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News of the Week

CURRENT EVENTS IN THE CIVIL ENGINEERING AND CONTRACTING FIELDS

Hoisting of Suspended Span in Progress at Quebec

Began Monday and Proceeding Favorably at Rate of Nearly 50 Ft. per Day—Completion Expected Friday

Hoisting the new 640-ft. suspended span of the Quebec Bridge to its permanent position between the ends of the cantilever arms was begun on Monday, Sept. 17, 1917. The span replaces the one which fell into the St. Lawrence River during the attempt to hoist it, on Sept. 11, 1916, on account of breakage of one of the supporting rocker shoes of cast steel. During the year a new span has been built, identical with the first one, and at the same site, Sillery Cove. The same method of floating it to the bridge site was followed, and in a general way but with some changed details the same method of hoisting is being used. The work is in progress as we go to press, and is expected to reach completion on Thursday, Sept. 20, or early Friday.

The start of hoisting had been tentatively scheduled for Saturday, Sept. 15. But rising wind the evening before and reports of an approaching gale caused postponement to Monday. At sunrise, with perfect weather, the span was floated out from its erection sup-

Continued on page 571

New England Water-Works Men Get Together

Convention Held in Home City of President Saville, Who Is Awarded Brackett Medal for Best Paper in 1916

War times may have kept some from going to Hartford last week for the 36th annual convention of the New England Water-Works Association, but it did not interfere with the get-together spirit of the 150 active and 100 associate members and the 150 to 200 guests who received their blue, red or white badges at the registration desk.

By way of innovation, the convention opened a day earlier than usual, or on Tuesday instead of Wednesday. This gave opportunity for greetings from city officials and other prominent citizens of Hartford on Tuesday afternoon and for an informal reception the following evening. At the afternoon session Caleb Mills Saville, chief engineer and manager of the Hartford water-works, responded to the official and citizen welcome already mentioned and gave a brief address devoted to the interests of the association and its members. An abstract of the address appears on page 540 of this issue.

A particularly happy incident of the convention was the award to President Saville of the Dexter Brackett medal for the most meritorious paper appearing in the association *Journal* during 1916. The paper on which the award was based was entitled "Some Water-Works Experiences in Hartford, Conn.," read Nov. 10, 1915, and published in the *Journal* for June, 1916.

Some twenty papers were scheduled and nearly every author responded when his name was called. The program went through like clockwork, with ample time for discussion, and without wearisomely protracted sessions. Strictly speaking, there was little discussion. What did happen was the asking of scores of questions from the floor in order to elicit further information from the authors of papers.

A notable feature of the program was a group of seven papers on the Hartford water-works by members of President Saville's engineering staff. These came Thursday forenoon and prepared the way for a more thorough appreciation of the enjoyable automobile trip over the water-works, to which Friday morning was devoted. The seven papers mentioned included a historical and descriptive review of the works, by W. E. Johnson; outline of distribution system, by Frank Brainard; engineer-

SUSPENDED SPAN OF QUEBEC BRIDGE JUST BEFORE IT WAS FLOATED TO PLACE AND RAISED THIS WEEK ing work on additional gravity supply, by H. W. Horne; design of spillway at Richard's Corner dam, by R. E. Wise; construction of Phelp's Brook dam, by J. H. Shaunessy; construction of Nepaug River masonry dam, by H. W. Griswold; and grouting dam foundations, by J. E. Garrett.

Water Filtration Given Entire Session

A feature of the well-devised program was an entire session devoted to filtration, with three papers on rapid or mechanical and one on slow sand filters. The session was led off by George A. Johnson, consulting engineer, New York City, who presented an extended review of "Rapid Sand Filtration," sufficient to fill a whole number of the *Journal* of the association. How far rapid filters exceed slow sand filters in numbers and population supplied is shown by extracts from Mr. Johnson's paper, on page 542. The paper also showed the striking decline of typhoid since water filtration was well established in this country, went into details of rapid filters, and discussed pretreatment and after-treatment of water subjected to either of the two types of filtration.

Robert Spurr Weston read a paper on "Mechanical Filter Bottoms and Strainer Systems," abstracted on page 543.

Mechanical filtration at Evanston, Ill., was described in a paper sent by John W. Gaitenby, superintendent of filtration. After experience with both kinds, Mr. Gaitenby does not think high-velocity filter washing with water alone is any better than air-and-water wash. The wash-water velocity at Evanston is 15 ft. per second. The operation of the slow sand filters at Providence, R. I., was described by F. L. Cady, bacteriologist, Providence Water Department.

Some Questions Answered

In answer to a question following Mr. Johnson's paper the author said that after filtered water becomes available, flushing through hydrants is generally all that is necessary to get rid of possible contamination in the mains. E. E. Lochridge, Springfield, Mass., said that when filtered water was introduced in that city a reversal of the direction of flow was caused. A bushel or two of sediment per hydrant was flushed out.

Answering another question, Mr. Johnson said that wash water at the Baltimore rapid filters is conserved by discharging it into a settling pond. W. C. Hawley stated that at Wilkinsburg, Penn., sedimentation and reuse reduces the wash water to 0.1%—a matter of moment, since some of the supply is pumped against a total head of 630 feet.

Water Rates and Allied Matters

Problems connected with the regulation of the private companies supplying water to portions of New York City were reviewed at some length by Delos F. Wilcox, deputy water commissioner. In the case of one company, the city effected an increase in hydrant rental at public expense to gain a needed reduction in rates to private consumers. The city now has a large surplus gravity supply on hand, from the Catskill system, which would naturally be used in place of water now pumped from wells by private companies, and might be furnished at lower rates than the companies are charging.

How Waltham, Mass., voluntarily revised its water rates in accordance with the general plan adopted by state public service commissions was told by Bertram Brewer, city engineer and superintendent of sewers and waterworks. Reproduction cost was estimated, the expenses of the past five years reviewed, the needs of the future forecast and new rates fixed accordingly. An annual surplus of $8000 having been produced by unexpected economies, due to improved city administration, further revision is proposed, with reference to doing away with conditions particularly annoying to consumers. Mr. Brewer believes that a municipal water-works plant should pay taxes into the public treasury and should, in turn, be paid for all service it renders other municipal departments.

Various Practical Experience Papers

A combined repair and service shop, costing $29,000 with land and equipment, was described by H. W. Hosford, water commissioner, Northampton, Mass. The building is about 40 x 120 ft. in ground plan. Part of it is two stories high. Provision is made for ordinary repair work, meter testing and storage of supplies. There is a garage.

Experiences in laying 48,000 ft. of 4-, 6- and 8-in. universal joint pipe, beginning in 1908, were described by John H. Walsh, superintendent, water-works, East Hartford, Conn. No repairs due to the pipe itself have been necessary. Another member, who had laid 25,000 ft. of this pipe since 1911 with good results, stated that elastic paint seemed to be better than white lead at the joints.

A variety of interesting problems met and solved at Windsor, Conn., were detailed by H. R. Turner, superintendent of water-works. His experiences with Leadite for joints are presented on page 544.

How 69 master meters of the venturi type and a steadily increasing number of service meters are reducing water consumption in the Massachusetts Metropolitan Water District was told by S. E. Killam, superintendent of pipe lines and reservoirs. An abstract of this paper is given on page 541.

The use of copper sulphate to control microscopic organisms causing bad tastes and odors in water was dealt with by William Haine, of the Newlands Sanitary Laboratory. J. L. Jackson, one of the engineering members of the Advisory Council of the Connecticut Department of Health, reviewed some stream pollution problems in the state.

The customary exhibit of water-works appliances was well staged by William F. Woodburn, of the Warren Foundry and Machine Co. The Water-Works Manufacturers' Association provided funds for whist and theater parties for the ladies. The Hartford Water Board took the members and guests on an automobile trip to its water-supply sources and provided lunch at the Hartford Golf Club. Other courtesies were extended by the Pratt & Cady Co. and the Terry Steam Turbine Works, of Hartford, and C. W. Blakeslee & Sons, contractors for the Richards' Corner dam.

Quebec Bridge Raising

Continued from page 570

ports, using the same scows that did the work a year ago. It reached the bridge site and was moored to the hanging mooring-trusses by 7:30. The four chairs under the ends of the span were attached to the eyebar lifting-chains, and at 9:30 jacking was begun, raising the span clear of the scows in an hour. By 4:40 p.m. twelve 2-ft. lifts had been made, and then work was stopped for the night, the span being first anchored against wind. Last year's program contemplated continuous work until the span was up in its permanent position, which it was believed could be accomplished within 24 hours. This year no nightwork is being done.

Jacking was resumed at 7 a.m. Tuesday and except for the noon-hour interruption continued till 5:30 p.m., 22 more lifts being made, a total from the start of 34, or 68 ft. of lift. The work was not hurried, and it was interrupted from time to time to remove the freed links of the lifting chains.

Judging from the rate of progress attained Tuesday, at least two more days were then required to finish the hoisting. The final steps, including attachment of the permanent hangers, may carry the work over to Friday.

Association of Engineers Organizes Three New Chapters

The board of directors of the American Association of Engineers, at their meeting on Sept. 5, granted charters to the members in St. Paul, Indianapolis and Milwaukee. This makes a total of seven chapters which have been organized since the association was incorporated about two years ago. The total enrollment is now over 2200.

A joint meeting of the association and the Detroit Engineering Society was held in the Commerce Building, Aug. 30. It was the unanimous opinion of the engineers present that the Detroit society should form a working coöperation with the American Association, as they have been carrying out a similar program locally for Detroit as the other organization has operated in a national way. The Detroit society has a total enrollment of about 700 members, and if this working coöperation is established it will mean the furthering of the work laid out by the Committee on Engineering Coöperation.

QUEBEC SUSPENDED SPAN HAD TO BE LIFTED 150 FEET AFTER IT HUNG CLEAR

Quebec Suspended Span Successfully Hung from Cantilevers

Fifty-Four-Hundred-Ton Structure Floated $3\frac{1}{2}$ Miles on Scows and Hoisted 150 Feet by Hydraulic Jacks and Lifting Links—Work Done Entirely During Daylight Hours

By HARRY BARKER
Associate Editor, "Engineering News-Record"

A NEW MILESTONE in bridge erection was passed last week when at Quebec the greatest single fabricated part of a structure was placed in position, the heaviest span ever floated was moved $3\frac{1}{2}$ miles and the greatest job of jacking, both in total load and total lift, was completed. The complete success of every detail of the floating, hoisting and pinning, the remarkable adherence to schedules and the accurate checking of the engineers' computations of deflections and clearances throughout were the final answer of the St. Lawrence Bridge Co. and the Government board of engineers to critics of the design of the Quebec bridge and of the boldness of the scheme of placing the center span. Success has vindicated the judgment of the designers whose confidence was unshaken by last year's failure.

The entire operation was peculiarly dramatic to all the engineers who were fortunate enough to see it. The first day of the floating and connecting to the hoisting chains, and the last day when the final lifts were taken and the big pins slipped through the eyes of the permanent hangers, were filled with inherently spectacular moves. Even the two days of steady jacking were hours of constant interest in the ease with which the apparatus worked and the changing perspective in which the huge span was seen as it slowly rose above the river.

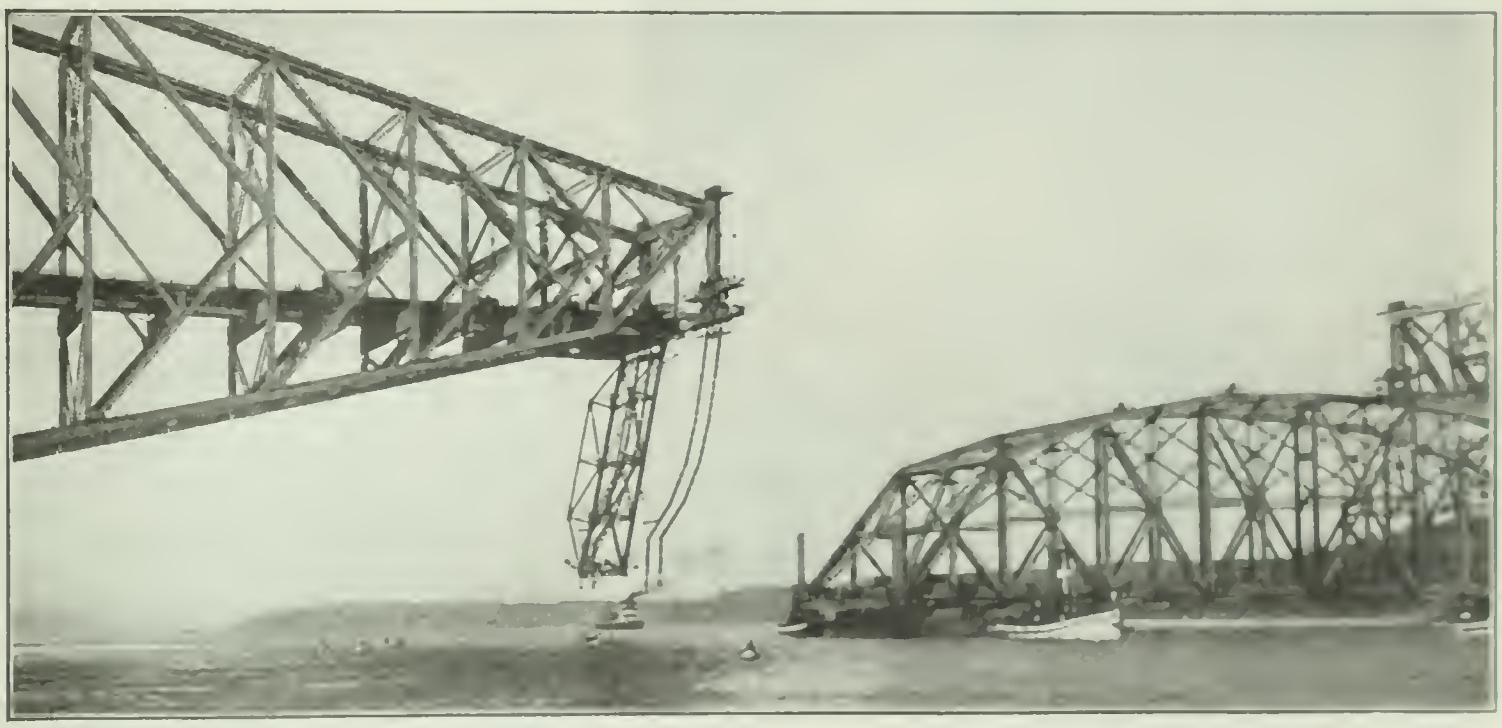
With each step of progress the confidence of workers on the bridge and watchers on shore grew firmer and firmer and at the end of the third day's work, when the plank platforms on the spans could easily be reached from the cantilever working floor, there was an eager rush of all the men to be in the first group to go across.

The faith of the men in the ultimate success of the enterprise was notably increased by the unique interest and confidence of the Sillery parish priest—Father Mc-

THE SPAN REACHED ITS FINAL POSITION AFTER FOUR DAYS' WORK

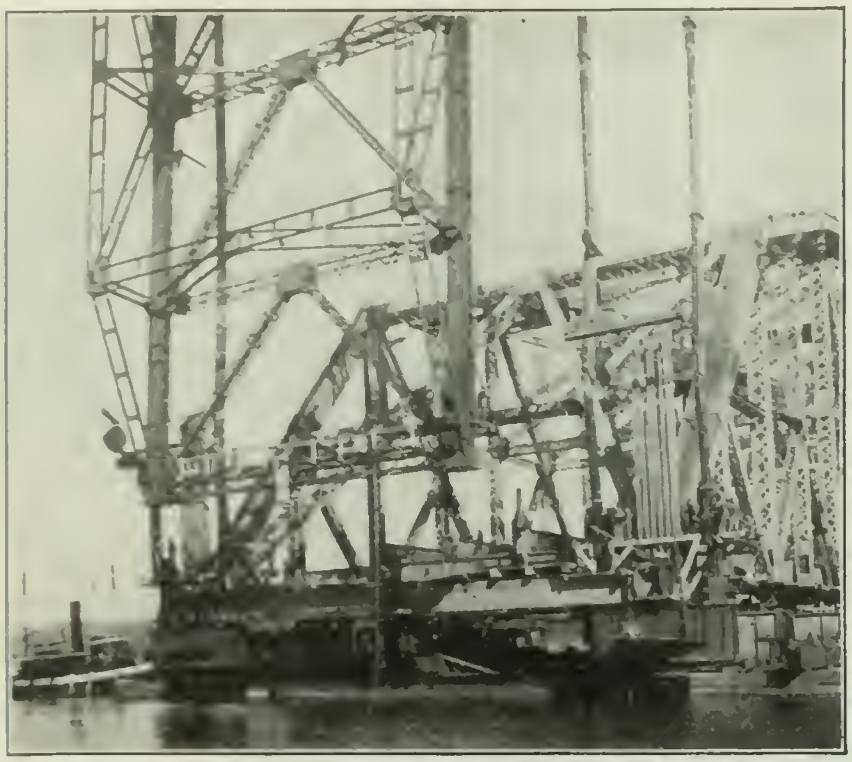
Three Preliminary Stages in the Raising of the 640-Foot Suspended Span of the Quebec Bridge Last Week

AT SUNRISE THE SPAN WAS TOWED OUT FROM SILLERY COVE



AS THE SPAN CAME CLOSE UNDER THE CANTILEVERS, GUIDE LINES WERE CARRIED OVER TO MOORING TRUSSES

WHEN THE SUSPENDED SPAN WAS LIFTED FROM THE SCOWS [illegible]

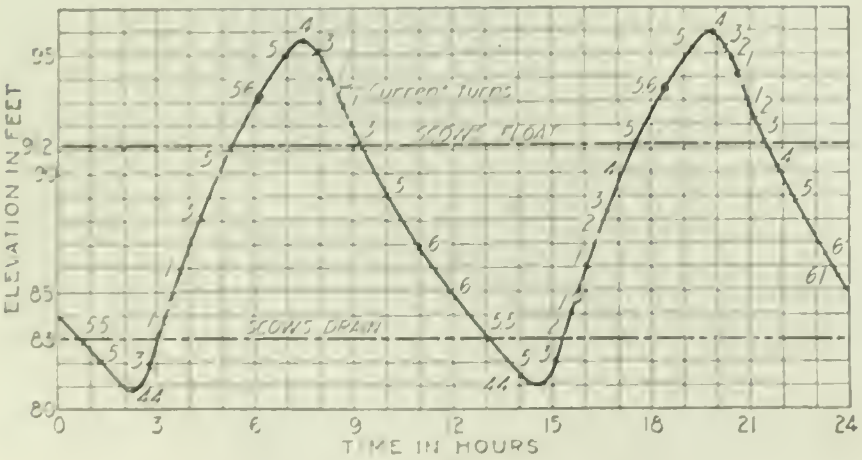


CONNECTING THE FLOATING SPAN TO THE LIFTING LINKS

Guire. A new force making for success was injected into the work and a new element was added to already dramatic scenes. On Father McGuire's initiative, the span and both cantilevers were blessed with due ceremony some days before the floating, and on the Sunday morning before the start a special Mass was offered. When the span floated past the Sillery church, all its bells rang out. Then the priest came out in a launch, boarded the span and rode up the river with it. He was around the work thereafter and spent the whole of the last day on the end platform of the north cantilever.

It was first intended to float the span Saturday, Sept. 15, but high winds Friday night and reports of an approaching gale led to postponement of the work for a day; then as the workmen were rather desirous of not working on Sunday, the start was put over one day more. With Sunday and Monday came perfect weather and good prospects for Tuesday and Wednesday, and the undertaking was started. The delay was not without benefit, for the smoothness of the operations on the succeeding days was due in no small measure to the practice drills with the jacks and pins.

As the tide reached low ebb Sunday night, men closed the bottom valves in the scows that were to float the span. The water rose steadily on the six scows until they lifted gently off their foundations and let the flat bearings, employed for the swinging on fixed end supports, come free. This was approximately at 5: 15, and by 5: 22 the lifting girders were perceptibly clear of the end bents. A few minutes' wait was necessary to get the needed depth of water channel for this strange tow and its tugs. At 5: 47 the first move out was made.



QUEBEC TIDE DIAGRAM FOR SEPT 17

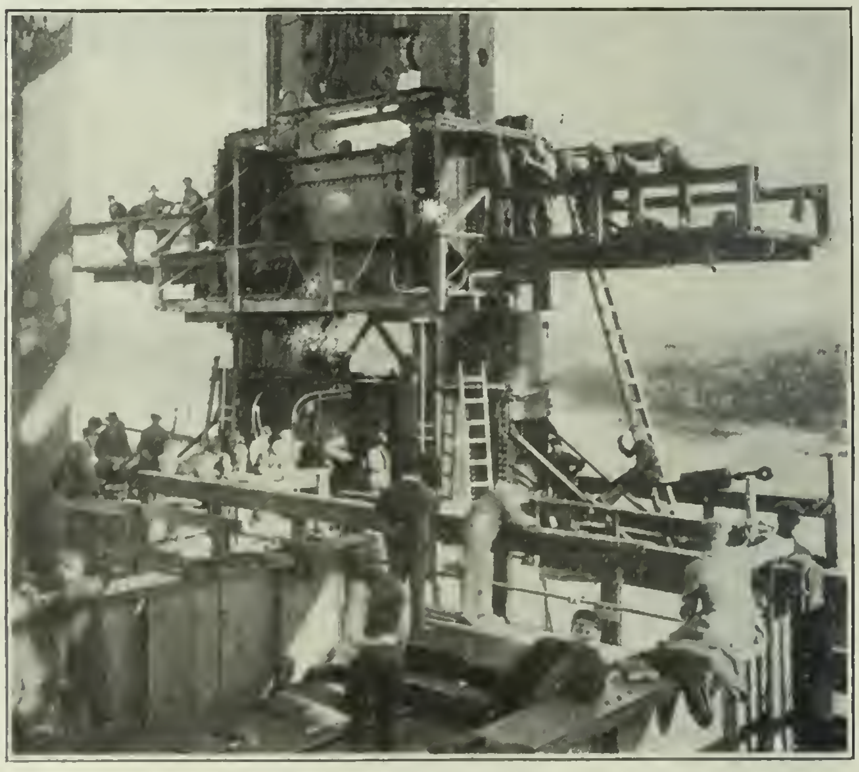
Showing the rise and fall of the river and changes in current at all stages of the floating operations

Two tugs had taken position outside the scow groups and easily handled the floating span on the smooth water. The span came out as the sun was rising and was turned cross stream as it went out, so that by the time it was in mid-channel, at 6: 15, it was ready to move up the river.

The strong tidal current (6 miles per hour) swept the span upstream with little effort required from the two towing tugs. Five tugs downstream stood by, stern on, with lines in place and waiting to serve as brakes.

By 7: 25 the span was roughly in its place, and five minutes later the first lines were run out to the mooring trusses. In 18 min. the six lines at the end of the span were all out and the tugs were standing by with lines eased off. At 8: 05 the lifting chains, which had been drawn back, were let down and the ends appeared to be pinned in place in 20 minutes.

At 7: 30 the tide had turned, and by 8: 30 the current had shifted from upstream to down. By about nine o'clock conditions were right for beginning the 150-ft. hoist. At 9:10 the jacks started; the bottom chain pins came to the bottom of the lowest-link slots with the jacks a few inches from the top of the first hitch-adjustment stroke—which, being taken for more than half the lift without the load of the span, was not counted as one of the 75 lifts needed to do the work according to schedule. (Five such adjustment lifts were provided for beyond the normal scheduled operations in case any delays in connecting the hanging and stub links were longer than anticipated. In such an event the chains could have been lowered to connect with the span at any time down to low tide.)

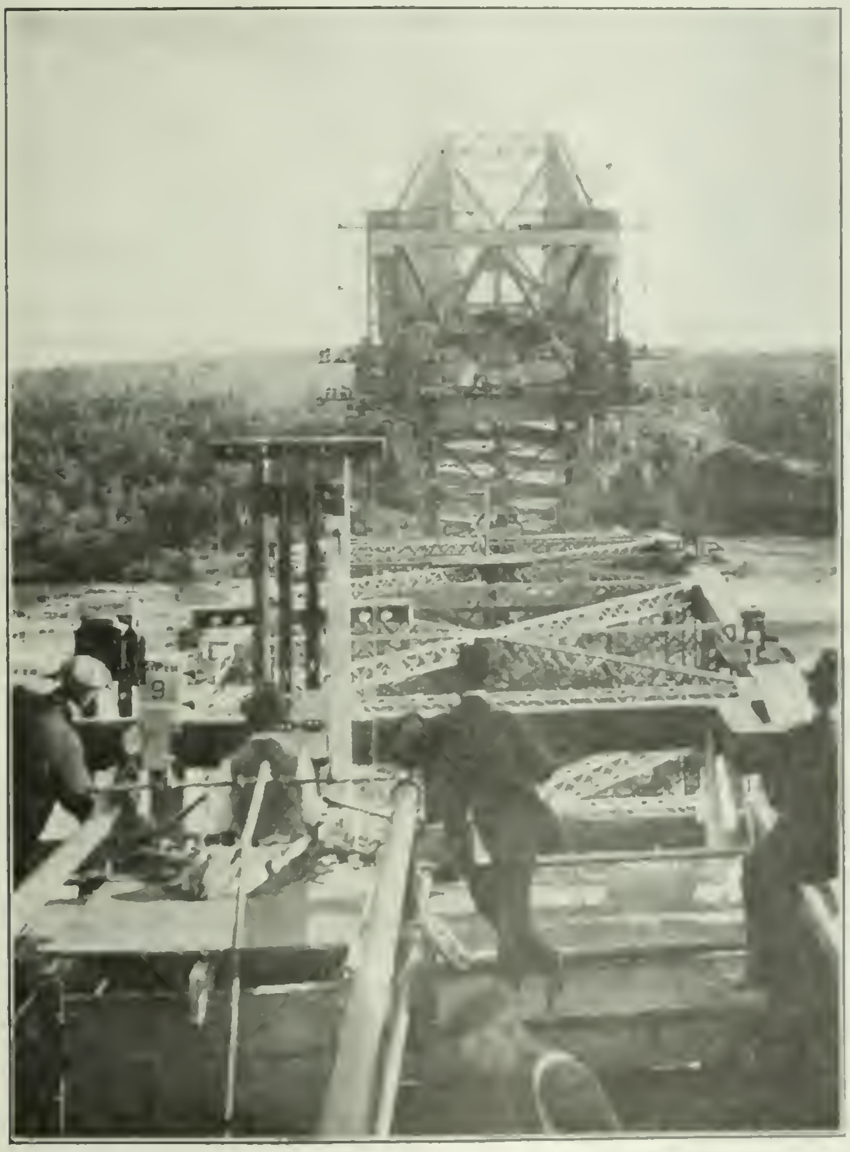


EASE WITH WHICH APPARATUS WAS OPERATED GAVE EVERYONE CONFIDENCE

At the end of the third counted lift, at 10: 28, the scows came free and were swept from underneath by the current, the south-shore group preceding the north by a minute. The blocking beams between the span and scows were not relieved of the load at quite the same time on the upstream and downstream sides, so that the barges began to swing around as they came out and for a moment gave some apprehension to those onlookers who did not realize the massiveness and strength of the hoisting details.

The imposing spectacle of the span hanging clear was received by the thousands on shore and on excursion craft in absolute silence—there was not a shout or a whistle. The feeling was tense, the scene most impressive. Everyone realized that the crucial test was at hand, for the work had reached this same stage last year when the span slipped from its supports.

Once the span was clear the men went in to a delayed breakfast. After an hour's intermission they returned, and at 11:25 jacking was resumed. Two lifts were made and another recess was taken. The fourth lift was started after lunch, at 2:05, and nine were made



THE SPAN GREW IN APPARENT PROPORTIONS AS IT ROSE

in rapid succession, ending at 4:40. The actual time required for a lifting cycle varied from 13 to 19 minutes, and the actual lift period was from 6 to 8 minutes.

Up to this time there had been no wind, and the mooring tackle used to warp the span into its final floating position had not been shifted. For tying the span up for the night, however, the anchor lines were set, being better arranged for holding the span fixed.

The first task of the second day was the lowering of the top links, which had come through the top jacking girders. Taking off the pin caps, pulling out the short pins and lowering the links to the platform used up a trifle more than three-quarters of an hour. Jacking started at 8:16 and continued steadily to 12:02, when the twenty-sixth lift had been taken. Another set of links had to come off after the noon hour, and it was 3:40 before jacking began again.

During this part of the work there occurred the only accident of the entire job—and that was a minor one without anything more serious than an extra half hour's delay and a broken nose for one workman. For supporting the link-removal tackle, there were brackets bolted to the upstream jacking-girder box hangers, and several bolts on one at the southwest corner were

A CLOSE VIEW OF THE WHOLE HOISTING EQUIPMENT

sheared off. This was probably due to overloading, which was possible on account of the substitution, after the brackets were erected, of a heavy platform hoist for the light powered hoist mounted on the end diagonals of the cantilevers. The bracket was reinforced with slings and steamboat ratchets.

Seven more lifts were added to the score between 3:40 and 5:31, making the total number 34 and the lift 68 ft.

The third day was one of steady progress—of jacking interrupted only for letting down the top links as they came free. There was no wind, and the anchor tackle had to be shifted up the mooring truss only once, that being done at noon. In all twenty-six lifts were made this day, completing the sixtieth. This third day gave the appearance of the greatest progress to watchers on shore, on the river and even on the bridge. From all points of view the proportions of the span appeared to increase as it rose.

The fine weather broke just at the close of the second day, with a heavy shower that ushered in rising east winds. By Thursday morning the wind had risen to

25 or 30 miles per hour, and was coming in gusts. But a moderate pull on the anchor leads held the span in place, and it could be manipulated with ease to ½ in. or less. When allowed to hang free the wind held the span from 5 to 7 in. off center, the total length of the suspension system being 100 ft. at that time. A ½-in. longitudinal oscillation with a period of about 10 or 12 seconds was observed.

The jacking started at 9: 05 and by noontime (11: 53) ten lifts had been taken. Only 8 ft. remained to be covered when the recess was taken. The span portal was in full view; the upstanding permanent-hanger eyebars had come up through the jacking girders and were approaching contact with the eyebars suspended from the cantilevers.

The last afternoon's work started at one o'clock in an atmosphere alive with mingled excitement, expectancy, confidence and anxiety. The first afternoon lift, the seventy-second, was made in 15 minutes, and 5 minutes was taken for a look at clearances all around. The seventy-third lift was made from 1: 20 to 1: 40, and then 30 minutes were used up in taking down the inside free top links and a pair of angles across the lower box hangers, so as to secure the maximum room for driving the pins.

The seventy-fourth lift was taken very slowly (2: 10 to 3:10), as some of the wooden working platforms had to be taken down, the clearances inspected, and the eyebars guided into proper position interlaced. The seventy-fifth lift followed immediately, and locomotive cranes were run out to all four corners with pin-driving cages and pins. At the end of the stroke, at 3: 25, the first of the eight pins was driven. The clearances were perfect, and each long pin slipped through its eyebars with a few taps from a short rail swung by about ten men. Every ringing blow of the rails stirred the onlookers. And when at 4 o'clock the last foreman shouted, "Right, here!" all restraint among workers and watchers was lost. The crane whistles on the bridge picked up the men's cheers and the river boats passed the signal down to the City of Quebec, where (by the Mayor's proclamation) every whistle and bell and automobile horn was turned loose, and flags and buntings were thrown to the breeze everywhere, for Quebec realized that its dream of thirty years had come true.

But with the driving of the pins the day's work was not quite done. The jacks had to be lowered to let the load come on the permanent hangers and to let the lifting girder bearings come free—which they did with from ⅛- to ¼-in. clearance at the end of the seventy-fifth return stroke of the jacks. With this the day ended.

On Saturday the work of dismantling the hoisting equipment started and the wind-stress (pin-and-socket) connections between span and cantilever were brought forward. The span floor system has yet to be erected, the footwalks laid, and some lateral-bracing connections have to be riveted. Trains may perhaps pass over the bridge in six weeks, but the last work can barely be finished this year.

The story of the Quebec bridge has now been written. For one man, Phelps Johnson, who now retires from active work, it is the story of his last great effort. For many others, Duggan, Porter, McMath, Mitchell, Monsarrat, Modjeski, Borden, it is only the record of another achievement. For a score of younger men it is the inspiration of promising careers opened up by their notable work here under the guidance of the older men.

New Details Found in Quebec Span Hoisting Arrangement

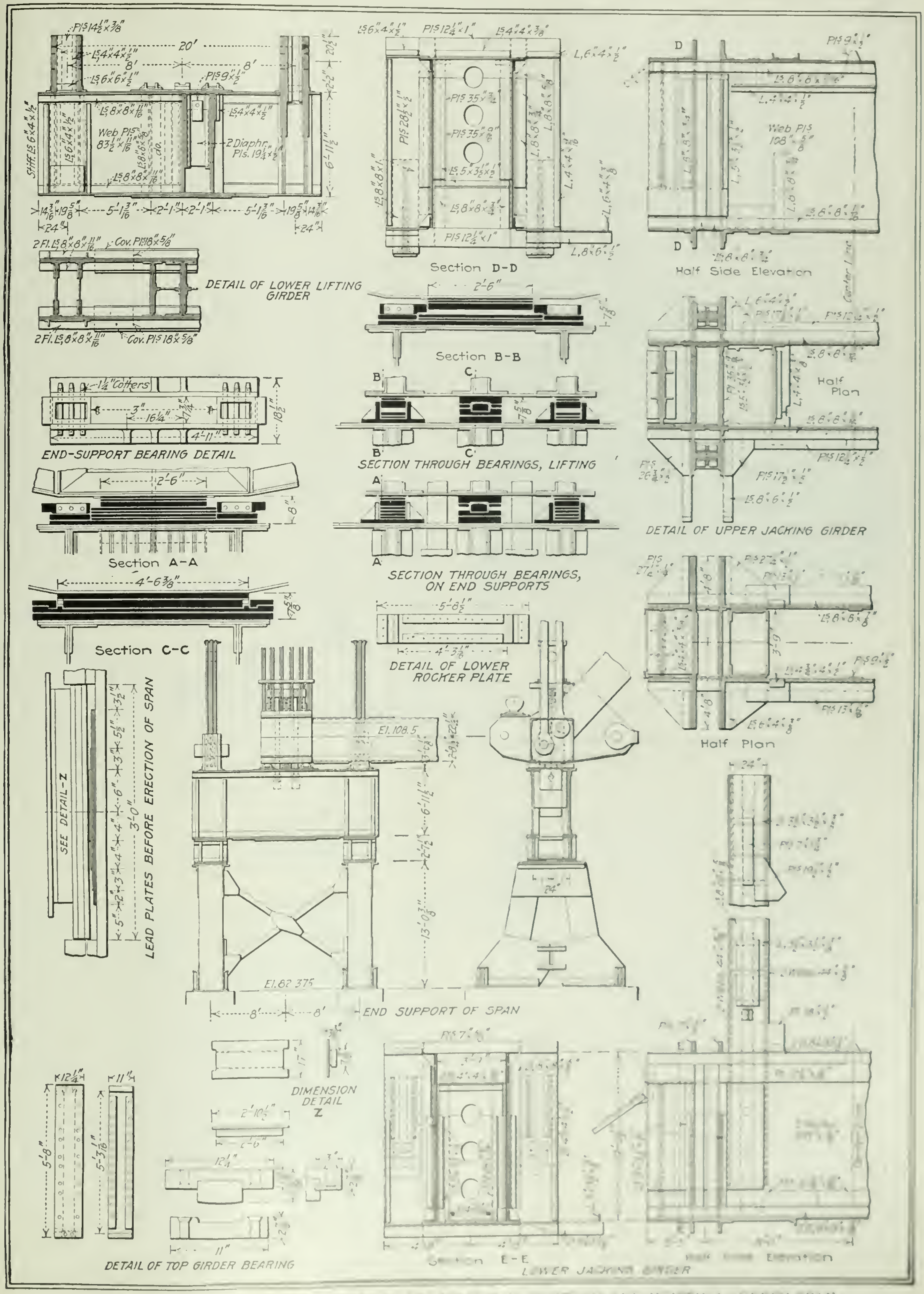
General Scheme Employed Last Year Retained, but Radically New Bearings Used Between Span and Chairs—New and Heavier Hoisting Links and More Follower Jacks

THE SCHEME and equipment for hoisting the new suspended span of the Quebec Bridge, successfully completed on Sept. 20, as noted elsewhere in this issue, follow the general practice employed in 1916, but with a few important modifications which the events of last year made advisable—though not all sprung out of the loss of the first span.

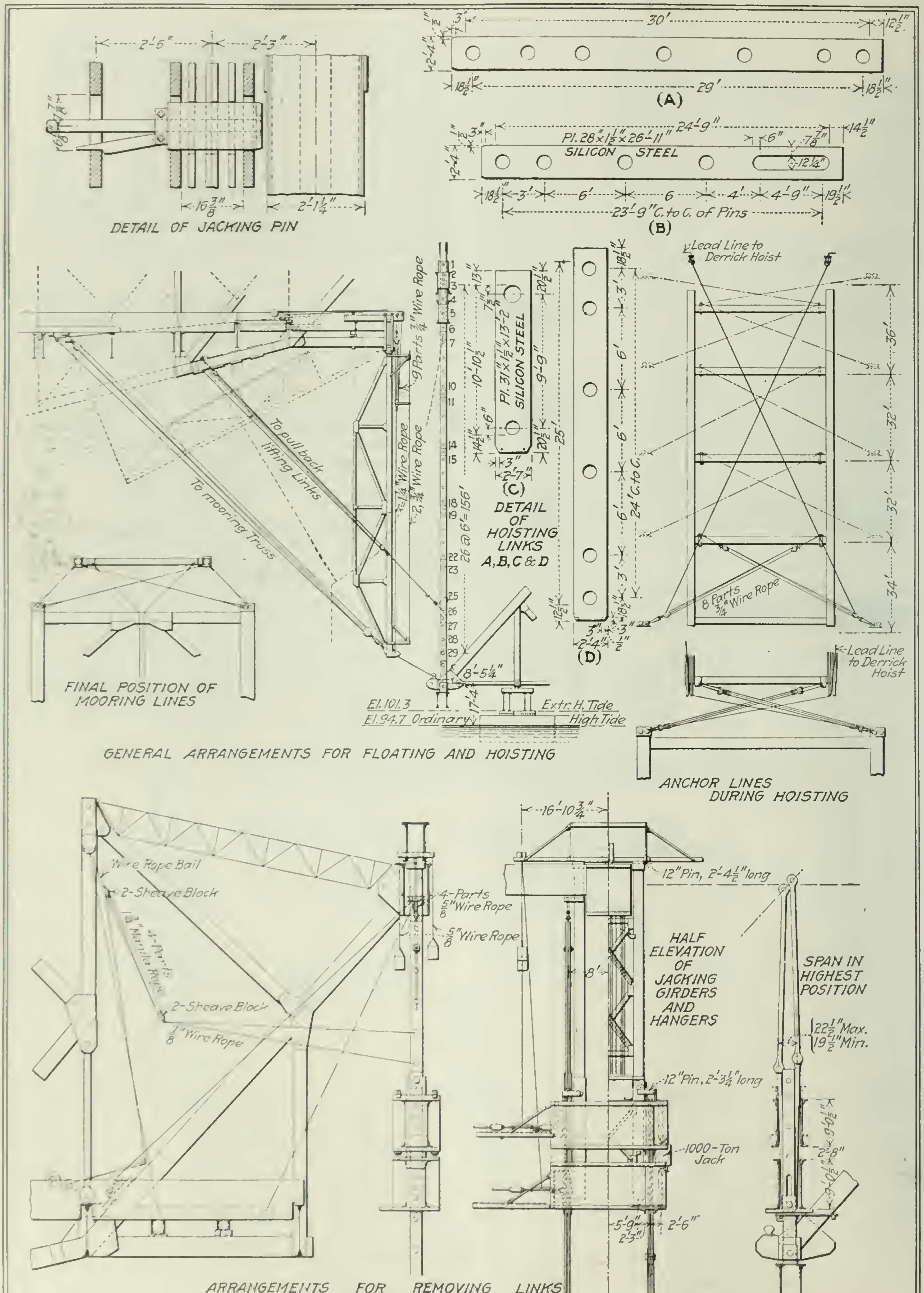
The new span is a duplicate of the old one—640 ft. long, 88 ft. wide and weighing 5400 tons The task of rolling the steel (about 75% of which was nickel alloy), fabricating it in the shop and erecting it on falsework was completed in ten and one-half months—itself a notable performance in view of wartime demands for material and labor. The shopwork, if possible, was even better than that on the first structure, and the erection time was cut by ten days. The same site at Sillery Cove was used, and the same falsework and end supports. The identical six scows before employed for floating were used again.

It will be recalled (see *Engineering News*, Aug. 31, 1916, and *Engineering Record*, Sept. 23, 1916) that the program called for erecting the span on falsework over shallow water, lowering it upon its end supports; letting six scows, moored underneath near the ends, pick it up as the tide rose; towing it to the main bridge site; connecting lifting chairs carried under each corner to pairs of lifting chains hanging from the cantilevers, and then jacking the span as a unit until pins could connect the permanent hanger bars carried by the cantilevers and the span.

The corner chairs, or "lifting girders," as they have been commonly called although they were employed while the span was being erected, when it was resting on its four end supports at Sillery, and while it was being hoisted to final position between the cantilever arms, were the old girders used with the first span, but largely rebuilt to meet the needs of the different intermediate bearings between chairs and span corners. These girders



DETAILS OF LIFTING GIRDERS AND SPAN BEARINGS FOR ERECTING AND HOISTING QUEBEC SPAN

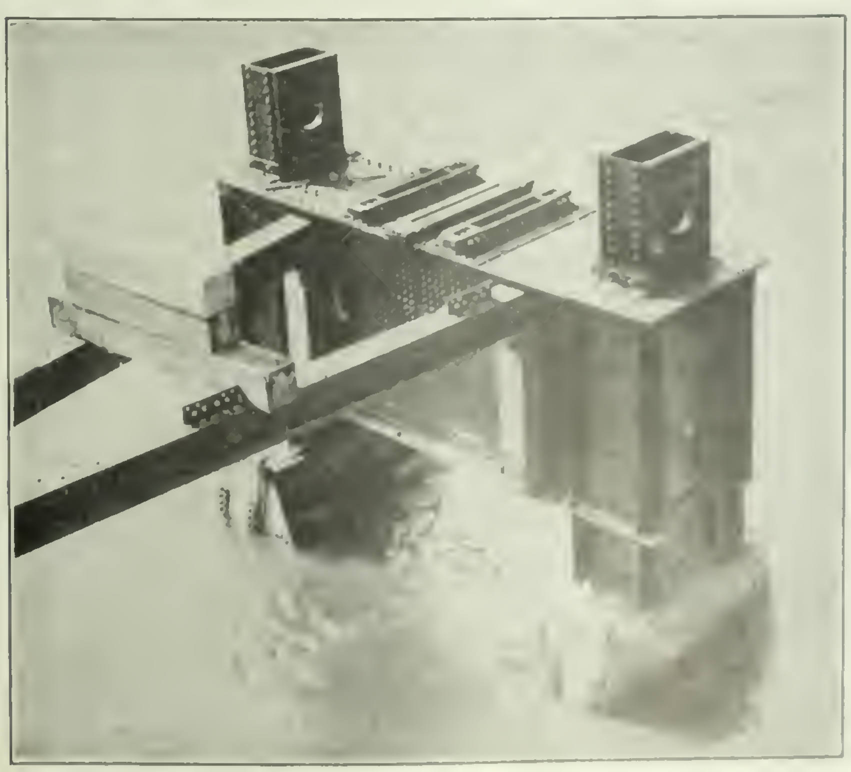


ARRANGEMENTS FOR FLOATING, MOORING AND LIFTING THE NEW QUEBEC BRIDGE CENTER SPAN are briefly described as being built up of two plate girders connected by bearing and stiffening diaphragms and cover plates. They are 5 ft. 6 in. x 20 ft. in plan and 7 ft. in depth. Some details are shown in the accompanying sketches.

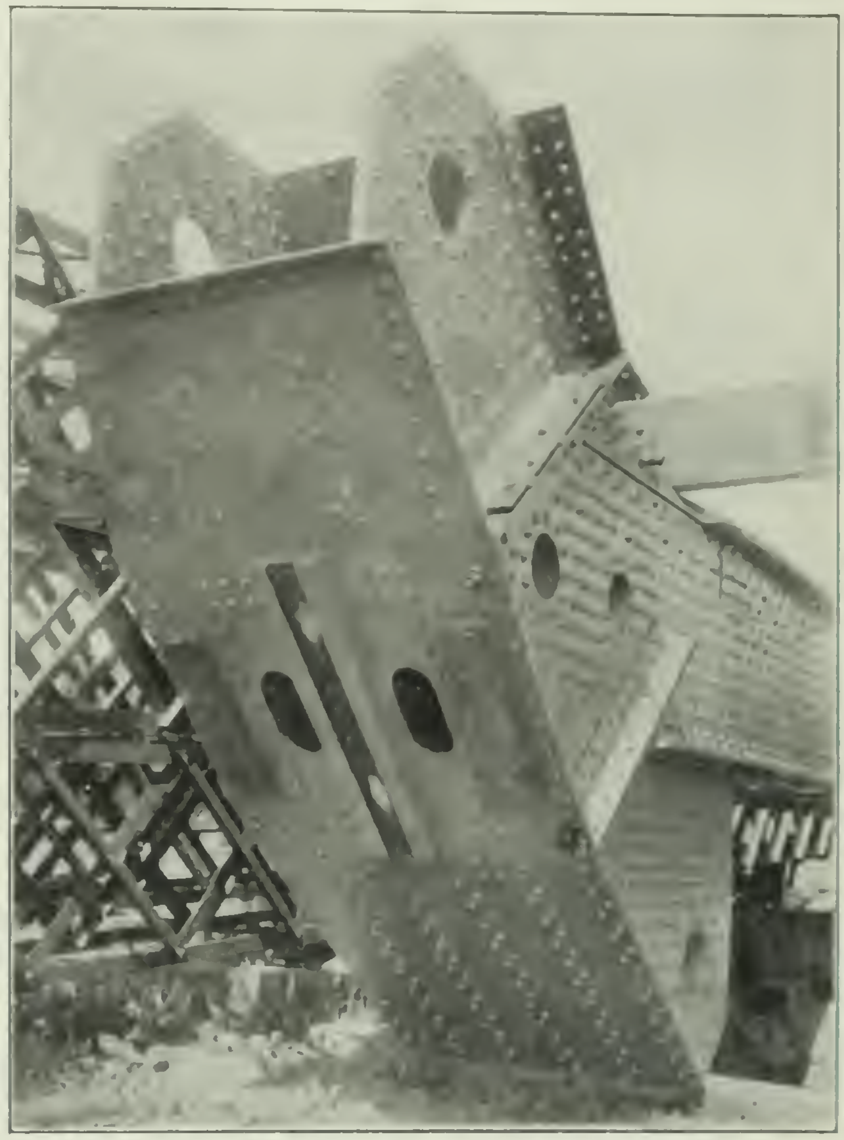
When the suspended span was swung on its fixed end supports, the load was concentrated at each corner upon two flat-plate bearings having their centers 4 ft. 2 in. apart, directly under the two outside ribs of the truss end post. Considerable sliding movement had to be accommodated, as the span elongated 4 in. as it was let down from its supporting falsework to the end supports alone. Then there was provided for a possible range of travel of $3\frac{9}{16}$ in. for each corner, due to expansion and contraction from temperature changes.

These plate bearings comprised a base—a machined steel casting, shown in detail in the accompanying sketches, in the pocket of which are six lead strips of varying length—and above these two steel filler plates, the lower one fitting the casting very closely to prevent extrusion of lead, and a bronze bearing plate on top of all. The lead strips were placed in initial position like the leaves of a carriage spring, so that as the load on the bearing increased during erection and swinging and as the inclination of the corner XLO changed, the lead would flow and give a firm seat for the bearing filler plates, and so provide uniform load distribution.

On each polished bronze top plate rested the polished face of a built-up steel bearing shoe, 2 ft. 6 in. long by $7\frac{7}{16}$ in. wide, bolted underneath the suspended-span corner. The upper steel filler plate and the bronze seat plate were held pocketed by finished and fitted guide blocks, each held in the bottom casting by three large cottered pins. The polished surface of the bronze plate was lubricated with paraffin before being placed. When the span was floated these bearing plates came out of contact and the lifting girder was then carried by a pair of small hanger links coming down from short channels on brackets attached to the gusset plates of the end diagonal. When the sliding bearings were free—that is, when the span was afloat—the bronze seat and one steel filler were taken out and the end blocks then turned around so as to serve as guides between the lifting girder and suspended span, in order that the girders might remain properly centered ready for the hoisting operation. These sliding bearings did not again take load when the lifting girder and span were picked up by the hoisting chain; they served thereafter only as guides and as emergency bearings intended to come into play in case of any accident to the single corner bearing employed during the lifting operations.



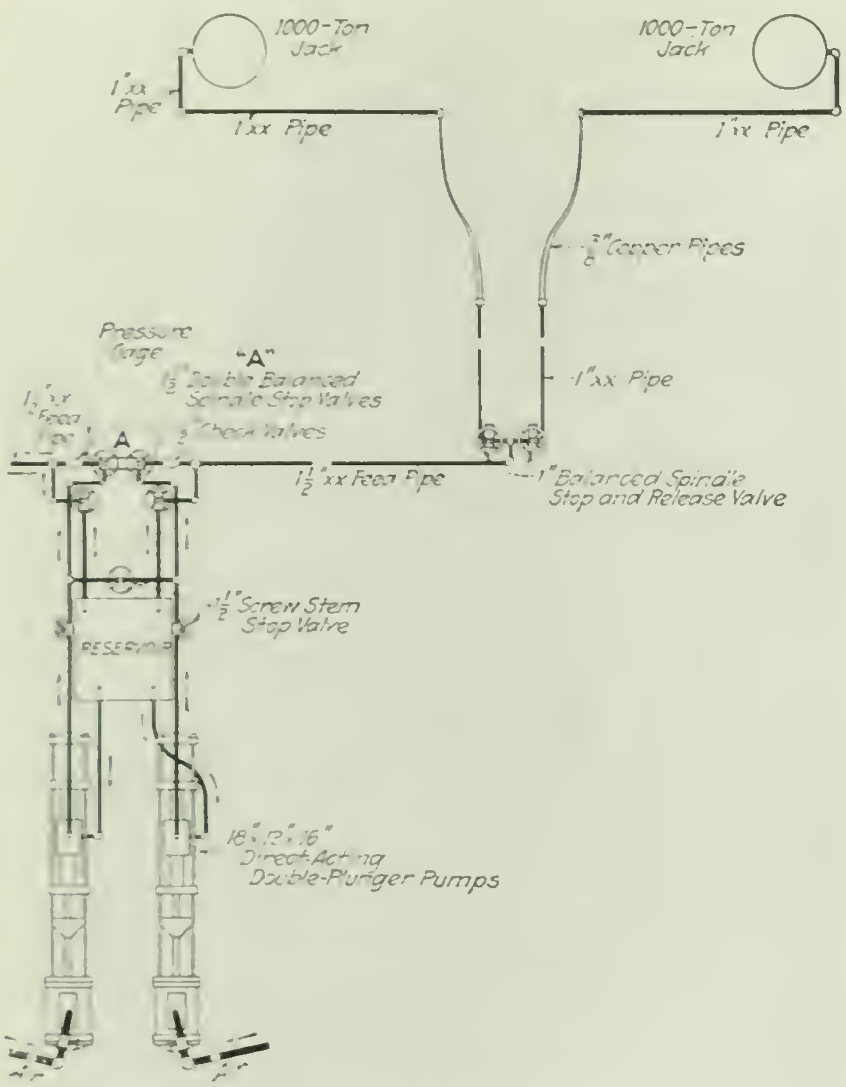
CORNER-BEARING POCKETS ON LIFTING GIRDER



SLIDING SHOES AND ROCKER PLATE UNDER SPAN CORNER

Between the slide bearings, and between the center of the lifting girder and the center rib of the span corner XLO, was the single bearing used during lifting (and idle during swinging and floating). This bearing contains no castings; it was fabricated entirely out of rolled material. On top of the lifting girder was first a $2\frac{1}{16}$-in. filler plate, and on this a machined holding plate grooved for end stop blocks and for a nickel-steel rocker 5 in. wide, $2\frac{1}{2}$ in. deep and 4 ft. 3 in. long, having its top surface a cylinder of 24-in. radius. A nickel-steel plate with machined groove to center the rocker was riveted to each span corner under the center rib. The centering stop blocks of this rocker were bolted into place after the span floated free, and together with the end blocks on the converted sliding bearing guided the nickel-steel rocker into the shoe under the span corner.

Each lifting girder during the hoisting was carried by two chains going up to the jacking girder. Each chain was formed by four strings of lifting links. In each string one link was 26 ft. 11 in. long, five were 27 ft. 1 in. and one was 32 ft. 1 in. They were bored for the 12-in. jacking pins at 6-ft. centers, with [illegible] in. clearance transversely and [illegible] in. longitudinally. The lifting links were bored in sets of sixteen, and each link had a



SYSTEM OF FOLLOWER SCREW JACKS

designated place in the chain, so that the spacing of pin holes at each end of the span was identical for each lift made. The lifting links were fastened together into a chain by 12-in. pins, 1 ft. ¾ in. long, held in place by caps and through bolts. The links themselves were each 2 ft. 4 in. wide and 1½ in. thick, and were not attached to each other except through the common bearing pins of each chain (four links). The allowable stresses through the pinhole were 18,000 lb. per sq.in., including stress from 20% of the load as impact and an assumed additional load of 500,000 lb. per corner to allow for possible differences of level between corners of the span.

The stub links and lowest section of the lifting links were made of silicon steel with an elastic limit of 50,000 lb. per sq.in. All other links were of carbon steel rolled to the same specifications as the material for the permanent structure—62,000 to 70,000 lb. ultimate strength. Full-sized tests of similar links developed an ultimate strength on net section through pinholes of 60,000 lb. per square inch.

The mooring arrangements were the same as last year. Six lines were used to guide and haul the floating span into final position between the mooring trusses hanging down from the cantilever end. Two lines came down from electric hoists on the cantilever to each mooring truss corner and spread out to the two corners of the span; and two came across from steam hoists on the floating span along the center to the end, and spread across to the corners of the mooring truss.

The only change was the provision made for replacing the mooring lines by an 8-part ¾-in. steel line thrown from each corner of the mooring truss to the diagonally opposite span corner. As the jacking progressed, these lines could be held taut by derrick hoists on the platforms above. Each time the bottom of the span rose past a panel of the mooring truss, a 24- to 36-ft. lift, these anchor lines could be shifted to the next higher anchorages on the trusses. This provision for anchoring at any time on very short notice was provided so that work could be stopped at any time and the span held against wind movement. The tackle was kept tight, however, only during the idle night hours and on the last day, when the wind was strong.

To facilitate connection at the slotted bottom hole of the bottom links in the lifting chain, the stub links borne by the lifting girders under the span corners had fastened at their top a pair of guide straps between which were cross bolts—one continuously in place and the other removable through a top slot. On swinging down the chains to engage the stub links the slotted links were brought up against the back guide bolt, and then the front bolt was dropped into its slot and fastened, leaving ¾ in. total play between bolts and links. With the hanging and upstanding links thus guided, it was easy to slip home the 12-in. connecting pin.

The upper supporting girders, at the ends of the cantilever arms, were similar in design to the lower supporting girders, except for arms which carried various counterweights. Between the center of each girder and the center of the supporting arm is a rocker joint very much like the center bearing under the suspended span, the rockers in both cases being parallel to the bridge axis. At the top support the rocker was locked to the bearing plate on the supporting girder, and the cylindrical surface was down against the bearing plate on the cantilever.

Pinned to the upper supporting girder (at right angles to the span and thus, with the rockers, accommodating movement of the suspended span in any direction from external forces) were the box hangers, about 2 ft. 3 in. square, which came down some 44 ft. to carry the lower, or fixed, jacking girder. Each pair of box hangers was cross-connected by two panels of X-bracing. Coming up from each fixed jacking girder to meet these box hangers coming down from the upper supporting girders was a pair of cross-braced box hangers about 15 ft. long. The two sets of box hangers met at a pin joint. The lower pair of hangers was riveted into the lower or fixed jacking girder and served as a guide for the upper jacking girder as it was raised and lowered.

The fixed jacking girder carried on its center line at the extreme end, outside the supporting hanger, two 1000-ton hydraulic jacks, and four auxiliary, or follower, screw jacks on brackets in line with the lifting chains. The hydraulic jacks had rocking seats at both upper and lower bearings to accommodate, without binding, the deflection of the girders under load. The reaction from the hydraulic jacks was carried by transverse diaphragms in both jacking girders, while that from the follower screw jacks was borne through brackets to the main members.

Each follower jack consisted of a 12-in. screw, a nut and a barrel casting. Each barrel was supported by brackets on the lower girder, and the nut fitted a recess in the top of the barrel. The screw carried below it a vertical splined shaft by which it could be rotated. The screw and shaft were supported on a clearance yoke below, from which two cables ran up to a similar yoke above. From the latter yoke a cable ran to a counterweight. Loose on the screw shaft, but restrained by guides on the lower jacking girder, was a feathered bevel gear meshing with a gear on a shaft going through other gears to a drum and handwheel carried by the lower jacking girder. As shown in the accompanying sketch, the two follower screws at each hydrauic jack were geared to one handwheel. Two men easily followed the movement of the upper jacking girder.

The lifting links passed between pin-bearing cross diaphragms in each jacking girder. The chains, as al-

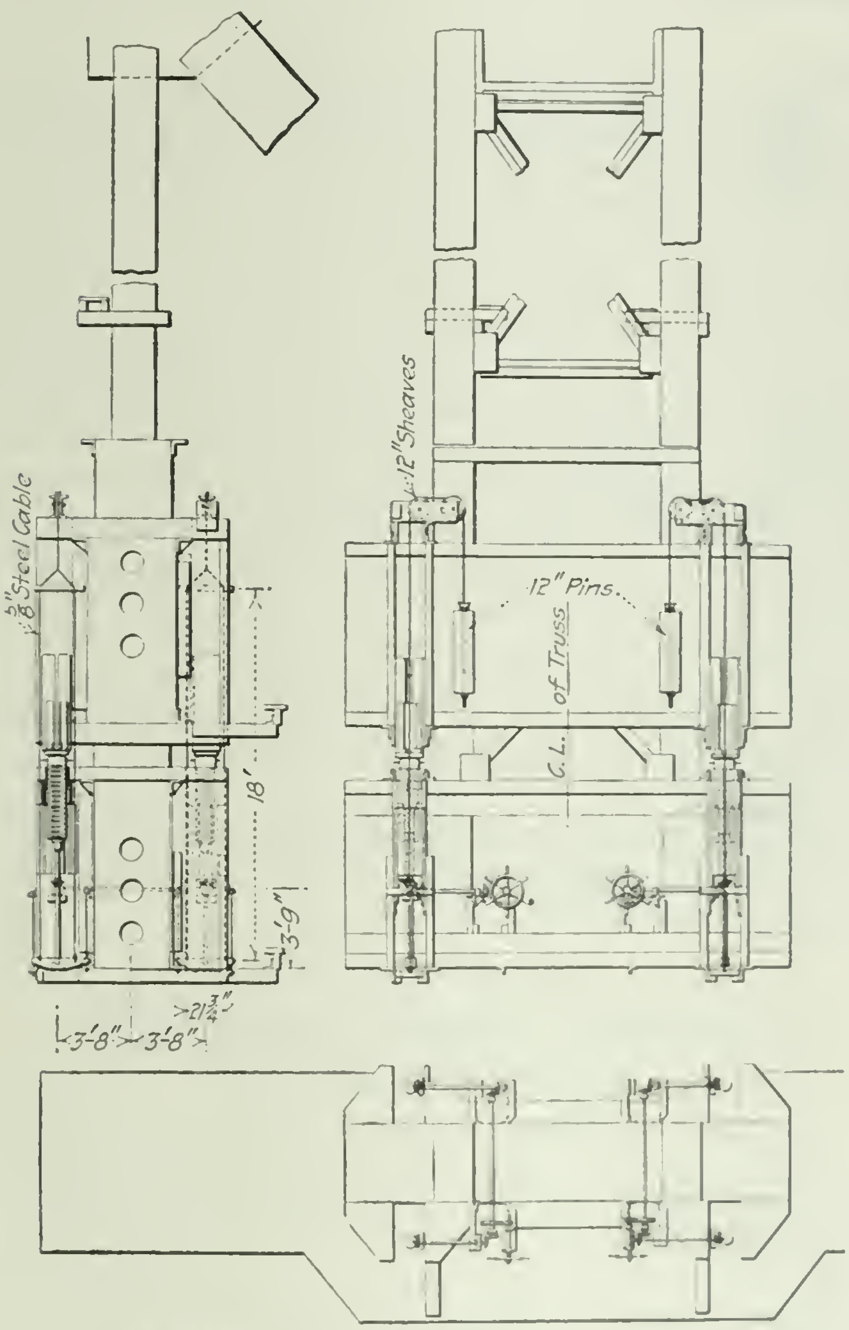


DIAGRAM OF HYDRAULIC JACK CONTROL

ready noted, were bored every 6 ft. to receive a 12-in. pin, while the girder pin diaphragms were similarly bored on 2-ft. centers. There was ½ in. transverse and [illegible] in. longitudinal clearance in the chain holes, and larger clearances of 1 in. and 1[illegible] in. in the pin diaphragms.

Each upward jacking movement carried the span up 2 ft., the platform pins holding the chains to the upper girder. At the end of the upstroke the lower platform pins were entered through the lower girder diaphragms and a registering chain hole. Then the jacks were eased off to let the load come on the lower pins, while the upper pins came out. After a return stroke of the jacks and the upper girder, the upper pins were inserted and a new lift began, the lower pins coming out as soon as released from their load.

The two 1000-ton hydraulic jacks lifting each corner of the span were supplied at 4500 lb. pressure by a parallel pair of air-driven direct-acting double-plunger (18 x 2 x 16-in.) pumps drawing water from a wooden tank into which the jacks discharged on their return strokes. The stopping and starting of the jacks was controlled by the valves on the air-supply lines to the pumps, and no air or hydraulic receiver was inserted in any of the lines, the long lines coming over the cantilevers amply cushioning all shocks. Air was supplied by three motor-driven compressors, each with a free-air capacity of 534 cu.ft. per min. at 110 lb. pressure.

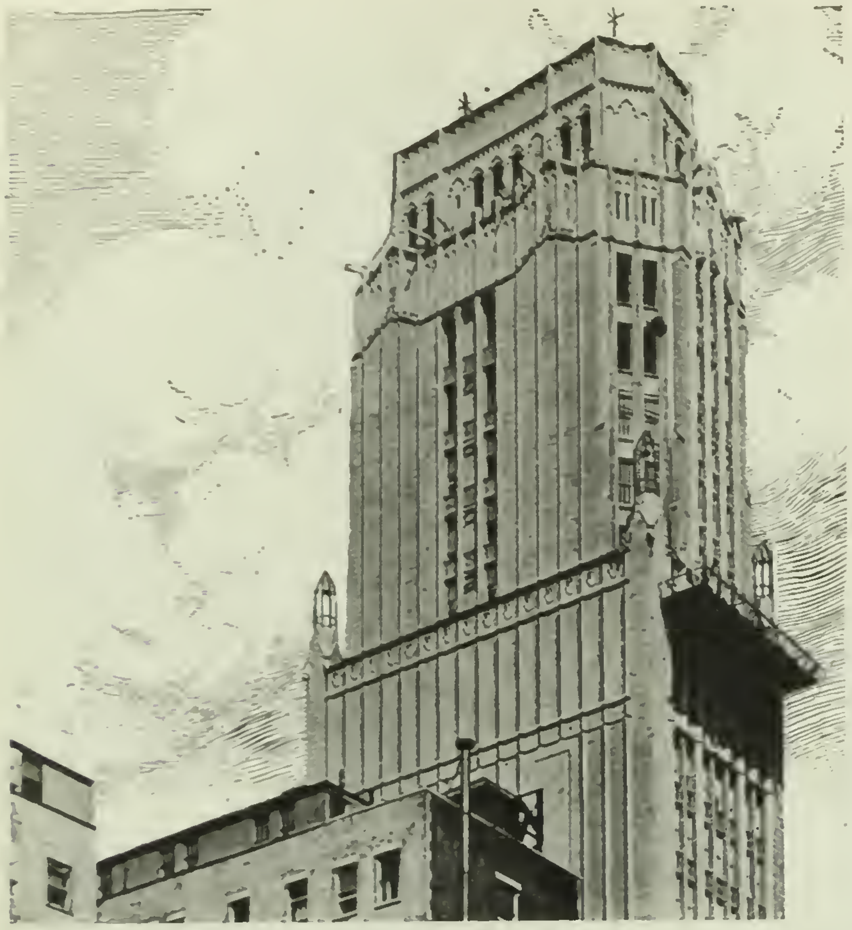
The flow to the various jacks was controlled by stop valves, used as throttles, in the first feeder line, in the distribution block (connecting one or both pumps to the east or west pair of jacks) and in the branches leading to each jack connection. The actual lifting and release of the jacks was in the hands of the central pump operator solely, the east and west valve men merely holding alike the travel of their two jacks.

All the connections on the cantilever platform were of 1½-in. *XX* pipe and fittings. The jacks were connected first to a 1-in. *XX* pipe on the jacking platform, and the platform systems were connected by double 16-ft. lengths of ¾-in. copper pipe in S-bends. All the hydraulic equipment was made by the Watson-Stillman Co., of New York City, and was set up under the direction of that company.

Telltales were placed before the three valve men on each end of the span. Each indicator comprised a pair of cords and counterweights, sliding on firm guides and carrying registering targets. The corner telltale cords came from the ends of the upper lifting girder; the cords for the center telltale came from the center of the same girder. Only the center indicator had a scale. On each central telltale board were mounted four incandescent electric lamps representing the four pairs of screw jacks. These were on a circuit which was broken at an automatic contactor when the follower screws were about [illegible] in. below their uppermost position. Their chief use was in warning the operators when the follower screws had retired far enough so that the return stroke of the hydraulic jacks could be started.

Both end platforms of the suspended span during floating were connected to the central control platform of the span by telephone lines. When the span was moored these instruments were disconnected and the circuit was used as a line between the north and the south cantilever platforms. Each cantilever platform also had a connection with the main-office switchboard of the company.

The actual lifting operations were directed by W. B. Fortune, erection superintendent of the St. Lawrence Bridge Co., but under the general direction of G. H. Duggan, chief engineer, G. F. Porter, engineer of construction, and S. P. Mitchell, consulting engineer of erection. The Board of Engineers of the Quebec Bridge, representing the Dominion Government—C. N. Monsarrat, chief engineer and chairman, Ralph Modjeski and H. P. Borden—personally inspected the floating and hoisting.



CAMOUFLAGE IN BUILDING. THE VERTICAL RIBS ARE NOT OFFSETS BUT COLORED BRICK

apparent pilasters on the side walls, giving the structure the appearance of a tower architecturally complete on all four sides. These offsets are in fact nothing but colored brick, so arranged as to simulate the shadows of vertical ribs, which simulation is helped by two horizontal bands of tile corbels, which are triangularly indented to represent the juncture of two angular surfaces. Up to the 27th floor the east and west walls of the building are flat and on the lot line, except for the window inset mentioned and the 4-in. projection of the tile corbels. The building is finished in two-toned brick and terra-cotta, with a finial of decided ecclesiastic touch.

The architects for the Bush Building are Helmle & Corbett, of Brooklyn, the structural steel designers, Post & McCord of New York, and the general contractor, the Thompson-Starrett Co., of New York.

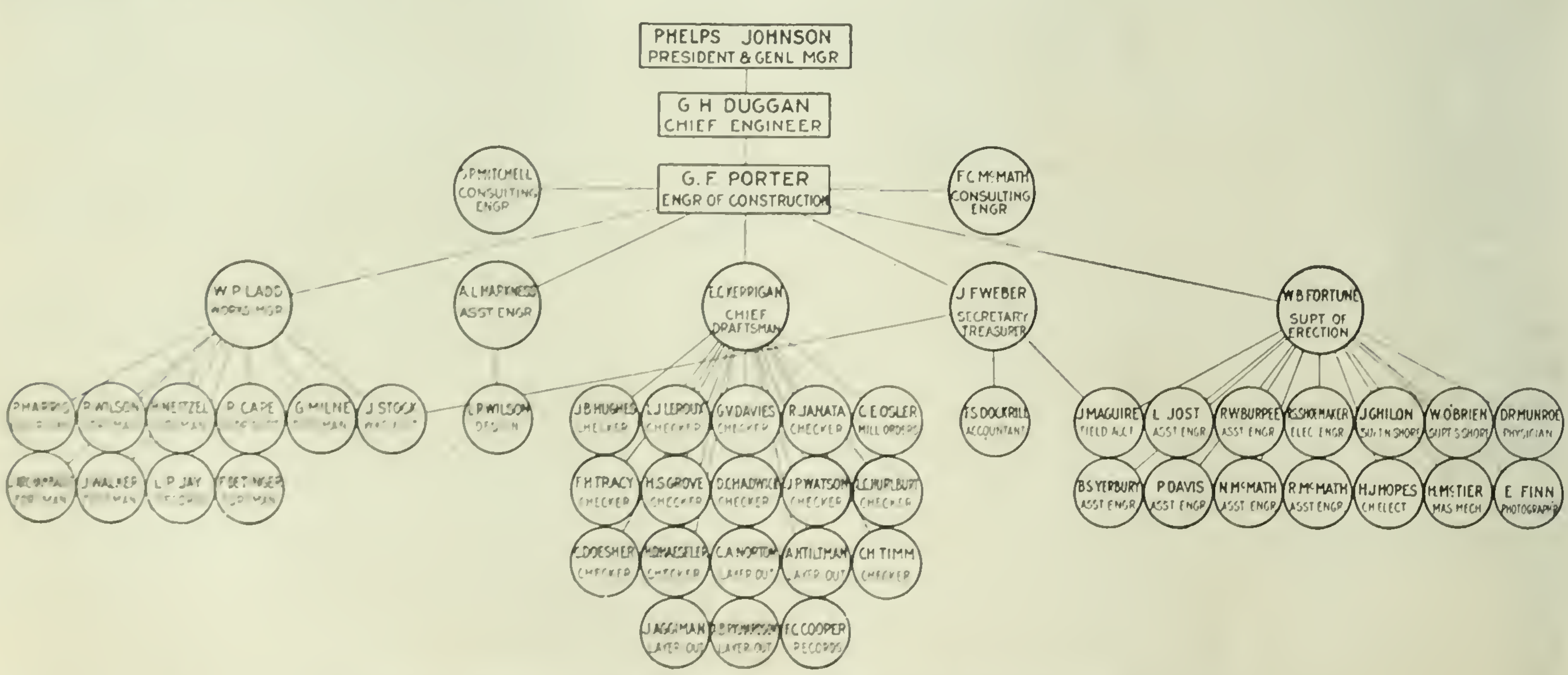
The Men Who Built the World's Greatest Bridge

Remarkable Organization Developed for Erecting Giant Structure at Quebec After Disaster of 1907

THE ENGINEERING world is familiar with the names, at least, of the men most closely connected with the second and successful attempt to construct the world's largest bridge, across the St. Lawrence River above Quebec. It is appropriate, however, as the work passes through its final stage following the raising of the suspended span, chronicled in *Engineering News-Record* of Sept. 27, p. 580, to publish their photographs for the benefit of the large part of the profession in this country and abroad which cannot have the privilege of knowing them personally.

In addition to the better known men most closely and continuously identified with the carrying out of the project as a whole, many others have contributed to the success of the undertaking years of their lives spent on the different sides and phases of the problem. The names and responsibilities of the men brought together in this work by the St. Lawrence Bridge Co. are shown in the diagram below. Of the organization formed by the Dominion government to carry through this great project after the failure of 1907, the names of the members of the Board of Engineers, at first composed of C. N. Monsarrat, chairman and chief engineer, Ralph Modjeski and C. C. Schneider, and after the latter's death of the first two and H. P. Borden, are well known.

Besides the men whose names appear on the chart below, the organization included Joseph Mayer, principal assistant engineer; A. J. Meyers, chief draftsman; M. B. Atkinson, assistant chief draftsman; H. W. McMillan, chief shop inspector; C. J. Yarnall, chief mill inspector; J. D. Wilkens, resident engineer, 1909 to 1915; John Rankin, resident engineer since 1915; W. P. Copp, chief inspector of erection; H. E. Bates, assistant engineer in shop and field work, and E. H. Pacy, assistant engineer.



ORGANIZATION CHART OF QUEBEC BRIDGE ENGINEERING FORCE


DESIGNERS and BUILDERS of the QUEBEC BRIDGE
Lt. Col. Monsarrat
Ralph Modjeski, C.N. Monsarrat, C.C. Schneider
H.P. Borden
S.P. Mitchell
Phelps Johnson
Geo. H. Duggan
Walt. P. Ladd
G.F. Porter
W.B. Fortune
J.D. Wilkens Geo. F. Porter, S.P. Mitchell