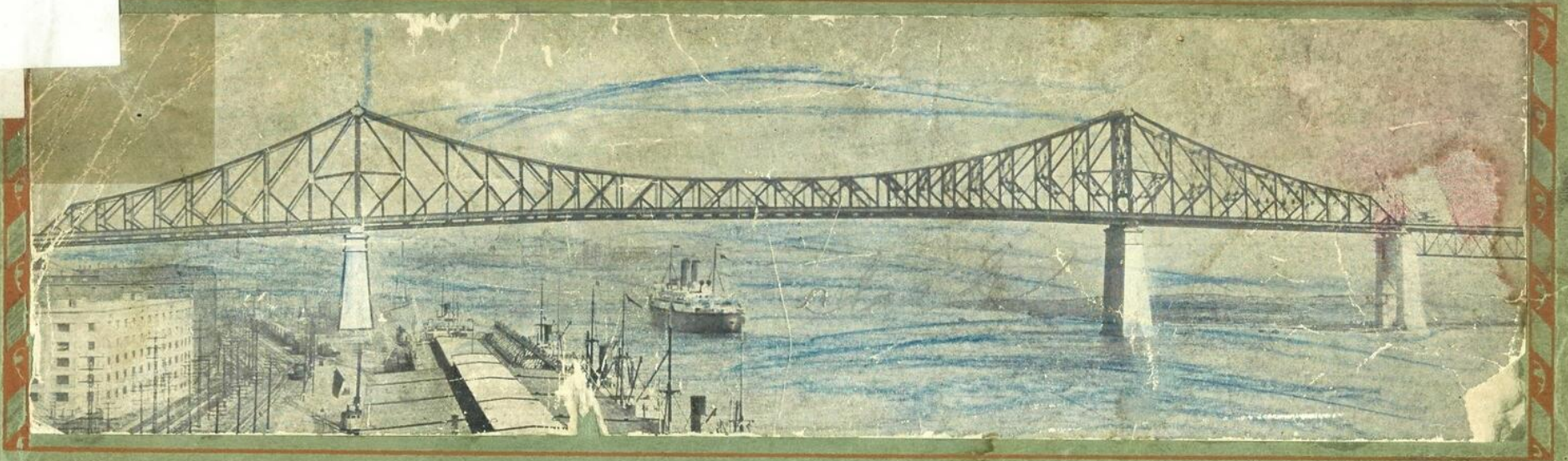


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THE SUPERSTRUCTURE OF  
**MONTREAL HARBOUR BRIDGE**  
OVER THE ST LAWRENCE RIVER

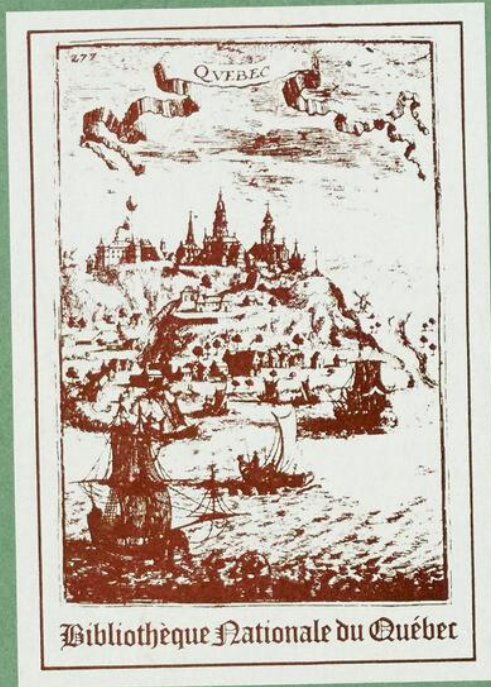


DOMINION BRIDGE COMPANY LIMITED  
MONTREAL



*Bridge*  
*100 St. Lawrence*  
*1930*  
*Madam Smith*

- 1930 -



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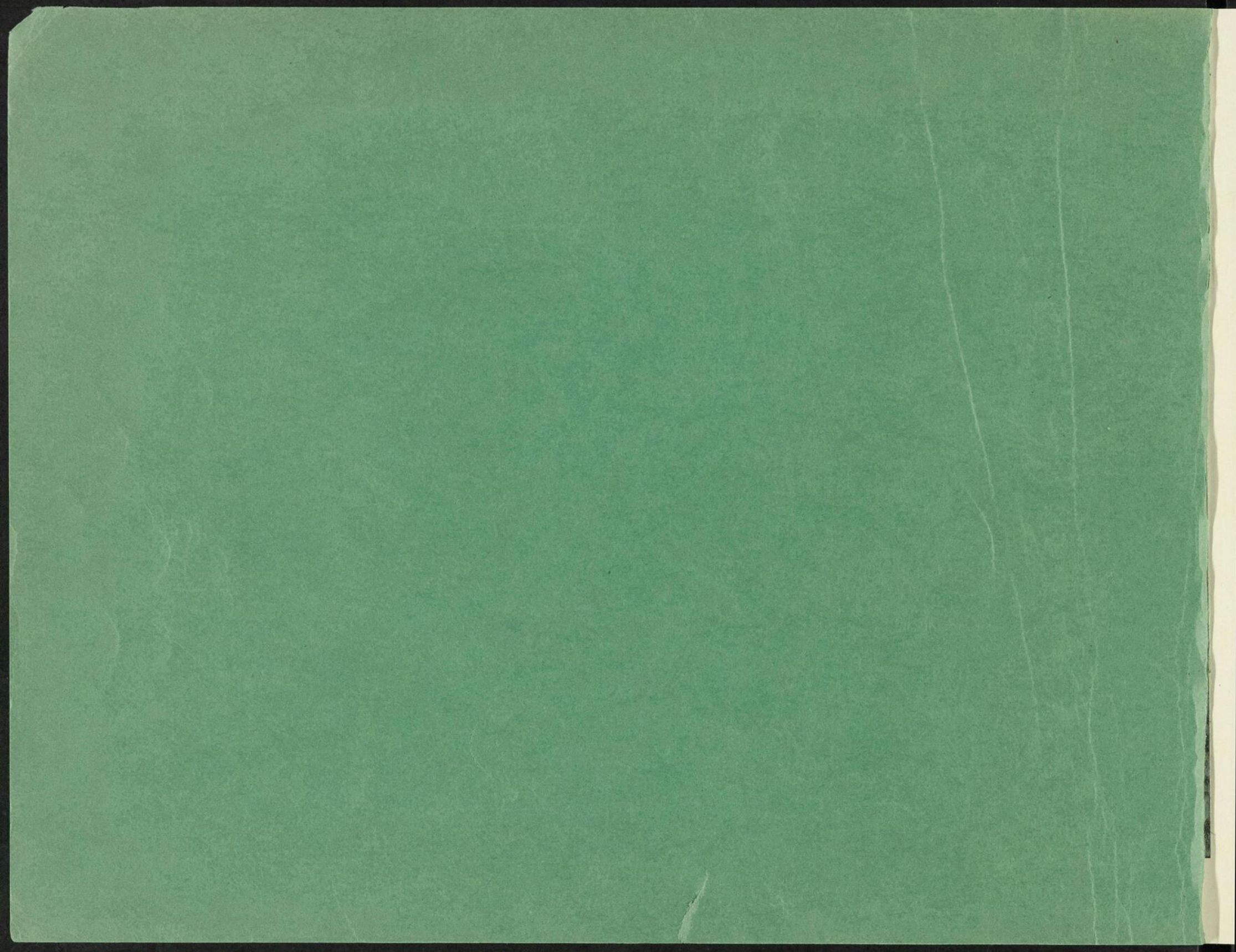


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**D. B. Co.**  
**L I M I T E D**

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THE SUPERSTRUCTURE  
OF  
MONTREAL HARBOUR BRIDGE  
OVER THE  
ST. LAWRENCE RIVER

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CONTRACTOR FOR THE SUPERSTRUCTURE  
DOMINION BRIDGE COMPANY LIMITED  
MONTREAL : CANADA

# MONTREAL HARBOUR BRIDGE

WAS BUILT FOR

THE BOARD OF HARBOUR COMMISSIONERS OF MONTREAL

*consisting of*

SENATOR, THE HONOURABLE W. L. McDOUGALD, M.D., *President*.  
DR. MILTON L. HERSEY,  
EMILIEN DAOUST (deceased 1928),  
ALFRED LAMBERT.

## ADVISORY BOARD OF ENGINEERS

T. W. HARVIE, M. INST.C.E., *General Manager*, PORT OF MONTREAL, *Chairman*.  
G. H. DUGGAN, LL.D., D.SC., M.INST.C.E., *President*, DOMINION BRIDGE COMPANY, LIMITED.  
H. M. MACKAY, LL.D., M.E.I.C., *Dean*, Faculty of Applied Science, MCGILL UNIVERSITY.  
PROF. S. A. BAULNE, *Professor of Civil Engineering*, UNIVERSITY OF MONTREAL.  
H. A. TERREAUULT, M.E.I.C., *Director of Public Works*, CITY OF MONTREAL.  
IVAN E. VALLEE, A.M.E.I.C., *Chief Engineer*, DEPT. OF PUBLIC WORKS, QUEBEC.

*Note:—Mr. Duggan resigned from Board at time of calling for tenders.*

## DESIGNING AND SUPERVISING ENGINEERS

MONSARRAT AND PRATLEY, *Consulting Engineers*, MONTREAL.  
J. B. STRAUSS, *Associate*.

TG  
416  
\$86  
1930  
FOL

# DOMINION BRIDGE COMPANY LIMITED

## *Directors*

	G. H. DUGGAN	-	-	PRESIDENT		
W. F. ANGUS	-	-	VICE-PRESIDENT	F. L. WANKLYN	-	VICE-PRESIDENT
G. W. ALLAN, K.C.	-	-	WINNIPEG	C. B. McNAUGHT	-	TORONTO
A. J. BROWN, K.C.	-	-	MONTREAL	HOWARD MURRAY	-	MONTREAL
P. BURNS	-	-	CALGARY	W. G. MURRIN	-	VANCOUVER
NORMAN J. DAWES	-	-	MONTREAL	C. E. NEILL	-	MONTREAL
A. A. HODGSON	-	-	MONTREAL	JULIAN C. SMITH	-	MONTREAL
SIR HERBERT S. HOLT	-	-	MONTREAL	JAMES STEWART	-	WINNIPEG
J. W. McCONNELL	-	-	MONTREAL	H. H. VAUGHAN	-	MONTREAL
	W. J. BLAKE WILSON	-	-	-	-	VANCOUVER

## *Executive Officers*

G. H. DUGGAN	-	-	-	-	PRESIDENT AND MANAGING DIRECTOR
N. W. WARREN	-	-	-	-	VICE-PRESIDENT AND GENERAL MANAGER
L. R. WILSON	-	-	-	-	VICE-PRESIDENT IN CHARGE OF OPERATIONS
W. TAYLOR-BAILEY	-	-	-	-	VICE-PRESIDENT IN CHARGE OF SALES
F. P. SHEARWOOD	-	-	-	-	CHIEF ENGINEER
F. W. EVENS	-	-	-	-	SECRETARY-TREASURER

## *Special Organization on Construction of Montreal Harbour Bridge*

L. R. WILSON	-	-	-	-	VICE-PRESIDENT IN CHARGE OF OPERATIONS
					ENGINEER-IN-CHARGE

### *Engineering*

D. B. ARMSTRONG	-	ASSISTANT ENGINEER
R. S. EADIE	-	ASSISTANT ENGINEER
F. J. McHUGH	-	CHIEF DRAUGHTSMAN
F. BOWMAN	-	ERECTION ENGINEER
F. NEWELL	-	MECHANICAL ENGINEER AND CONSULTANT ON EQUIPMENT

### *Fabrication*

H. W. McMILLAN	-	WORKS MANAGER
G. M. JONES	-	PRODUCTION MANAGER
R. E. CAPE	-	STRUCTURAL SUPERINTENDENT
J. B. LECLAIRE	-	MECHANICAL SUPERINTENDENT
T. LOCHHEAD	-	CHIEF INSPECTOR

### *Erection*

D. BELL	-	GENERAL SUPERINTENDENT
A. M. MacDERMID	-	SUPERINTENDENT
L. J. McMAHON	-	SUPERINTENDENT
W. E. BELL	-	RESIDENT ENGINEER
C. PHILLIPS	-	RESIDENT ENGINEER

## INTERESTING DATA

Length of Main Span centre to centre of Main Piers	-	-	-	-	-	-	-	-	1,097 ft.
Length of Main Span overall	-	-	-	-	-	-	-	-	1,937 ft.
Length of North Approach Viaduct at Montreal end	-	-	-	-	-	-	-	-	1,950 ft.
Length of South Approach consisting of 24 deck spans and Pavilion on St. Helen's Island	-	-	-	-	-	-	-	-	4,930 ft.
Total length of steel construction	-	-	-	-	-	-	-	-	8,817 ft.
Clear height above Summer High Water in Ship Channel	-	-	-	-	-	-	-	-	163 ft.
Height of Main Span at piers centre to centre of Chords	-	-	-	-	-	-	-	-	162 ft.

### WEIGHT OF STEEL IN STRUCTURE

	SILICON STEEL	CARBON STEEL, ETC.	TOTAL
Main Span	10,515 tons	5,135 tons	15,650 tons
Approaches	3,465 tons	14,170 tons	17,635 tons
Total	13,980 tons	19,305 tons	33,285 tons

### PROVISION FOR TRAFFIC

Roadway—36' 10<sup>3</sup>/<sub>4</sub>" wide between curbs, providing for four lines of traffic.  
 Rapid Transit Tramway track on each side of, and clear of roadway.  
 Sidewalk, 5' 0" wide on each side of bridge.

Contract for Superstructure awarded	-	-	-	-	-	-	-	-	October, 1925
Erection of South Approach commenced	-	-	-	-	-	-	-	-	September, 1926
Erection of South Approach completed	-	-	-	-	-	-	-	-	June, 1928
Erection of North Approach commenced	-	-	-	-	-	-	-	-	October, 1928
Erection of North Approach completed	-	-	-	-	-	-	-	-	February, 1929
Erection of Main Span commenced	-	-	-	-	-	-	-	-	May, 1927
Final connections made at centre of Main Span	-	-	-	-	-	-	-	-	July 10, 1929
Erection of Superstructure completed	-	-	-	-	-	-	-	-	September, 1929
Contract date for completion of Superstructure	-	-	-	-	-	-	-	-	March 1, 1931

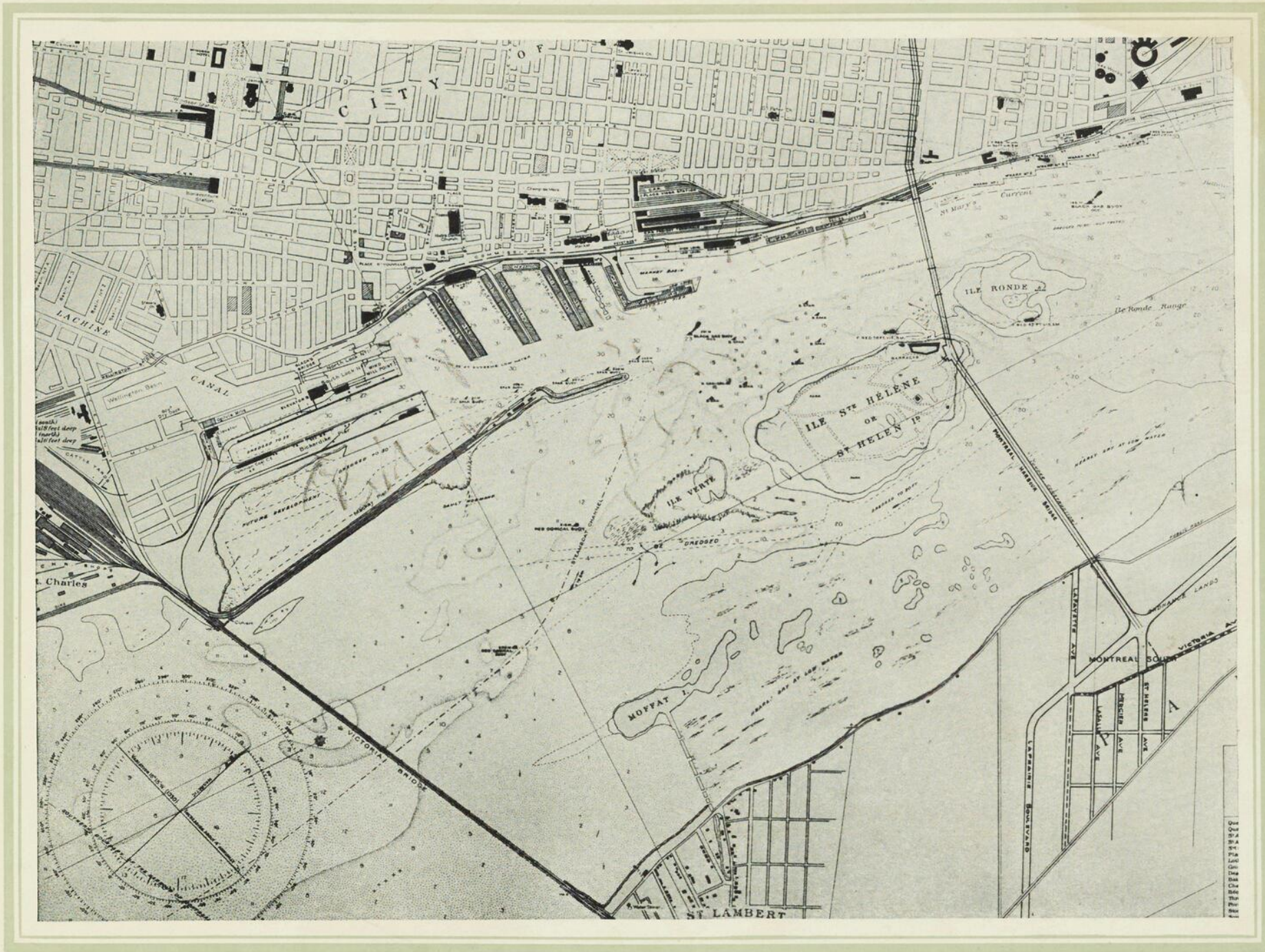
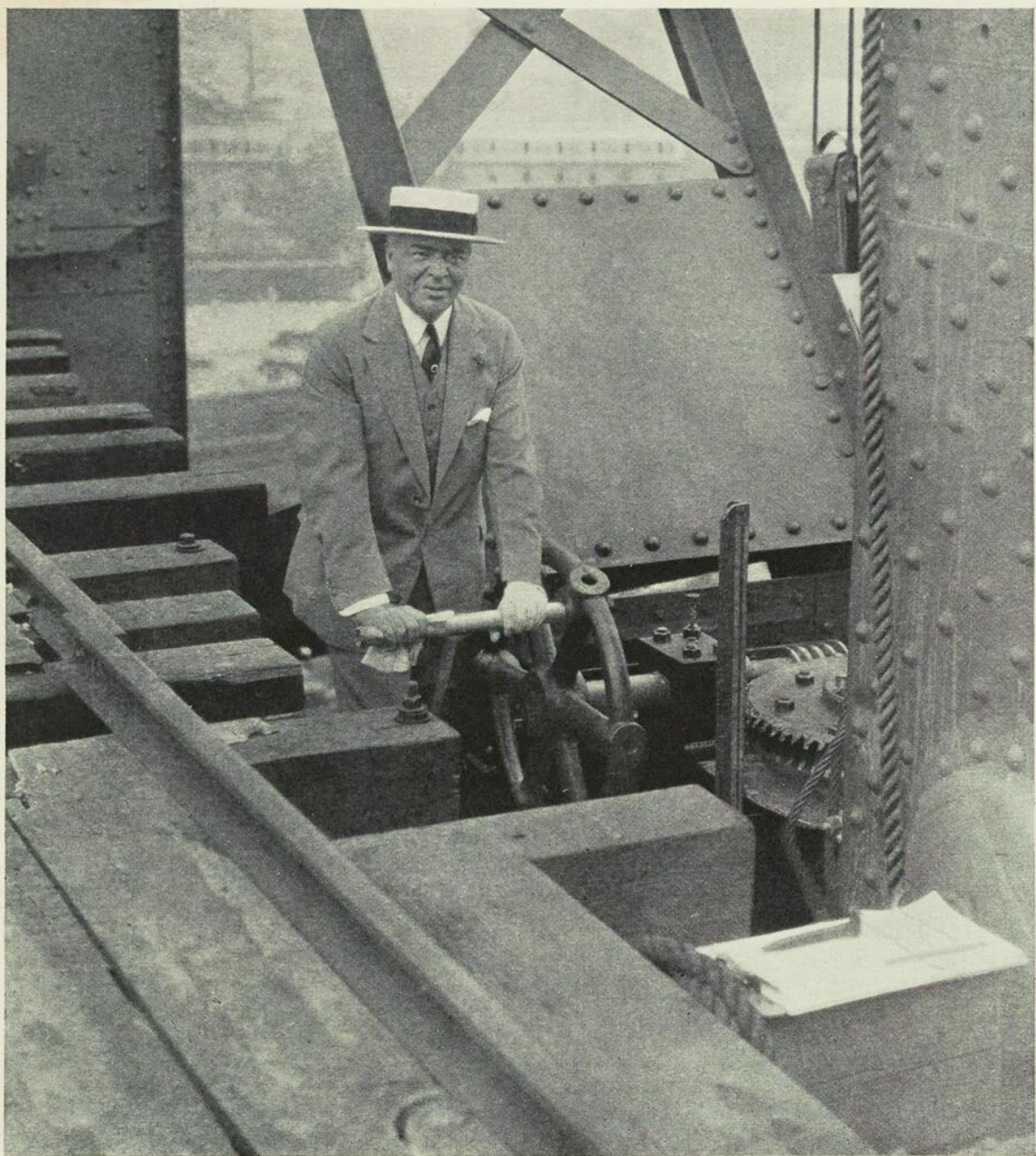


Figure 1.—PLAN OF HARBOUR SHOWING LOCATION OF BRIDGE.



HON. W. L. MCDUGALD, M.D.

PRESIDENT of *the* MONTREAL  
BOARD of HARBOUR COMMISSIONERS,  
MAKING *the* LAST TURN  
of *the* WEDGE MECHANISM  
*which* RELEASED *the* SUSPENDED SPAN  
of *the* MAIN CANTILEVER SPAN,  
JULY 10, 1929

# FOREWORD

*by*

SENATOR, THE HONOURABLE W. L. MCDOUGALD, M.D.

*Chairman of the Board of Harbour Commissioners*



GLADLY accede to your request for a short foreword as introduction to your booklet which, I understand, purposes to illustrate and describe briefly the outstanding features of construction of the new Montreal Harbour Bridge superstructure with the purpose of recording the circumstances out of which that project was developed.

The opening of this structure for public service marks the realization of hopes that had their origin many years ago and were widely held throughout the community. It also marks the culmination of over seven years activity during which time the structure gradually emerged from first nebulous, then definite plans into the tangible thing that it is to-day. During this period a large organization of engineers and contractors have worked in close co-operation, back of all their effort being the Board of Harbour Commissioners, entrusted by the Federal Government with the undertaking.

For many years prior to the war the eventual necessity of a second bridge over the St. Lawrence River was realized and accepted as an integral factor in the development of the port facilities at Montreal. In the earlier investigations and reports, the bridge was to be essentially for railway purposes, partly to connect the existing harbour trackage with future developments on

the south shore and partly as a means of entrance to the city for independent railway lines which might make use thereof to advantage. The provision to be made for vehicular and pedestrian traffic was regarded as incidental, as in the case of the Victoria Bridge.

There had also been other projects than those reported upon by the Harbour Commissioners, and in 1895 the Montreal Bridge Company offered prizes for the best designs for a high level bridge to be located near the site of the present structure. A number of well-known engineers submitted designs for this competition.

Shortly after the war the question of the new bridge again became of active interest, a number of new and important factors now having a vital bearing on the project. The growth of motor traffic increasingly overtaxed the limited facilities of the Victoria Bridge, this feature being emphasized by the fire during the mid-summer of 1920 which destroyed a large part of the plank roadway on the latter bridge and occasioned serious inconvenience and loss to traffic. Furthermore, the rapid growth of the city itself pointed to the need for opening up the adjacent south shore district to industrial and residential development and to the need for adequate access facilities to St. Helen's Island in order that its value as a city park and recreation centre might be made full use of.

Soon after the installation into office of the present Commissioners early in 1922, the bridge question was pressed upon their attention by many interested individuals and agencies. Though the Harbour Board had an interest, at least insofar as the safety of navigation and shipping might be affected and was very sympathetic to the project, it was not clear that there was legislative authority under which it could deal affirmatively with any phase whatever of such an undertaking. Concurrently, the alleged urgency of the case was being diligently pressed upon the Federal Government.

In these circumstances the Minister of Marine and Fisheries requested the Board to make an investigation of the whole situation, especially having regard to its relation to the interests of the Harbour, and to make surveys, soundings and borings in order that preliminary or suggestive designs and plans might be prepared for the information and guidance of the Commissioners and of the Federal Government. On August 14th, 1922, the Committee of the Privy Council of the Dominion of Canada concurred in the appropriation of the sum of \$50,000 of funds of the Harbour Board to be expended for these purposes.

It appeared to be the consensus of opinion at that time, in the light of then available facts, that any structure located across the lane of ship travel into and from the inner harbour, that is to the east of McGill Street, now the Prince of Wales Dock, either would be likely to endanger navigation or, in the alternative, might be prohibitive in cost. In initiating its investigation, therefore, the Engineering Department was instructed to confine itself to the area lying above McGill Street and, for the time being, to exclude consideration of any other possible sites.

The Engineers developed three alternative plans under Scheme "A" embraced in each one of which is the development of St. Helen's Island into a modern public park. The main harbour span would extend from the west end of St. Helen's Island to the Guard Pier and thence to the city shore either at the vicinity of McGill Street or Bridge Street. Any of these designs would impose the necessity of recasting the entire canal basin, and canal portal, with the great cost which this would inevitably entail accompanied by dislocation of shipping during construction.

Under scheme "C" the Engineers developed tentative plans for the erection of a highway bridge paralleling the existing Royal Victoria Bridge to carry the vehicular and foot-passenger traffic which it was considered would relieve existing traffic congestion and provide for the probable normal needs for a reasonable period. It was estimated that this bridge would cost appreciably less than any of the designs under Scheme "A."

Neither one of the four designs as developed was wholly acceptable to the Commissioners. In all the circumstances, however, they were constrained to recommend the adoption of Scheme "C" as involving a capital outlay within limits conforming to standards of economy and intrenchment, which at that time were being strongly urged. Further, because uncertainty existed with regard to the participation of the municipal and provincial bodies concerned in the project and because the collateral park and municipal features embraced in Scheme "A," though impressive, were considered to be strictly municipal or provincial undertakings.

A tentative report embodying the foregoing was made to the Minister in 1923.

In submitting their tentative conclusion and recommendation above set forth the Commissioners observed that they considered that they were dealing with this important problem primarily as custodians of the navigation interests of the Harbour of Montreal. They were, therefore, imbued with the strictly utilitarian needs and aspects of the problem and with the necessity of fixing definite limitations in costs and in the extent of the facilities to be presently provided.

It is pertinent here to note that all of the later projects brought forward had been based upon the theory that a low-level bridge only was feasible. Such structure, if it embraced features of municipal development at St. Helen's Island, must traverse that area at the west end thereof and thence over the Guard Pier to the vicinity of McGill or Bridge Streets.

All of the great utilities of the Harbour, the docks of the ocean steamship companies, the warehouses, grain elevators, cold storage plants, etc.—where are intensively concentrated day and night, in the season of navigation, its principal activities—are located in the area above St. Mary's current and the Lachine Canal portal.

Therefore, in considering a design for a bridge over this area, it had been determined it must have a clear span of at least 1,000 ft. and it must be at a level to allow the loftiest ships to pass under—about 160 ft. above high water. The cost of such a structure with its approaches was at that time thought to be prohibitive and no plan had been developed for it.

This was the condition of affairs when the Commissioners made their interim report to the Minister in May, 1923. There were mental, if not actual, reservations when the materials accumulated by them

were laid before the Minister and by him before Parliament. The Commissioners, though reporting and recommending upon the basis of the knowledge then developed, yet had no intention of excluding any other project the feasibility of which might be able to be demonstrated.

Accordingly, during that season, they diligently pursued their enquiries and investigations, being anxious to discover the best possible ways and means for meeting the manifest public necessity. The Commissioners were the more anxious to pursue their enquiries to a finality inasmuch as it was pressed upon them urgently that the Harbour Board was the only public body which appeared to have the means and facility for doing this, which at the same time had at its command an appropriation of public money to enable an adequate investigation and a programme to be developed. They were influenced, moreover, by the consideration that whatever project might be brought forward under any other initiative would in the final analysis have to be dealt with by them as affecting the harbour and its shipping interests.

The Commissioners issued a "Mandate to Designers of Projects" and during the winter of 1923-24 several Consulting Engineers developed designs for a bridge.

Of the different plans which were put forward, those for the Delorimier Avenue site proposed by Monsarrat and Pratley, and by J. B. Strauss, appeared to be the most adequate in their main features.

Progress reports were submitted to the Minister of Marine & Fisheries in the Spring of 1924 for consideration of the Government.

Earlier in the year the Honourable P. J. A. Cardin had succeeded the Honourable Ernest LaPointe as

Minister, when the latter became Minister of Justice in succession to the Honourable Sir Lomer Gouin. The Minister at once manifested a lively and sympathetic interest in the bridge project. Following a canvas of all of the large mass of material which had been accumulated upon the subject in collaboration with the Commissioners and their Engineering staff, the Minister decided to propose to Parliament legislation for enabling the undertaking to be proceeded with as soon as practicable. An Act, 14-15 Geo. V, Chap. 58, was passed with the unanimous consent of the Commons and Senate and assented to July 19, 1924, by His Excellency Baron Byng of Vimy, which amended an Act to Amend and Consolidate the Acts relating to the Harbour Commissioners of Montreal, 57-58 Vic. Chap. 48 (1894), for enabling the Harbour Commission, as the appropriate authority, since the bridge would become an appurtenance of the harbour, to determine its site and to proceed with the designing and erecting thereof, subject to the approval of site and of all plans by the Governor-in-Council; with necessary powers of expropriation; of operating and managing and fixing tolls; with provision for mortgaging and pledging and for creating hypothecs; of issuing bonds which might be guaranteed by His Majesty the King, etc.

During the ensuing weeks the Commissioners were required to consider a great variety of representations with regard to all phases of the project. These they felt obliged earnestly to consider and a large amount of time was consumed in pursuing these inquiries, so that it was not until Nov. 19th, 1924, that the Commissioners were able to announce that Monsarrat and Pratley, and J. B. Strauss as associate, had been appointed "Joint Designing and Consulting Engineers" for the project.

In order, however, to obtain an unbiased and comprehensive report to assist the Commissioners in determining both upon the site and the general design of the structure, the Commissioners also appointed the following as an Advisory Board of Engineers:

T. W. HARVIE, M.INST.C.E., *General Manager*, PORT OF MONTREAL,  
*Chairman.*

G. H. DUGGAN, LL.D., D.SC., M.INST.C.E., *President*, DOMINION  
BRIDGE COMPANY, LIMITED.

H. M. MACKAY, LL.D., M.E.I.C., *Dean*, Faculty of Applied Science,  
MCGILL UNIVERSITY.

IVAN E. VALLEE, A.M.E.I.C., *Chief Engineer*, DEPARTMENT OF  
PUBLIC WORKS, QUEBEC.

H. A. TERREAU, M.E.I.C., *Director of Public Works*, CITY OF  
MONTREAL.

PROF. S. A. BAULNE, *Professor of Civil Engineering*, UNIVERSITY OF  
MONTREAL.

The Advisory Board was charged to report on the site, the plans, the specifications and all matters relating to the proposed bridge. The Board applied itself assiduously to the task submitted and after an exhaustive examination of the various schemes and all the data that had been laid before the Commissioners, an interim report was made unanimously recommending the Delorimier Avenue site, so that after consideration of this report the Commissioners were able definitely to announce the selection of that site on the 27th January, 1925. The Advisory Board then proceeded, in collaboration with Monsarrat & Pratley, and J. B. Strauss, Associate, to prepare plans and specifications for a bridge at the site selected.

Interim reports were submitted to the Commissioners from time to time, type of structure was fixed, and plans and specifications were so far approved and adopted

during the Spring of 1925 as to enable tenders to be invited for the piers in the South channel. Six tenders were submitted, and upon their examination by the Designing and Consulting Engineers, who unanimously recommended the acceptance of the lowest tender, that of Quinlan, Robertson & Janin, Limited, a contract was entered into with that Company on May 22nd, 1925.

Engineering and navigation problems of some magnitude affecting that section of the bridge extending over the ship channel from St. Helen's Island to the North shore necessitated delay for investigating the conditions to be dealt with affecting navigation, including currents and ice, as well as the selection of the sites of the North and South main and the anchor piers and for determining the length of the channel span. These matters, after lengthy and assiduous consideration, were disposed of by the final report of the Advisory Board on design and plans and specifications in the month of August.

Tenders were thereupon invited for the remaining or northern portion of the substructure and five contracting firms having submitted bids and proposals, the lowest tender—that of the Dufresne Construction Company—was accepted and a contract was entered into for construction of the north and south main and anchor piers, three piers on Ile Ronde and the foundations and retaining walls of the City approach.

Tenders for the steel superstructure were submitted by three corporations in response to public invitation. These tenders and proposals, having been made up upon the unit basis, were submitted for examination to the Designing and Consulting Engineers, upon whose recommendation the lowest tender, that of the Dominion Bridge Company, Limited, was accepted and a contract accordingly entered into on October 2nd.

The entire structure, including the Pavilion on St. Helen's Island, was at last, late in the year 1925, placed under contract, in every case under public competition, and the various contractors were proceeding actively with their undertakings with suitable speed.

The admirable team work displayed by the members of the Advisory Board so completely justified the method of procedure adopted by the Commissioners in thus safeguarding the public interest in respect of this great public utility that it was resolved to continue the Advisory Board of Engineers as an active body during the period of construction. The Commissioners feel certain that this procedure has been the means of insuring the maximum of value for the contemplated outlay together with assurance of a structure in which is combined every suitable utilitarian feature with all known safeguards. The Advisory Board not only exercised the function of revising and checking but collaborated with the Designing Engineers. Every detail of the plans and specifications was examined by the members of the Board, as were also the forms of tender, and contracts were not closed by the Commissioners except with the sanction of the Board in respect to all technical details.

The Designing and Supervising Engineers have not only performed their duties with thoroughness and zeal but have also collaborated whole-heartedly with the Advisory Board in the effort to ensure a structure of the highest order. They have closely supervised and inspected the work of construction in all its stages and have co-ordinated the work of the various contractors in a highly co-operative spirit.

The contractors for the several portions of the structure have carried their work diligently to a successful

completion. It must be a source of gratification to them, that the favorable progress of construction is enabling the opening of the Bridge for its intended traffic a year earlier than originally anticipated.

It is notable that no untoward incident marred the course of events at any time and that all contracts were completed within the time limitations fixed. It is believed that the record of casualties is within the minimum for a work of so great magnitude. Actual fatalities totalled five, whilst minor casualties, though a larger number and in some instances sufficiently distressing, were nevertheless kept within negligible numbers having regard to the long period of construction, the very large forces employed and the highly hazardous nature of much of the work.

This summary of events may very fittingly conclude with an appreciation of the contribution made to the enterprise by the various personalities who have been identified with it. First there were my colleagues on the Board of Commissioners, Dr. Milton L. Hersey and Mr. Emilien Daoust, who aided ably in its initiation and in the extremely difficult problem of site selection, in the consideration of design and ultimately in the awarding of contracts upon the plans and specifications. Upon August 9, 1926, during his period of service as Acting President of the Board, Dr. Hersey presided at the ceremony of laying the corner stone of the bridge when suitable memorials of the event and the year were deposited. Mr. Alfred Lambert joined the Board in the summer of 1928 following the regrettable death of Mr. Daoust early in that year. Though the project was then very far advanced and was wholly in the hands of the contractors, Mr. Lambert's varied service and experience in public capacities were of advantage to the Commissioners.

Mr. T. W. Harvie, the General Manager at the Harbour, took over the arduous and strenuous functions of manager of the project and later, as Chairman designated by the Commissioners, organized the Advisory Board of Engineers. Mr. Harvie rendered indefatigable service the value of which was enhanced by his professional talent and long experience in public undertakings at the Harbour and in Europe.

And finally the Commissioners have been fortified in their task by the sympathy and support of the press of both languages no less than by that of their constituency of readers in all the metropolitan areas of greater Montreal. For all of them and their successors in generations to come, my colleagues and myself shall ever hope, that we have produced, not alone "a thing of beauty" which shall be a "joy for ever," but that the existence of this great municipal and national utility will afford them as well convenience, facility of transport and profit as they proceed with their share in the development and expansion of the City of Montreal.

*Editor's Note*—Those who have been closely in touch with the accomplishment of this project will feel that Senator McDougald is altogether too modest in the above note. While many have worked hard for the attainment of the Bridge, it was he who co-ordinated their efforts and who for the Harbour Commissioners enlisted the support of the Federal Government, the Provincial Government and the City of Montreal, without which the project could not have been started; and it was he who by his untiring advocacy of the Bridge created a practically unanimous popular demand for it. Moreover, it was through his individual tact and organizing ability that the various schemes for the Bridge and the many contending interests represented therein were harmonized and the support of all was enlisted. Indeed, it is felt by many that had Senator McDougald not put his shoulder to the wheel, the Bridge would probably still be in the nebulous condition it had been in before he applied himself to it.

CITY OF MONTREAL.

BURNETT ST.

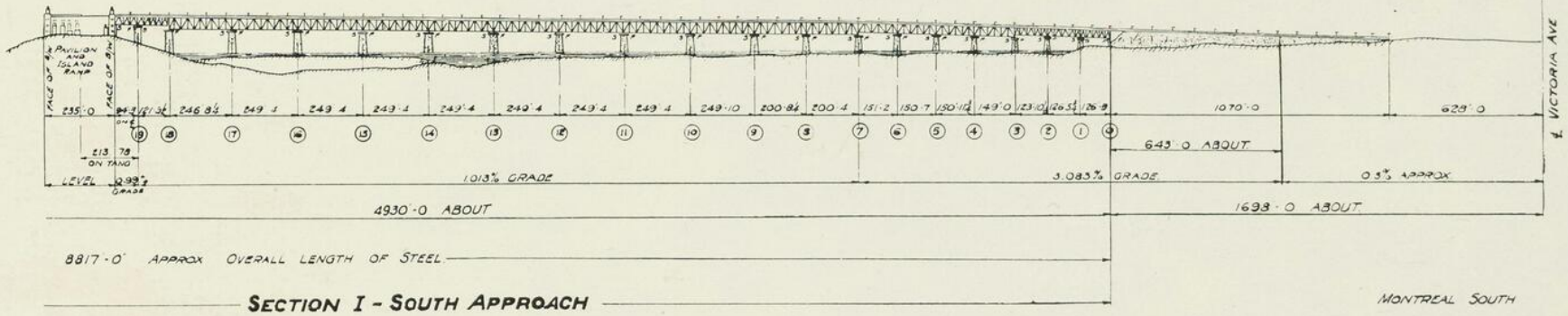
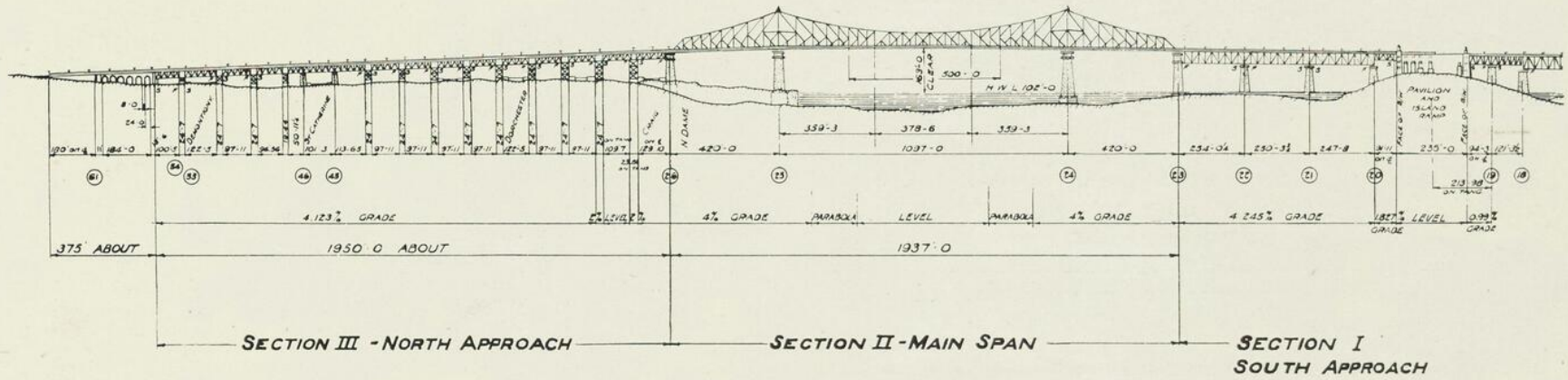


Figure 3.—PROFILE OF BRIDGE.

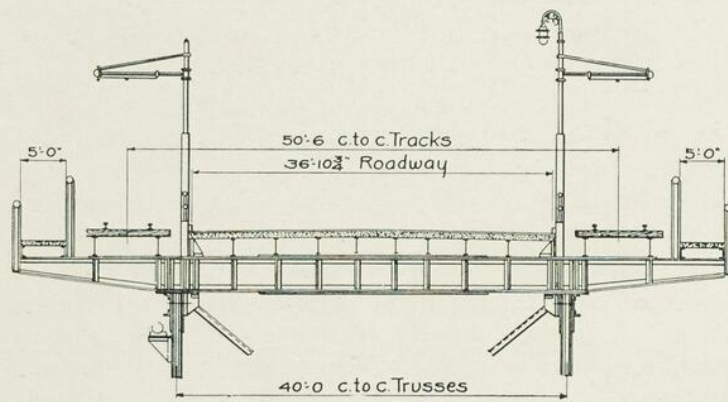


Figure 4.—TYPICAL CROSS SECTION OF FLOOR ON APPROACHES.

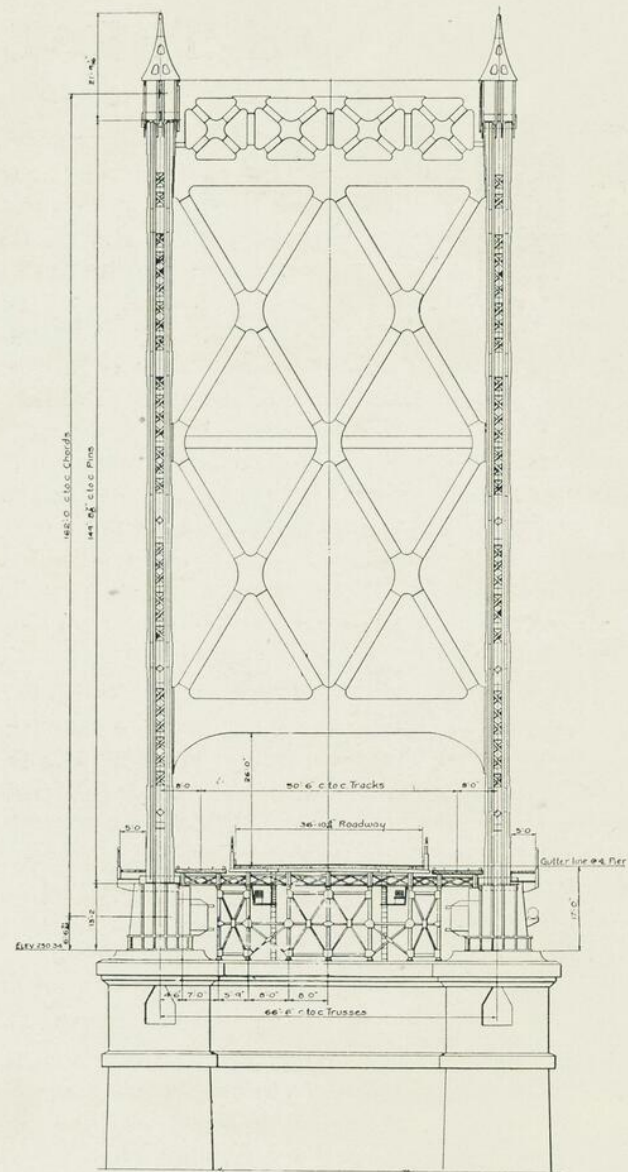


Figure 5.—CROSS SECTION OF MAIN SPAN AT MAIN PIERS.

## MONTREAL HARBOUR BRIDGE



THE governing feature of the Montreal Harbour Bridge is the main cantilever span over the navigation channel in St. Mary's Current where the flow is from 5 to 7 miles per hour. The docks of the transatlantic liners and the principal activities of the Harbour being situated above the bridge it was important that the safe navigation of the entrance to this part of the Harbour should not be interfered with in any way. A clear waterway of 1,000 ft. was therefore demanded; provision for a dock width of 50 ft. in front of the north main pier and the width of the piers resulted in a main span of 1,097 ft. centre to centre of piers. The natural and most economical location for the north anchor pier was near the intersection of Craig and Notre Dame Streets which established the length of the north anchor arm at 420 ft.; the south anchor arm was made of the same length.

At the location selected, the bridge crosses the main channel on a line approximately at right angles to the dock wall and current; it touches the upper end of Isle Ronde and crosses the lower end of St. Helen's Island. From the latter point to the south shore, the current is not parallel to that in the main channel and the axis of this portion of the bridge was therefore deflected about  $10\frac{1}{2}^\circ$  downstream, it being desirable from all considerations to keep the piers parallel with the stream and perpendicular to the bridge axis.

The fore-shore of the south channel is subject to severe ice jams and shoves which pile the ice high above the normal level, and it was necessary to keep the steel-

work of this section well above the highest recorded levels. The navigation clearance in the main channel was specified as 150 ft. at high water, with 163 ft. for a length of 500 ft. under the centre of the main span. The maximum floor grade was limited to  $4\frac{1}{4}\%$ . These considerations determined the floor elevations and gradients.

The arrangement and lengths of the various spans is shown in the general elevation of the bridge, Figure No. 3.

The bridge is designed to carry a roadway 36 ft.  $10\frac{3}{4}$  ins. wide between curbs providing for four lanes of traffic; two electric tramway tracks at 50 ft. 6 ins. centres on each side of and clear of the roadway; and a 5 ft. sidewalk on each side of the bridge.

The trusses of the main cantilever span have the K-system of bracing, first employed in the Quebec Bridge. They are spaced 66 ft. 6 ins. centres with the sidewalks outside. The approaches consist of deck spans with trusses spaced 40 ft. centres, the floor beams resting on and cantilevering over the top chord.

Figure No. 4 shows a typical section of the approach spans; Figure No. 5 is a section of the cantilever span at the main pier.

In accordance with the "Specifications for Steel Superstructure" the anchor and cantilever arms of the main span were designed for the following live loads.

ROADWAY:—Uniform load of 720 lbs. per lineal foot for each lane of traffic. For four loaded lanes, 80 per cent. of the above. No impact.

TRAMWAY:—Train on each track 500 ft. long weighing 1,400 lbs. per lineal foot. Impact 10 per cent.

SIDEWALK:—40 lbs. per sq. foot. No impact.

The suspended span and the spans of the approaches were designed for the following liveloads.

**ROADWAY:**—Uniform load of 720 lbs. per lineal foot plus a concentrated load of 25,000 lbs. for each lane of traffic. For four loaded lanes, 80 per cent. of the above.

Impact:— $\frac{100}{4L + 300}$  of above load.  
where L = length of span in feet.

**TRAMWAY:**—Two 45-ton cars per track but not less than 1,500 lbs. per lineal foot per track.

Impact:— $\frac{100}{L + 300}$  of above load.  
where L = length of span in feet.

**SIDEWALK:**— $40 + \frac{2000}{L}$  lbs. per square foot.

Where L = length of span in feet.  
No impact.

The principal physical requirements for the structural steels were as follows:—

	CARBON STEEL lbs. per sq. in.	SILICON STEEL lbs. per sq. in.	RIVET STEEL lbs. per sq. in.
Ultimate tensile strength	60000-70000	80000-95000	48000-56000
Minimum yield point. . .	36000	45000	28000
Minimum elongation in 8 inches. . . . .	1,500,000 ÷ ultimate strength.		
Minimum reduction in area. . . . .	42 per cent	35 per cent	50 per cent

The permissible normal unit stresses used in the design of the superstructure were as follows:—

	CARBON STEEL lbs. per sq. in.	SILICON STEEL lbs. per sq. in.
Tension on net section. . . . .	18000	23500
Compression of gross section. . . . .	$17000 - 70 \frac{1}{r}$	$22000 - 100 \frac{1}{r}$
with a maximum of. . . . .	15000	19000
Shear on webs. . . . .	11000	13000

An increase of 25 per cent. was permitted in the above normal unit stresses during erection.

The details and workmanship conformed in general to the C.E.S.A. 1922 specification for highway bridges.

The field connections are riveted throughout except that pins are used on the main span to connect the main truss members at the top and bottom of the main posts in order to minimize the secondary stresses at these points. Pins were also used to connect the anchorage members, and in the ends of the hangers connecting the suspended span to the cantilever arms.

Silicon steel was used for the truss members of the 245 foot spans of the south approach and in the floor system, bracing and trusses of the main span whenever weight could be saved by its use. Of the total weight in the main span 67 per cent. is silicon steel. All pins were of forged nickel steel.

The steelwork was fabricated at the Lachine Plant of the contractor. While not of unusual difficulty, workmanship of the highest quality was required.

Provision for unobstructed navigation made it necessary to erect the main span by cantilevering over the channel from either side and connecting at the centre. The bridge was thus divided for erection purposes into two main divisions; one division included the south approach and the south half of the main span, while the other included the north approach and the north half of the main span.

Storage yards were installed on each side of the river with rail connections. The south storage yard was connected to the Canadian National Railways; the yard was also connected to the floor of the bridge by service tracks over which the material was forwarded

to the erectors as required. The north storage yard was located on the harbour wharf immediately below the north anchor arm and was connected to the harbour railway tracks. The material was hoisted from the ground to the floor of the bridge above and distributed to the erectors over service tracks.

Erection was commenced at the south shore on September, 1926, seven spans being erected by the end of the season. The following spring, work was resumed on this section and rapid progress was made as soon as the pier construction was sufficiently advanced. During a period of seven weeks from August 15th to October 6th, seven spans were erected, representing a length of 1,750 feet and a weight of 4,190 tons. At the end of the season, the steelwork of the St. Helen's Island Pavilion was erected together with the flanking span beyond. Circumstances necessitated the remaining three spans being left until the spring of 1928.

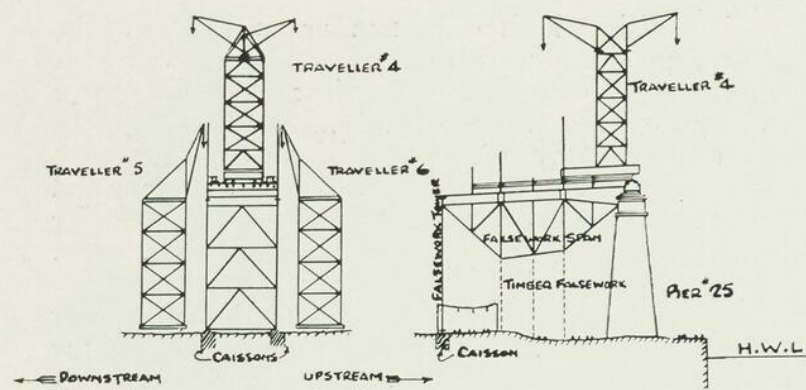
The spans of the south approach were erected either on timber falsework or by cantilevering. Three of the four 150 ft. spans and ten of the twelve 245 ft. spans were cantilevered, a temporary harness being used in the latter spans to increase the effective depth of the trusses at the piers. The method employed is illustrated in Figure No. 8, which shows one of these spans in course of erection. The type of falsework used for a number of the spans is shown in Figure No. 9.

The sequence of erection for the main span is shown diagrammatically in Figures Nos. 6 and 7. Erection was commenced on the north side in the spring of 1927. The north anchor arm spans the railway tracks of the Harbour and Canadian Pacific Railway, high tension power lines, a large brewery building, and Notre Dame Street, which is a busy thoroughfare. The congested

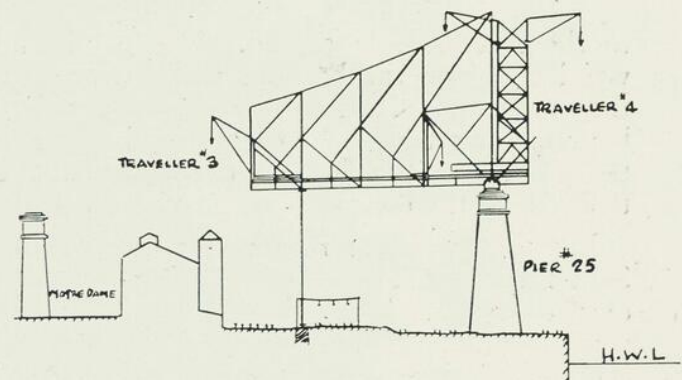
ground conditions limited the temporary support of the anchor arm during erection to a single point. A temporary steel tower was erected at this point, three panels or 175 ft. 6 in. north of the main pier. For the support of this tower two reinforced concrete piers 12 ft. in diameter were sunk by the pneumatic method down to the rock 85 ft. below ground surface, one pier being situated directly below each anchor arm truss. To permit the location of the tower at this point, an extensive re-arrangement of railway tracks and power lines was necessary. Between and supported by the temporary tower and main pier was erected a temporary steel bridge, on the deck of which to start the erection of the permanent structure. (See Figures Nos. 10 and 11.) The temporary construction just referred to was erected by means of 50-ton derricks mounted on top of moveable timber towers 40 ft. square and 120 ft. high, one of which was set up on the ground on each side of the structure. The derricks were equipped with booms 75 ft. long.

The erection of the permanent structure was commenced with the placing of the shoes on the main pier, followed by the progressive assembly of the portion of the anchor arm supported directly on the temporary bridge (see Figure No. 12), the structure being finally self-supporting between the main pier and temporary tower. The temporary bridge was then taken down for use during the erection of the south anchor arm.

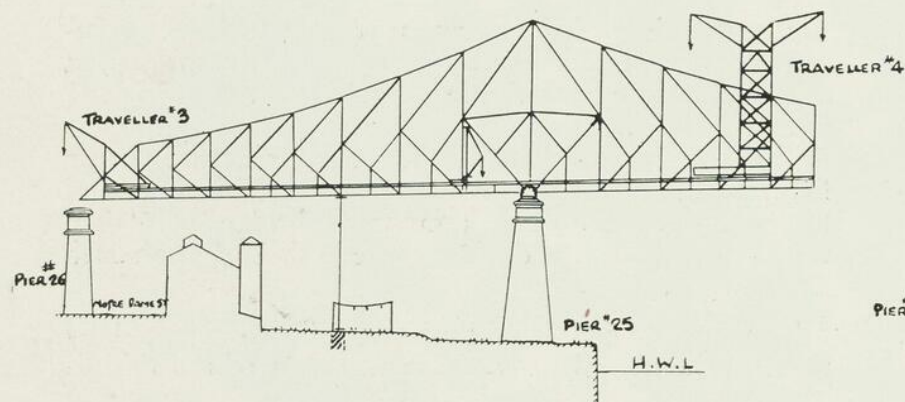
The upper portion of the structure was erected by means of a traveller set up on the floor of the bridge. The traveller was of steel construction and consisted of a tower 120 ft. high on top of which were mounted two 40-ton derricks in fore and aft fashion so that both 70



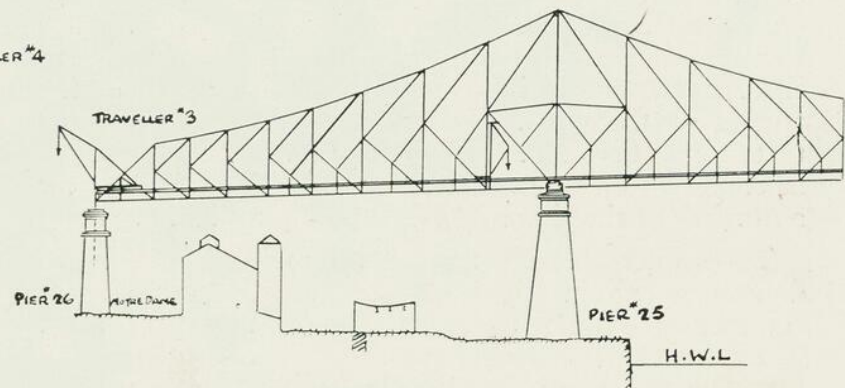
STAGE I



STAGE II

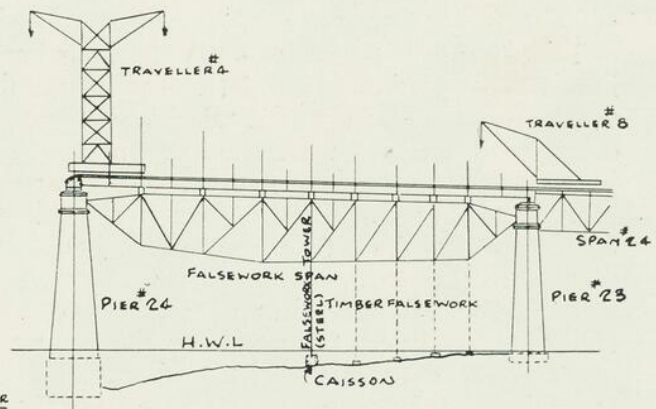
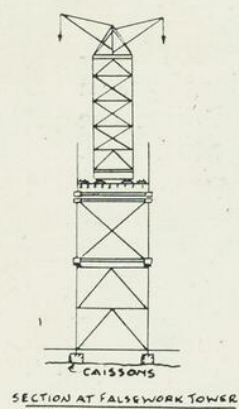


STAGE III

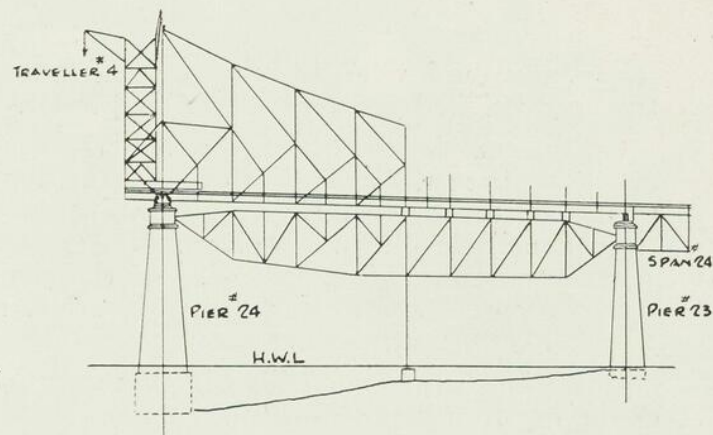


STAGE IV

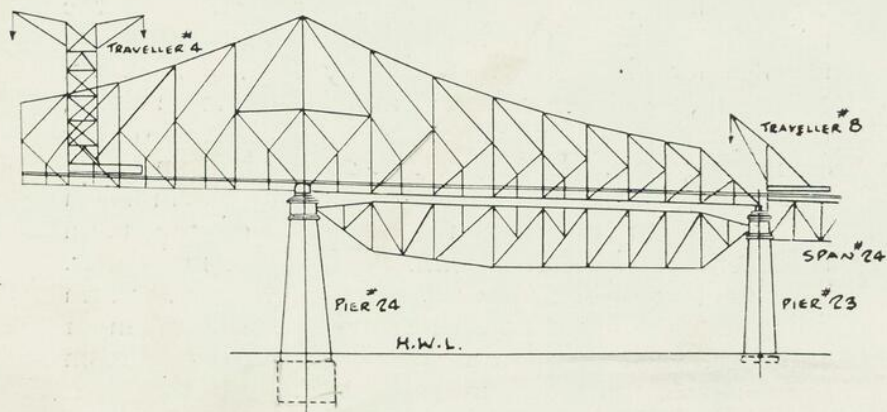
Figure 6.—DIAGRAM SHOWING SEQUENCE OF ERECTION OF NORTH ANCHOR AND CANTILEVER ARMS.



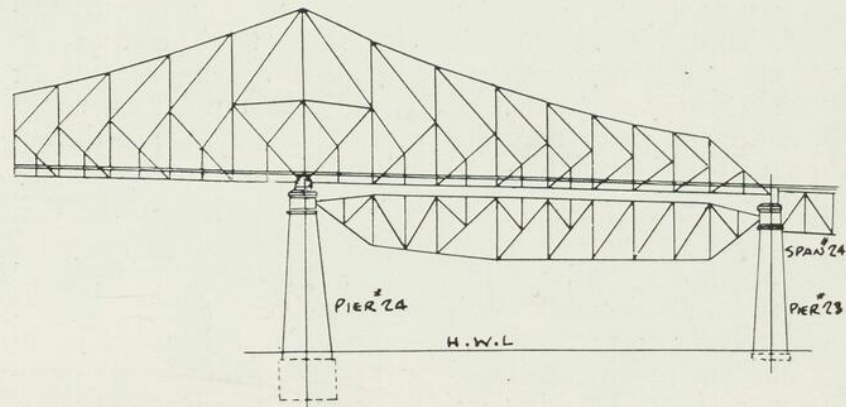
STAGE I



STAGE II



STAGE III



STAGE IV

Figure 7.—DIAGRAM SHOWING SEQUENCE OF ERECTION OF SOUTH ANCHOR AND CANTILEVER ARMS.

ft. booms could work together on either side. The traveller weighed 300 tons in working order.

On the completion of the portion of the anchor arm extending from the main pier to one panel beyond the temporary tower, the main traveller was transferred to the channel side of the main pier and the erection of the cantilever arm was commenced. At the close of the season progress was as shown in Figure No. 13, some 3,300 tons of the permanent structure being then erected.

Operations were resumed in March, 1928, the erection of the north anchor and cantilever arms being carried on concurrently in order to partially balance the weight on each side of the main pier and reduce the load on the temporary tower and its foundations. (See Figure No. 14.) An auxiliary traveller was used on the anchor arm, the main traveller progressing outward on the cantilever arm. By the end of May the anchor arm and the major portion of the cantilever arm were completely erected. The end of the anchor arm was then jacked from the anchor pier until the temporary tower was relieved of all load and disconnected. It was then lowered to its final position and the pins were driven to connect to the permanent anchorages. Shortly afterwards the temporary tower and the main traveller were removed for use during the erection of the south half of the main span.

The south anchor arm is beyond the navigation channel, but as the river here is subject to ice jams which frequently build up to a height of 30 ft. the usual type of falsework could not survive a winter season. It being improbable that the whole anchor arm could be erected in one working season, a full-length temporary steel bridge was used, supported at the ends by the respective piers.

The temporary span was 402 ft. long between bearings and weighed 1,625 tons, including the floor system of the anchor arm which was supported during the erection of the span on the top chords of the latter. During May and June, 1928, temporary piers were built in the river for the support of the falsework under the temporary span (see Figure No. 15). On the completion of the south approach the erection of the span was commenced, the first portion being supported on timber falsework. On reaching the approximate mid-point of the span, the steel tower previously used under the north anchor arm was erected on the temporary piers just referred to. The span, having been landed on top of the tower, was cantilevered beyond to the main pier (see Figure No. 16). By means of hydraulic jacks on top of the tower, the end of the span was then lowered until it rested on its end bearings at the pier, the tower being relieved of all load.

The erection of the permanent structure followed immediately, the bottom chords, lateral system and floor steel of the whole anchor arm being placed in position first and supported on the top chord of the temporary span. The method of handling some of the heavier pieces is illustrated by Figures Nos. 17, 18 and 19, which show the assembly of the main shoes, the adjoining bottom chords and the driving of the connecting pins. In Figure No. 20 the bottom chord and floor system is seen in progress of assembly in its permanent position; the erection of the main traveller has also been commenced at the main pier. The erection of the upper portion of the anchor arm followed (see Figures Nos. 21, 22 and 23), using the main traveller which by this time had been transferred from the north side and reassembled on the floor of the south anchor arm. Four panels of the latter having been

completed, the main traveller was transferred to the cantilever arm and erection was proceeded with concurrently on both arms until the close of the season, progress at that time being as shown in Figure No. 24.

The severity of the ice movement during the spring break-up in the river is illustrated by Figure No. 25, a photograph of the conditions existing on March 28th, 1929. The ice level shown is approximately 25 ft. higher than normal water level in this section of the river.

Advantage was taken of the winter to erect the north approach viaduct, making use of the equipment employed at an earlier date in the erection of the south approach.

Shortly after the resumption of operations in April, 1929, the south anchor arm was completed and concurrently the major portion of the south cantilever arm. The end of the anchor arm was then connected to its permanent anchorages and the temporary span relieved of all load, being removed later.

Auxiliary travellers completed the erection of the outer ends of both cantilever arms, operations proceeding concurrently on both sides of the channel. The erection of the central suspended span followed (see Figure No. 26) the gap between the ends of the respective arms rapidly narrowing until by July 1st the centre panel alone remained. (See Figure No. 27.) Soon afterwards this panel was completed, the final operation of making the closure connections at the centre being carried out on July 10th, 1929.

The preparations for the closure operations were

governed by the following considerations: the suspended span, 378 ft. 6 in. in length and weighing 1,515 tons in its erected condition, is in its completed state a virtually independent structure suspended at each end from the corresponding cantilever arm. During erection, however, each half of the suspended span was projected outward as an extension of the cantilever arm, resulting in heavy stresses in members at the ends of the latter which ordinarily are almost or entirely free from stress. In making the closure at the centre it was necessary to be able to connect the members irrespective of the expansion or contraction effect of variable temperature. It was also necessary to follow the making of the centre connections immediately by a process of adjustment whereby the stresses in the members referred to above were released and the suspended span was allowed to assume its normal condition of a simple span swinging freely under its own weight between the ends of the cantilever arms.

To provide for the adjustments incidental to these closure operations, adjustable wedge mechanisms, eight in number, were placed in the top and bottom chords adjacent to each end of the suspended span. The design of the wedges is illustrated in Figure No. 28; one of the top chord wedges is seen in position in Figure No. 29 prior to the construction of the working platform. These wedge mechanisms were designed to carry and be released under a load of 800 tons per wedge.

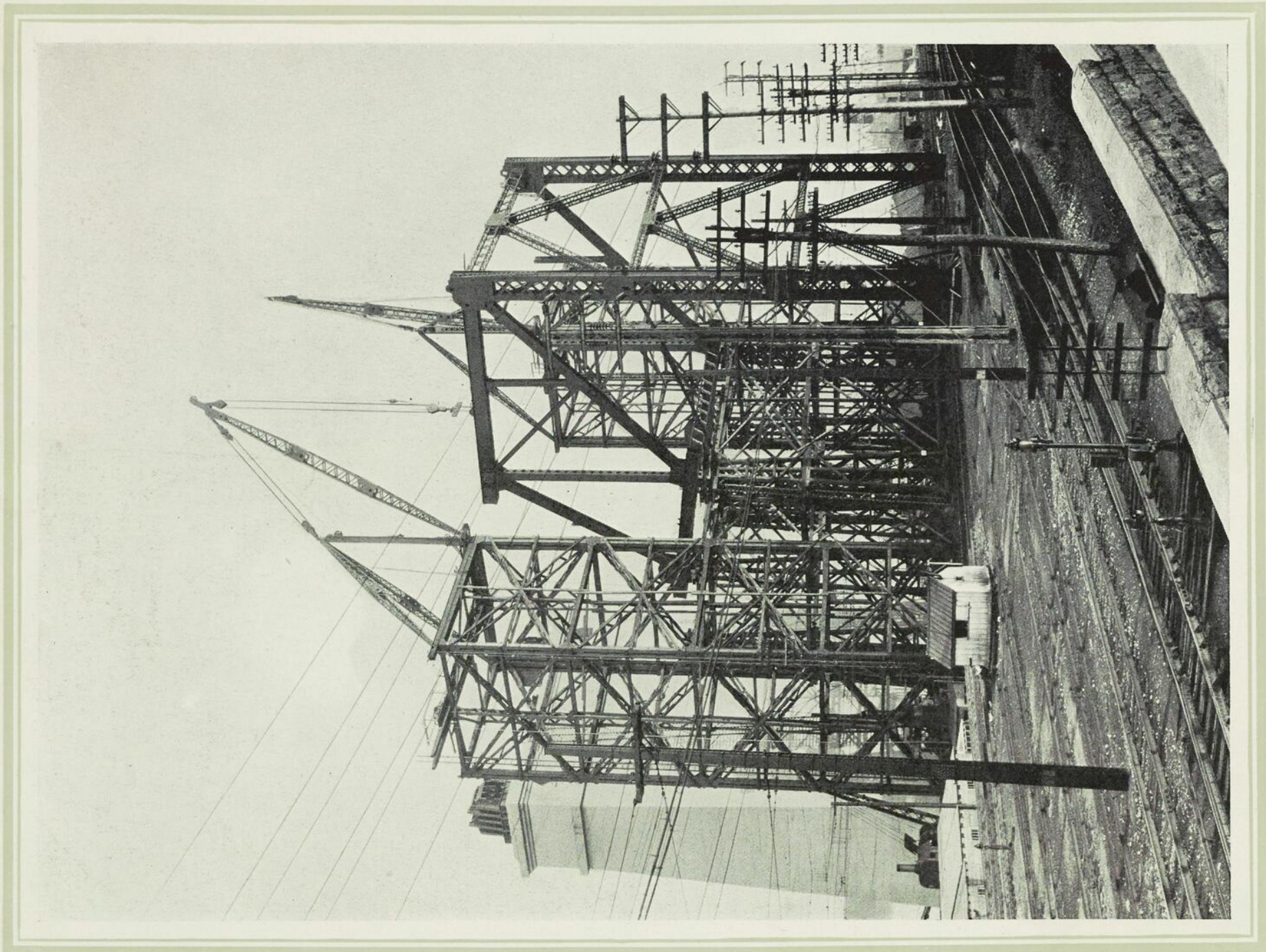
The final closure operations were commenced at 5 a.m. on July 10th, 1929, under favourable weather conditions and were completed successfully in less than five hours.



Figure 8.—CANTILEVER ERECTION OF 245 FOOT SPAN OF SOUTH APPROACH.



Figure 9.—ERECTING FIRST 245 FOOT SPAN NORTH OF PAVILION.



*Figure 10.*—ERECTION OF FALSEWORK FOR NORTH ANCHOR ARM.

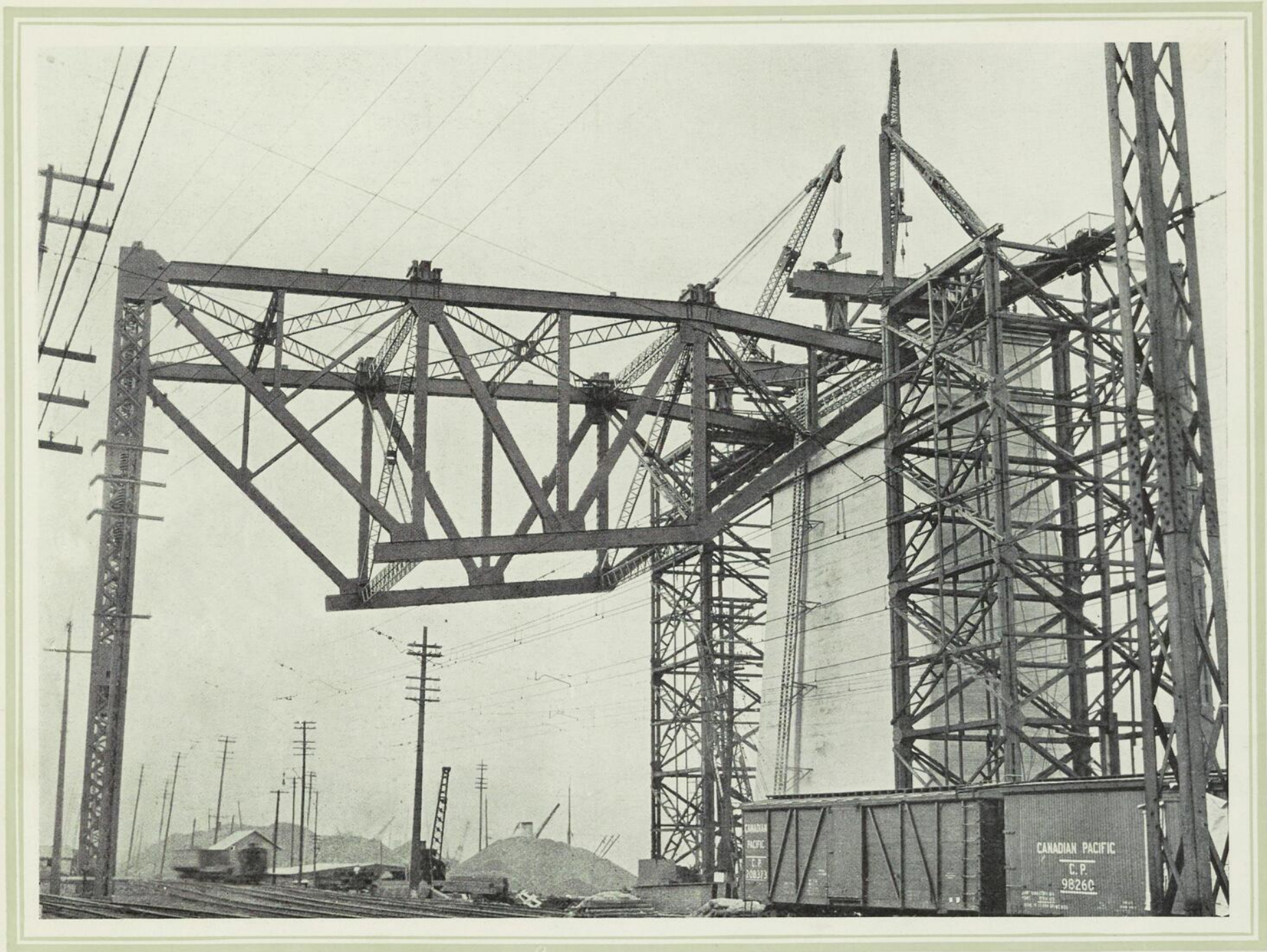


Figure 11.—ERECTING FIRST CHORD SECTIONS OF NORTH ANCHOR ARM.

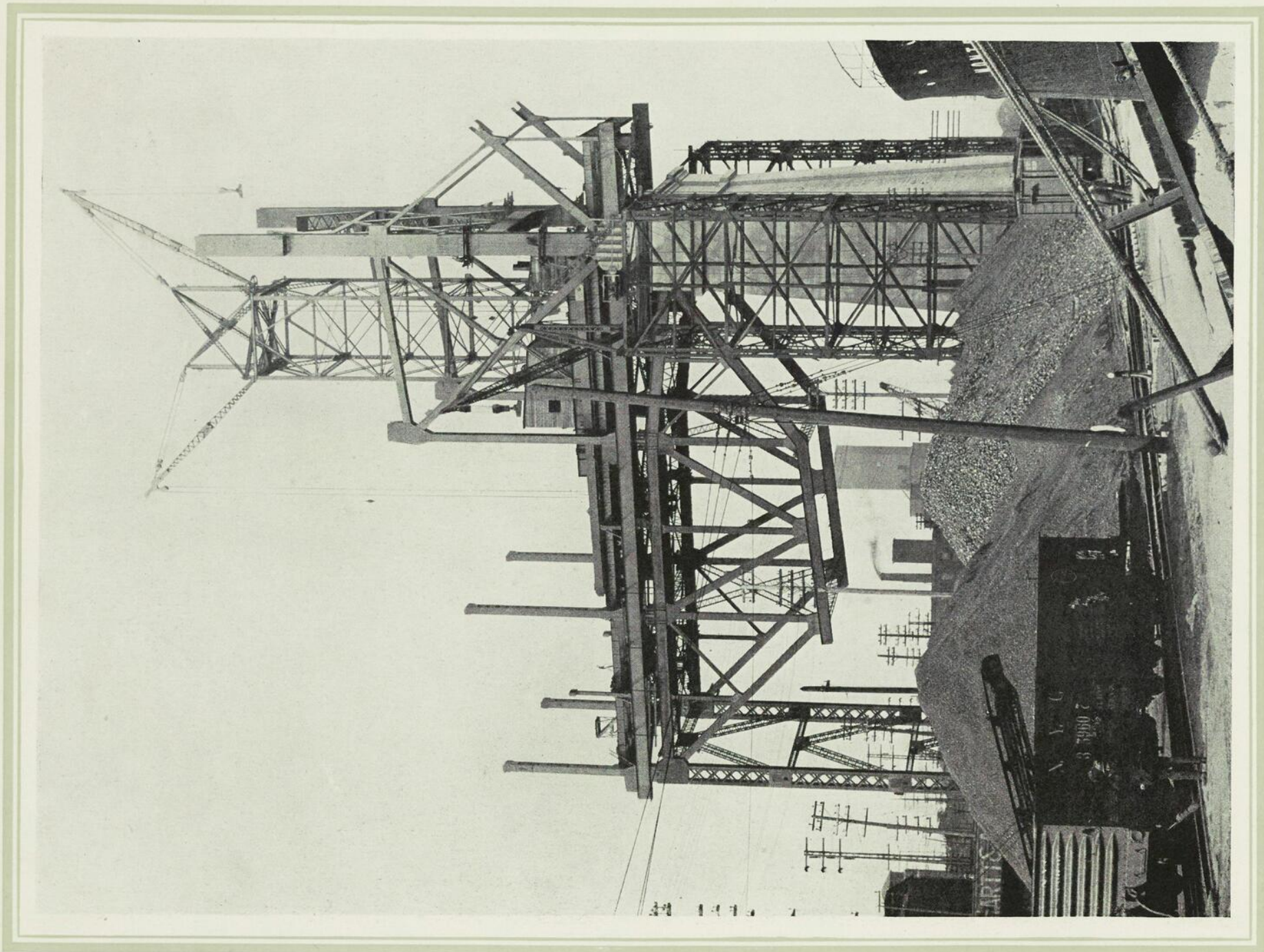


Figure 12.—ERECTING MAIN POSTS AND ADJACENT STRUCTURE OF NORTH ANCHOR ARM.



*Figure 13.*—PROGRESS ON NORTH HALF OF MAIN SPAN AT DECEMBER 14TH, 1927.



*Figure 14.*—CONCURRENT ERECTION OF NORTH ANCHOR AND CANTILEVER ARMS.



*Figure 15.*—SOUTH APPROACH COMPLETED. TRAVELLER FOR ERECTION OF FALSEWORK BEING SET UP, AND TEMPORARY PIERS UNDER CONSTRUCTION. 29

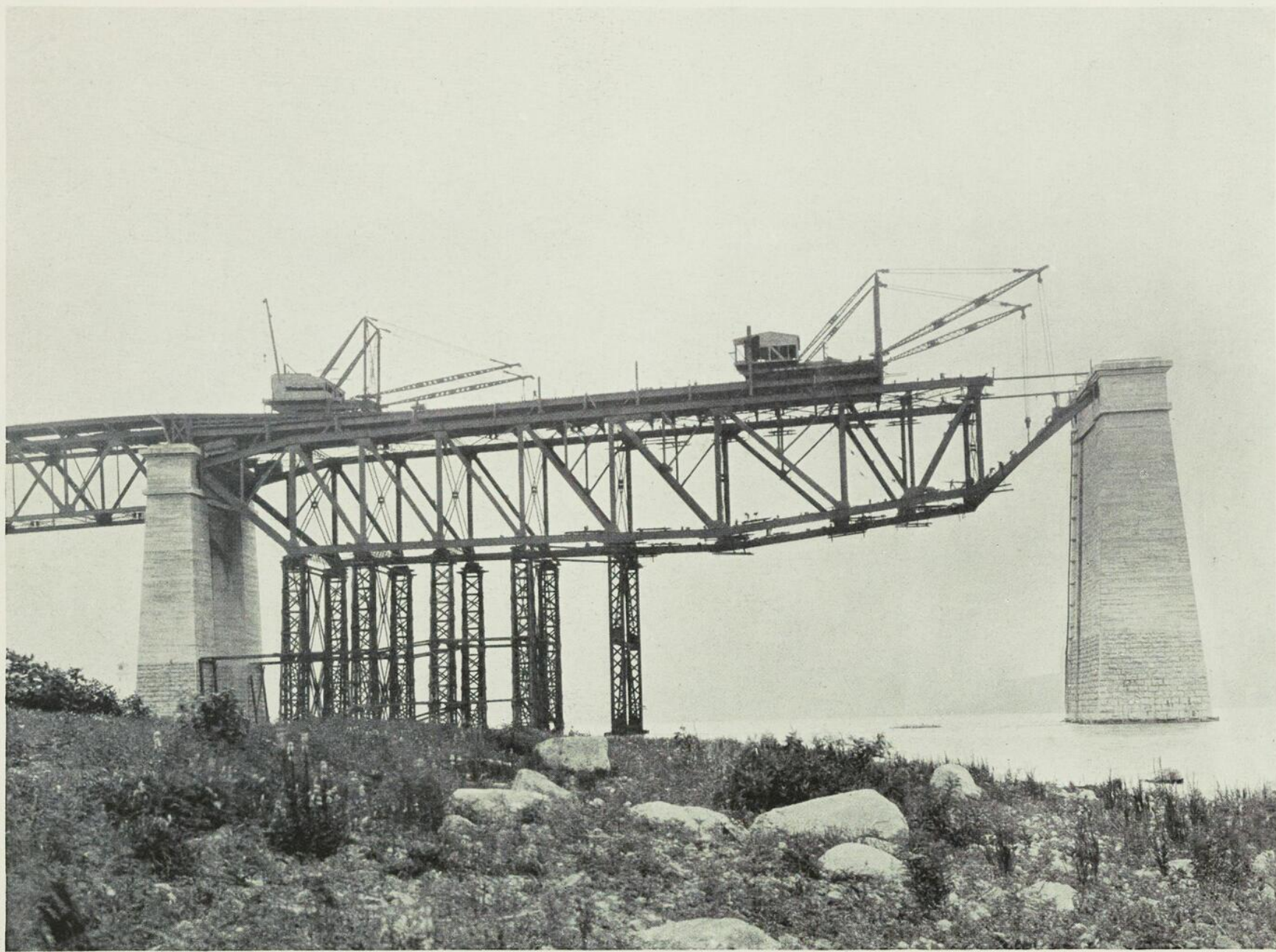


Figure 16.—ERECTING FALSEWORK FOR SOUTH ANCHOR ARM.

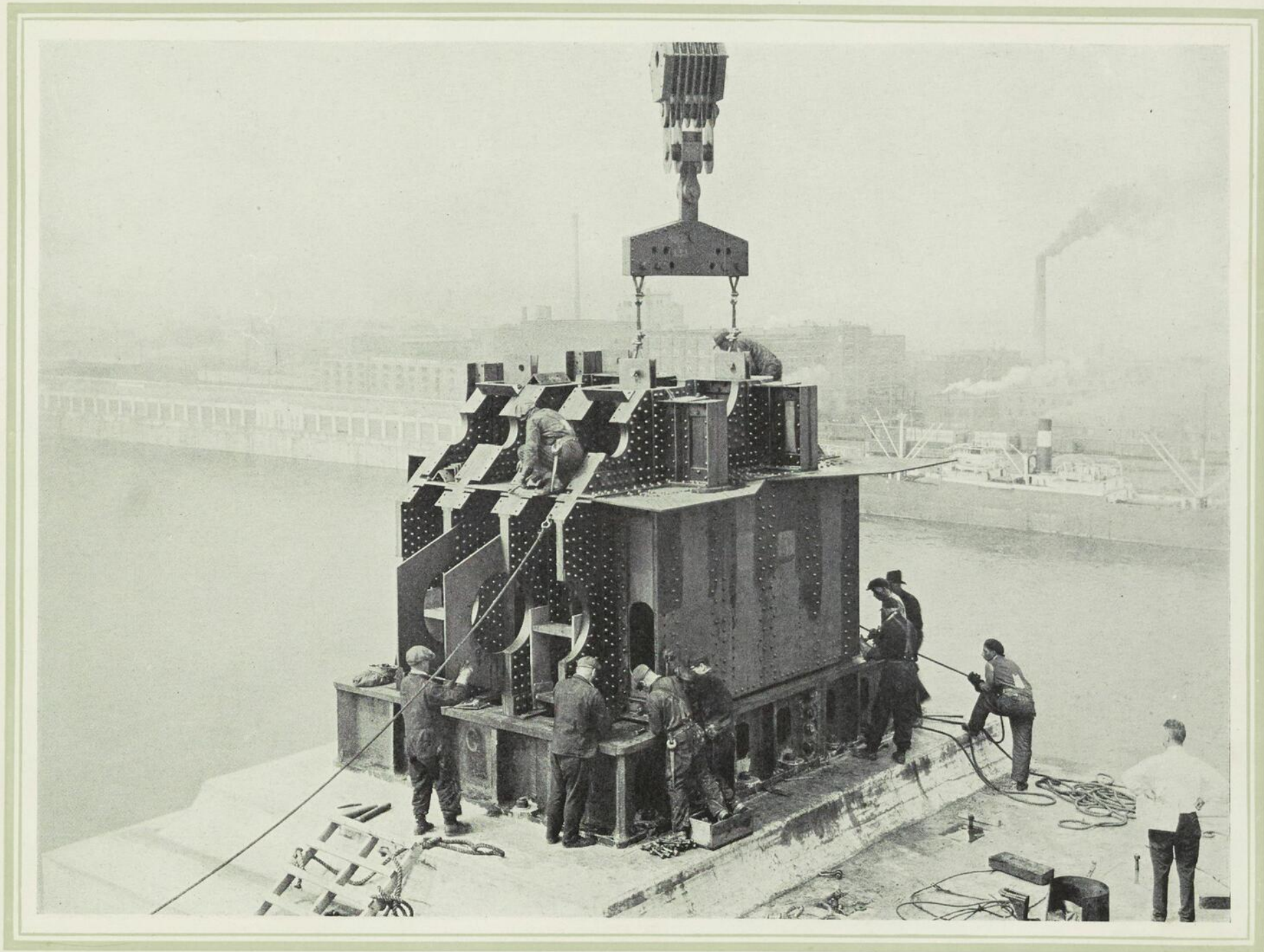


Figure 17.—SETTING SHOE ON SOUTH MAIN PIER.

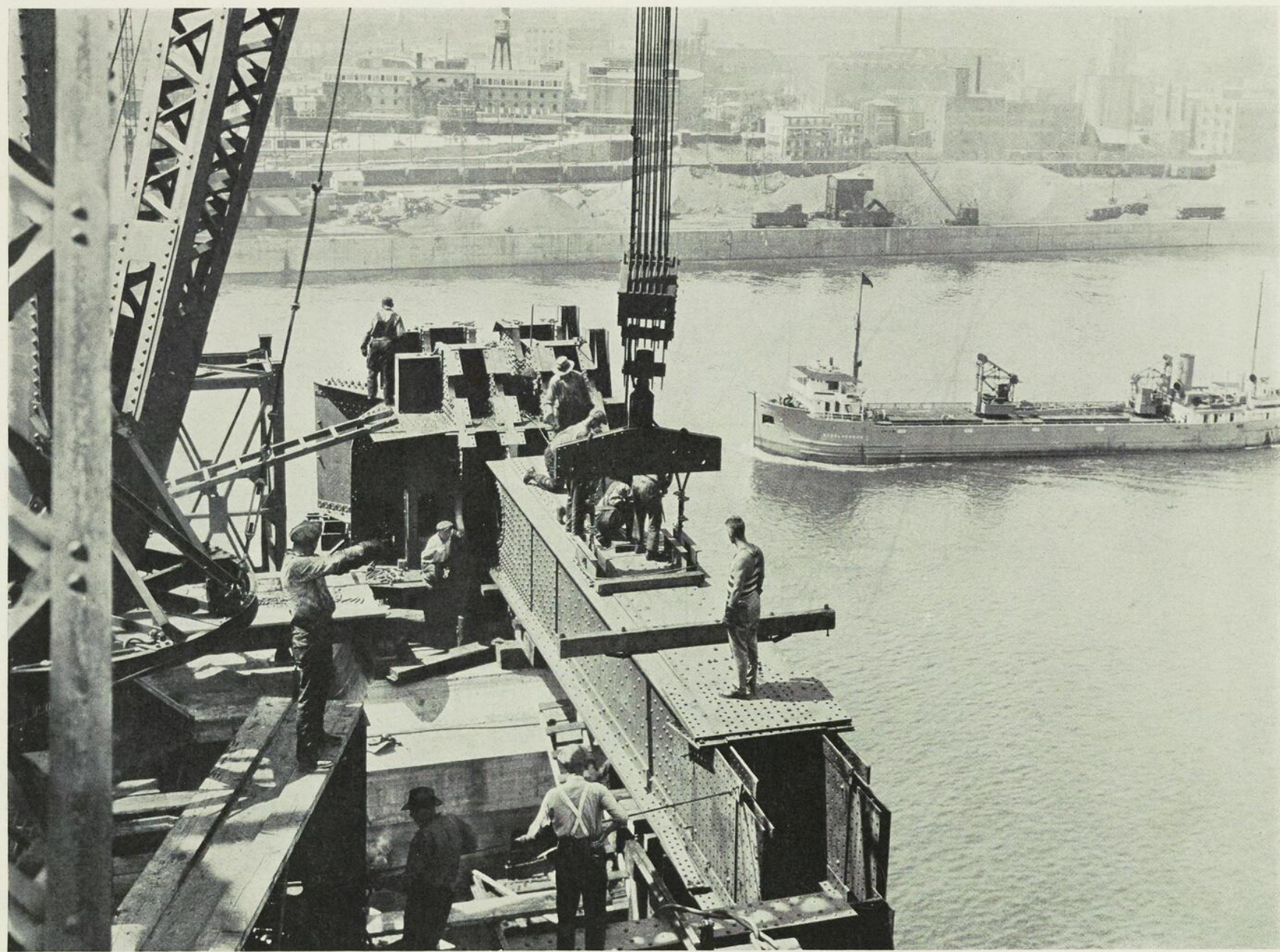
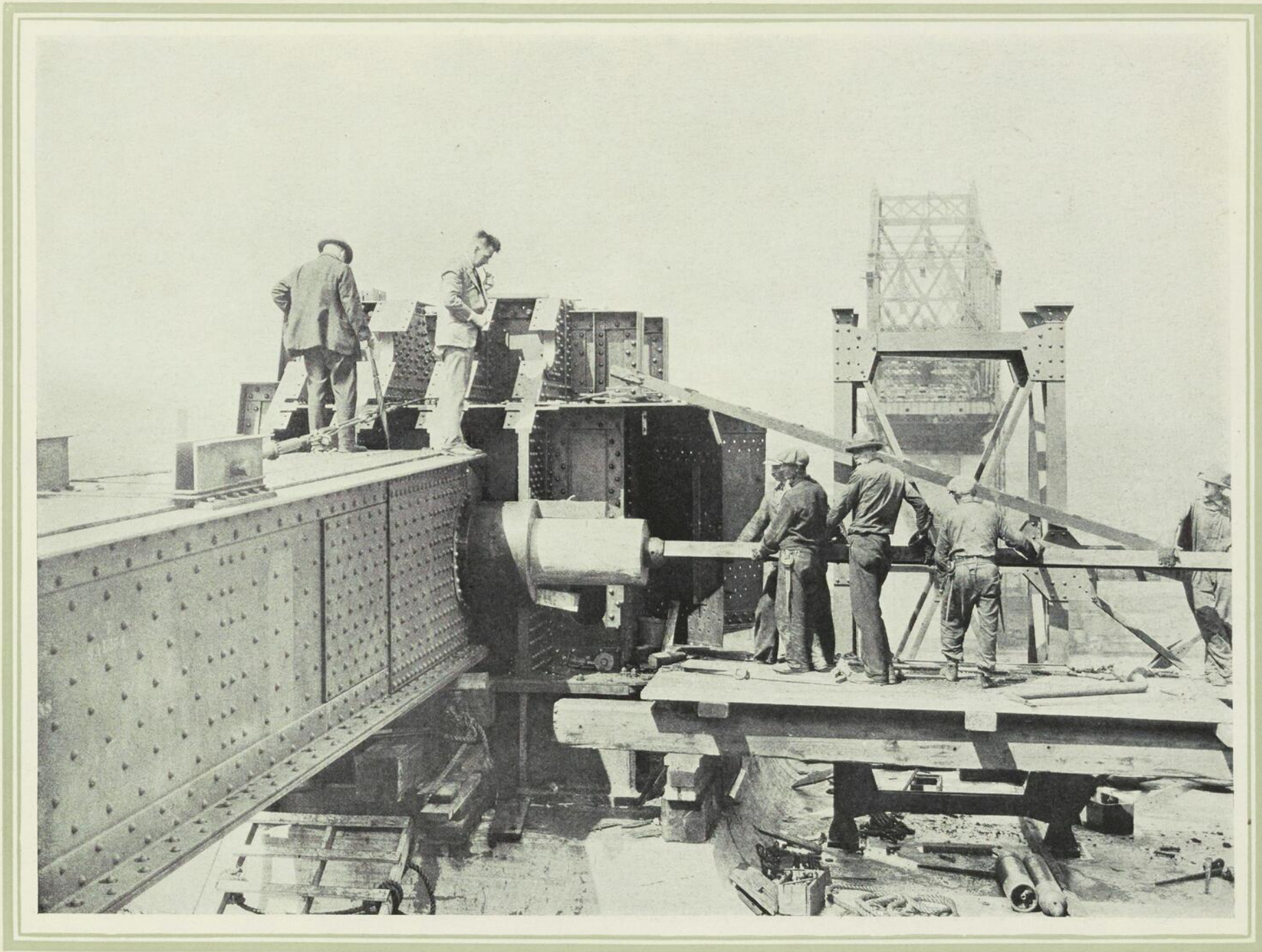


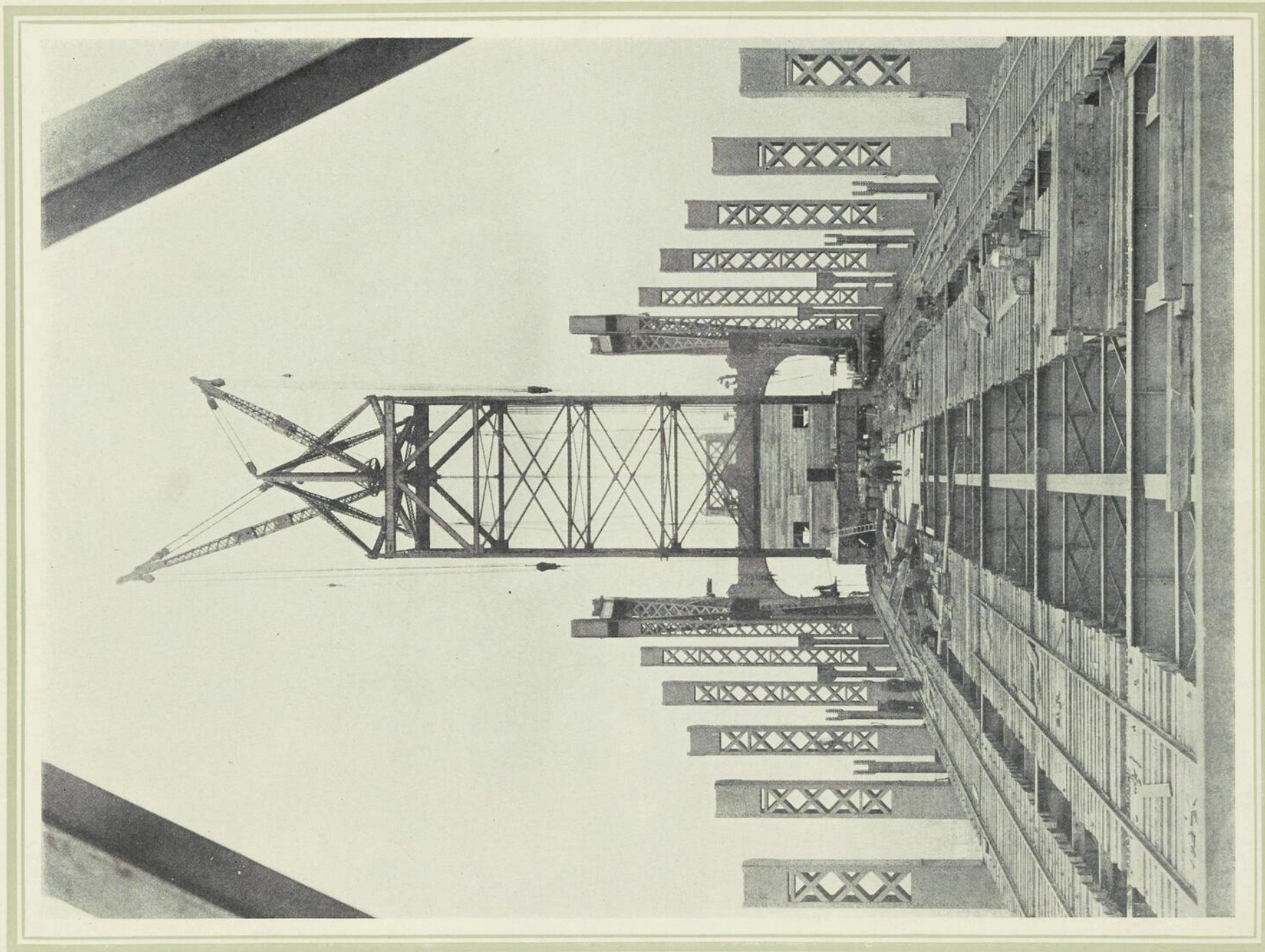
Figure 18.—ERECTING FIRST CHORD SECTION OF SOUTH ANCHOR ARM.



*Figure 19.*—DRIVING PIN CONNECTING BOTTOM CHORD TO SHOE.



*Figure 20.*—ERECTING CHORDS AND FLOOR SYSTEM OF SOUTH ANCHOR ARM, AND MAIN TRAVELLER.



*Figure 21.*—REAR VIEW OF MAIN TRAVELLER AND BRIDGE DECK.

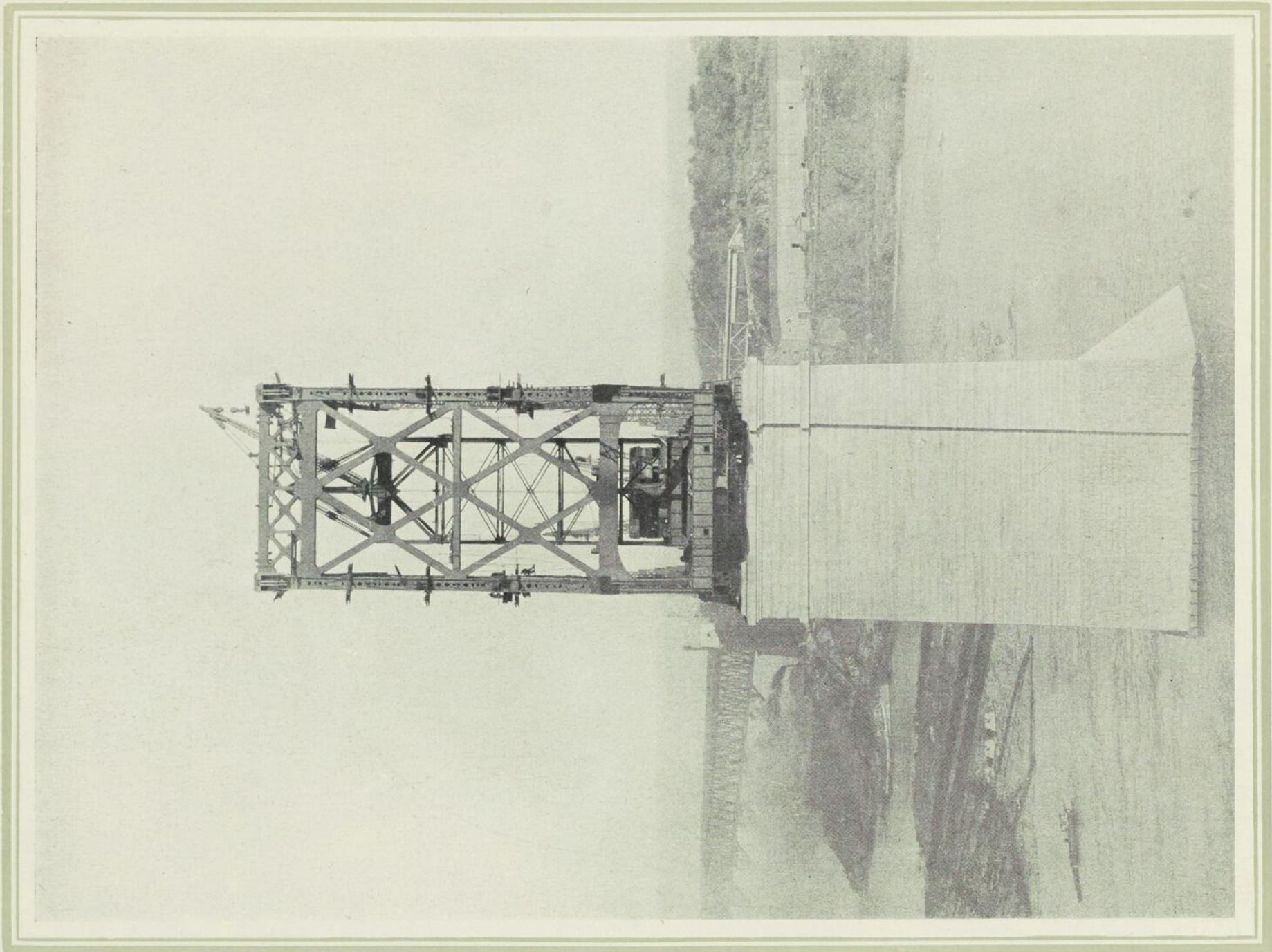


Figure 22.—FRONT VIEW OF MAIN POSTS, BRACING AND MAIN TRAVELLER.



*Figure 23.*—ERECTION PROCEEDING ON SOUTH ANCHOR ARM.



Figure 24.—PROGRESS ON MAIN SPAN AT DECEMBER 14TH, 1928.



*Figure 25.*—ICE CONDITIONS ON MARCH 28TH, 1929.

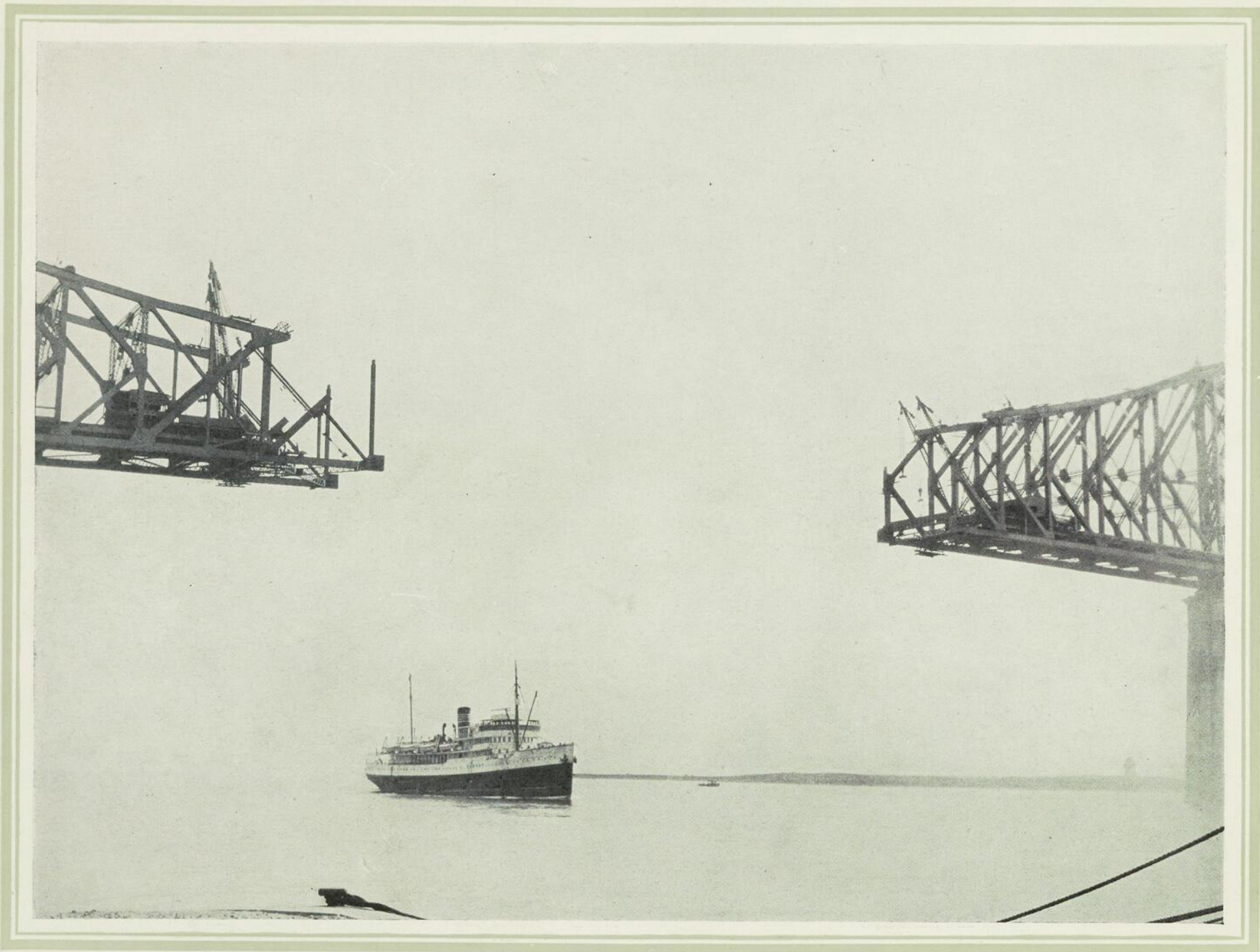


Figure 26.—CONCURRENT ERECTION OF BOTH CANTILEVER ARMS.



*Figure 27.*—PROGRESS ON MAIN SPAN AT JULY 1ST, 1929.

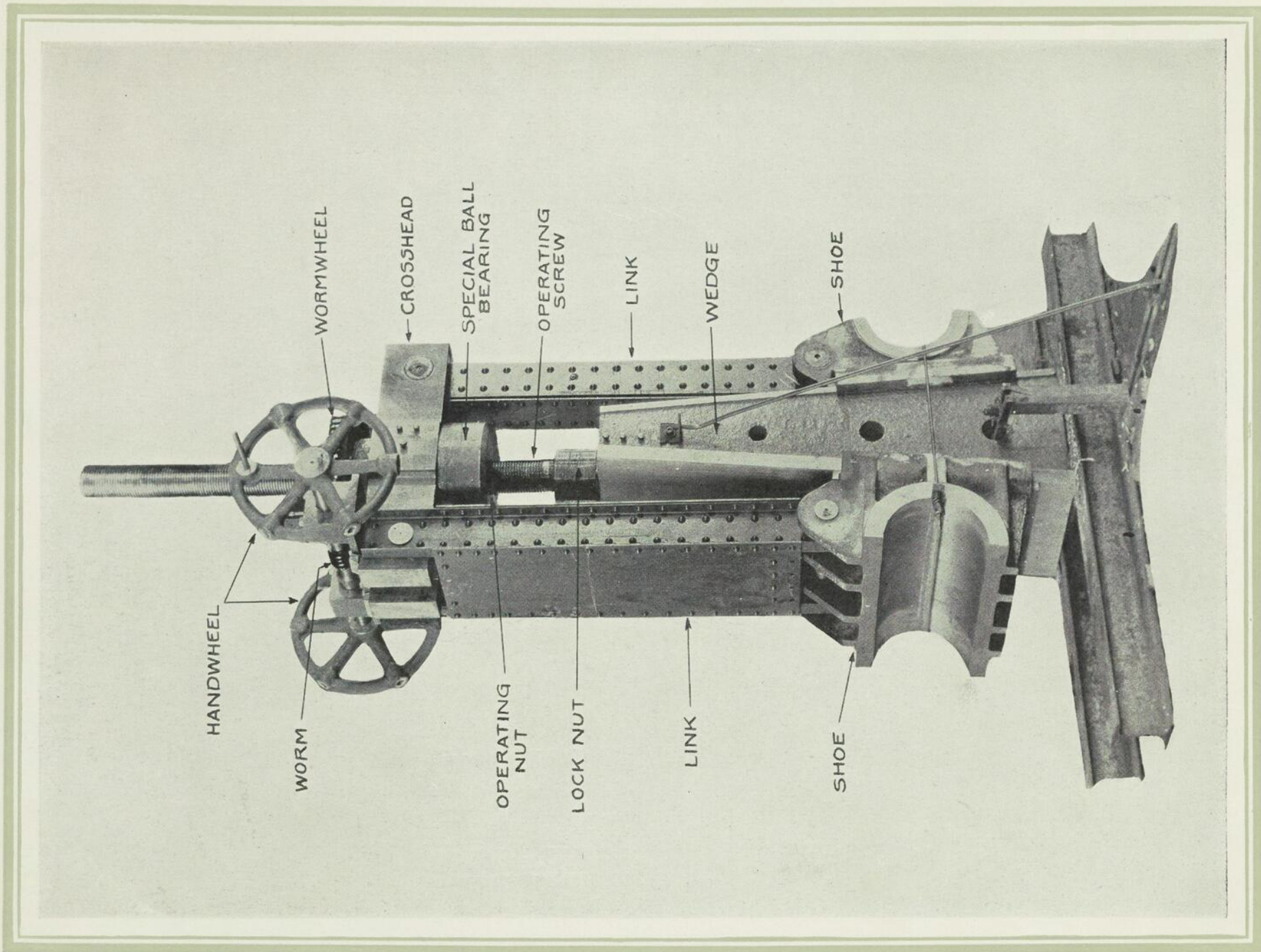
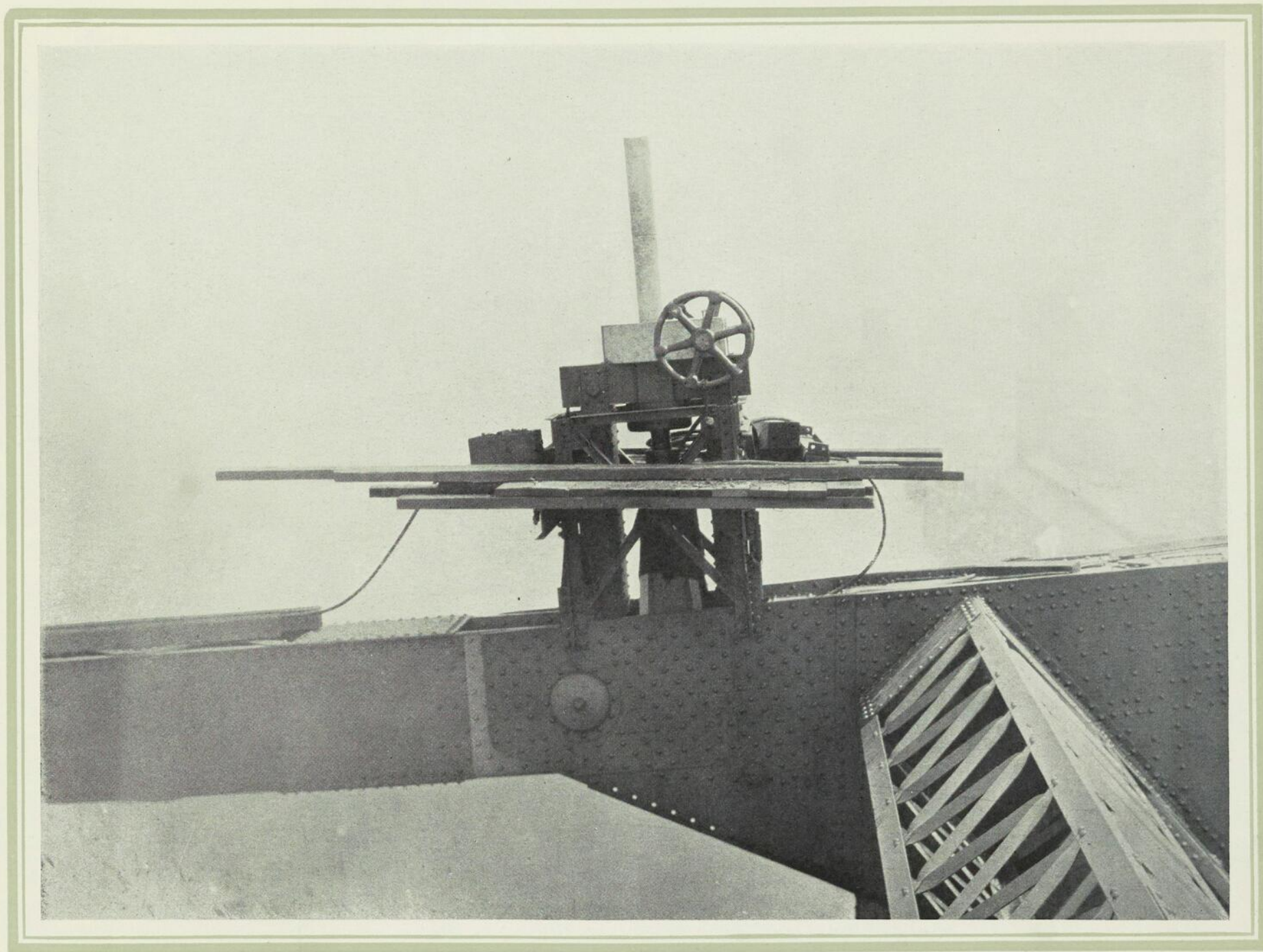


Figure 28.—WEDGE MECHANISM USED DURING ERECTION OF SUSPENDED SPAN.



*Figure 29.*—SIDE VIEW OF WEDGE MECHANISM IN PLACE AT CUO.

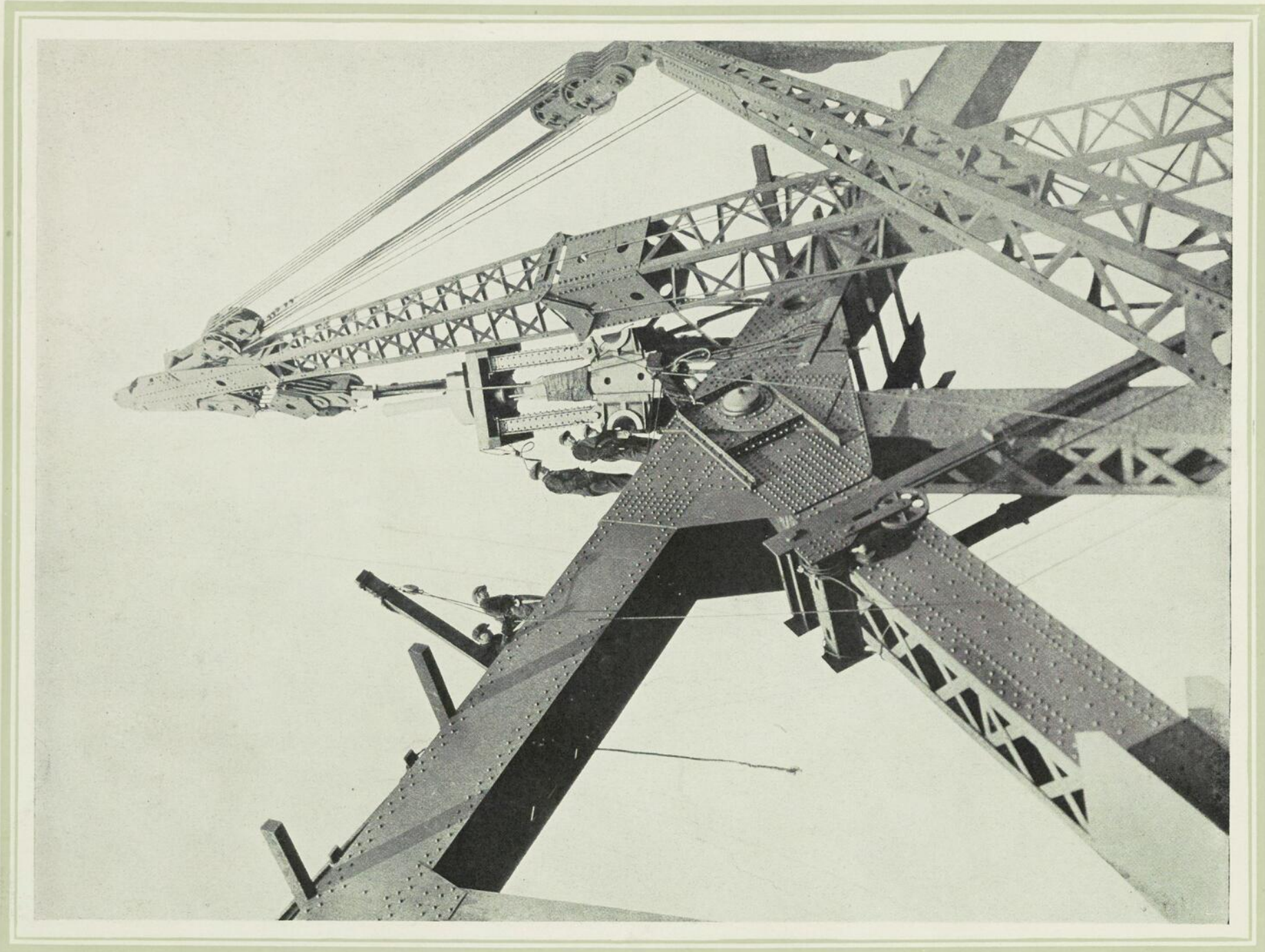


Figure 30.—PLACING WEDGE MECHANISM IN POSITION IN TOP CHORD.



*Figure 31.*—DRIVING PIN IN BOTTOM CHORD AT CENTRE OF SPAN ON DAY OF CLOSURE.

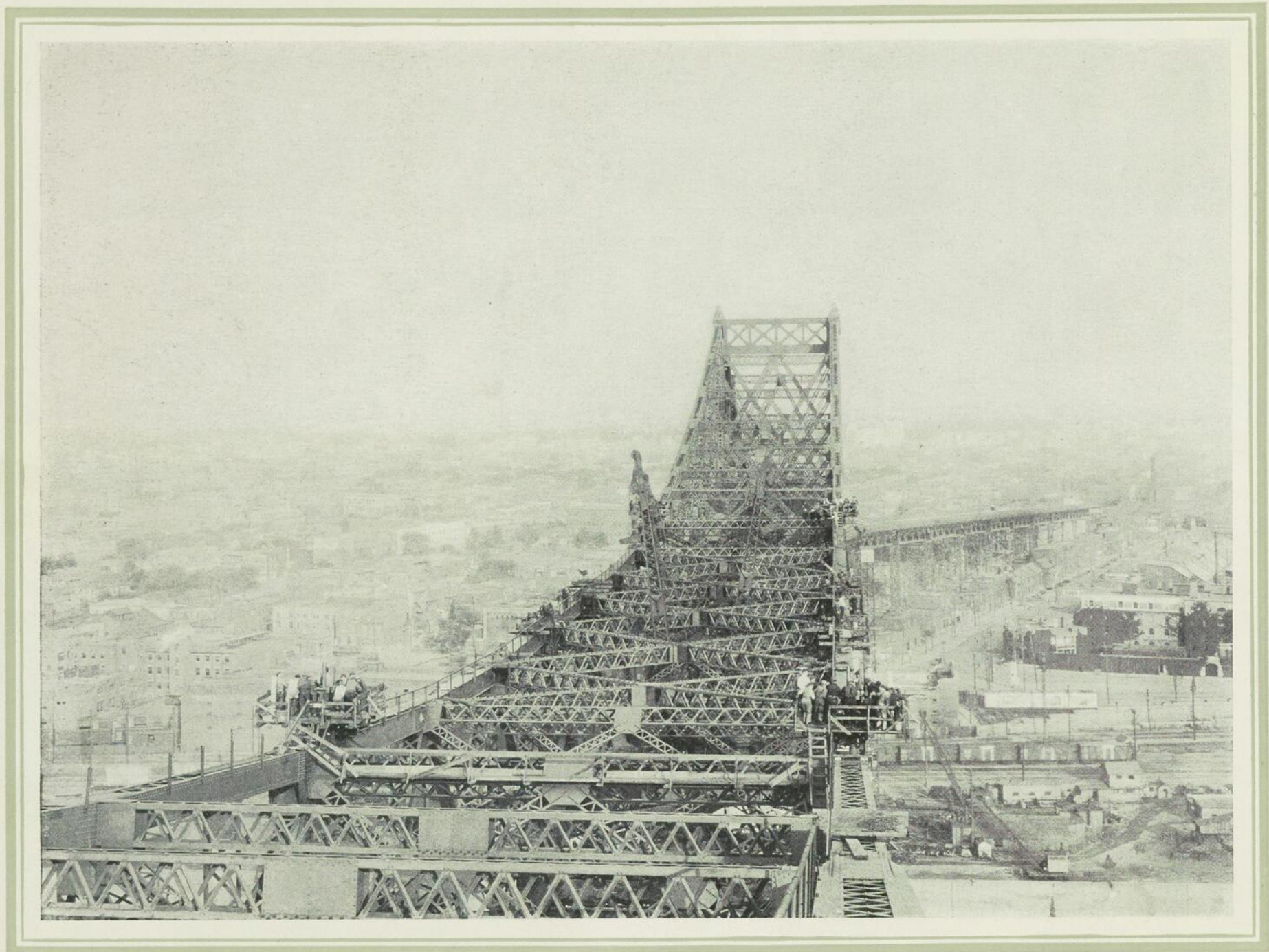
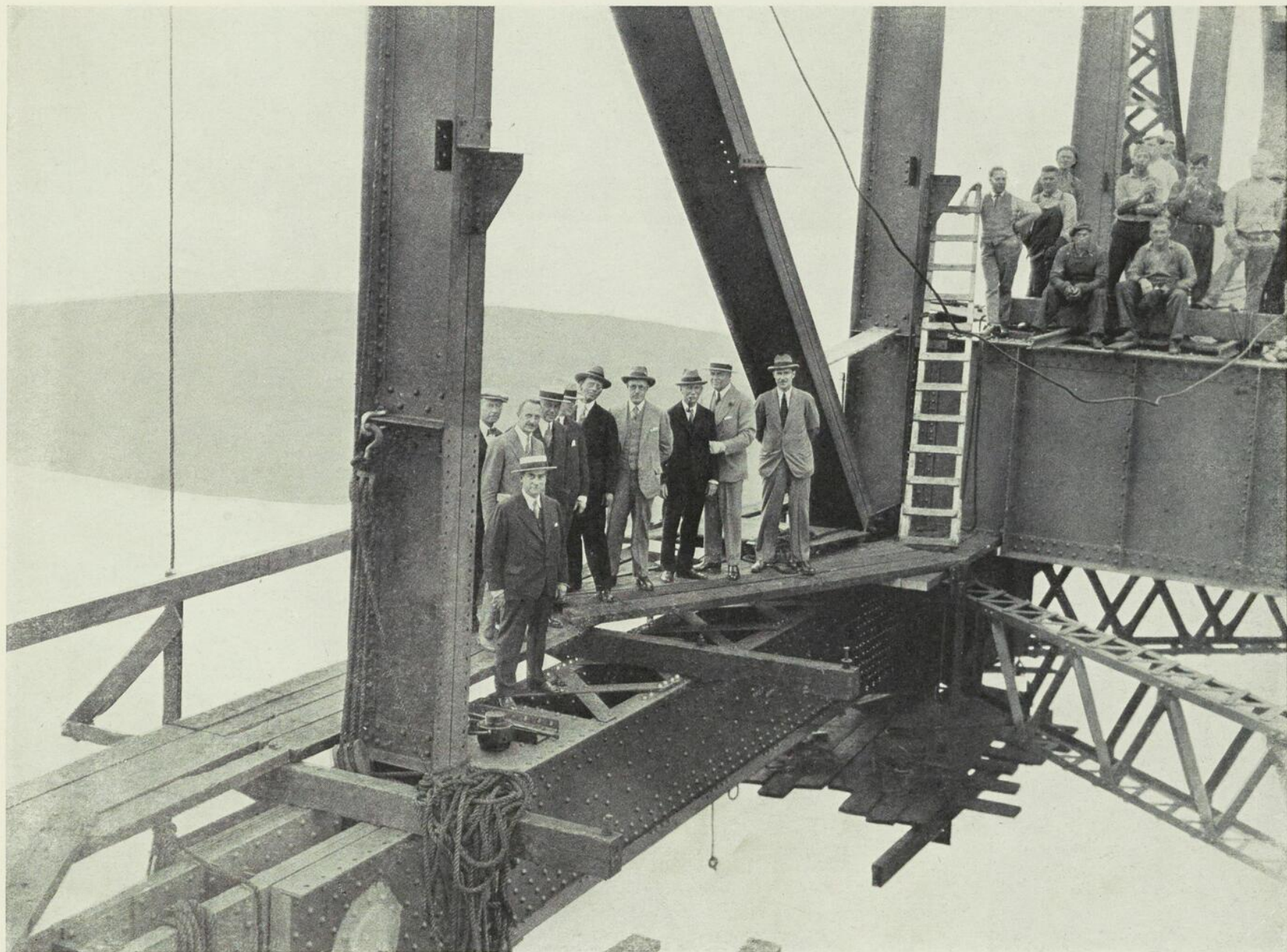


Figure 32.—OPERATION OF WEDGES ON TOP OF SUSPENDED SPAN DURING CLOSURE.



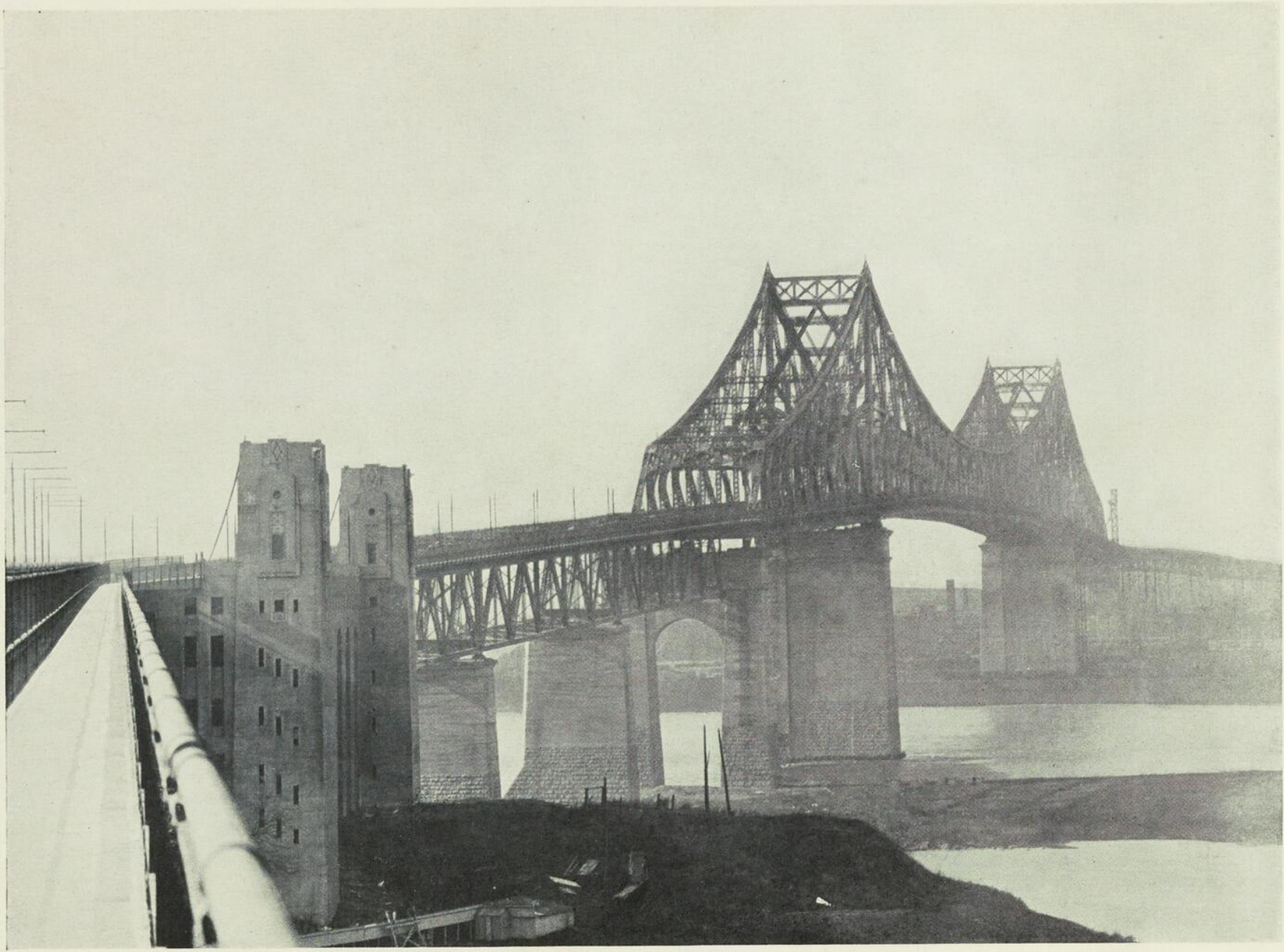
*Figure 33.*—GROUP OF PROMINENT OFFICIALS CONNECTED WITH CONSTRUCTION OF THE BRIDGE WHO WITNESSED THE CLOSURE OPERATIONS—JULY 10TH, 1929.



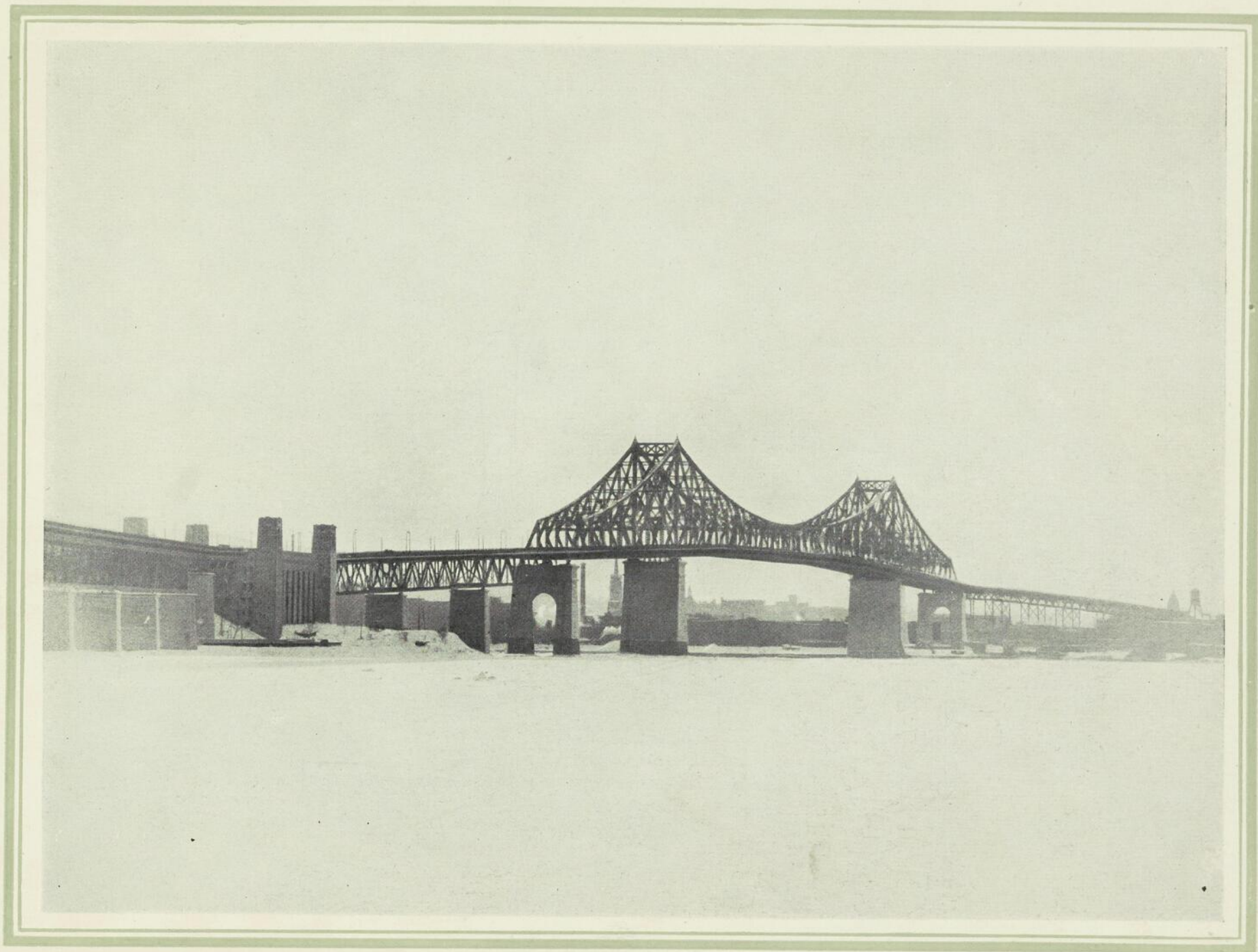
*Figure 34.*—ERECTION OF MAIN SPAN COMPLETED, FALSEWORK REMOVED, AND EQUIPMENT BEING DISMANTLED.  
S.S. "DUCHESS OF ATHOL" IS SEEN PASSING UNDER SPAN.



*Figure 35.*—THE BRIDGE AS SEEN FROM THE MONTREAL END.

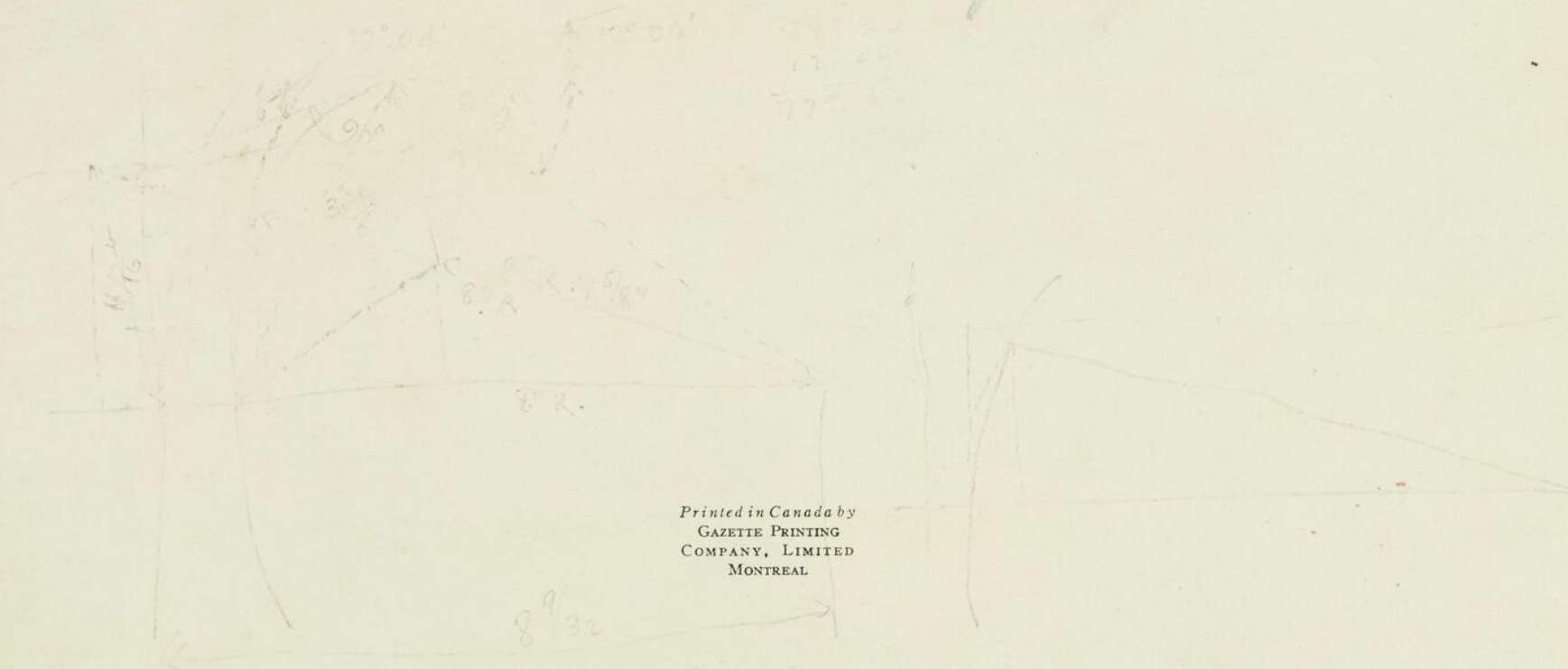


*Figure 36.*—THE MAIN SPAN AS SEEN FROM THE SOUTH APPROACH.

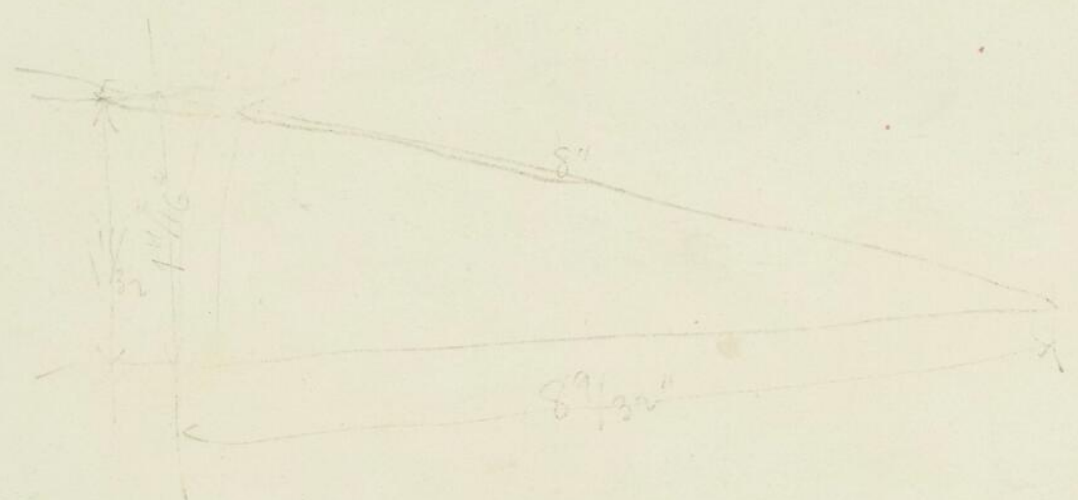


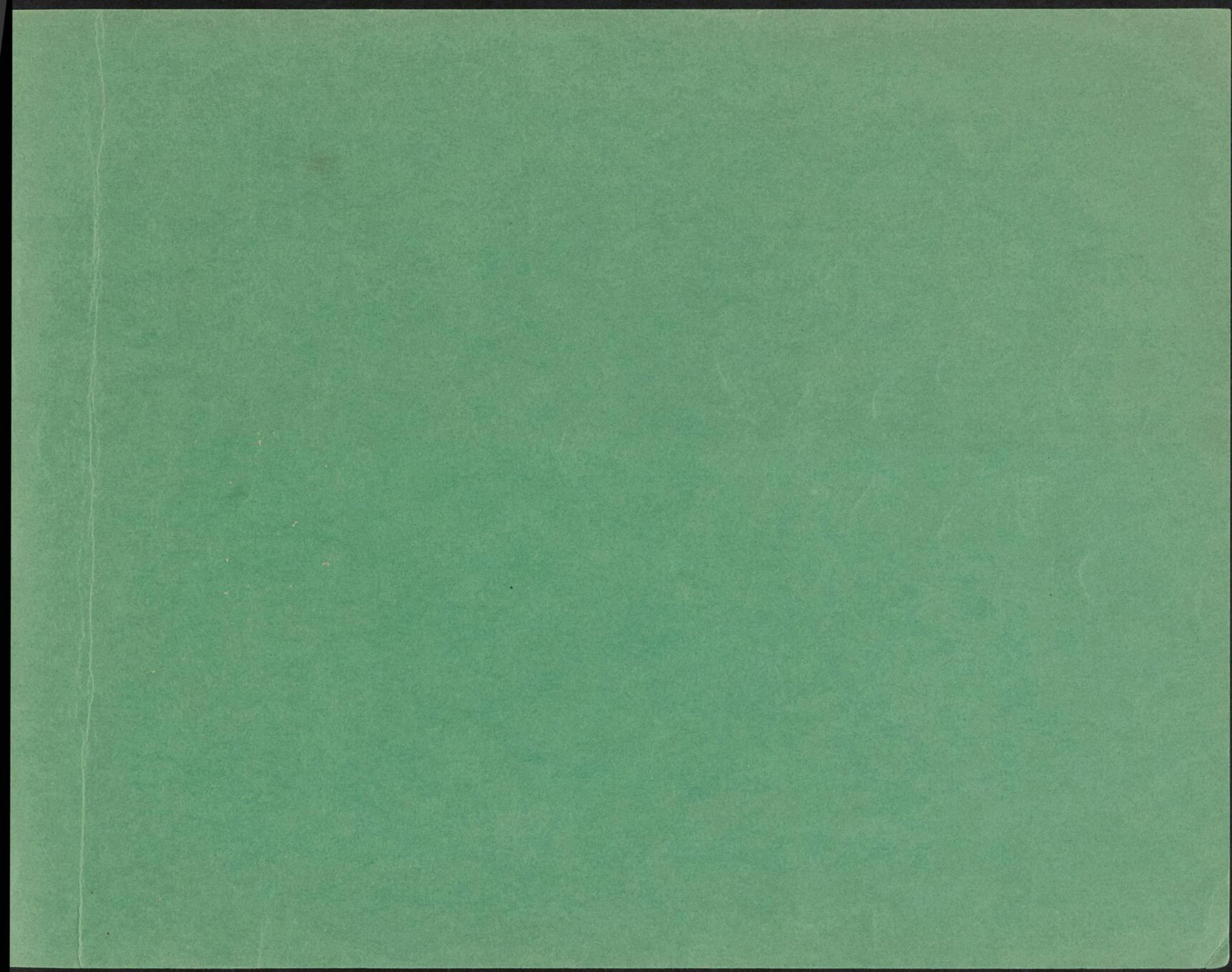
*Figure 37.*—THE BRIDGE AS SEEN FROM THE SOUTH SHORE.

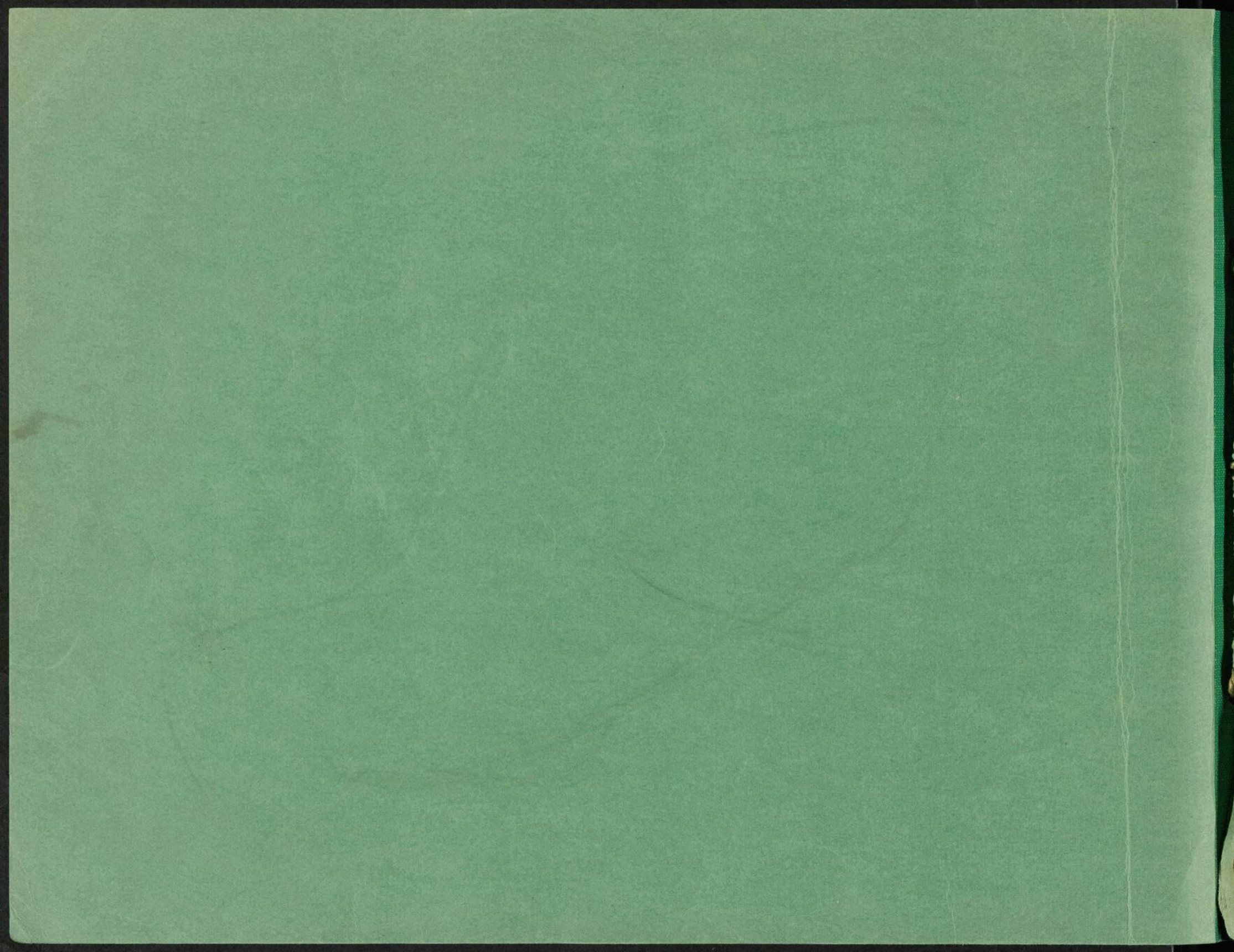
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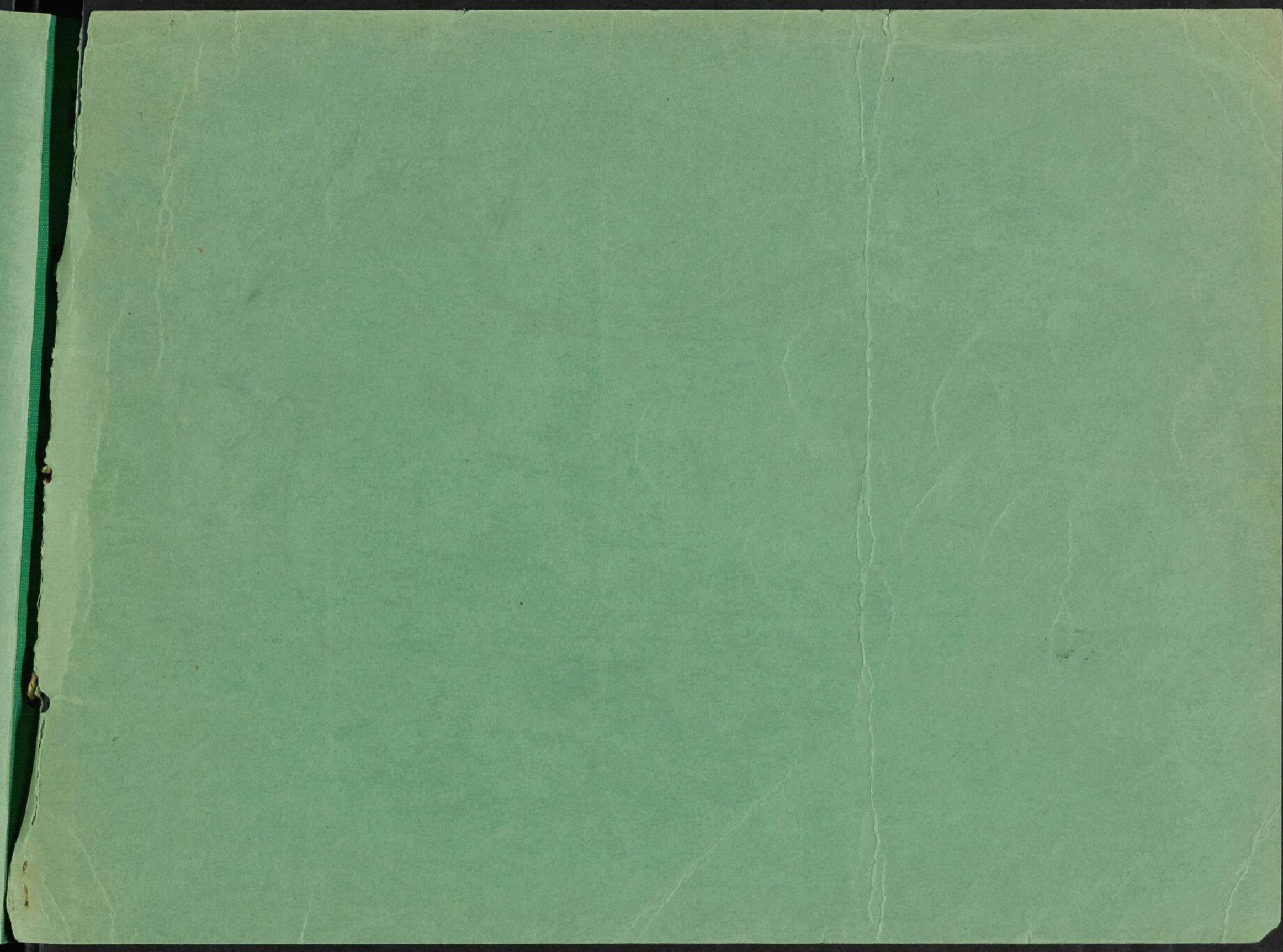


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