the work was satisfactory before it was finally left.

Q. How often did you visit the bridge site during the erection of the superstructure?—A. Never. I have never been able to visit the bridge since the erection commenced. I was disabled before that was undertaken.

Q. By whom and how often were you advised of the progress of the work and of matters of interest connected with it?—A. Mr. McLure made me weekly reports detailing pretty clearly, and apparently thoroughly, the progress and the occurrences of the previous week, and he occasionally sent me an additional special letter when something would occur that he thought should have more prompt attention than a matter contained in the weekly report.

Q. Did you find it necessary to interfere with the conduct of the erection, and if so, what were the circumstances of such interference —A. As narrated in a previous answer, I stopped the erection of the centre post until it was made satisfactory. In the latter part of September, 1906, on receipt of Mr. McLure's letter of September 22, 1906, and letters following, it was made clear to me that the anchor arm was not acting in accordance with the theoretical expectations. On studying the detailed reports of Mr. McLure and the levels contained in his reports, I found that instead of the anchor arm working itself free from the false work near chords 8, 9 and 10 first, as it should have done, it was showing a tendency to lift at the far shore end. This was so anomalous that I sought for the reason thereof, and I came to the conclusion that they had not considered the compression of the main centre post under the additional load of the cantilever arm; that this was throwing an undue load upon the bents near point 9 of the anchor arm, and without giving at that time, September 24, any positive orders, I drew Mr. McLure's attention to this point, believing that he and the engineer of the Phœnix Bridge Company were also watching for these contingencies, and would take the proper action to remedy the difficulty. It appears that nothing was done by the Phœnix Bridge Company until several weeks later, when in an interview with Mr. Szlapka at my office, I showed him the correspondence between Mr. McLure and myself, and pointed out what I considered to be the difficulty. He acknowledged the theory upon which I was working, and I believe that he that day did send orders to Phœnixville to take the proper steps to relieve this undue strain at this point. There was some friction between Mr. McLure and the superintendent of erection in reference to this matter, which will be found in the correspondence, indicating that the Phœnix Bridge Company did not recognize the rights of anybody except themselves to control the erection. That point was brought up in a later discussion with Mr. Szlapka in an amicable way, and I distinctly told him that the Phœnix Bridge Company were not the only parties who had financial interest in this structure, that the parties whom I represented, the Quebec Bridge Company, had paid for the structure as it stood, that it belonged to them and they had an interest in seeing that it was not risked or injured, and while I always endeavoured to get along amicably with everybody, if it came to a point of determining my right or the right of any employee under me to protect the property of the company, I thought they would find themselves in the wrong. I think the correspondence will further illustrate all that without my going further on that point.

(*Note.*—The correspondence here referred to is marked Exhibit 68.)

Q. Do you think that the leaving the position of this chord at that time, with the falseworks not lowered to their proper position, could have produced any injurious effects near or about lower chord 9 of the anchor arm?—A. That an undue and an

unprovided-for strain was produced by this neglect seems very possible to my mind, especially considering that at that time the splices, which were the weakest and most hazardous portions of the structure, were not riveted and perhaps not fully and properly bolted.

Q. Was appeal to you for assistance and advice in the face of difficulties ever made by the Phœnix Bridge Company?—A. That I suppose I could answer by saying that Mr. Szlapka and myself were in frequent intercourse discussing and considering many points as they occurred.

Q. 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?—A. As far as I know all difficulties, all questions, all decisions on any matter relating to the structure were referred to me, and practically, as I now see it, I was acting not only as the consulting engineer but as the chief engineer of the Quebec bridge.

Q. What was the agreement between yourself and the Quebec Bridge Company as to your remuneration for your personal services and expenses, and under what circumstances was the original arrangement amended? Did the Quebec Bridge Company allow you anything for the necessary staff of assistants? What proportion of your fee have you had to expend for assistance in the interest of the Quebec Bridge Company?—A. At the original interview where I made the offer to undertake the examination of the competitive plans I was asked what my fee would be to act as consulting engineer when the work was started. I stated that my fee would be $7,500 a year for such services. I did not recognize at that time that there was to be any expense except an occasional visit to Quebec, so that I made no agreement regarding expenses. In August, 1901, being in Quebec and my fees backward in payment, finding that the company apparently were embarrassed for funds and considering that under the circumstances then before me it might be some years before any actual and important work would be required from me as consulting engineer, I wrote a new offer which amounted to reducing my fee to one-half. A member of the board suggested at the time to make it the round sum of $4,000 instead of the one-half which I had offered. That amount has been paid to me up to the commencement of this year. When other duties than those of the consulting engineer began to be placed upon me, I suggested to Mr. Hoare that it was hardly fair, considering that I had reduced my fee to one-half, that I should not be granted some additional remuneration to aid me in carrying out the duties that had been placed upon me. No such additional remuneration has ever been granted me, and no offer has ever been made to restore my original fee. My staff and office expenses due to the work required in the interest of the Quebec Bridge Company have been paid entirely from my own fee, and they have amounted to approximately the sum that I have received from the Quebec Bridge Company to cover my employment.

Q. Did the officers of the Phœnix Bridge Company fully appreciate the engineering difficulties connected with the undertaking, and did they willingly and immediately make good all defects that were brought to their notice?—A. I think the technical staff as represented by Mr. Szlapka and his subordinates did fully appreciate the engineering difficulties connected with this undertaking, but I do not think that that branch, which might be called the commercial side of the Phœnix Bridge Company, were willing to or did make good defects that were brought to their notice until they were compelled to, when compulsion was applied. When the elongation of the eyes of the eyebars under the strains that we were intending to employ was brought to my notice by certain preliminary tests, feeling it to be a matter of serious moment to know the truth, I urged the Phœnix Bridge Company to make a thorough investigation of this subject, and suggested to them that as it was a matter of special interest to all bridge construction, they should enlist the co-operation of other bridge companies in making a thorough examination into the whole problem. After more or less discussion it was made clear to my mind that the Phœnix Bridge Company were more desirous of hiding the matter than they were of exploiting it. I was asked not to make the matter public. Finding this to be the position, on January 8, 1905, I wrote to Mr.

Edwards, the inspector at Phœnixville for the Quebec Bridge Company, directing him to accept no more eyebars for the Quebec bridge until further orders, and directed him to furnish a copy of this letter to the Phœnix Bridge Company. Then the Phœnix Bridge Company showed eagerness to carry out the investigation that I demanded, and did carry it out to my satisfaction.

In other matters from time to time I did find them sluggish in making corrections or remedying defects. To come down to a later date, on August 6, 1907, Mr. McLure reported the condition of chord 7 and 8, cantilever arm, and the method of remedying proposed by the Phœnix Bridge Company. Upon the receipt of this letter from Mr. McLure on August 8, I immediately telegraphed the Phœnix Bridge Company that the method was not satisfactory and asked them: How did this occur? The following correspondence containing my letters to Mr. McLure and Mr. McLure's letters to me, my correspondence to the Phœnix Bridge Company and their replies to me, all of which are consecutive, indicates that the Phœnix Bridge Company did not desire to make any corrections of importance, did not desire to put this chord in a safe condition, tried to convince me that the error was unimportant, and even tried to explain that the error had always been there. Before I could take final action as I had fully prepared to do at the time, the more serious problem of the bending of chord 9, anchor arm, was reported to me.

Q. Was due care exercised throughout in the handling of the bridge members?—A. For that information, gentlemen, you will have to depend on the testimony of other persons. I judge, however, from results reported to me, that there was not due care at certain times.

Q. Are you aware of any cases in which members were damaged in handling?—A. It is now before the commission in evidence that chord 9 was damaged in handling.

Q. Are you aware of any cases in which the connections between members in place were not fully made?—A. It would appear from the evidence and from the records of Mr. McLure, that the splices of the lower chords were not fully made or properly considered.

Q. What deviation of a rib of a main compression member from the straight would be passed in first-class inspection, and what variation from the true plane is permissible in the faced ends of the ribs at butt joints?—A. It is impossible to draw any general and definite rule that applies to all cases. There must be a certain amount of engineering judgment applied to each special case, but I should consider that in a general way, bearing in mind the compression chords of this structure, that any deviations from a straight line corresponding to the axis of the member exceeding half an inch would not be good, and if this amount of deviation is only for a short length it becomes far more serious. In regard to the amount of error that might be permitted in facing the ends of compression members, bearing in mind the large dimensions of those in this structure and the importance of having the best workmanship on account of the high demands made on all parts of the structure, I should think that one-sixty-fourth of an inch variation from a straight line on the full width of the lower chord would be the extreme limit that should be permitted.

Q. Where these limits have been exceeded in the Quebec Bridge members do you consider that the fault lay with the shop inspection or that the distortion might be due to insufficient care in handling?—A. Both or either.

Q. Would such faults materially weaken a compression member?—A. Any departure from a perfect fit or straight line in a compression member does weaken that member. How much, of course, depends upon the relative departure from the true lines.

Q. Was the progress of the riveting such as you desired that it should be at the various stages of erection?—A. To the best of my knowledge it so appeared.

Q. Why was the south half of the suspended span to be erected in 1907 when the north half, in all probability, could not be erected until 1909?—A. Simply because

the material was there, the tools were there, and it was undoubtedly perfectly proper to complete that portion of the work while they had it in hand, everything else being satisfactory.

Q. Was your approval of this procedure requested or obtained and, if not, was this procedure in your judgment good practice?—A. The matter was discussed, and I considered it perfectly proper and good practice.

Q. 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?—A. In the early stages of the erection, long before the large traveller was passed over to the cantilever arm, I drew Mr. Szlapka's attention to the undesirability of using the large traveller for erecting the suspended span, pointing out that it was unduly hazardous and was unnecessary for various reasons which we discussed. He agreed with me and agreed to have a small traveller designed for the purpose of erecting the suspended span. The small traveller was designed and they then appealed to me that it would be necessary to use the large traveller for the purpose of erecting the small traveller into position. I gave my consent to that being done, but it was clearly understood that as soon as the small traveller was erected, the big traveller would be removed from this structure and that the erection of the suspended span would be continued with the use of the small traveller only. I was under the supposition that the large traveller was being taken down, I knew they had commenced to take it down, and I was very much astonished when I found that they were continuing the erection of the suspended span with the use of the small traveller and most of the weight of the large traveller still at the extreme point of the cantilever arm. This knowledge, however, only came to me after the failure of the structure.

Q. From your present knowledge what do you consider the weakest and most hazardous part of the design?—A. Unquestionably the splices of the lower chord. While, from the appearance of the wreck these splices when properly and fully rivetted were the strongest part of the compression chord, when unrivetted or improperly bolted they were in a condition of great hazard and uncertainty. As these splices in the anchor arm could not be rivetted until the camber action had taken place and the joints had come to full and proper bearing, they were, if improperly stayed and bolted, very dangerous points and should have been most carefully watched and protected. From the report of the condition of splice 7-8, cantilever arm, which is contained in Mr. McLure's and other correspondence following August 6, 1907, there was first made clear to me the seriousness of these splices and the lack of appreciation of the necessary care to be given them by the Phœnix Bridge Company.

Q. Do you consider that the initial failure took place in the lower chord?—A. I feel thoroughly satisfied, with the history now before us in regard to chord 9, west anchor arm, that it was the initial point of failure.

Q. Were you satisfied with the care and intelligence shown by the Phœnix Bridge Company in placing the members of this chord?—A. I think I have answered that already when I have spoken of their lack of caution in staying and protecting the splices of this lower chord. With the facts before us, seeing their lack of appreciation and consideration of the splices at 7 and 8 cantilever arm, there is grave suspicion in my mind that similar neglect and lack of appreciation may have prevailed before.

Q. At what date did you first become uneasy about the lower chord members?—A. On August 8, 1907, upon the receipt of Mr. McLure's letter, as I have before mentioned, narrating the condition of splices in chord 7-8, cantilever arm.

Q. Starting from this date please relate all the circumstances in which you were personally concerned up to the time of the failure, referring to all communications that reached you and all action that you advised?—A. I have already stated and drawn your attention to the correspondence between the Phœnix Bridge Company, Mr. McLure and myself, following August 6th. On the morning of August 29, on reaching my office somewhere about 11.25 o'clock, I found Mr. McLure at the office. After speaking to him I passed to my office and took up my morning mail among which was

the communication of Mr. McLure narating the condition of chord 9, west anchor arm. After carefully reading and considering the letter, I called Mr. McLure into my office and cross examined him to find out whether the facts given were actual or whether he had been scared, and satisfying myself that the date there was from actual measurement and actual observation, I said: 'It is very serious.' He said: 'Mr. Cooper, they have moved out the small traveller, but we have estimated that it will not add to the strain on chord 9 more than 50 lbs. per square inch, but they are going on this morning to erect more of the work; do you think that is right? I said: By no means right. I said: Is Mr. Milliken on the work?—intending to immediately telegraph orders to Mr. Milliken to stop it. No, he said,Mr. Milliken is not present on the work; there is only a foreman present. Well, I said, I do not know whether a foreman would take a suggestion from me or not; I will have to telegraph immediately to the Phœnix Bridge Company for them to wire to the bridge. I said: Are you sure that the Phœnix Bridge Company have these same facts before them that you have presented to me? and he said: Exactly the same report has gone to Phœnixville that you have now received. That was confirmed by a telegram handed me about the same time from Mr. Hoare, stating that Mr. Birks had received a telegram from Phœnixville stating that this chord had been bent before it left the shop. Satisfied then that the Phœnix Bridge Company had the same facts I immediately telegraphed them to 'add no more load to bridge till after due consideration of facts.' I then said to Mr. McLure: You must go to Phœnixville immediately and tell the Phœnix Bridge Company that I do not want any delay such as that involved in the discussion that we have had heretofore on similar occasions, but I want immediate action to strengthen that chord and to protect the bridge. He pulled out his time table and said: Mr. Cooper, I cannot reach Phœnixville before five o'clock. I then added to the despatch: Mr. McLure will be over at 5 o'clock. Mr. Berger went to the Western Union office and they have the telegram endorsed: 'Sent from the Western Union office at 12.16 p.m.' I immediately took up the problem of how to protect and how to strengthen that chord and made some sketches which I showed to Mr. Berger. I said: If the Phœnix Bridge Company do not themselves adopt some better method I would suggest that to them. At 9 o'clock that evening I was called up on the long-distance telephone, and Mr. McLure reported that the bridge was in the river.

Q. Where do you think that the first failure took place and in what manner do you think the bridge acted during the fall?—A. Considering the history of chord 9, which is before the Commission, there is no doubt in my mind that chord 9, west truss, failed first, and after it passed a certain degree of flexure the lattice bars in the centre of the chord were perhaps what first gave way. To my mind, the noise that the men first heard was the explosion of the lattice bars of chord 9 at the centre. Unrestrained by the lattice the webs of this chord undoubtedly buckled together as so many sheets of paper crushed in the hand. When chord 9 had passed a certain point the lateral braces between that truss and the opposite truss in that panel were disabled from doing any staying duty. It appears to me, then, necessarily that the opposite chord 9 east truss, must have given way even had it been far stronger than it actually was. With the giving way of chord 9 west, immediately followed by the failure of 9 east, the cantilever arm would naturally deflect towards the river. The evidence of the wreck, showing the continuity and unbroken condition of the eyebar top chord, and that the anchor towers and anchor bars which were vertical in position before rupture were pulled out to a horizontal position, indicates clearly to my mind that the main towers must have remained intact until this was done—indicating that the main towers and the whole of the anchor arm declined towards the river and downwards until either the main towers slipped from their footings or the great strain of this long eyebar chord produced the final rupture of the main towers. That the great mass of fallen material moved several feet towards the east was due to the probable action and later rupture of the eastern truss, which would produce a tendency to drag the material towards the east.

Q. Do you consider that there was clear indication that the failure was imminent and was it possible, by prompt and intelligent action, to have prevented the failure? —A. I think the deflection of an important member, as chord 9 west, to the extent of 2¼ inches would indicate to any intelligent mind that that chord was less capable of doing the duty that it would have done if in a perfectly straight condition, and I do think that it was perfectly possible by prompt and intelligent action to have stayed that chord and prevented the failure of the bridge.

Q. By whom should the orders for such action have been given and to whose lack of judgment and initiative can the failure therefore be charged?—A. To the executive officers of either company who were present or within sufficient touch to have given any orders.

Q. In your opinion, is it good practice to leave the ordering of such action to any employee of a contracting company?—A. The contracting company should have had on the structure an employee of sufficient intelligence to have appreciated the necessity for and to have given such an order. At the same time, the responsible executive of the Quebec Bridge Company should not have hesitated, in the absence of proper action by the contractor, to have given such an order.

Q. Do you think that at moderate expense the ribs could have been made absolutely safe?—A. I do. I believe if prompt action had been taken to protect chord 9 west from further deflection, which could have been done by the employment of three hours' work and $100 worth of timber and bolts, the defects and deficiencies which we now recognize in the compression chords and members, could, at a later date, have been corrected and the bridge could have been made perfectly safe and efficient for its intended purpose.

Q. Do you 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? Would you now recommend any material changes in the detailing of these or any other members, and, if so, what would these changes be?—A. My responsibilities, gentlemen, end as soon as I have served by duty of aiding you in reaching the truth in regard to the destruction of this bridge. While I have my views and such views are at the service of those who have heretofore relied on me, I shall decline to take any executive or responsible position in connection with the correction of the errors that we now recognize in this work; it must be referred to younger and abler men.

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From October 23 to November 22 the Commission was engaged in taking evidence and collecting information in Philadelphia and Phœnixville.

I, Ellsworth L. Edwards, of the town of Pottstown, in the state of Pennsylvania, one of the United States of America, bridge inspector, make oath and say:—

1. That I attended before the Board of Royal Commissioners appointed under the great seal of Canada for the purpose of inquiring into the causes of the collapse of the Quebec Bridge, on several days during the months of October and November, 1907, in the town of Phœnixville, in the state of Pennsylvania aforesaid.

2. That the attached six pages, numbered 857 to 862, both inclusive, contain my present evidence in this matter; the answers to the questions are true statements to the best of my knowledge and belief.

Sworn before me, in the city of Philadelphia, in the state of Pennsylvania, this day of November, 1907.

Mr. EDWARDS' testimony.

Q. Please file complete list of shop errors detected by the inspectors and indicate those which were specially brought to the notice of Mr. Cooper?—A. Herewith I file

with you a book (Exhibit 84) which contains memoranda of all the errors discovered at shops by inspectors. Those marked with an X in red were specially brought to Mr. Cooper's attention, for the most part on the occasions of my frequent visits to his office. Minor errors were sometimes referred to in the course of my conversation with him.

Mr. Cooper had advised me to confer with Mr. Szlapka regarding minor errors. This I did and before the shop was allowed to remedy such errors Mr. Szlapka was consulted. In matters affecting clearances his advice was particularly valuable.

My method was to exchange ideas with Mr. Szlapka as to the remedying of these less important errors and come to a conclusion satisfactory to us both. While such minor errors were not then brought to Mr. Cooper's attention it was my understanding that he approved of this course.

Q. Please file a list of errors which were not detected in the shop inspection and which were subsequently detected and reported from the field?—A. I do not have a complete list of errors found in the field and which were not detected in the shop. Mr. McLure wrote me concerning some of these, but I understand you have this information in detail in his book labeled 'Record of Shop Errors found in the Field.' This record includes the errors of drawings as well as those of shop and a distinction is made between these two classes.

As you are probably aware errors of drawings are not chargeable to inspectors, as drawings are supposed to be correct when received by us.

Q. Was every important error that you detected reported to Mr. Cooper and were his instructions in regard to these errors promptly carried out?—A. Every error which I considered of sufficient importance was referred to Mr. Cooper, and his instructions were carried out implicitly. Members for the south side were always remedied very promptly. As there was no hurry for those of the north side these were not attended to with such promptness but were finally remedied or passed by Mr. Cooper.

Q. Please refer to your letter of February 26, 1906, to Mr. Cooper and explain in detail the conditions you therein described in the second paragraph?—A. In reference to the second paragraph of my letter of February 26, 1906, to Mr. Cooper, I would say that at that particular time there seemed to be an unusual number of errors being made both at the bridge, shop and the eye-bar plant, and we were endeavouring to get things back to a normal condition. Notwithstanding the efforts being made errors continued. Such conditions were only temporary and as stated in this same letter 'We expect better results before long.' And these were obtained.

My reference to 'being up against a pretty tough proposition' means that new errors were appearing in spite of precautions which were being taken by the Phœnix officials and ourselves.

It is my experience that there are occasional short periods when an unusual number of mistakes occur and, vice versa, there are periods when unusually few errors are made.

Q. Within what limits do you consider it practicable to straighten the ribs of bottom chord members, and of the main posts, and how closely can the ribs of consecutive chord members be made to match each other?—A. In reference to the limits considered practicable to straighten ribs, I would say that this depends to a large degree on the thickness of these ribs and also the nature of the bend. If the bend is a long curve it is a comparatively easy matter to take out a 3-inch to 4-inch bend, but if the bend is a short 'kink' this would be a different proposition and could only be decided by the case at issue.

However, we are not aware of any chords on the Quebec Bridge where it was necessary to remove any short or sharp kinks. Long bends were always removed before milling.

In the matching of consecutive chord members it must be taken into consideration that the web plates may vary in thickness and angles are not always true (viz.: one leg not at exact right angles to the other). Our practice in inspection was to endeavour to have the ribs absolutely the correct distance apart from top to bottom at ends of chords. We did occasionally allow as much as ⅛-inch (max.). I do not believe it is

possible to secure greater accuracy than this where measurements are taken between *rolled* surfaces.

Q. How closely to true plane will the large rotary planers cut ?—A. From actual measurements we know that the accuracy of the milling done by the rotary plane for the larger members of the Quebec Bridge varied from a true plane, where such variation occurred, from one-sixty-fourth to one-thirty-second of an inch. This was the best the machine could do.

Q. We understand that a post section was found 3/64-inch out of true on one corner, and that this was accepted on the ground that the planer could not cut within these limits. Is this correct and was this reported to Mr. Cooper ?—A. Regarding main post section found to be out of true 3/64-inch at one corner, the fact of the bearing surface being so great and the unevenness in question being so small and at one point only I deemed it advisable to accept the member, believing that when the weight of other post sections was on there would be perfect contact. It is a question if any better results would be secured by remilling a section so slightly imperfect over so small an area, and by remilling we would be reducing the thickness of bearing surfaces. This error was not reported to Mr. Cooper so far as I now remember.

Q. Were any full size tests of plates, angles or built up members made during the fabrication of the work ?—A. Some tests were made of built up members to present the ears of posts and hangers. The results of these tests are produced (Exhibit 85). Dwg. 2—T.O. 267.)

No full size tests of angles or plates were made.

Q. Please file a statement giving the particulars of all full size, eye-bars tests and specimen tests of the materials of which they were made.—A. I produce a statement as asked. (Exhibit 86.)

Q. State exactly what tests for accuracy were made upon each of the main members and how were these tests made, not only as to dimensions but as to the setting of the pieces in the machine ?—A. In reference to tests for accuracy, the facing was first tested with steel straight edge. Dimensions from faced end to centre of pin holes were taken by means of a standardized tape secured at one end of member by a stop and supported at points the entire length of piece. To determine the exact centre of pin hole, a circular leaden disc was held in place by three set screws and the exact centre was established from four points on the bored surface of pin hole.

A spring balance was attached to the tape and 12 pounds tension used in all cases. In measuring distances less than 15 feet from C to C of pin holes the centres above described were put in but trammel points were used to check distances in place of tape.

Cast-iron gauges about 6 feet long were put in all pin holes. Care was taken to see not only that the pin would enter the hole without difficulty when the member was erected in the field, but that the allowed clearance between pin and hole was not exceeded.

While all holes for splice plate connections were drilled from iron template, the dimensions between holes were always all carefully measured and, in fact, this was done in the case of all open holes.

As to the laying out of members and setting same in machine it is not customary for inspectors to check these operations. It is the duty of the shop foreman to attend to such checking, but notwithstanding the custom we did (at Mr. Cooper's suggestion) check the laying out and the boring in many cases in order to reduce the liability of error.

Q. On May 3, 1907, Mr. Hoare asked you for another set of strain sheets for anchor and cantilever arm, and states that he is aware that the strain sheet for the suspended span was not then ready; was there any work on the suspended span at that date in the shops ?—A. Yes. the eye-bars for the south half of suspended span, about one-half of the material for panel one south side and some stringers were completed by May 3, 1907.

I, David Reeves, of the borough of Phœnixville, in the state of Pennsylvania, one of the United States of America, president of the Phœnix Iron Company, make oath and say:

1. That I attended before the Board of Royal Commissioners appointed under the Great Seal of Canada for the purpose of inquiring into the causes of the collapse of the Quebec Bridge, on several days during months of October and November, 1907, in the borough of Phœnixville and city of Philadelphia, in the state of Pennsylvania aforesaid.

2. That the attached eleven pages, numbered 864 to 874, both inclusive, contain my evidence in this matter. The answers to the questions are true statements, to the best of my knowledge and belief.

Sworn before me in the city of Philadelphia, in the state of Pennsylvania, this day of September, 1907.

Mr. David Reeves' testimony.

Q. What is your position in the Phœnix Bridge Company and from what date have you occupied that position?—A. I am president of the Phœnix Bridge Company and have been since 1884, and prior thereto, from 1872, I was a member of the bridge building firm of Clarke, Reeves & Company, who were the predecessors of the Phœnix Bridge Company. Mr. Thomas C. Clarke, past president of the American Society of Civil Engineers, and Mr. Adolphus Bonzano, member of the society, and at one time vice-president and chief engineer of the Phœnix Bridge Company, were my partners in that firm.

Q. Who are the other officers of the Phœnix Bridge Company and what are their duties?—A. Mr. John Sterling Deans is chief engineer. Mr. Frank T. Davis, treasurer, and Mr. Wm. H. Reeves, general superintendent. The duties of the president and treasurer are those usual to such officers of a corporation. The duty of the chief engineer is to make contracts, to be in charge of the design and construction of bridges and other structures entering into the business of their transportation and erection, and to do and perform all other necessary things in connection therewith. The duty of the general superintendent is to take charge of the work in the mills and the shops until delivered upon the cars.

Q. Is the Phœnix Bridge Company a manufacturing company at all, or is it entirely a contracting company, and is it entirely separate from the Phœnix Iron Company? State the relations between the companies?—A. The Phœnix Bridge Company is an engineering and contracting, not manufacturing company. It is entirely separate from the Phœnix Iron Company. It has an arrangement with the latter under which its bridge and other structural work is manufactured in accordance with requirements. Formal methods of accounts, charges and payments are administered between the two companies precisely as in other contracts.

Q. Who is president of the Phœnix Iron Company? Who are the other officers of the company and what are their duties?—A. I have been president of the Phœnix Iron Company since 1888. Mr. George C. Carson, jr., is treasurer, and Mr. George Gerry White, secretary, all having the duties that usually pertain to these officers in corporations.

Does the Phœnix Iron Company provide material for and carry out the manufacture of all work under the contracts made by the Phœnix Bridge Company?—A. The Phœnix Iron Company provides the materials and fabricates the shop work in its mills and shops in accordance with the specifications and plans furnished by the Phœnix Bridge Company under its directions.

Q. Is this under a regular standing arrangement, or is there a separate arrangement made for each piece of work?—A. This is done under an arrangement standing since 1884, and prior thereto, with the predecessors of the Phœnix Bridge Company, the said firm of Clarke, Reeves & Company.

Q. What, if any, was the arrangement made between the companies in respect to the Quebec bridge?—A. The work embraced by the Quebec bridge was done under the regular standing arrangement.

Q. After Mr. Cooper reported favourably upon your company's proposal in 1899, had you any assurance from the Quebec Bridge Company that if the project were carried out your company would be the contractors, and, if so, what was the nature of your information?—A. No. The next step after the favourable report was the tender of the contract to the company by letter of Mr. Parent, president of Quebec Bridge Company dated 23rd of August, 1899, copy of which is filed as 'Exhibit 87.'

Q. Did you consider that the financial standing of the Quebec Bridge Company was sufficently good to justify either the Phœnix Bridge Company or the Phœnix Iron Company in making serious expenditure in preparation for the construction of the main spans before you felt assured of the passing of the guarantee legislation by the Dominion Parliament in 1903?—A. We believed that the Quebec Bridge Company was either strong enough or had the means of becoming so to warrant us in making the expenditures for the construction of the main spans.

Q. Please state in detail what these expenditures were, if any, and when incurred.—A. It first became necessary to more fully design the bridge, to make some experiments respecting the eye bars and other shop work, and to obtain certain requisite tools. All of this was done as will be stated by those who were in charge of the several departments. The expenditure in tools amounted in the aggregate to over $200,000.

Q. Was there any delay, after the signing of the contract, in the preparation of plans and, if so, for what reason?—A. There was no delay of any kind after signing the contract in the preparation of the plans, the whole work proceeded with the utmost diligence.

Q. Did you keep in touch with the work as it proceeded; with what matters did you more especially concern yourself and, in view of what has occurred, will you please state fully all the circumstances of your own knowledge and your comments upon them?—A. I kept in touch with the work at all stages of its progress. I fully appreciated its magnitude and importance, the engineering difficulties involved, and the necessity of the highest class of workmanship in all members of the bridge. I believed the appointment by the Quebec Bridge Company of Theodore Cooper as consulting engineer assured the success of the undertaking, that our engineers and constructors were fully competent to design, construct and erect the bridge under Mr. Cooper's supervision and that of the engineers of the Quebec Bridge Company and of the Department of Railways and Canals. Mr. Cooper insisted upon reserving to himself the final authority over his colleagues, and I especially regarded his approval of the detailed drawings as of the highest importance, believing that with the details and sections of the bridge members approved by him, as well as the general procedure in shop and field, a perfect organization existed. I never suspected he was overworked, and I believed he would have been allowed any assistance asked for. I was advised that the Department of Railways and Canals intended to appoint an assistant engineer with a staff to actively co-operate with him, but was prevented at Mr. Cooper's imperative demand. I directed that all the special tools required in the shops, and all the special appliances needed for erection, be procured of the best types regardless of cost; and this resulted in the installation of every needed tool and an expenditure for these purposes of several hundred thousand dollars more than had been anticipated. I also directed that all the special tests advised by the consulting engineer, Mr. Cooper, or by our own engineers, arising from the unusual size of the bridge be promptly and fully made. This was done, and a full size model of the complete main panel point was built as a study before the templates and shop work were started, and other models of large size were also used for the purpose of instructing the shop foremen and erection department. Mr. Cooper was in the shops but twice, only once saw any of the finished bridge members and was never at the bridge site at all after erection started, and consequently did not see or know of much of this preliminary work, and was

not familiar with the processes by which the bridge members were constructed. But his inspectors and our inspectors, working independently as checks upon each other, did not use their usual discretion, but I understand reported every error however slight directly to Mr. Cooper for his information and approval. This was an extra precaution on account of the importance of the work. It probably caused Mr. Cooper, who never saw the matters in question, to magnify their importance and to believe an unusual number of errors had been made, which is not true. On the contrary very few errors were made and all were properly and fully corrected before shipment in the most workmanlike manner. No member left the shops that was not fully inspected and accepted by the representatives of the Quebec Bridge Company.

The erection of this bridge was an important undertaking and every precaution was taken to avoid unnecessary risks, and our whole organization was impressed with this idea. Every one who observed its progress regarded it as a remarkable instance of performance in accordance with a pre-arranged plan, as a masterpiece of erection. This has been fully described to you by others. When the compression chord members began to yield at several places one after another as we can now see, and the whole bridge was on the verge of collapse, as afterwards developed, our staff at the bridge site observed the signs, and acted promptly and efficiently. They calculated correctly the stresses on the several members, and decided that failure from such stresses was impossible. When reported to Mr. Cooper he foresaw no immediate danger, and the same was true at the office of the engineers at Phœnixville. After the event we have learned what we did not know, and could not have known, before. Mr. Cooper states he would have saved the bridge, that he now knows the weakness of the members that failed, and could have remedied them at the cost of $100, but he does not say how, nor did he tell Mr. McLure on August 29, when he called on him, nor did he tell any one else, when the information might have been acted upon. I believe from all the evidence that was available at the time, there was no possible way to save the bridge, and the impending catastrophe could not have been foreseen or averted.

I believe that no engineer is able to state positively the cause of the failure or would wish to undertake to strengthen the compression members now built for the north side until after a satisfactory number of built up compression members of corresponding design of the largest possible section had been tested to destruction, but I think it is now possible to foresee that after such tests have been made the members already built for the north side can be increased in section, and made perfectly safe for use at a comparatively small cost, and that new members can be made for the south side to correspond exactly. We shall be glad to put our testing machine at the disposal of the Commission and to make when desired a series of tests upon it for this purpose, up to a cross-section of about eighty square inches. In respect to the sections of the compression members as built up for the Quebec bridge, I wish to say that it was not in the interest of the Phœnix Bridge Company to restrict the area or weight of these, as has been intimated, but that in a commercial way it was largely to its interest to increase the sections and the size and weight of the bracing, and from that point of view we should have been glad to have increased the weight. Our contract being not for a lump sum, but by the pound, any increase of metal would have been to our advantage. It was simply imperative, from the point of view of good engineering, and in accordance with the fundamental requirements of the contract and specifications, not to make the weight or the price of the bridge any more than was demanded by the best practice. The consulting engineer, in the interest of his clients, was supreme in this respect. We proceeded with the contract unrestricted by any consideration of the financial strength of the company which employed us. No restriction of that kind was ever heard of by us—we were always promptly paid, and we never economized in any respect by reason of any such consideration. It can be seen now that some increase of weight was requisite, especially in certain compression members, and prior to the shipment of any of these members we called this matter to the attention of Mr. Cooper, but Mr. Cooper

would not allow any increase whatever in these members, and decided they fully met the requirements.

There was no undue haste. Progress in the drawing room was always retarded while the engineers checked and rechecked their calculations. Progress in the shops was always retarded while the drawings were being examined and approved, and re-checked to provide for every possible condition of loading during erection and after; and progress in the field was always subject to delays by the engineers on the bridge, who controlled the operations of the erectors, and saw to the proper level and alignment. Due expedition was essential from many points of view, but it was never permitted at the expense of safety or good workmanship.

Every opportunity and facility has been given you while in Phœnixville to find out for yourselves, and from the officers, engineers and employees of the company, that this company was fully qualified and able to construct this great bridge in the most workmanlike manner; to observe the extensive preparations which were made in advance in additions to plant, in special tools, and in the increased number and capacity of cranes; to ascertain that in actual construction the best quality of material was used, the best workmanship performed in the shops, and the greatest care taken in transportation. You have been given access to all our books and papers. The same facilities were previously extended to you at the bridge site, to ascertain our method and work in erection. I believe that, with the bridge members at Quebec designed and manufactured in accordance with the approved drawings, the work of erection was scientifically and properly conducted with appliances best suited to the purpose, and in a manner that was superior to anything ever previously attempted or performed. In all respects nothing was left undone that might have been done. I do not go into strictly engineering questions, leaving that to the engineers, nor into the question of what Mr. Cooper calls 'the defects and deficiencies which we now recognize in the compression members,' or whether chord 9 west truss failed first, as he says, because of deficiencies which he has since recognized, or how the bridge might have been saved. I disagree, however, with Mr. Cooper on all these points, and leave it to our engineers to fully explain the facts. I wish to say, however, that Mr. Cooper told me personally when I called upon him the Saturday following the collapse of the bridge, that he had no idea at the time there was any immediate danger, nor could he account for the actual failure.

I was well acquainted and in touch with the principal men we employed in erection, and with those representing the other interests at the bridge site, and know they were all well qualified for the several positions they filled, and superior men could not have been engaged to perform their duties. The cause of the failure cannot be found due to any departure from the specifications in design, material or workmanship, or lack of good judgment in the field. No engineer under the circumstances will accept the idea of a local defect to account for it. The profession is bound to look beyond that—in the employment of the unusually high stresses prescribed for compression members, beyond all precedent and, as it now appears, beyond the existing technical knowledge of their effect.

Mr. Cooper was appointed consulting engineer to the Quebec Bridge Company on May 6, 1900. He stated to the Commission he found nothing could be done in the way of changing the original specifications except with the authority of the Deputy Minister of the Department of Railways and Canals, and after considerable correspondence and discussion and a personal visit to Ottawa, he received on August 23, 1903, a copy of an order in council dated August 15, giving him the authority to make modifications from time to time in the specifications and the proposed loadings, provided the efficiency of the structure be fully maintained up to that originally defined in the original specifications attached to our contract.

He stated that this order in council gave him absolute authority to amend the specifications, and to order such alterations in the construction plans as seemed best in his judgment, that he discussed these alterations with the designing engineer of the Phœnix Bridge Company, but not for the purpose of getting at their wishes but the

benefit of the views of Mr. Szlapka. This expression of his absolute and final authority coincided with our understanding of it in our dealings with him under the contract. He made modifications in the unit stresses to be employed upon the various members which very much increased them beyond any precedent, and by so doing placed the whole design in a field outside the benefit of experience. Such high stresses had never before been used, and in using them he acted with the authority of the Quebec Bridge Company and the Dominion of Canada vested in him. The fail of the bridge is to be laid directly to the change in the unit stresses as made by Mr. Cooper.

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I, Frank P. Norris, of the borough of Phœnixville, in the state of Pennsylvania, one of the United States of America, manager of the Phœnix Iron Works, make oath and say :

1. That I attended before the Board of Royal Commissioners appointed under the Great Seal of Canada for the purposes of inquiring into the causes of the collapse of the Quebec bridge, on several days during the months of October and November, 1907, in the borough of Phœnixville, in the state of Pennsylvania aforesaid.

2. That the attached twelve pages, numbered 876 to 887, both inclusive, contain my evidence in this matter. The answers to the questions are true statements to the best of my knowledge and belief.

Sworn before me in the city of Philadelphia, in the state of Pennsylvania, this 20th day of November, 1907.

Mr. NORRIS' testimony.

Q. What is your official position and how long have you occupied this position ?—A. Manager of the Phœnix Iron Works. Was appointed to this position in February, 1900, and was assistant superintendent of the works from May 1, 1896, until appointed manager.

Q. Have you any official connection with the Phœnix Bridge Company ?—A. No.

Q. What are your duties?—A. My duties are to manage the works of this company.

Q. Who is your immediate superior ?—A. Mr. William H. Reeves, general superintendent.

Q. Who are your subordinates in the carrying out of the work—give name of each with their respective duties and describe your organization?—A. My subordinates in the carrying out of the work are the department superintendents, as follows :—

Steel plant, N. E. Maccallum; rolling mills, E. G. Edgerton; bridge shops, R. W. Wright; templet shop, William Adams; pattern shop, Archibald Hoyle; machine shop, J. A. Murphy; eyebar plant, John Eagle; iron foundry, Joseph Challingsworth; steel foundry, W. C. Miller; beam and column shop, A. M. Setzler; testing, D. Gainor; general yard foreman, Albert Brehm.

Q. What was the date you were first officially advised to prepare for the construction of the Quebec bridge and who so advised you ?—A. In the spring of 1900 I was advised by Mr. William H. Reeves, general superintendent, that we were likely to receive instructions very soon to proceed with the Quebec bridge and that it was important that we look carefully into the question of the manufacture of the eye-bars for top chords and diagonal tension members, and at the same time stated that no bars must be used in the structure over 2 inches in thickness as he was satisfied from past experience that bars over 2 inches in thickness were not as efficient as those of this thickness or less.

Q. Prior to June 19, 1903, what work had you done in the shops in anticipation of having to build the Quebec bridge, and under whose authority was this done ?—A. The work done in shops prior to June, 1903 in anticipation of having the Quebec bridge to build was as follows, and was authorized by Mr. William H. Reeves, general superintendent :—

It was thought by some that we could not forge bars of such large dimensions, namely, 15 x 2 inches with eyes of proper width, to suit the different sizes of pins that would be necessary to use. We had frequent discussions as to how we would make these large eye-bars for the Quebec bridge. It was thought by some that we would have to cut them out of plates. Owing to the immense size of the bars it would have been next to impossible to get plates large enough, some of the bars requiring eyes 35½ inches in diameter, and the bars measuring 85 feet in length, which would have required a plate 36 x 2 inches x 85 feet 6 inches, weighing 20,948 lbs., which no mill in the world could roll. I then made up an estimate showing the comparative cost of upsetting and forging these eyebars from a 15 x 2 inches and of cutting them from a solid plate. This estimate was made up August 28, 1900, and satisfied us that cutting bars out of plates was out of the question and that forged bars must be used.

After much thought I formed the opinion that by making certain changes to our eye-bar upsetting machine we could upset and forge these 15-inch bars and obtain much better results than by cutting them out of large plates. To show that this theory was correct we made the changes necessary to the upsetter, made dies for hammer and all necessary appliances for forging 15-inch bars, and on October 6, 8 and 9, 1900, we forged ten 15-inch x 2-inch bars and tested two bars, one on October 12, and the other on October 13, test report herewith attached. This experiment cost in the neighbourhood of $1,000, and proved that we could make the bars and thus avoid delay in design of the bridge.

We were expecting to receive instructions any day to proceed with the bridge and we were thoroughly aware of the fact that before the fabrication of the different members was begun in the shop, owing to the immense size and weight, we should have to erect numerous large travelling cranes and secure a large number of new machines to do the shearing, straightening, milling, boring, &c., as tools for ordinary work were nowhere nearly large enough to take care of work of the magnitude of the Quebec bridge. Owing to the size and length of these sections it was necessary to make certain additions to our main bridge shop and strengthen the columns that supported the crane runway girders, and also replace the old runway girders with much stronger ones in order to carry the heavy loads. We did this work in the fall of 1902, as we realized it would take considerable time, and decided to make these improvements at once rather than to take chances of delaying the work.

The above changes to crane runways and additions to shop cost us between $28,000 and $30,000.

Q. After the date of the contract between the Phœnix Bridge Company and the Quebec Bridge Company, June 19, 1903, what special preparations were made in the shops for the manufacture of the bridge?—A. On June 19, 1903, the formal contract for the Quebec bridge was signed, and I was instructed to proceed at once to obtain whatever machinery and tools were needed to make the best job possible, regardless of their cost, and these instructions were carried out to the letter. Our total cost for extensions to plant, machinery, tools, cranes, &c., necessary to build the Quebec bridge was between $225,000 and $250,000.

Q. At what date was the manufacture of the steel commenced? At what date was the first working drawing given you; when was the shop work commenced and upon what member?—A. Manufacture of steel was commenced June 14, 1904, for the tower shells C. O.'s 604 and 605. The first working drawing was received at shops on June 1, 1904, and was for strut T. S. 3, between tower shells (the orders for the metal having been sent to 'mills' several days previous to sending drawings to shops). Shops started to punch the metal for this strut June 24, 1904.

Q. At what date was material ordered for lower chords and at what date was work on them begun in the shop?—A. Material was ordered for No. 1 chords C. O.'s 606, south anchor arm, July 19, 1904, and shops started to punch the metal for them August 5, 1904.

Q. Will you please state from your personal knowledge the main facts in the course of manufacture as they concern you, and any comments you have to make

upon them?—A. Every department superintendent, as well as the workmen in the steel plant, rolling mills, bridge shop—and in fact, all employees of the works were instructed to take the utmost care in preparing and handling the material for this bridge, as well as the punching, assembling, reaming, drilling, milling, boring, planing, &c. The engineers furnished the shops with drawings showing just how all the large members were to be loaded on the cars for transportation to Quebec, and numerous special appliances were employed for this purpose. All these instructions were followed with the greatest care.

During the months of May and June, 1904, we made a full-sized model of a panel point of the anchor arm to let our shop men see the size of the members we had to build, and to further impress upon them the magnitude of the work and the great importance of building the work just right, and also that they could familiarize themselves with details and avoid the possible chances of mistakes in the shops. This model cost between $600 and $800 to build, and can be seen on the second floor of the bridge company's office.

All the shapes for this bridge were rolled in our works; the plates were furnished by the Central Iron and Steel Company and the pin material by the Bethlehem Steel Company, and inspected at the different mills by the inspectors appointed by the consulting engineer.

After the chords, posts, &c., were riveted up complete, they were laid out by the shop superintendent personally—in his absence by his assistant—before being placed in the rotary planers (for facing) and boring mills, and were checked up after each cut to make doubly sure the work was being done correctly. In many cases, if not always, these layouts were checked by either Mr. Edwards or Mr. Meeser, as an extra precaution, and were always checked by the Phœnix Bridge Company's inspector. We threw every safeguard possible around this work to avoid errors, and notwithstanding, a few minor errors did creep in, but none of a serious character. They were remedied to the entire satisfaction of the consulting engineer's representative. The chief inspector of the Phœnix Bridge Company kept a complete record of all variations from the drawings, even to the chipping of a rivet. This record can be seen by the Commissioners if desired.

When the question of inspection of the Quebec bridge in the shops was first brought up I made a strong plea that the best shop inspectors that were obtainable should be placed on the work. The consulting engineer, as I remember, stated distinctly that he would not have the inspection done by an inspecting firm, as he wanted men of his own selection who would have no duties but to be right on this work all the time. This met with my ideas exactly, except that the consulting engineer stated that he wanted young men just out of college who, being without any practical experience, could be trained according to his own ideas. This I, as well as other officials of the company, protested against strongly, as we wanted experienced men from the start. The result was that Mr. Edwards, a man with some twenty years' experience, was appointed chief shop inspector, and later Mr. Meeser, another experienced inspector, was appointed to assist him. Mr. McLure also spent considerable time assisting Mr. Edwards with the shop inspection before taking up his duties as inspector of erection. Mr. McLure also spent the winter months assisting with shop inspection.

The inspection on this work was the most thorough of any I have ever witnessed.

Everybody appreciated the magnitude of the work, and the great importance of making it to conform to the drawings.

With a view of keeping the shop work right up to the highest standard, I called Mr. Edwards in the office at different times, and requested him to accept nothing but the very best work, and at the same time cautioned both him and Mr. Meeser to always check the measurements with their own private tape, and to the best of my knowledge and belief they did this.

There was never any friction between the Quebec Bridge Company's inspectors and our men; all were working to the same end, namely, to make a bridge second to none.

Realizing the absolute importance that every part of this bridge must be right, and to impress all the shop men with this fact, I placed notices around the shops, before the actual fabrication of the work commenced, calling their attention to the fact that we were about to start work on what was to be the largest bridge in the world, and requested every man to do his best.

We put the very best mechanics in the shop on this work. The boring was all done by expert machinists.

I want to say most emphatically, and the actual work will bear out my statements, that we all appreciated the great magnitude of the work and the utmost importance of doing it just right. The way the work went together in the field proved it was right. Everybody who has seen the work does not hesitate to say that it is the very best.

Any tests that were asked for by the consulting engineer were always willingly and promptly made and with the greatest care. Together with Messrs. Edwards and Meeser, the inspectors, and Messrs. Deans and Szlapka, I spent many hours in the testing room witnessing the making of the eyebar tests. We placed our toolmakers at the disposal of the inspectors to check their readings of the Vernier callipers. These tests cost a considerable sum.

All the members in this bridge, including the eyebars, were measured by steel tapes, standardized by a tape in the possession of Mr. Edwards, the Quebec Bridge Company's chief inspector, to which were attached spring balances or scales, and 12 pounds pressure was put on the tape for every measurement made. This insured uniformity of measurements throughout the whole job. The pins for this bridge were forged in the armour plate forges of the Bethlehem Steel Company, at an extra cost of $20 per ton over and above what we could have purchased ordinary hammer forged pins for, and which would have filled the requirements of the specifications. We all appreciated the great importance of getting the best pin material obtainable, as they had an enormous load to carry, and after many weeks of careful consideration of this particular part of the structure we were instructed to order these pins at this large additional cost, by Mr. David Reeves, president, who from the very beginning said that we must use the best of everything in this bridge, regardless of cost. These instructions have been rigidly lived up to.

In October, 1904, we spliced chords No. 1 and No. 2 of the anchor arm together under the shipping crane in our yard and requested the consulting engineer to come to Phœnixville to see how nicely the work went together. After waiting nearly a week he finally came over and was evidently much pleased, as we never heard anything to the contrary. The last week in November of the same year we spliced chords No. 4 and No. 5 of the anchor arm together—(these are the first two chords that are cambered).

After putting on all the splice plates we had our transit man square and level them up with the instruments, then compare them with the drawings, and found them as near to the drawings as it was possible for human hands to make them.

We did not complete the splicing of the above chords until late on a Saturday evening and on the following Sunday morning Messrs. Edwards, Szlapka, Scheidl, Wright (shop superintendent) and myself, together with a number of others, were there to see whether the work came together as it should, and as stated above, the work was accurate. The next day, and for the next couple of weeks, we made several attempts to get the consulting engineer to come to Phœnixville to see these chords, but he positively refused to come. We were very much surprised at this as we were told many times by Messrs. Deans and Szlapka that these cambered chords were probably the most important sections in the bridge and so much depended on having them just right so as to keep the bridge in perfect alignment.

When the first shoe was completed in the shops we assembled both bottom and top pedestals, shoe No. 11 chord, main post foot, floor beam connections, and all the various plates that connected the shoe for brace connections. (We have photographs of the above assembled together.)

Again we requested the consulting engineer to come to Phœnixville to see for himself how well each part fitted to the other and the excellent work we were doing, but he refused absolutely.

The consulting engineer in his testimony speaks of the company being slow in making the special eyebar tests. This was due to the fact that it took considerable time to get the plain bars from the plate mill. After they reached our works it required considerable time to forge, anneal, straighten and bore the bars, and the testing, owing to the numerous measurements that had to be made, was a slow process and required many days.

Mr. Hoare, chief engineer of the Quebec Bridge Company, was at the works numerous times during the past four years and always seemed well satisfied with the class of work we were doing for him. At the same time he always kept impressing on us, as well as on the inspectors, the great importance of making everything just right.

Before the main traveller was completely designed for erecting this bridge we made tests of different kinds of antifriction metals to make sure of getting the very best for the bearings of this traveller, on account of its great weight and the heavy sections it would have to lift. The shackles were made by the best makers in the country and when they arrived here we tested several of them in the testing machine. The results were not satisfactory and we refused to accept them and forged them here from solid steel billets. The same care was taken with the false work and travellers, both large and small, as with the bridge proper, and the materials and workmanship were of the very best. Many tests were made of the materials that went into the false-work and travellers, same as were made for the big bridge. Great care was taken to have all sections carefully painted before being shipped or put in storage, and the material in storage has been carefully looked after.

I gave the Quebec bridge material my most careful attention through its various stages in mills and shops, and realizing the great responsibility that naturally was placed upon me as the works' manager, I gave up everything in the way of vacations, and have been in the works practically every day since we commenced work on the bridge in 1903, except for five days in October, 1905, that I spent going to and at the bridge site in Canada.

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I, JOHN STERLING DEANS, of the town of Phœnixville, in the state of Pennsylvania, one of the United States of America, engineer, make oath and say:—

1. That I attended before the Board of Royal Commissioners appointed under the Great Seal of Canada for the purpose of inquiring into the causes of the collapse of the Quebec bridge, on several days during the months of October and November, 1907, in the town of Phœnixville and the city of Philadelphia, in the state of Pennsylvania aforesaid.

2. That the attached 24 pages, numbered 889 to 912, both inclusive, contain my present evidence in this matter. The answers to the questions are true statements to the best of my knowledge and belief.

3. That the letters and letter-books produced before the Commission, from which exhibits 74 to 83, both inclusive, purport to be copied, are the correspondence received and sent by the Phœnix Bridge Company and its officers in the ordinary course of business, in relation to the Quebec bridge.

Sworn before me in the city of of Philadelphia, in the state of Pennsylvania, this day of November, 1907.

Mr. DEANS' testimony:

Q. From whom and at what date did you receive the cross-section of the River St. Lawrence at the bridge site and other data required for the preparation of the

first preliminary plan?—A. On June 16, 1897, Mr. E. A. Hoare wrote to the president of the Phœnix Bridge Company, asking if any engineer of the company expected to attend the annual convention of the American Society of Civil Engineers, which was to convene in Quebec on June 30; if so he asked that the engineer call to see him, in connection with a project for bridging the St. Lawrence river near Quebec. It was natural that Mr. Hoare should address the Phœnix Bridge Company in this connection, as about twenty years before, while he was chief engineer of the Quebec and Lake St. John Railway, the company had constructed bridges for his road. I attended the convention and met Mr. Hoare for the first time, and also met Mr. Audette, Mr. Boswell, Mr. Dobell and other directors and officers of the Quebec Bridge Company. Mr. Dobell entertained the entire convention at his home on the St. Lawrence near the bridge site, and during the trip by steamer explained to the engineers present the proposed site of the bridge and the steps the company were taking towards its construction. Mr. Cooper, afterwards consulting engineer of the Quebec Bridge Company, was in attendance at this convention, and learned of the enterprise at that time. Mr. Hoare said to me on the occasion of this visit to Quebec that if we were interested in the bridge project: 'I shall be glad to send you a profile of the crossing at the proposed site and other necessary general information so that you may, if you wish, be prepared to bid, if the project is carried out.' Shortly afterwards I received from Mr. Hoare the said profile and information.

Q. Please file copies of the outline plans prepared by the Phœnix Bridge Company dated November 30, 1897, and December 7, 1897, respectively?—A. I file copies of general outline plans prepared by the Phœnix Bridge Company dated November 30, 1897 (Exhibit 88) and December 7, 1897 (Exhibit 89) respectively.

Q. Please examine the official plan prepared by the Quebec Bridge Company, dated January 13, 1898, and subsequently filed with the government of Canada, and state if the truss outlines, as shown on it, are identical with those shown on the Phœnix Bridge Company's plans, dated December 7, 1897?—A. I have compared these plans and find that the truss outlines are identical.

Q. Please refer to your letter of November 8, 1897, to E. A. Hoare, and state whether or not the general features of the Quebec Bridge were determined by the Phœnix Bridge Company's engineers?—A. No, except as to the general outlines of trusses, and lengths of spans.

Q. Please state why, in advance of the submission of competitive tenders, the Phœnix Bridge Company allowed its plan for this bridge to become public property by being filed in the Department of Railways and Canals and thus becoming available for use of its competitors?—A. I do not remember that I knew that our preliminary studies of this work, as shown on plan dated December 7, 1897, were incorporated in a plan filed by the Quebec Bridge Company with the Department of Railways and Canals. Had the Quebec Bridge Company asked permission to use the plan I would not have objected. In any case I do not consider the fact of any special significance or as giving our competitors any advantage. At the time tenders were asked, about a year later, bidders had free scope in the matter of design, length of anchor arms, &c., and were asked to bid not only on cantilever span, but on suspension design. As a matter of fact our own tender did not agree exactly with the above preliminary study.

Q. Please refer to your letter of April 14, 1899, to E. A. Hoare and state if you did not understand that economy in design was to be of first importance in arriving at a final choice between competitive tenders?—A. I understood economy in design was of importance but not of first importance and not to be secured at the expense of any requirement of the specifications or of obtaining the most capable contractor for the work.

Q. Was the subsequent letting of various contracts to the Phœnix Bridge Company in pursuance of the understanding referred to in the letter of April 14, 1899?—A. No. Mr. Cooper reported favourably upon our plan and tender as submitted March 1, 1899, and the contract was awarded to us on this report of Mr. Cooper.

Q. Please refer to your letter of 19th of April, 1899, to E. A. Hoare, and state your understanding of the instructions that had been given to Theodore Cooper when that engineer undertook the examination of the competitive designs and tenders?—A. I have read my letter to Mr. Hoare of April 19, 1899, I understood that Mr. Cooper was to recommend for acceptance the lowest and best tender and plan which met every requirement of the specifications.

Q. Did consultations take place between Mr. Cooper and the engineers of the Phœnix Bridge Company relative to the determination to increase the main span and to the determination of amendments to the specifications, and had these conclusions the approval of the engineers of the Phœnix Bridge Company?—A. At Mr. Cooper's request Mr. Szlapka had interviews with him at which Mr. Cooper stated it was proposed to increase the span and amend the specifications. The Phœnix Bridge Company had nothing to do with the determination of these questions. We were not asked to approve the proposed action.

Q. Did the Phœnix Bridge Company fully concur in and approve the action of the Quebec Bridge Company, and of the government of Canada in practically making Mr. Cooper's approval of the plans for the bridge final for all parties?—A. We neither concurred or dissented. Were not asked to do so. We were bound by the action of the Quebec Bridge Company and the government of Canada in making Mr. Cooper's approval of the plans final for all parties.

Q. Did Mr. Cooper suggest to you his inability to continue as consulting engineer, and if so when was this, what reasons did he assign and how did you view his suggestion and with what result?—A. About two or three years ago Mr. Cooper spoke to me about the possibility of his being unable, owing to illness, to continue his duties as consulting engineer and suggested the name of Mr. C. C. Schneider as his successor, should this contingency arise. I told Mr. Cooper that we would consider it unfortunate if a change in authority in the midst of construction occurred and that I hoped and believed he would soon be better and remain through the entire operation. As a matter of fact Mr. Cooper did improve promptly and as far as I could see was soon in his usual state of health and continued his duties in the same manner as previously.

Q. Did the Phœnix Bridge Company at any time suggest the employment of Mr. Cooper, Mr. Edwards, and Mr. McLure in their several capacities?—A. No suggestion of the employment of any of them was made by this company. About the time the necessity of appointing a consulting engineer arrived, Mr. Hoare said the Quebec Bridge Company was considering the names of four or five engineers, among them the name of Mr. Cooper, and asked me as to their ability and experience, and I said I considered Mr. Cooper the best fitted for the work. We received an application from Mr. McLure for a position. I did not know him, but knowing that Mr. Cooper desired to secure the services of a young graduate of some experience in bridge work, I turned the application over to him.

Q. Do you consider that ample time was given to the study and preparation of the plans? In this connection we understand that the actual weight of the suspended span over-ran that assumed in the calculations for the anchor and cantilever arms by fully 25 per cent?—A. Yes. Ample time was given. The actual weight of the suspended span did over-run that assumed in the original calculations. The estimated weight was necessarily approximate.

Q. At what date was first plan approved by the Department of Railways and Canals received by you and what was this plan?—A. The first plan of the main structure, approved by the Department of Railways and Canals, was received by us October 28, 1903; it was the plan of the floor beam drawing B anchor arm.

Q. Prior to October, 1904, was your office work confined to the anchor arm?—A. No. Prior to October, 1904, our office force was at work on stress sheets of the entire bridge and on the shop details of the approach span, anchorages and anchor arm.

Q. At what date were the final arrangements made under the contract of June 19,

1903, which permitted you to proceed freely with your work?—A. February 22, 1904. The final arrangements were concluded on this date. We had in the meantime been working on our plans and details of the structure and making provisions for properly and promptly constructing the work.

Q. When you sent the stress sheet of the anchor arm for approval to the Department of Railways and Canals, had you completed your stress sheets for the suspended span and the cantilever arm, and had you designed the traveller?—A. The anchor arm stress sheet was approved by Mr. Cooper, June, 1904, and by the Department of Railways and Canals October 11. The traveller was designed April, 1904.

Q. When did you sent the stress sheets of the suspended span and cantilever arm for approval and had you then designed the traveller?—A. Stress sheets for the suspended span was sent February 19, 1904, and for the cantilever arm, May, 1905; the traveller was designed in April 1904.

Q. After completing the stress sheets of the suspended span, and of the cantilever arm, and the design of the traveller, did you find that modifications were necessary in the stress sheet of the anchor arm, what were they and did they tend to increase or decrease the stresses?—A. Yes. It was found necessary to make modifications in the stress sheet of anchor arm, due to increase in weight of suspended span and cantilever arm, but not to the traveller.

Q. Were the members of the anchor arm designed from the stress sheet of October, 1904, which sheet reached the Department of Railways and Canals at the same time as the plans of the details of the bottom chords?—A. Yes.

Q. When the plans for the bottom chords were approved had any of the chords already been built, and were they in accordance with the plans as approved?—A. None of the chords were built before Mr. Cooper approved the plans.

Q. Was any work done or material ordered prior to receipt of approved plans from the Department of Railways and Canals, and if so give details.—A. Yes. Work was done in many instances including anchor arm chords and other members upon receipt of plans approved by Mr. Cooper and before the plans were actually approved by the government, as Mr. Cooper's approval was final as far as we were concerned. No changes were ever made by the government on any plans approved by Mr. Cooper.

Q. The contract between the Phœnix Bridge Company and the Quebec Bridge Company provided for payment at prices per pound of material erected complete. Was there any limit at all placed upon your company as to the amount of money the bridge should not exceed in cost, or was any sum mentioned by you that it would not exceed?—A. No.

Q. What financial considerations governed you in the design of the structure?—A. We were not governed by any financial consideration in connection with the design of the structure.

Q. Did the consulting engineer at any time urge upon you the necessity of economy, beyond the point where you considered the best efficiency could be obtained?—A. He effected economy in cost by changing the specifications, and these changes lowered the efficiency of the bridge. In details not expressly covered by the specifications he also exercised economy. He endeavored to reach an economical design, and we did not think he carried this so far as to lead us to question the safety of the structure.

Q. Did any one else?—A. No.

Q. Have you and your staff acted harmoniously with Mr. Cooper throughout this work?—A. Yes.

Q. Did the changes in unit stresses meet with your approval?—A. The changes in unit stresses were made by Mr. Cooper and were not submitted to us for our approval. Mr. Cooper merely talked the matter over with Mr. Szlapka as a brother engineer, but not however for the purpose of getting the wishes of the Phœnix Bridge Company. He then reached a decision of which we were notified and upon which we acted.

Q. Did these changes follow previous experience, or did they take the work out

of the field of past experience in bridge construction and detailing and in what respect?—A. The changes in unit stresses for compression members carried them out of the field of past experience in bridge construction and detailing and did not follow usual practice.

Q. Do you consider, in view of this, that enough time and study were devoted to the preparation of designs?—A. Yes. We took all the time considered necessary for the study and preparation of plans and I believe Mr. Cooper's office also took all the time that they considered necessary.

Q. To your personal knowledge, was Mr. Cooper's examination and criticism of plans aggressive and did he insist on discussion of all matters in which questions arose?—A. Yes. The examination of details and plans by Mr. Cooper's office, I believe, was conscientiously and carefully done. Discussions often arose but Mr. Cooper's decision always prevailed.

Q. Were all plans to your knowledge approved by the consulting engineer?—A. Yes.

Q. In any instance were plans sent to the Phœnix Iron Company before the approval of the consulting engineer was obtained and was any fabrication commenced prior to such approval?—A. In a few instances and late in the work, plans were sent to the shops for preliminary work before the actual approval by the consulting engineer; so that we would be prepared to carry on the work promptly. This was only done in the case of plans of which the design and detail had already been established and approved by the consulting engineer. We took the risk of possible alterations by him. But in no instance was a single member of the bridge actually completed which was not in accordance with the final approved plans.

Q. Was the design of details of the lower chord particularly discussed with Mr. Cooper, and was his opinion specifically obtained on the latticing and other details and, if so, please state fully what took place?—A. Yes. I had no interview with Mr. Cooper on this subject, but I instructed our designing engineer particularly to submit the question of size of latticing of chords to Mr. Cooper. Mr. Szlapka later reported to me that he had an interview with Mr. Cooper on this point, and Mr. Cooper advised him that the lattice angles were correct as shown on approved plans. Mr. Szlapka will give you the details of his interview with Mr. Cooper on this point.

Q. We understand that the Phœnix Bridge Company maintained an independent inspection of the shop work done by the Phœnix Iron Company. Please file a copy of the record of the errors detected by your inspector?—A. An independent inspection was maintained and I herewith submit the daily record. Exhibit No. 90. Every error, however small, is noted in that book, and all these errors were corrected before the work left the shop.

Q. Were all errors reported satisfactorily corrected by the Phœnix Iron Company?—A. Yes.

Q. What precautions were taken to insure the safety of the bridge members in handling and transportation? What measurements were made at the bridge site to detect distortion or injuries occurring to members in transit?—A. Special precautions were taken to insure the safety of the bridge members during handling in transportation. We consulted with the superintendent of the Motive Power of the Pennsylvania R. R. Company and devised with his representative special schemes of loading. All large and heavy pieces were the subject of special consideration with the transportation companies. All members were carefully inspected as to distortion and injury during transit, after the members arrived at bridge site and before they were erected in place. I cannot say just what measurements were made in the course of this inspection. This inspection was by the representatives of both the Quebec Bridge and Railway Company and the Phœnix Bridge Company.

Q. Please file a full list of all members injured in handling or in transit with a statement of what subsequent action was taken in each case.—A. Only one member was injured in transit, being the shell frame south anchorage. The repairs to this member were explained in detail in the evidence of Mr. A. B. Milliken. One member

was injured in handling at south storage yard, being chord 9 L anchor arm, repairs of which have been fully covered in evidence. One member was dropped in handling in the shops, slightly injuring it and one or two other smaller members. Thorough repairs were made, all as shown in detail in shop inspector's report. These members were thoroughly repaired under the direction and to the satisfaction of the inspectors.

Q. Please file a complete list of 'field corrections' reported from the bridge site. —A. We file herewith complete list of field corrections reported from the bridge site and noted during the erection of the structure. (Exhibit No. 91)—most of these refer to false work and erection apparatus.

Q. Please file a statement compiled from your weekly records showing the weight removed from and added to the cantilever arm and suspended span during 1907.—A. We file the statement compiled from weekly records showing weight removed and added to cantilever arm during 1907. (Exhibit No. 92.)

Q. Please give a statement with dates complete showing fully Mr. Birks' experience and the nature of the work upon which he had been employed?—A. A statement of Mr. Birks' experience in no sense conveys a proper estimate of his ability which was unusual for a man of his years. He was specially fitted by character and temperament for the work entrusted to him. His experience was as follows:—

On March 22, 1902, we received a letter from Geo. F. Swain, prof. C. E. Mass. Institute of Technology, Boston, suggesting the name of A. H. Birks to us as a desirable man for our engineering department. He wrote as follows:—'I also have an exceedingly good man who graduated in architectural engineering and has been taking a post-graduate course with me. His name is A. H. Birks. Birks is a man of exceptional ability in this line and having taken all my work in structures is as well up in bridge work as building work. He has also had some experience, having worked one summer with a bridge company, and one year in an architect's office, I believe. He is an exceptional man.'

We gave Mr. Birks a position and he started to work in our draughting department and worked there for about six months. We soon found he had traits of character and ability that would well fit him for erection work, and he was transferred to the erection department on October 7, 1902.

Between October 7, 1902, and November 8, 1902, he was in the field on erection of plate girder spans N. & W. bridge, Circleville, O.

December 1, 1902, to June 15, 1903, on Central Railroad of New Jersey bridges, Wheelers Locks, Parryville and Glen Onoco (plate girder structures) and Lehigh river bridge, Parryville (through riveted spans).

June 18, 1903, to August 13, 1903, Southern Railway bridges, Caswell, Tenn., Mascot, Tenn., Knoxville, Tenn., Alexandria, N.C., Wolf Creek, Tenn., Jefferson City (all plate girder spans) and Tennessee river bridge, Straw Plains, Tenn., 105 feet (deck plate structure).

February 11, 1904, and during the month he was inspector on Southern Railway bridges—James river bridge, Lynchburg, Buffalo river bridge, Rappahannock river bridge. (All through truss bridges.)

July 24, 1904, to August 3, 1904, at Deepwater, French Broad river, Hot Springs, N.C., 264 feet (through pin span) during the erection of the trusses.

In March, 1905—Jacksonville, Fla., examining sites of two Atlantic Coast Line Railroad draw bridges, securing necessary information for preparing erection plans.

February, 1906, New London, Conn., arranging method of erecting Jordans Cove bridge.

During the intervals not covered by above, Mr. Birks was engaged on erection plans and details in the office at Phœnixville.

When the Quebec erection was taken up early in 1904, Mr. Birks assisted in all the preliminary studies and continued on this work until the entire plan was fully developed and settled upon. Many of the features of this erection scheme which worked out so successfully in practice were due to Mr. Birks' peculiar ability in this line. His familiarity with every detail of the erection scheme and the behaviour of

the trusses during erection, his thorough technical training, his absolute reliability, decided us to appoint him resident engineer of erection, and he was sent to Quebec in September, 1904. He was on the work during the working season from that time until the date of the disaster, with the exception of the period during the erection of the main traveller, when Mr. C. W. Hudson was resident engineer.

Mr. Birks was fearless and was able to climb over the entire structure. He had a lovable character and that about him which instantly demanded respect and confidence. He could have his orders carried out readily without friction. It would be difficult to find a man combining the many traits of mind and character which so eminently fitted him for the position of resident engineer of erection.

Q. Please file a detailed statement of all the long span bridges that have been built by the Phœnix Bridge Company since 1890?—A. The Phœnixville Bridge Works have constructed since 1865 about six hundred and ten thousand tons of bridge work. They are the pioneers in bridge construction in the United States. Among the larger works constructed by the company we mention the following :—

Pecos Viaduct, Texas, Southern Pacific Railway, 2,080 feet long, 326 feet high. (1889).

Ohio River Bridge, Cincinnati, O., C. & O. Ry. One and one-half miles long, containing 550 feet through pin span, the longest and heaviest truss constructed. (1888).

Harlem river draw, New York City, 303 feet through riveted. Turntable 60 feet diameter, largest in the world. (1896).

Red Rock cantilever, Santa Fé Railway, 660 feet central span. (1890.)

Mississippi river bridge, Rock Island, Ill., for United States government. A double deck structure 1,850 feet long. (1896).

Cambridge bridge, Boston, Mass., 11 plate arch spans, weight 16,000,000 lbs. (1904).

Omaha draw, 520 feet through pin. (1893).

Sioux City bridge, Nebraska, two 470 feet draw spans; two 500 feet through spans, 4,000 tons. (1896).

Manhattan bridge, New York, 1,470 feet central span, 725 feet side spans, 34,000 tons (not including cables). (1906-7.)

Q. Why were Mr. Cooper's suggestions of August 9, 1907, for the repair of the splices at 7 L and 8 L cantilever arm not adopted and promptly executed?—A. After the lower chords, including the details of shop and field splices, were approved by the consulting engineer, the engineers of the Phœnix Bridge Company and the Erection Department carefully considered the action of the field splices during connection of trusses and the camber movements of splices while members were receiving their full dead load. A special camber blocking was designed and placed on false work under each panel point. This blocking was easily adjusted and free to move longitudinally. Special consideration was given to the bolting before the riveting of splices. Full instructions were prepared in advance of erection and incorporated in a blue print book of instructions to the field force. The bolting was checked in person by the resident engineer and regular reports sent to Phœnixville. The action of the joints was noted and reported on printed forms as erection proceeded, by the resident engineer in charge of field instrument work. The action of joints was also noted specially by the designing engineer and assistant engineer in charge of details during several visits to the bridge site. All of this was in addition to the regular erection supervision by the general foreman and his assistants. The splices were under the closest scrutiny at all times and they acted as expected in closing to complete contact. No report was received at Phœnixville advising us of anything wrong in connection with any splice until August 8, 1907, in a letter from Mr. Birks dated Bridge Site, August 6, 1907. In this letter he advised us that one of the inside ribs at bottom of splice chord 7 L—8 L cantilever arm was bent out of line and enclosed a sketch of a diaphragm to be riveted between the ribs to hold them in their position. This proposed diaphragm was sent to Mr. Cooper by Mr. McLure on same

date as it was sent to us, but he did not approve it. See telegram from him, August 8, 1907. (Exhibit No. 79-F & 73-J.) Mr. Cooper never gave us any instructions concerning the matter. His letter of August 9, simply deals with ideas and you will notice by his letter of August 13, that he desired before acting to get further information from his resident engineer Mr. McLure. His letter of August 21st indicates that he had not yet reached a decision and the matter was still in this unsettled state when the accident occurred. There were no joints in the anchor arm where similar bend in rib was noticed; they all lined up true and satisfactory.

Q. Were chords 9L, anchor arm, and 9R and 8R, cantilever arm, in perfect condition when they left Phœnixville?—A. Yes.

Q. Were requests and suggestions made by Mr. Cooper with regard to tests and to matters of erection always promptly considered and, when acted upon, was it with all possible promptness, giving specific instances?—A. Yes, as instances: Special tests of eyebars in connection with deformation of eyes; water gauge levels for use at bridge site; investigation of top section of main post by Mr. Scheidl.

Q. What is your opinion concerning the movements of the bridge when falling?—A. The position of the wreckage indicates to my mind that a compression member, a lower chord in anchor arm down stream truss, failed first and, immediately following, the compression member directly opposite failed. The failure of these two compression members permitted the anchor arm to move two panels toward the river. The lower chord of cantilever arm being relieved of support forced the two shoes towards shore and broke off a lower section of main post. The down stream chord anchor arm failing first permitted the truss to drop vertically as well as horizontally and had a tendency to pull the higher parts of the superstructure down stream. The pinnacles at the top of main posts are pointed in this direction.

Q. Please explain the references in Mr. Birks' letter of August 29, 1907, with regard to the telephone conversation about stopping the work of erection?—A. On August 29, 1907, we first learned from the letter of August 27 from Mr. Yenser that buckles were noticed in webs of lower chord 9L of anchor arm. Consultation then took place at Phœnixville between the engineers, shop officials and inspectors, and it was determined that chord could not be bending from any excessive stress, as it was carrying only three-quarters of the work load for which it was designed and approved. We then called Mr. Yenser and Mr. Birks on the 'phone and advised them of our conclusion. During this conversation on the 'phone they notified us that a portion of the bends had been in the webs for a long time. That since writing on August 27 they had carefully watched and repeatedly examined the chords and found there was no further movement, and that they had proceeded with the erection without waiting for advice from us. As this action agreed with our own conclusion we told them we thought they had acted wisely in not stopping the erection. Mr. Birks' letter refers to this 'phone conversation. While a chord with bent webs, even though bends are slight, is not capable of performing its functions as well as a perfectly straight member, the bends in chord 9L noted on August 27 and of which we learned on August 29 were not such as to shake absolute confidence of years which all had in the entire structure. If the consulting engineer then believed there was imminent danger and that all work should be stopped immediately it was not necessary to inquire whether Mr. A. B. Milliken was at site or not. Mr. Hoare had sent Mr. McLure to Mr. Cooper to report on the bends in chord 9L and to receive his advice. Mr. Hoare was in Quebec and any message to him would have stopped the work instantly, as was done on a previous occasion by direction of Mr. Cooper. The testimony of others shows that Mr. Cooper on August 29, no doubt, had no thought of imminent danger. We all now see, what no one dreamed of before, that the compression chords were beyond any scheme of protection on August 29 and were failing under less than half the load for which they were designed and approved and were considered capable of sustaining without failure. While it is difficult it is essential, in order to reach an accurate judgment, to keep in view the frame of mind every one was in before August

29 regarding this structure and its strength and the respect and confidence all had in the engineers responsible for its design and detail.

Q. Was the bridge in all particulars designed by the engineers of the Phœnix Bridge Company and were these designs fully approved by the Quebec Bridge Company through their consulting engineer, Mr. Cooper?—A. The bridge was designed in its general features by the engineers of the Phœnix Bridge Company. The details of the bridge were worked out in connection with the consulting engineer, to agree with the modified specifications which he had prepared, and all plans and details were approved by the consulting engineer, Mr. Cooper.

Q. Please file the reports showing the condition of the joints in November, 1906, and also a similar report to August, 29, 1907. At what date was the joint 8-9 L anchor arm riveted?—A. Reports herewith show the condition of joints November, 1906, and also a similar report of August 29th, 1907. (Exhibit No. 93.) Joint 8-9 L anchor arm was riveted, June 1907.

Q. The contract for the main spans was signed June 18th, 1903, and called for the completion of the work by December 31, 1906. Was the time allowed, in your judgment, sufficient for the satisfactory carrying out of the work? Did Mr. Cooper express any opinion to you concerning this?—A. The time for completion in our contract of June, 1903, was given as December 31, 1906, and was fixed by the Quebec Bridge Co. We believe this time was too short and would not agree to be bound by it, and on the date the contract was executed, letters, which have been submitted to you, passed between the two companies extending the time to December 31, 1908. Mr. Cooper subsequently expressed his opinion in this connection saying four or possibly five years would be required for the construction of the bridge, this long time being required because of the short working season for erection and not because of other construction demands. As a matter of fact the Phœnix Bridge Co. was unable to start on the work as early as had been expected because of the delay in the completion of the south approach to the bridge, and hence notwithstanding due diligence on its part the work could not have been completed for some time after December 31st, 1908.

Q. Please state the circumstances that called for the letter to you from Mr. E. A. Hoare, dated October 20th, 1906?—A. Mr. Hoare's letter of October 20th, 1906, was called forth by correspondence I had with Mr. Milliken in connection with the demand which Mr. McLure had made to him to stop certain work on falsework of south anchor arm, after Mr. Milliken had received instructions from me over the 'phone to proceed with this work at once. It was work which demanded prompt attention and was not of such an important character as to call for action on the part of the consulting engineer; and while it was a change from our original printed instructions, it was only such a change as might be looked for in work of this character. Mr. McLure was fully informed of all our erection methods, etc. In this particular instance there was no opportunity to advise Mr. McLure in advance. Mr. McLure or any other representative of the Quebec Bridge Co. could have had the work stopped by communicating with his superiors. The correspondence which you have will give you further details.

Q. Is there any known system of bridge erection that could eliminate or modify the camber system adopted by you in the erection of the Quebec Bridge, and was the system adopted by you after careful study and calculation, the proper mechanical method to adopt?—A. I know of no system of erection of a stiff frame which can be carried out without some form of a camber system. It is a mechanical necessity. This system has been used with success from the beginning of bridge construction, and in the Quebec Bridge was worked out in greater detail than ever before. A special camber blocking at each panel point enabled us to keep the work in absolute control. As the dead load was applied and changes in anchor frame were taking place, the action of all joints was watched and reported and we found that the truss was behaving exactly as expected and it continued to do so up to the time when all joints had a full and complete bearing.

Q. Is a statement that the Phœnix Bridge Company had promised both the

Quebec Bridge Company and the Dominion government to complete the bridge in 1908 and was therefore pressing the work with all speed consistent with safety, a correct statement of facts?—A. The Phœnix Bridge Co. when asked at the time of signing the contract and later, assured the Quebec Bridge Co. and the government that it would use every effort to complete the bridge within the contract period, but no promise was made to do so.

Q. Please state what technical knowledge of permanent value to the engineering profession has been obtained in connection with the construction of the Quebec Bridge?—A. It is too soon to give in any proper manner the 'technical knowledge of permanent value to the engineering profession' which will grow out of the construction of the Quebec Bridge and the disaster of August 29.

Q. We understand that the bridge was struck by lightning on more than one occasion. Will you please say what effects were observed due to lightning and do you connect them in any way with subsequent events?—A. During the construction of the work lightning struck the wooden derrick at top of main traveler, destroying the mast but doing no other damage. Lightning also struck the end of the traveler which was raising falsework on north side, damaging the end of traveler only. These two occurrences had no connection with subsequent events.

Q. Did you interest yourself in any way at any time, and when, in any attempt to negotiate or dispose of securities of the Quebec Bridge Company, and with what result?—A. At their request we introduced the officers of the Quebec Bridge Company to bankers in this country at the time the Quebec Bridge Company desired to dispose of their securities. Nothing definite came out of these negotiations.

Q. What was the reason for the failure of these negotiations, and what reasons did the parties give for not taking up the project?—A. As I remember, the experts of the bankers reported at that time that they did not find a sufficient possible traffic in the near future to pay interest on the bonds. Then all expressed their belief in the ultimate value of the property but the returns were too remote for bankers in this country.

Q. Did you fully consider the Quebec Bridge Company's project at this time from a business standpoint and did you approve it after you had made your investigation?—A. At the earliest date I had personal confidence in the Quebec Bridge Company's project and strongly approved of it to the officers and directors of my company.

Q. Was the executive work in the negotiating and carrying out of the contract done by you on the part of the Phœnix Bridge Company?—A. The executive work in connection with the negotiations and carrying out of the contract was done by me.

Q. In your negotiations with the Quebec Bridge Company did you find that all matters were conducted on a purely business basis?—A. In all my negotiations with the Quebec Bridge Company all matters were conducted on a purely straight business basis.

Q. Did you receive any favours over your competitors?—A. No.

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I, Charles Scheidl, of the town of Phœnixville, in the state of Pennsylvania, one of the United States of America, engineer, make oath and say :—

1. That I attended before the Board of Royal Commissioners appointed under the Great Seal of Canada for the purpose of inquiring into the causes of the collapse of the Quebec Bridge, on several days during the months of October and November, 1907, in the town of Phœnixville, in the state of Pennsylvania aforesaid.

2. That the attached twenty pages, numbered 914 to 933, both inclusive, contain

my evidence in this matter. The answers to the questions are true statements to the best of my knowledge and belief.

Sworn before me in the city of Philadelphia, in the state of Pennsylvania, this day of November, 1907.

Mr. SCHEIDL'S testimony :

I was born on July 11, 1860, in Neuburg, on the Danube. In 1866 I went to the public school and in 1871 I entered the Royal Bavarian Gewerschule in Neuburg on the Danube, graduating in 1875. For a few months I was in the employ of the Royal Bavarian Railway as draftsman on a new railway line. In 1875 I entered the Royal Bavarian Industrieschule in Augsburg and graduated in 1878. I was next in the employ of Civil Engineer Heilman who had the largest construction business in Munich. I was there for two years and had the advantage of a very considerable practical experience. I also had charge of a large construction work there for one year. I joined the Bavarian army in 1880, serving for one year, after which I went back to my former employer in Munich. In 1882 I re-entered the army and remained for two months only, I having passed the examination for a reserve officer. In 1882 I went back to my former employer in Munich and had charge of construction work again. In the fall of 1882 I was employed as draftsman by the New York firm of Schwarzman, my work there being in connection with building work. In 1883 I was employed by Civil Engineer Bergner of Philadelphia as draftsman in connection with the building of some manufacturing establishments. On May 25, 1883, I entered the employ of Clark, Reeves & Company, now the Phœnix Bridge Company as draftsman. I was given charge of the drafting work in 1889 and since that time I have had charge of almost every kind of work in the bridge line; for instance, a part of the Pecos Viaduct, Fairmount Avenue bridge in Philadelphia and a large number of different kinds of spans for various railway companies. I had charge of two 500 feet spans at Sioux City, of the Rock Island bridge—a government bridge—and of part of a second Rock Island bridge for a railway company. At present I am assistant engineer of the Phœnix Bridge Company in charge particularly of detail designing. I have occupied that position since 1889.

With reference to the work of designing the Quebec Bridge, Mr. Scheidl made the following statement :

*I.—Preliminary office work after approximate stress sheets of bridge had been determined.*

The first step in connection with the detail work for this structure was to remove to a private office and go over the outlines of the bridge at the same time looking over the general stress sheets which had been furnished. The first thought was: How will the suspended span be connected to cantilever, how supported by it and is it to swing free at one or both ends? Next my thoughts were given to details of shoes for main posts and then follow the anchorages. In building this structure one naturally had to find first the manufacturing limits of existing bridge plants regarding :

First, tension members. It had been decided to use 15-inch eyebars as best suited for this bridge and it was found that a 12-inch round pin was the limit at that time on account of the large size of such eyebar heads. Yet, it was known that the top chord of anchor and cantilever arms must be composed of a broad chain of eyebars of dimensions hardly ever used before. The packing of top chord eyebars had therefore to be so arranged that a 12-inch round pin would satisfy all the requirements of the specifications, while for built up members any size of pin could be used.

Second, compression members. The building of compression members seemed at first to involve no difficulty whatever, but as soon as some of the connections had

been studied it was found that more than one pin at a panel point must be used for any successful detail and for safe erection and the question of links presented itself at once . Through the attachment of links for eye-bar connections these compression members assumed such dimensions that the question of transportation became a most important consideration. The carrying loads and clearances of the different railway companies transporting material to Quebec had to be studied before any large compression member could be detailed.

Returning to the detailing of suspended span, one end had been arranged fixed while the other end moved on a nest of rollers. This roller arrangement caused a bulky detail at end of cantilever besides which the end posts of suspended span could not be braced properly near the floor line. Moreover, great difficulty was experienced from the eccentric loading in a longitudinal direction caused by the movements principally due to temperature, but also due to deflection of trusses, which movement might have been further increased by some slight error in not building main piers 1,800 feet C to C. This movement amounted to about 2 feet. Finally the erection of such a roller end would have involved additional difficulties and it was found that the use of swinging end posts would give the best results.

The next question was how to provide for the transfer of wind stresses from suspended span to cantilever arm. Such a transfer was made at first in the four bottom chord ends of suspended span, but this scheme had to be abandoned because of the difficulty of making these arrangements in both stresses work simultaneously. Finally, a design with only one transfer of wind stresses per span end was decided upon as it gave safe and determinate results.

All the different panel points of the suspended span were now detailed, and exact pin packings made, etc. This suspended span, though larger than ordinary long spans, presented no special difficulty. The erection problem could at this time be gone over only in a general way.

The details for the suspended span were those generally used. The details at intersections of top of hangers and top of sub-posts were first tried with one pin, but the connections made the one pin very long and the connected members had undesirable, long, weak jaws, while with the introduction of links the hanger and sub-verticals could be connected in a most satisfactory and substantial manner to the transverso bracing, giving greater stiffness. Besides the difficulties of erection were reduced, as otherwise the traveller would have had a much greater overhang and this would not only have increased the weight of the traveller but also the weight of the structure. It was the intention at this stage to try some toggle arrangements for adjusting suspended span halves during erection.

The next study was that of the arrangement of the top chord packing for cantilever and anchor arms. Links fast to posts for diagonal eyebars were deemed necessary. The question of using two pins for top chord connections at main posts of cantilever also arose and it was proposed to use only one pin at these apices. The details of the principal panel connections were drawn out next. The links for connection at bottom end of diagonal eyebars were first designed fast to bottom chord as being more desirable and smaller in size, but this scheme had to be given up as the connections of floor beams to posts and bottom chords became weaker, while links fast to posts gave a splendid connection between floor beams and posts. This obviated the necessity of having end stiffners on floor beams shipped loose as depths of floor beams exceeded shipping limits. After all these apices had been sketched out and the packing plans for trusses completed the main shoes and main posts were gone into. Extraordinary dimensions were required for the pedestals under the main shoes to properly distribute such an enormous weight over the masonry. The original idea was to build each tier of pedestals in one piece, but shipping limits forbade this and special milling machines had to be constructed. The shoe had been so designed that all loads passed through its pin, but the scheme of letting the main post bear directly on the pedestals while shear from bottom chords only passed through shoe pin was considered too. Special attention had been given to transferring all wind loads collecting near

shoe into masonry. The detail at top of main post was at first tried with one pin but two pins were found necessary. The main post had been so designed that the placing of its ribs gave the best resistance to bending of that part of post where transverse bracing had to be omitted for passage of trains and wagons, while ribs of posts near top and bottom had to b ed in a longitudinal direction.

The details for cor tion of top laterals, top transverse strut and top chord should be specially mentioned as many devices were sketched out before a selection was made.

The anchorages had already been built with a liberal allowance at that time for any increase of uplift and also the two 214 foot approach spans had been built. These items require no special notice here. All this preliminary work had been done during January, February and March, 1902, by myself and I was always in charge of all detail work of this bridge.

*II.—Preliminary Work*

After the receipt of the revised specifications, preliminary work, showing practically final results, commenced in July, 1903.

The first step was to determine normal lengths of all bridge members. As trusses had not a single horizontal member all inclined members were designated by ordinates and co-ordinates expressed exact in feet and inches. The elevation of any panel point could quickly be checked without knowing the length of any inclined member. To get lengths of inclined members three different methods were applied. One method was squaring sides, adding and taking square root. This was done independently by three men. Another method was the use of logarithmic tables and a last method was by means of tables of squares, thus eliminating any error that might be hidden in a book of squares. During the further progress of the work the lengths were checked at least ten times. Next in order, preliminary drawings of all plate and trussed floor beams and of all stringers were made and sent for approval. The execution of these floor beams and stringers was most elaborate with reference to the spacing of rivets in webs and covers, taking care of end shear, net sections, &c. Then, details showing type of transverse bracing were made for approval; also details showing very clearly main shoes, pedestals, connecting chords and bracing of same.

The arrangement of eyebars for the anchor arm required considerable time and study as the bending moments on pins had not to exceed the allowed values of a 12-inch round pin. After some packings had been arranged and the problem of manufacture studied carefully the final decision was to have no eyebars thinner than 1¼ inches nor thicker than 2⅛. To avoid additional stresses on eyebars the skew in regard to C. line of trusses had not to exceed 4 inches in 50 feet. If the skew could not be kept within that limit on account of clearances for bridge, eyebars were bored skew to eliminate additional stresses in eyebars and the method of marking such eyebars was most distinct and precise so as to make sure that any such bars would not be placed the wrong way in the bridge. The sides of these eyebars were marked before being removed from the boring machine and the heads were painted 'inside' and 'outside' with different colours. It is needless to say that the calculations for packing all top chord eyebars was a most tedious and time swallowing operation.

In all cases the desire was to avoid difficult calculations by placing eyebars so that moments could be reduced to zero as often as possible. All eyebars were so grouped and ribs of chords were so divided as to get 2, 3, 4 or 5 (or even half sets) equal sets; in other words all ribs at connections were packed alike and, therefore, stressed alike. In all top chords the stresses coming from diagonals were counterbalanced by eyebars in chords and placed so that this transfer was practically direct while the rest of the chord eyebars, getting their stress from former panel points, were side-lined.

The details for anchorages were worked out next. The method of transferring windshear at end of anchor arm to masonry had been made through checks between end floor beams and top strut of windbent. The uplift caused from wind had been

taken care of by means of long foundation bolts. This wind uplift was finally ordered to be taken care of by the main anchor bars themselves and only the horizontal transverse shear was resisted by foundation bolts. The transferring of windstress from end of anchor arm to top strut of windbent was finally accomplished by means of a tenon girder which had a roller bearing against top strut of windbent and could move in any direction whether the movement was caused by temperature or by change in the loading of the bridge.

The lengths of all stringers were determined then by calculating the length of chords for all the different ways of loading and finding therefrom the lengths of stringers according to their elevation between chords. These stringer lengths were fixed so as to give the least bending in floor beam. The result was that every other panel had an expansion joint. At expansion joints the railway stringers only were fast to the floor beam on one side, while all other stringers were slightly loose so that bending of floor beam could not take place in the short distance between chords and nearest stringer.

At this stage the preliminary detail of all anchor arm panel points was started commencing with the end bottom chord. All these plans were made in a most elaborate manner, all stresses, pin bearings, number of rivets, calculations for each, etc., were clearly given on each drawing. All ribs of chords were so arranged as to divide each truss connection into two, three, four or five equal ribs, so that each got its proper share from diagonals; in other words 'all roundabout' connections were avoided to secure the simplest and most direct connection in all cases.

Though all main posts consisted of only two ribs, the ends had to be provided with four or more ribs for proper chord connection. At bottom of posts the floor beam shear was transferred to all four ribs in the most direct manner.

Sub-posts and hangers were built of only two ribs throughout, but where they were connected, for instance, to a four rib detail, each rib got quarter of the stress in vertical and horizontal direction. Wherever additional ribs and posts were placed all such connections fully provided for shear, chord stresses, etc. The bearing values on pins had been made one and a half times the allowed stress, but this was later changed to 1¼ times the allowed stress. Shear on pins was made ¾ times the allowed stress. The net section through pin hole was made first 1¼ times and later 1·3 times the net section of member, while the net section back of pin holes was made ¾ of that through pin hole. In determining net sections through pin holes not only rivets directly opposite pin were considered, but the placing of any rivets in such links was most carefully followed throughout. The net sections of all riveted tension members were found by assuming the rupture to take place through any diagonal line of rivet holes where the net section does not exceed by 30 per cent the net section of the transverse line. All panel points of anchor arm had been sketched out in the most studious way. Most points were shown giving several ways of making the connections until a final one had been selected. As these sheets showed not only every detail but all the calculation throughout, it was an easy matter for any draughtsman to make final shop drawings therefrom in a most intelligent manner. Neither pains nor time were spared in any of these preliminary details for the anchor and cantilever arms and suspended span. Every detail had been clearly demonstrated in every conceivable manner before shop drawings were made; in fact, many of the draughtsmen became disgusted with the never ending trials to improve these details. When the details for anchor arm were completed and those for the cantilever arm partially completed the weights of all details were calculated by the computing department and final anchor arm stress sheets furnished. This was the beginning of the shop drawing period. Only the anchor towers had been shop detailed in the meantime, as sketched out sometime previously.

### *III.—Shop Work.*

Before commencing the shop work on the anchor arm a clear understanding with the erection department had to be arrived at as to where the field splices had to be

finally placed. As an overhead traveller, running on falsework and straddling both anchor arm trusses was provided for, the erection problem of the anchor arm was simplified as far as the office work was concerned. The work of getting out shop drawings for the large traveller and steel false work had been assigned to two other assistant engineers.

For the cantilever arm and suspended span complete plans were got out showing the location of splices, the number of each piece in the order in which it was to be erected, temporary rods and struts and support of large traveller. A special drawing had been made for each position of the large or small traveller, and these drawings formed a binding contract between the draughting office and erection department. Before any shop drawing of the larger pieces could be made sketches giving the extreme dimensions, weight, &c., had to be made for the different railroad companies. This took considerable time as these companies had not only to determine if these large pieces could be shipped over their own lines but if they could be shipped the whole distance from shop to bridge site. Such sketches were, in many cases, quite extensive drawings requiring much time in the office for preparation and often showing special beams, struts, castings, pins, &c., to rig up cars, without reference at all to the work in this line usually done by the shipping department. It was necessary to provide for the proper distribution of loads between sets of wheels and to lay out railroad curves so as to make sure that links on posts, &c., placed in special well cars would not touch the wheels or be otherwise injured on sharp curves.

The normal condition of truss shape had been fixed for a certain position of live load giving practically the maximum uplift and all cambers were derived therefrom. All angles and abutting splices were figured for this position so as to be sure that under full loading any extra initial stress would equal zero.

Pinholes for 10½-inch°, 12-inch° and 14-inch°, pins were bored $\frac{3}{64}$-inch larger than size of pin.

Pinholes for 24-inch°, pins were bored $\frac{1}{16}$-inch larger than size of pin.

Pinholes for 7 11-inch, pins were bored $\frac{1}{32}$-inch larger than size of pin.

Pinholes 2 $\frac{7}{8}$-inch, pins were bored $\frac{1}{50}$-inch larger than size of pin.

In determining the length of eye-bars the first correction was for camber, the second for permanent set, the third correction was on account of play in pinholes and in eyebars placed skew, the fourth correction was for skew. The permanent set in eyebars was determined by a series of tests. The correction for permanent set in anchor eye-bars was $\frac{3}{64}$-inch per head, while for the rest of the bridge $\frac{1}{32}$-inch only was used as the eye-bars were finally made of a higher ultimate steel. The correction in built lengths was $\frac{1}{32}$-inch for each eye.

All posts with link attachments involved additional work in determining the lengths as the exact position of pin in pinhole for chord connection had to be found first and correction in all directions was made therefrom. In all cases the distances C. to C. of pins represented the lengths of members and not the distances C. to C. of pinholes. In posts with links the eye connecting to chords had to fulfill all the requirements of a regular tension link to suit the resultant stresses of chords.

All rivets were determined by these values.

For shop rivets 1:5 times allowed stress for bearing value.
" 0:75 times allowed stress for shear.
For field rivets 1:1 times the allowed stress of bearing value.
" 0:55 times the allowed stress of shear.

To get the proper elevation of bottom chord for erection purposes the deformation of the anchor arm was found according to Williott's method. It was assumed at first that the main post was plumb and that the whole anchor truss rotated around the pin of the main shoe until the end bottom chord pin could be connected to the top of anchor eyebars. For this purpose a rotation diagram was constructed which gave the location of every apex after rotating the struss. For the purpose of jacking up the trusses special jacking blocks were provided for two 500 ton jacks per panel point.

To get deformation diagram in the most exact manner all the vertical members had to be corrected again for compression, as they carry heavy top loads during erection, while for all diagonals and chords a position for pins in pinholes had been assumed which seemed most probable.

As the bottom chord is 4½ feet deep the abutting splice ends could not fit exactly as they were designed to fit perfectly under full load. Therefore, these differences had to be calculated and ½ of the amount considered as an increase in chord length. These openings were intentionally made only half the amount that had been figured. In like manner the deformation of trusses was found for any position of the traveller on the cantilever arm or suspended span; also, for final position under dead load, dead load and live load, and according to temperature. The result was that the horizontal movement due to temperature was the greatest, the changes from dead load or live load seemed small and the vertical movements did not affect the detailing to any appreciable extent.

For erection of cantilevers the tops of main posts were provided with two pins giving an improved and safer method of erection.

For adjusting suspended span halves during erection, two 1,250 ton jacks were provided at each end of bottom chord. For the same purpose a toggle arrangement, worked by two 500-ton jacks was provided at each end top chord of cantilever. The bottom panels of suspended span half to be erected last were built of eye-bars, while all other chords had to be of 'built section.' By means of this arrangement the bottom chord could be erected completely although the end distance was too little, as truss halves were jacked up and no fine adjustment would have been required. The last diagonal of suspended span had a special pin connection for quick connection although the joint was to be a riveted one finally. The details of the suspended span were still further improved by making most of the joints riveted connections. Of course, diagonal eye-bars were connected by pins. This method simplified the erection. As soon as two members had been erected final connection could be made and they were self-sustaining.

In getting out the shop drawings for this bridge only a small force of expert draughtsmen were selected at first and the number was gradually increased. It required three years to complete the office work. It was thought best not to subdivide the work among the different assistant engineers but to give one man full charge from beginning to end. All drawings were prepared under his direction and whenever a drawing was completed it was examined by him carefully in regard to lengths, sizes, strength of all details, notes for shops, inspectors and transportation. It was only then that these drawings were forwarded in duplicate to the consulting engineer for his approval. If approved seven additioinal prints of complete, checked drawings were sent to the consulting engineer for his approval and six copies were returned by him to the Bridge Company, who sent five copies to the chief engineer of the Quebec Bridge Company. The Phœnix Bridge Company received one print back approved by the Dominion government. The drawings were made in such a manner that all information necessary for the proper execution of the work in the shop was given, as clearances, notes explaining any peculiar detail or calling attention to all important dimensions regarding width, depth, &c., and information for the sole use of inspectors.

In building some of the posts with many heavy top links, where a large number of plates form one link, these links were bound to vary in thickness. The collars for pin packing were only ordered after each post was built and the clearances reported to the office. The second checking of finished drawings in regard to spacing rivets fitting to the other members, &c., had at first been done by the assistant engineer in charge, but this work was then assigned to other assistant engineers, thus relieving the one in charge of this burdensome work and giving him more time for the preparation of drawings.

All shop drawings were executed in a most elaborate manner. Most of the principal drawings are real masterpieces illustrating how shop drawings should be made.

The Phœnix Bridge Company can show these drawings with pride to any expert bridge draughtsman.

As the checking of drawings had to be done by different assistant engineers some doubt arose as to whether some errors might not occur as a result, but thus far the part of the bridge erected has proven that the checking has been done in a most excellent manner.

At no time during the progress of the office work were more than eighteen men working upon it at a time. If twice that number had been employed the result would have been the same. The rate of progress depended upon the rapidity with which the person in charge performed his work.

As said before, the preliminary details were made with all calculations and the best results were obtained in preparing the final details. Every draughtsman who was employed in the preparation of the drawings for this bridge will testify to the unusual care which was taken to bring this work to a successful conclusion. In comparing the details of this bridge with those of existing long spans with pin connections, one finds, for instance, at the intersection of diagonals with hangers and secondary posts, a large number of forked members with long thin jaws, packed on one pin, which certainly does not give the impression of good rigid connection. We have striven, in preparing the details for this bridge, to avoid members with long thin forks. Even a casual observer will notice their absence from this bridge, and it will also be evident to him that a stiffness in the connections has been secured through the application of links not obtained in similar pin bridges before.

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I, Peter L. Szlapka, of the borough of Phœnixville, in the state of Pennsylvania, one of the United States of America, engineer, make oath and say:—

1. That I attended before the Board of Royal Commissioners appointed under the Great Seal of Canada for the purpose of inquiring into the caures of the collapse of the Quebec bridge, on several days during the months of October and November, 1907, in the borough of Phœnixville, in the state of Pennsylvania aforesaid.

2. That the attached thirty-six pages, numbered 934 to 969, both inclusive, contain my evidence in this matter. The answers to the questions are true statements to the best of my knowledge and belief.

Sworn before me in the city of Philadelphia, in the state of Pennsylvania this day of November, 1907.

Mr. PETER L. SZLAPKA'S testimony:—

Q. What is your official position in the Phœnix Bridge Company?—A. My official position with the Phœnix Bridge Company is that of designing engineer.

Q. How long have you occupied this position?—A. For the last twenty-one (21) years.

Q. When did you enter the Phœnix Bridge Company's service and in what capacity? How much time during this period have you spent—in drawing office, in computing department, in the erection office and in field work?—A. I entered the Phœnix Bridge Company's office in 1880 as bridge draughtsman. I spent six years in the drawing room and twenty-one years in the designing department. I was not engaged in either the erection department or field work.

Q. In your present capacity are you the responsible designing engineer for the company?—A. Yes.

Q. Previous to entering the service of the Phœnix Bridge Company, will you please state generally what your experience in bridge work had been.—A. I took a

seven years' classical course in a German college, and a four years' general engineering course in the Royal Polytechnic School in Hanover, Germany, and when entering the service of the Phœnix Bridge Company, I had the above thorough theoretical college training.

Q. During the period you have occupied your present position will you please state what large bridge structures you have designed which have been built by the Phœnix Bridge Company, giving dates and general dimensions?—A. The following are some of the largest structures designed by me, viz.:—

Ohio River Bridge, at Cincinnati, Ohio, consisting of two (2) 490 foot and one (1) 550 foot double track through spans, designed in 1888; the three spans weighing over 5,000 tons.

Ohio River Bridge at Louisville, Ky., consisting of three (3) 546 foot single track through spans, built in 1890; the three spans weighing 2,700 tons.

Tennessee River Bridge, at Decatur, Ala., one (1) 382 foot draw span, built in 1901, weighing 500 tons.

Tennessee River Bridge at South Pittsburgh, Tenn., built in 1906, weighing 650 tons, one (1) 436 foot single track through draw span.

Bridge over St. Lawrence River, at Cornwall, Ont., three (3) 365 foot single track through spans, built in 1897, weighing 1,500 tons.

Bridge over St. Lawrence River, at Cornwall, Ont., main span, 840 foot cantilever, built 1898, weighing 1,200 tons.

Q. Please state your office engineering organization in the course of designing, detailing and checking your bridge work?—A. The general design of the bridge was prepared in the designing department, under my personal supervision. The work was then handed to Mr. Scheidl, engineer in charge of the shop drawings—the main features of the design were explained and complete specifications as prepared by the consulting engineer were given to him for his guidance in designing the details of the bridge. After preparing the general preliminary details of the most important connections, Mr. Scheidl discussed same with me, and changes were made, if found necessary. These preliminary drawings were discussed with Mr. Cooper and changes made as directed by him. After these preliminary details were established to our complete satisfaction, an assistant engineer and a number of first-class draughtsmen (varying from five to fifteen) were assigned to Mr. Scheidl's charge, who prepared the final shop drawings, using the preliminary plans for their guide. The final shop drawings were only then considered as complete, after being changed as many as seven or eight times, when they were entirely satisfactory to us and when we believed they could not be improved. The general calculations were checked twice in the designing department and twice in the drawing room during the preparation of shop drawings.

Q. Did you design the Quebec bridge?—A. Speaking in a general way, yes. The bridge is of such a magnitude as to be beyond the ability and physical endurance of one man. The results achieved represent combined efforts on the part of all the departments of The Phœnix Bridge Company, under the direction of the consulting engineer, Theo. Cooper.

Q. Was the regular organization of your department made use of in connection with the designing, detailing and checking of the Quebec Bridge, or was there any special organization for this purpose? Please state your process in detail fully explaining all precautions taken to reach accurate results?—A. The regular organization of my department and of the drawing room were entirely capable of dealing with the problem. No addition was found necessary. The shop drawings were first checked by Mr. Scheidl, the engineer in charge, as to strength, general clearances, facility of erection and connections with other members. The assistant engineer, under immediate charge of Mr. Scheidl, checked the drawings as to their correctness for all connections and for shop work. At certain stages of the work, when the drawings were too far ahead of the checking, as many as six engineers and five of the best draughtsmen were used as additional help in checking. The few errors found during erection are the best evidence how carefully all the shop drawings were prepared and checked.

Q. We understand that your plan No. 1 of the Quebec Bridge dated November 30, 1897, (Exhibit No. 88) embodies information as to length of spans, cross section of river and height of bridge. From whom did you receive this information?—A. The information referring to the length of spans, cross section of river, and the clear height of bridge, was furnished by Mr. Hoare, chief engineer of the Quebec Bridge Company, on a plan which is in your possession.

Q. Please examine your plan No. 2, dated December 7, 1897, and compare it with the plan dated January 13, 1898, and signed by Messrs. Parent, Barthe and Hoare and say if these two plans are identical as to superstructure?—A. Our plan No. 2, dated December 7, 1897 (Exhibit No. 89) is identical as regards the superstructure, with the plan dated January 13, 1898, signed by Messrs. Parent, Barthe and Hoare.

Q. Is the plan of January 13, 1898, practically a copy of your plan of December 7, 1897?—A. Yes.

Q. Please file copy of plan No. 1 and plan No. 2, and also copy of the plan submitted with the tender to the Quebec Bridge Company in 1899 for 1,600-foot span?—A. I file copies of plan No. 1 (Exhibit No. 94) and plan No. 2 (Exhibit No. 95); also plan submitted with tender by the Phœnix Bridge Company in 1899 for the 1,600-foot span (Exhibit No. 96).

Q. Please file complete stress sheet and tables showing the unit stresses and net sections of all members, panel concentrations and estimated weight of structure divided between anchor arm, cantilever arm and suspended span corresponding with the design accompanying your tender?—A. I enclose complete stress diagrams for the design of the 1,600 foot span, being duplicates of plans submitted with the tender (Exhibit No. 97), also weights of the river crossing (Exhibit No. 98).

Q. Was this stress sheet worked out exactly in accordance with the specifications sent to your company by the Quebec Bridge Company?—A. In designing the 1,600-foot span the Quebec Bridge Company's specifications were followed in every particular except as regards wind pressure under 30 degrees to the horizontal, which requirement was disregarded as unnecessarily severe.

Q. Did the weights ascertained from your strain sheet agree with your assumed weights and, if not, will you please state in detail what process you use in arriving at your final stress sheet which was the basis of your tender of 1899?—A. The plans submitted with the tender being only of an approximate character, no recalculations were made based on the approximate weight ascertained from the first calculations.

Q. Was there any doubt in your mind at this time as to the existence of data sufficient to enable engineers of your experience to design this bridge especially in regard to large compression members?—A. No, I have no doubt on the subject, but as stated in the preceding answer, the first design was only approximate and the minor details were not considered at the time, except a few of the most important general points, which were given a careful study.

Q. Was this the largest structure that you had ever attempted to design?—A. Yes.

Q. In the course of the designing of this bridge, did you consult with engineers outside of the Phœnix Bridge Company, and, if so, with whom?—A. I did not consult with any outside engineers as to the design of the bridge, except with Mr. Theo. Cooper, consulting engineer.

Q. On April 22, 1900, you prepared two plans, one indicating the river span as 1,723 feet, and the other indicating it as 1,800 feet. Will you please say what caused you to make these plans?—A. About April, 1900, I received orders from Mr. John Sterling Deans, chief engineer of the Phœnix Bridge Company, to prepare a plan with a central span of 1,800 feet. Not understanding that the length must be exactly 1,800 feet, the panel lengths working out better for a slightly shorter span, I selected a central span of 1,723 feet, keeping the length between the anchorages 2,800 feet, as required. After I was informed that the central span must be exactly 1,800 feet, I prepared another plan in harmony with these instructions.

Q. Subsequently to April 22, 1900, you made several general plans of the Quebec Bridge, all of which show the river span at 1,800 feet. Was the change in span from 1,600 to 1,800 feet entirely feasible from an engineering point of view?—A. Yes.

Q. When the 1,800-foot span was decided upon what recalculation of the structure did you make and will you please file copies of your complete original stress sheets and tables for an 1,800-foot bridge and anchor arm showing unit stresses, net sections, load concentrations and erection stresses; also, please attach to these strain sheets a bill of weights and the data showing dead, live, wind and snow loads used in calculations. What were your reasons for adopting the lengths of spans?—A. During May and June, 1900, only the suspended span and the cantilever arms were recalculated for the new length of the central span according to Quebec Bridge Company's specifications. No table of weights was prepared at this time. As regards the lengths of the cantilever arms and the suspended span, the latter was made three-eighths of the main central span; the usual length of the suspended span varies from three-eighths to one-half of the central spans. I selected the lower limit in order to reduce the erection stresses at the connection of the suspended span with the cantilever arm. I also believe that this arrangement enhances the beauty of the design. The anchor arm was made 500 feet by order of the chief engineer of the Quebec Bridge Company, which length appeared to be desirable in order to avoid reversed stresses in the top and bottom chords, according to the different positions of the live load.

Q. Up to this time had there been any work done in the way of designing of details, or were the details merely roughly estimated?—A. The details were merely roughly estimated.

Q. Was the study of the design what you would call complete having regard to its unprecedented dimensions and also having regard to the fact that details had not fully considered?—A. A continuous study was given to the general design, while the details were perfected as the work progressed. The final design, I believe, cannot be improved upon.

Q. When did you begin the study of details for this structure?—A. Many of the details were roughly sketched out as early as 1897 and 1898.

Q. What progress had you made in the study of details between January, 1902, and June, 1903, and did you find in the course of this study that the weight of the details was very considerably over-running your previous estimate of weights?—A. All important general details were drawn out by Mr. Scheidl, during 1902, as a basis for further study and perfection. The details, at that time, not being final, their weights were not ascertained, in order to compare them with the rough weight of details assumed in the calculations.

Q. During this period Mr. Theodore Cooper was consulting engineer for the Quebec Bridge Company. Did you confer with Mr. Cooper during this period on questions of design, and if so, will you please explain fully?—A. The outline of the bridge was discussed with Mr. Cooper fully. The lengths of the cantilever arm and the suspended span were approved by him, while the length of the anchor arm was specified by the chief engineer of the Quebec Bridge Company governed by local conditions. The panel length, the arrangement of the web system and the depths of the trusses were discussed and approved. Mr. Cooper was at first of the opinion that trusses inclined from the vertical would be preferable, so that the effect of any settlement of the main piers would not be as readily perceived as in the case with vertical trusses, when one or both trusses might be out of vertical. This question was finally settled by Mr. Cooper in favour of vertical trusses in October, 1903. Another point raised by Mr. Cooper was the vertical end posts of the anchor arm. His attention was called to the fact that the vertical posts were preferable to inclined end posts, admitting of simpler details for end portals, and at the same time giving to the anchor arms the appearance of greater length than would be the case with the inclined end posts. This question was also settled by Mr. Cooper in favour of vertical end posts, October, 1903.

Q. In the final designs for the structure were you striving to design the best

bridge possible, or were you limited in any way as to the ultimate cost of the structure and, if so, to what extent?—A. In designing the structure, I followed closely Mr. Cooper's specifications, put forth every effort to obtain the best results, and to secure the best bridge possible irrespective of ultimate cost.

Q. Had you specific instructions on this point, and, if so, from whom and what were they?—A. I have never received any instructions to sacrifice any features of good design in order to keep the structure within any specified cost.

Q. When business arrangements were made between the two companies so as to justify you proceeding actively with the work in the designing office, what part of the structure did you commence your studies on?—A. The floor system was figured first (July 1, 1903), followed by calculations of the suspended span (November, 1903-February, 1904).

Q. Will you please file a copy of the strain sheet (giving the corresponding information asked for previously on the other strain sheets) which formed the basis of your detail design of the structure?—A. I inclose herewith calculations of the main span (Exhibit No. 98).

Q. Were the data available at this time in regard to the weights of the cantilever arm and the suspended span sufficiently accurate to enable you to correctly design the anchor arm in detail?—A. The weights of the cantilever arm and suspended span were then believed to be sufficiently accurate—and were so approved by Mr. Cooper—to enable me to correctly design the anchor arm. Subsequently, when the suspended span and cantilever arm were developed, it was found that the actual weights were somewhat in excess of those assumed for the calculation of the anchor arm.

Q. At this period we find that certain modifications in the specifications were suggested by Mr. Cooper. Were these modifications discussed between you and Mr. Cooper? What modifications in the Quebec Bridge Company's original specification did you suggest to Mr. Cooper and what provisions of the written specifications were set aside by Mr. Cooper's orders?—A. On May 13, 1903, the Phœnix Bridge Company received a letter from Mr. Cooper, stating that he was ready to see Mr. P. L. Szlapka to talk over specifications for the main bridge. I visited Mr. Cooper on May 14th, and received from him a full explanation of the loading and unit stresses to be used in proportioning the members of the main bridge. Mr. Cooper impressed upon me the importance of strictly following his specifications, but at the same time to be prepared to consider special important features with him irrespective of the requirements of his written specifications. In view of Mr. Cooper's proposition use, for certain combinations of conditions, unit stresses as high as 24,000 lbs., or ⅔ of an average elastic limit of 32,000 lbs., I mentioned to Mr. Cooper the fact that a German professor (I do not recollect his name at present) proposed to use a fraction of the elastic limit for unit stresses for truss members after first allowing for irregularity of shop work, for imperfect erection, for flaws in material, &c.

A table showing extreme velocities of wind at various stations as reported by the United States government from 1883 to 1893, for his consideration in discussing the question of wind pressures, I presented to Mr. Cooper. I did not suggest any modifications in the Quebec Bridge Company's specifications. After learning from Mr. Cooper his exact wishes as to the loading and unit stresses, the colculations were begun on the floor system, followed by the 675 feet suspended span.

Q. Please file a copy of all modifications of the Quebec Bridge Comapny's specifications which were approved by Mr. Cooper and which were actually made use of and adhered to throughout the designing of the structure as to loading, unit stresses, quality of material and workmanship?—A. Copy of the Quebec Bridge Company's specifications (Exhibit No. 99), a copy of modifications thereof prepared by Mr. Cooper (Exhibit No. 100) and copy of Mr. Cooper's specifications for workmanship (Exhibit No. 101-102) are attached herewith. These three specifications, together with occasional verbal instructions, referred to in the preceding answer, form a complete set of rules to be followed in designing and in the construction of the main bridge.

Q. Did you fully concur in all the amendments made in the specifications, having in mind that you were endeavouring to produce the best possible bridge?—A. The amendments made in the specifications by Mr. Cooper were not subject to my approval.

Q. Will you please state the exact condition of the work of designing, what detail plans had been completed and approved by Mr. Cooper up to October 1, 1904?—A. Stress sheet, suspended span, approved by Mr. Cooper, March, 1904.

Stress sheet, anchor arm, approved by Mr. Cooper, June, 1904.

General detail drawing, suspended span, approved by Mr. Cooper, May, 1904.

All typical drawings of top and bottom panel points were prepared and approved by Mr. Cooper, May, 1904.

Plate floor beams and stringers were approved, July, 1904.

Shop drawings of two end panels were approved, August, 1904.

Q. At this date had you completed the stress sheet for the cantilever arm or for the suspended span and had you designed the main traveler?—A. Stress sheet of suspended span completed February, 1904.

Stress sheet of cantilever arm completed December, 1904.

Main traveler designed April, 1904.

Q. At what date did you complete the stress sheet for the cantilever arm; at what date did you complete the stress sheet for the suspended span; at what date did you complete the design of the traveler?—A. See answer to preceding question.

Q. Previous to October, 1904, we understand that you had completed the design of the anchor arm and that many of the detail plans had been approved by Mr. Cooper. What was the exact condition of the design of the cantilever arm at this date, October 1, 1904?—A. The stresses in the cantilever arm were figured with the exception of the erection stresses.

Q. What was your practice in regard to issuing orders to the shop to proceed with work? Did you in each case await the approval of Mr. Cooper before commencing the construction of any piece of work?—A. As soon as shop drawings were completed in the drawing room, and approved by Mr. Cooper, they were placed in the shops; in some cases we did not await the approval of Mr. Cooper as has been correctly explained by Mr. Deans.

Q. Was any work of construction commenced or material ordered before Mr. Cooper's approval of the plan was obtained and, if so, state what was done or material ordered and why this course was followed?—A. In order to insure continuation of the work in the shops and in the field, lists of materials and shop drawings were placed in the shops, in some cases, before the approval of the plans by Mr. Cooper at the risk of the Phœnix Bridge Company, as has also been correctly explained by Mr. Deans.

Q. Was any work commenced in the shop or material ordered before the plans had been approved by the Department of Railways and Canals, and, if so, please give details and say why this course was followed?—A. For the same reason, materials were ordered and shop work commenced, in some cases, before the approval of plans by the Department of Railways and Canals.

Q. Did you consider the approval of the plans by the Department of Railways and Canals a condition precedent to the fabrication of the bridge?—A. No.

Q. Please state when the fabrication of each of the lower chord sections of the anchor arm was commenced?—A. Chords finished in the shops as follows:—

No. 1.—October 19-October 20, 1904.
No. 2.—October 24-October 27, 1904.
No. 3.—November 3-November 5, 1904.
No. 4.—November 12-November 14, 1904.
No. 5.—November 25-November 26, 1904.
No. 6.—December 3-December 6, 1904.
No. 7.—December 13-December 17, 1904.
No. 8.—December 24-December 31, 1904.

No. 9.—January 7–January 16, 1905.
No. 10.—January 18–January 19, 1905.
No. 11.—June 3–June 10, 1905.

Q. Did you consider that the unit stresses used in the designing of the anchor arm, as determined under the revised specifications adopted by Mr. Cooper, were up to the extreme limit of economy in design and safety to the structure?—A. Yes.

Q. In finally developing the stress sheet for the cantilever arm and the suspended span, did you find that the weights produced were in excess of those estimated in the design of the anchor arm?—A. Yes.

Q. Did these excess weights tend to increase the stresses in the anchor arm?—A. Yes.

Q. Was the detail design of anchor arm altered so as to meet these increased stresses?—A. No.

Q. Were the unit stresses in members of the anchor arm increased beyond the requirements of the specifications above referred to?—A. The weights of the suspended span, end of the cantilever arm, assumed in the first calculation of the stresses of the anchor arm, were smaller than the weights as finally obtained. Consequently, the stresses of the anchor arm, due to these increased weights, were increased, the anchor arm having been built in the meantime.

Q. Please file a stress sheet of the anchor arm indicating in detail any such changes in unit stresses?—A. Sheet attached (Exhibit 103).

Q. Did you consider that these increases in unit stresses were still within the limits of safety?—A. Yes.

Q. Why was not the whole scheme of the bridge fully considered in detail before shop work commenced?—A. This was not practically possible. General experience enabled us to proceed without occupying valuable time, and the time limit precluded any such arrangement. This followed the usual course of business in such cases.

Q. Having in view the unprecedented dimensions of this structure, was it the proper course to pursue, or did you pursue the ordinary course as followed previously in connection with bridge building?—A. The ordinary rule, which is imperative in all cases, irrespective of the unprecedented dimensions of this structure, was followed.

Q. Whose instructions did you follow in adopting the above course, and what were the instructions?—A. I received my instructions from Mr. William H. Reeves, general superintendent, and Mr. John Sterling Deans, chief engineer, of the Phœnix Bridge Company, viz.: to place with the shops any shop plans as soon as approved, and to generally arrange the office work so as to insure continuous working on the bridge, in the shops and in the field.

Q. Were your relations with Mr. Cooper of a perfectly cordial nature throughout the whole period of the designing and erecting of the Quebec bridge?—A. Yes.

Q. Did you freely consult him on all matters?—A. Yes.

Q. Was Mr. Cooper's criticism of plans and design such as you might expect from an engineer of his experience and ability?—A. Yes.

Q. Was Mr. Cooper aware of the exact conditions of design on October 1, 1904, at which period he had approved the design of a large portion of the anchor arm, and was he aware that strain sheets for the cantilever arm had not been made?—A. Yes.

Q. Did he approve your assumptions of weights for the designing of the anchor arm and, if so, we would like you to establish this fact?—A. Examining the stress sheets thoroughly, and finally approving same in every particular, Mr. Cooper certainly, by this very fact, approved every main feature given on our plans; therefore, also the assumed dead load.

Q. Did Mr. Cooper complain to you at any time of the growing weight of the structure and with what result?—A. No.

Q. Did he order recalculations to be made, or, to your knowledge, did he make them himself?—A. Mr. Cooper did not order any recalculations. Knowing, however, that the weights assumed for calculations were exceeded by the actual shipping weights

as reported to him by his inspectors, he no doubt made some calculations, as he remarked to me on one occasion during 1906 that 'this fact did not amount to anything.'

Q. Did Mr. Cooper intimate to you at any time that there was a limit which the cost of this bridge should not exceed, or did he complain at any time on the grounds of increasing cost?—A. Never.

Q. What was Mr. Cooper's reason for complaining of the increasing weights?—A Mr. Cooper never complained to me of the increasing weights.

Q. From your knowledge of Mr. Cooper would you consider that he would associate himself with a work which was inferior in any respect without protesting upon points which he considered inferior or inefficient?—A. I would not suppose anything of this kind for a moment, recognizing in Mr. Cooper the highest type of an able and honest engineer.

Q. What changes in general design or detail did Mr. Cooper suggest and did these changes enhance the value of the structure or detract from its value?—A. Mr. Cooper, amongst others, made the following suggestions:—

1st. Arrange anchorage of wind bent on anchor piers so that anchor bolts resist wind shear only, while the upward pull is transmitted to the anchor pier by the anchor bars only.—Adopted.

2nd. Change friction (due to lateral wind pressure and change of temperature) between end floor beam of anchor arm and top strut of wind bent from sliding to rolling friction.—Adopted.

3rd. Arrange expansion of floor system so that no undue bending is produced in the floor beams.—Adopted.

4th. Arrange expansion between suspended span and cantilever arm, at both ends, instead of at one end as proposed by the Phœnix Bridge Company.—Adopted, but not considered an improvement by me.

5th. Arrange packing of eye-bars in top chord of anchor arms, as per Mr. Cooper's two sketches.—Not adopted. Found entirely faulty by the engineering department. The Phœnix Bridge Company's packing adopted with very small modifications suggested by Mr. Cooper.

6th. Provide wooden traction arrangement between suspended span and cantilever arms, as shown on Mr. Cooper's sketch.—Not adopted, as not being in harmony with the high standard of the rest of the details of the bridge. Its design is still open. Mr. Cooper urged the adoption of this wooden arrangement as it could easily be made by a track-walker and attended to by him in case of repairs. Not wishing to criticise Mr. Cooper's scheme myself, I remarked that it might be criticised by the profession; to this Mr. Cooper answered 'there is nobody competent to criticise us.'

7th. Change lateral bracing in floor system, as per Mr. Cooper's letter.—Not adopted, as inferior to the Phœnix Bridge Company's design.

Q. Were you in any way hurried or rushed in the preparation of the design or did you consider at the time that you had ample time and opportunity for making all necessary studies in order to make the design perfect?—A. We were pressed in our office work, but we never sacrificed the perfection of the plans to the requirements of the shops or the field. I did consider that we had ample time and opportunity for making all necessary studies.

Q. From your knowledge can you say that Mr. Cooper critically examined all the plans submitted to him? We would like to know from you your candid opinion on this point and if you felt that when you received a plan from Mr. Cooper approved by him it had been scrutinized and analysed as fully as possible?—A. From my personal observations, I believe that all plans were carefully examined in Mr. Cooper's office; either by Mr. Cooper personally, or by his able assistant; the latter reporting on all important questions to Mr. Cooper. The fact that even unimportant mismatched connections did not escape the attention of Mr. Cooper's office certainly proves the thoroughness and careful study bestowed on the examination of the plans.

Q. Had you full confidence in Mr. Cooper as consulting engineer and did you feel

that in case of doubt arising in your own mind consultation with Mr. Cooper would assist you materially in arriving at definite conclusions on points upon which you might have certain doubts?—A. Yes.

Q. Did you, during the design and construction of the bridge, consult Mr. Cooper on matters such as are referred to in the previous question and were these consultations of material benefit to you in the designing of the structure? If you can give details, please do so?—A. Considering Mr. Cooper one of the ablest and most experienced bridge engineers in the country, I discussed fully with him all main features of the bridge. His advice and directions were always sought and appreciated.

Q. Was the design of the compression members particularly discussed by you with Mr. Cooper, more especially with reference to the lower chords, and, if so, will you please state precisely what special points were discussed in connection with these members and what were the circumstances that led to the discussion on the details of these members in particular?—A. After the first sections of the lower chords of the anchor arms were constructed in the shops, Mr. Reeves, president of the Phœnix Bridge Company, remarked, in our engineering office, that the lattices on the chords appeared too light and that they were liable to be injured or damaged in handling in the shops and transportation to site. I answered that lattices of any size might be injured and destroyed if carelessly handled in the shop or in transportation. This conversation was reported by me to Mr. Cooper. He answered that he looked into the question of the strength of the lattices while checking the plans and that 'we had it all right.'

Q. Were you unable to consult with Mr. Cooper at any time owing to the condition of Mr. Cooper's health?—A. No.

Q. How often did you go to New York to consult with Mr. Cooper? How often did Mr. Cooper come to Phœnixville?—A. I visited Mr. Cooper about once a month. Mr. Cooper visited Phœnixville twice during the entire process of designing and constructing the bridge.

Q. Was Mr. Cooper aware that it was the intention to use the big traveller for erection purposes as far as the centre of the suspended span and, if so, in what manner was he made aware of this and was he aware that all of the spans were figured with the big traveller in the centre of the suspended span?—A. Mr. Cooper was aware that it was the intention to use the large traveller for erection purposes as far as the centre of the suspended span, from conversations with me, and owing to the fact that he approved the unit stresses due to the erection based on the above condition.

Q. Will you please file a strain sheet using as your data for dead load stress the actual shipping weights of material constructed together with the concentrated panel loads and the other information called for as in the case of the other stress sheets? Indicate the net sections of each member on this stress sheet in red as constructed and in black as demanded by the stresses under the specification to which you were working and state generally what the comparison between the results is?—A. Exhibit attached (Exhibit No. 104).

Q. What was the first intimation you had that would lead you to suppose that any member in the bridge was showing distress?—A. When my attention was called to the curved condition of chord 9-L, south anchor arm, by Mr. Birks' report, inclosing a sketch of the chord, on August 29.

Q. For what reason were the repairs on the splices at 7-L and 8-L, cantilever arm, not promptly considered and executed?—A. Repairs were promptly considered and submitted to Mr. Cooper for his approval. His decision was awaited when the bridge fell.

Q. Did you, throughout the construction of the work in the shops, keep generally in touch with what was being done? Did you make a special examination of important members before they left the shop? Can you say that chords 9-L, anchor arm, and 9-R and 8-R, cantilever arm, were in perfect condition when they left Phœnixville? If they were in perfect condition when they left the shops, to what do you attribute the later deformation of these members?—A. I kept generally in touch with

the construction of the work. I examined carefully many important members before they left the shop. I am not able, however, to state in what condition chord 9-L, south anchor arm, or 9-R and 8-R, cantilever arm, left the shops. I do not know to what to attribute the deformation of the members.

Q. Will you please file a stress sheet and indicate upon it all unit stresses as existing in the bridge immediately preceding the accident of August 29?—A. Exhibit attached. (Exhibit No. 105.)

Q. Assuming the bridge to have been successfully completed, what would have been the unit stress in chord 9-L, anchor arm?—A. 21,200 lbs. working stress, including live and dead load and snow.

Q. In your judgment, what was the weakest part of the structure, first, during erection and, second, when completely erected?—A. The compression members of the bridge.

Q. Where, in your judgment, did the initial failure take place? Please give your opinion as to the sequence of the fall of the structure?—A. It appears reasonable to suppose that after the fall the centre of gravity of the top mass of the metal should be on that side of the centre line of the bridge on which the initial failure of any important truss member took place. This condition of the top chords actually existing clearly indicates to my mind that east chord section 9, south anchor arm, failed first, dragging the west chord, section 9, after it. The two main shoes have been pushed off their pedestals towards the south anchor pier by an unbalanced horizontal force over the main pier. This condition was created by the destruction of chords 9, anchor arm, and the release of the horizontal component of chord 10, cantilever arm.

Q. What reason do you assign for chords 9-L in the anchor arm yielding under a unit stress of 18,000 pounds when they were calculated to safely carry a much higher unit stress?—A. The main sections being sufficient to resist the stresses existing on that day, either the detail parts uniting the four ribs failed, or the ribs buckled individually, or both.

Q. In designing the compression members did you exhaust every known source of information and were they designed after the full consideration of all known or available data on the subject?—A. Yes. There were no precedents for designing compression members of this magnitude. Tests made on small pieces do not furnish adequate information for members of many times their size.

Q. What was the largest compression member you had heretofore designed and what unit stresses were used in it?—A. The largest compression member designed by me had 240° and the unit stress was 14,000 lbs.

Q. Did the use of these high unit stresses demand mechanical work in the fabrication of the structure superior to that demanded by work designed for lower stresses?—A. Yes.

Q. In this connection what would you consider the limit of good practice in the variation in lengths of the ribs comprising a lower chord section?—A. One sixty-fourth of an inch (1/64").

Q. Was this variation exceeded in any cases in the construction of the lower chords?—A. Not to my knowledge.

Q. Did the quality of the shopwork meet with your entire approval?—A. Yes.

Q. In the light of recent events have you changed your opinion as to the value of data available for the successful design of large compression members. If so, will you explain in detail?—A. There is no reliable theory established, nor are there any results of extensive tests on compression members on record as regards detailing of these large members. No data exist showing clearly when lattices only are sufficient to unite fully two or more ribs into one rigid unit. There is, no doubt, a limit to the depths of compression members when lattices only may be used, and when, on the centre line of the ribs, in addition to the lattices, a continuous horizontal plate girder must be added. We have no data showing how much more efficient top and bottom cover plates are than heavy lattices, nor do we know when, in addition to top and

bottom cover plates on the centre line of the ribs, girders as above mentioned should be used. All doubt as regards these important features of detailing large compression members should be eliminated by extensive tests, as arguments advanced by theoretical investigations are based on more or less vague assumptions. It is the duty of the entire engineering profession to strive to secure numerous tests to establish rules to be followed in designing compression members of large size, in order to replace or to corroborate present opinions.

Q. Similarly have you changed your opinion with regard to the use of high unit stresses, either in tension or compression? If so, will you give your reasons fully?—A. No; high unit stresses may be used in designing, if members in tension or compression are proportioned by rules supported by actual tests. But under existing conditions, I would not advocate such extreme unit stresses.

Q. In splicing large compression members do you consider that the area of the spliced plates would be sufficient if they represented from 15 per cent to 20 per cent of the area of the member?—A. Yes.

Q. Would you consider that a splice which was to be 60 per cent bolted up was properly bolted if 30 per cent bolts and 30 per cent drift pins were used?—A. Yes.

Q. Did the action of the anchor arm during erection meet your expectetions as previously calculated, or did it act in an unexpected manner? Please file a statement or diagram showing the movements of the camber blocking, giving the dates of orders issued in respect to these movements, and when each panel point was released?—A. The anchor arm, during erection, acted generally as expected. Considering the height of the false work (160 feet) the wooden false work foundations resting on natural ground, the variations in the field as compared with the office calculations were insignificant. Exhibits attached (Exhibit No. 105A).

Q. Were there any matters in the process of erection which were brought to your attention which indicated in any way miscalculation? If so, please describe them?—A. None whatever.

Q. Please state as concisely as possible the history of the development of the eyebar system in the bridge, stating what tests were made, and at whose instance; and also giving the general results obtained; and will you please file copies of the blue prints of the eyebar heads that were tested. Were other tests on full size numbers made, and if so, give details?—A. When making the first design for the bridge, in 1897 and 1898, I found that large eyebars must be used. In order to decrease their number, and to thus reduce the chances of errors in boring, to a minimum, and also to obtain shorter pins, 15 inches and 16 inches wide eyebars were considered, not over 2 inches thick, thicker bars being less reliable in testing. This latter feature was especially important, and well known to me since I knew the unreliable and often unsatisfactory results of tests made in our large testing machine for all bridge companies in the United States, on bars over 2 inches thick. I was requested many times by the officials of the company to be sure when determining sizes of eyebars, to keep the thickness, as much as possible, below 2 inches unless it were necessary, in exceptional cases, in order to overcome difficulties encountered in arranging eyebars and pins.

For our information we made preparations to test 15 x 2-inch eye-bars as early as 1900—ten of these bars, 15 x 2 inches, about 15 feet long, were manufactured and tested, with very satisfactory results, in 1901—demonstrating that bars of this size may be successfully forged, and that reliable results may be obtained.

Seventy-three full size tests were made on 10-inch and 15-inch eye-bars between July, 1904 and April, 1907, as required by the specifications, and ordered by Mr. Cooper.

In order to ascertain the character of stresses and resulting strains in the metal of the eyes, the latter were divided by lines parallel with the longitudinal axis of the bars, and by lines at right angles thereto into squares with 2-inch sides. These lines, in their new positions after the tests, were closely examined, and information secured,

useful in designing the size and shape of the eyes. No other full sized tests were made.

Q. Did you visit the bridge site during erection and will you please give the dates of these visits? Please file copy of your personal diary covering the Quebec bridge work?—A. I visited the bridge in May, 1901; June, 1905; June, 1906; and August, 1907. Copy of my personal diary attached (Exhibit No. 106).

Q. Did you make a personal examination of chords 7-L and 8-L cantilever arm in the structure? Did you personally examine any chords after erection and on what dates and with what results?—A. No.

Q. What stresses did you classify as secondary stresses and what secondary stresses did you make allowance for in your design and in what manner did you make this allowance?—A. Secondary stresses due to the enforced position of the members in the structure were considered; but no allowance was made for them.

1st. In floor beams due to bending induced by railroad stringers during change of panel lengths of trusses. No allowance made as directed by Mr .Cooper.

2nd. In eye-bars due to bending induced by deviation of the bars from longitudinal axis of bridge. No allowance made as directed by Mr. Cooper.

3rd. In end vertical posts of suspended span, due to temperature change. Insignificant.

Q. Mr. Cooper has stated that it is his opinion that the bridge could have been saved by promptly using timber blocking in the chords and strutting and bolts between the chords; what is your opinion?—A. I do not believe that the bridge could have been saved in any such manner.

Q. In the bridge as constructed, were any combinations of wind and loading considered which produced unit stresses in excess of those permitted by the specifications under which you were working and to which you were limited? Give particulars as to each member so affected?—A. Combinations of wind and loading assuming load increased by 50 per cent, produce unit stresses in:

*Cantilever arm—*

| | |
|---|---|
| Chord 7 | 25,600 |
| Chord 8 | 25,900 |
| Chord 9 | 26,800 |
| Chord 10 | 26,400 |

Q. Were these unit stresses approved by Mr. Cooper?—A. Yes.

Q. Do you consider that this procedure affected the efficiency of the structure and in what manner and to what extent?—A. The combination of conditions of loading being improbable, practically impossible, I do not believe that the efficiency of the bridge was affected by the high unit stresses given above.

Q. Please file sketches of both travellers and indicate their loads—weights and maximum concentrations of load?—A. Sketches of large and small travellers attached herewith. (Exhibit No. 107.)

Q. When was it decided to use the small traveller, and for what reason was the system of erection changed? Who suggested this change, and did you approve of it?—A. In order to begin the erection of the north anchor arm early in the spring of 1908, the large traveller had to be removed from the south side, and re-erected on the north side in the fall of 1907, before it was possible to finish the erection of the entire south half of the central span. Therefore, another traveller had to be provided for the erection of the south half of the suspended span, only about one-quarter as large as the large traveller thus effecting a considerable saving of metal in the suspended span.

The use of this small traveller was first suggested, and finally decided upon, by The Phœnix Bridge Company, about January of 1906, with my full approval. The original scheme of erection contemplated the use of the large traveller to the center of the suspended span; the erection stresses in the cantilever arms were so figured and sizes provided. The stress sheet of the cantilever arm was approved by Mr. Cooper, showing sizes for erection stresses for the above condition.

Q. Please file a stress sheet showing erection stresses only—on the assumption of the big traveller being used to centre of suspended span. Did the change in the travellers as adopted reduce these stresses and to what extent?—A. Erection stresses due to large traveller attached (Exhibit No. 108) stresses in the suspended span, due to small traveller, were only about 25 per cent to 33 per cent of the stresses due to the large traveller.

Q. What calculations were made by you on August 29, in respect to 9-L anchor arm. If you arrived at a conclusion please state what it was?—A. Knowing that every part of the bridge was figured with the utmost care as to its strength, that the results of the calculations were checked and compared at least three times in the Phœnix Bridge Company's office, that they were then sent to the consulting engineer for comparison with his calculations and for his approval, and that they were fully approved by him; knowing further that the shop plans were prepared under my personal supervision by a corps of able engineers and draughtsmen, that these plans were redrawn several times, that they were then sent to the consulting engineer for his study and approval, and that they were all approved by him; knowing further that every part of the bridge was constructed strictly in accordance with these plans; knowing also that the erection was conducted carefully and strictly according to plans prepared by the Engineering Department—knowing all these facts, I was forced to believe that on August 29, 1907, the bridge was in a safe condition, and that no part could show the least sign of weakness due to stress, especially as the loads of the bridge on that day were such as to produce stresses in the truss members only about three-fourths of the stresses the bridge was figured to be able to bear, with entire safety, after its final completion.

It was impossible for me to believe that the bridge was failing or that the amount of curvature in chord 9-L was as reported. Our resident engineer, Mr. Birks, stating on August 29th, on the telephone, that there was no distortion in any lattice, that all rivets were tight, that there was no change taking place in any part of the chord, I was further strengthened in my belief that there was nothing wrong with that member. I made rough calculations of the chord, however, using 14,000,000 lbs. axial stress, and an average curvature for the four ribs of the chord of 1½", and found that even with this improbable curvature, the chord was not in a dangerous condition.

Q. Does the elastic limit given by usual specimen test bear a direct relation to full size tests of plates, and what is it? Have sufficient tests been made to fully establish this?—A. Tests made on specimens of eyebar material show an elastic limit generally of 10 to 15 per cent. larger than full size eyebar. I am not familiar with any full size tests made on wide plates in order to compare results with the specimen tests.

Q. Do you consider that the elastic limit or the yield point of a built up member such for example as two or more plates riveted together, and which are intended to act in unison, has ever been accurately ascertained, it being assumed that buckling does not occur. What relation do these results bear to similar tests of a member of the same proportions, but consisting of one thickness, providing the same area of cross section?—A. I am not aware that tests of this character ever have been made.

Q. Do you consider that a large bridge member under eccentric stress may in time be so altered in form without failure that the irregularity of stress in the metal under the eccentric loading will disappear in whole or in part?—A. Yes.

Q. Please file a list of all groups of calculations that you made in connection with the bridge in chronological order, and state which stress sheets were used in designing the details of each part of the bridge?—A. Lists of calculations, with proper dates, attached (Exhibit No. 109).

Q. File copies of top chord packing which Mr. Cooper refers to in his evidence as having been sent to you by him?—A. Mr. Cooper's packing of anchor arm top chord bars attached herewith. (Exhibit No. 110.)

Q. Please calculate and file a stress sheet showing the stresses in the main truss members of the anchor arm arising from a uniform loading of 6,000 pounds per lineal

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.)

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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 :