Direct-Lift Drawbridges without Cables

SYNOPSIS—The two articles following describe different designs for a new type of drawbridge in which the span is raised vertically but without the aid of cables either for the operating system or the counterweight system. The operation is by rack-and-pinion gearing, and the counterweights are carried by lever systems, attached to the lift span and pivoted over the towers. Some bridges of this type are already under construction, and the articles describe several modifications of the general design, adapted to meet varying conditions.

Within the past few years the vertical-lift type of drawbridge has been regarded with some favor, and a number of bridges of this type (large and small) have

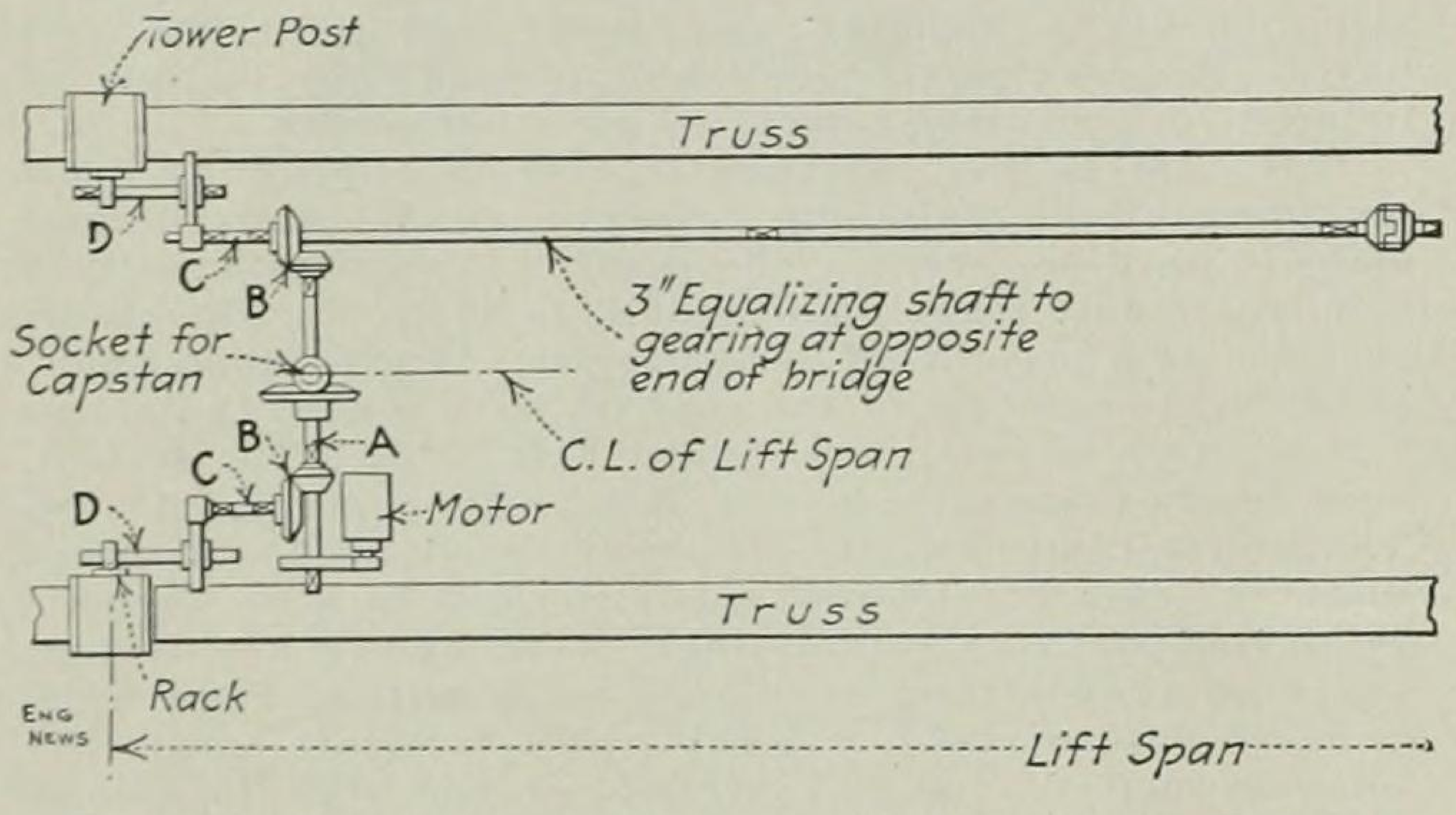

FIG. 1. OPERATING MACHINERY OF THE DIRECT-LIFT SPAN (STRAUSS SYSTEM) OF THE ARKANSAS RIVER BRIDGE, NEAR PINE BLUFF, ARK.

been built for both railway and highway purposes. Up to the present time all these bridges have been operated by cables and winding drums, the moving span being balanced by counterweights suspended from other cables. All these cables pass over sheaves on the top of high towers erected on the piers or abutments of the lift span, and between which the span moves. There are certain objections, however, urged against the cable system of operation, such as the possibility of breakage, the cost and trouble of renewing the cables, the adjustment for stretching, and the general care of the cables and sheaves. To avoid these objections, a direct-lift type of bridge has been designed, in which the operation is effected by pinions engaging with vertical racks on the tower posts, while the counterweights are carried by lever systems. Lift bridges of this type have been invented and patented by J. B. Strauss, engineer, of Chicago, and the Strauss Bascule Bridge Co. already has contracts for the design of some of these structures. The general type is capable of various modifications to meet special conditions.

Among the advantages claimed is the fact that the support of the lift span at points between its ends reduces the dead-load stresses and permits erecting the span in the open position when necessary without the use of falsework. This would avoid the trouble of building the span at a distance from the site and then floating it into position, or handling it in similar ways. In such case, the hanger points may be used as points of support from which the trusses are built out as cantilevers until they meet and are connected at the center.

OPERATING MACHINERY

The bridge is operated by spur pinions on the lift span which gear with vertical racks on the tower posts. The racks may be on the inside or outside face of the post, according to the detail requirements in each case. Fig. 1 shows the arrangement of the machinery on the Arkansas River bridge, the racks in this case being on the outer sides of the posts. The 25-hp. motor drives a cross-shaft *A*, on which are mounted three bevel gears. Two of these are bevel pinions, *B*, *B*, driving short individual countershafts *C*, *C*. These carry spur pinions which drive the operating shafts *D*, *D*, on which latter are the rack pinions. The third bevel gear on the cross-shaft engages with the pinion of a vertical shaft (on the center line of the bridge) having a capstan head, for operating the bridge by hand. The motor and gears are in duplicate at each end of the bridge, and to insure uniform action two of the countershafts are connected by a longitudinal equalizing shaft. On this last is a motor-driven emergency brake, which will check the motion in case of any accident to the counterweight system.

In this bridge, the 245-ft. lift span will weigh about 500 tons, and can be raised or lowered by the machinery

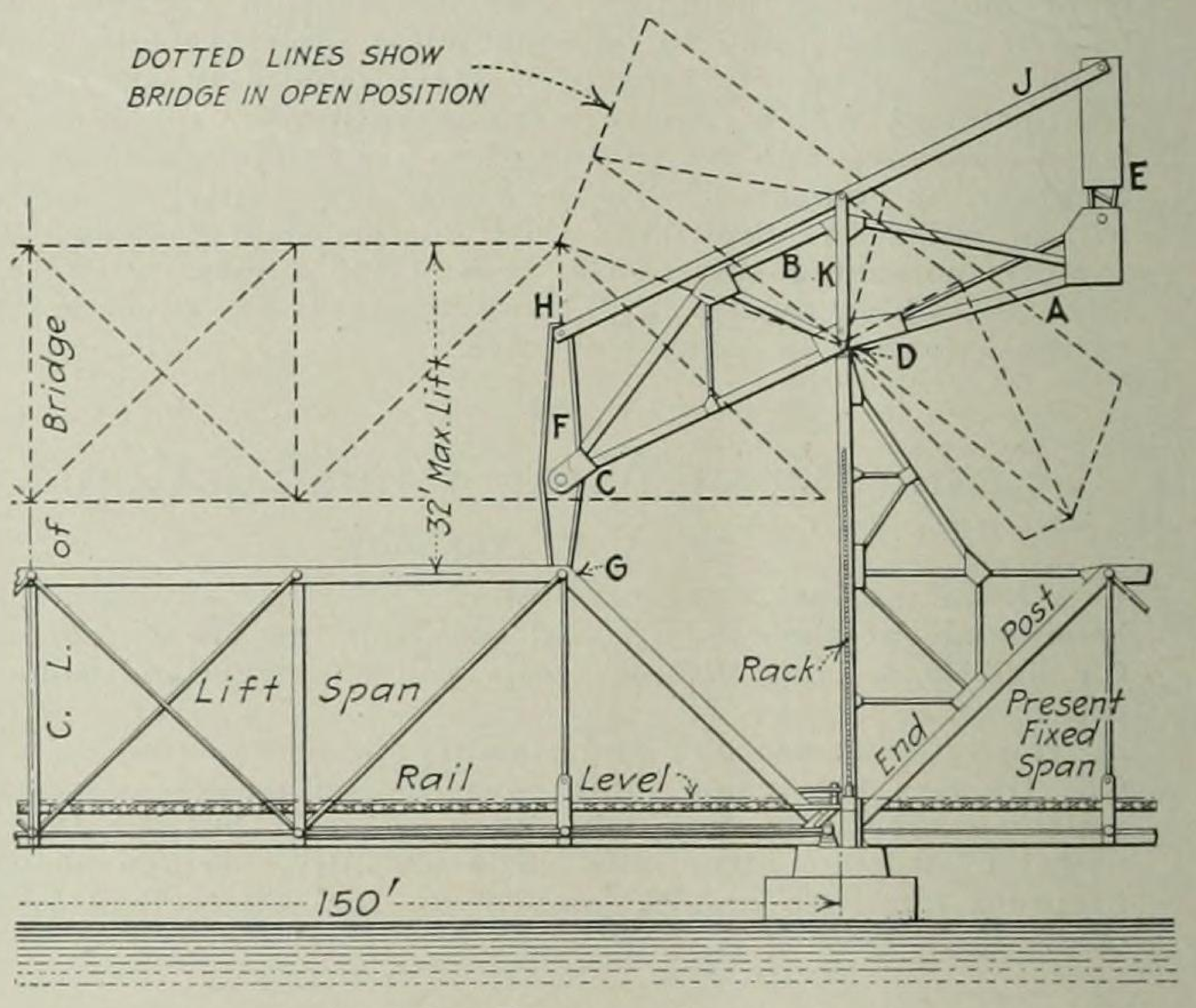

FIG. 2. COUNTERWEIGHT SYSTEM FOR DIRECT-LIFT DRAWBRIDGE (STRAUSS SYSTEM)

in about one minute, or by hand in about 50 minutes. The ratio of the gearing is as follows:

	No. of teeth	Pitch diam. in.	Pitch	Width of face in.
Motor pinion	18	15.14	3½ d.p.	3¾
Cross-shaft gear	126	36.00	3½ d.p.	3¾
Cross-shaft bevel pinions	20	10.00	2 d.p.	4
Countershaft bevel gear	60	30.00	2 d.p.	4
Countershaft pinions	15	8.36	1¾ in.	3½
Operating shaft spur gear	52	29.00	1¾ in.	3½
Operating pinion	15	11.94	2½ in.	6¾
Operating rack	240	.....	2½ in.	3½
Bevel pinion on hand shaft	16	12.72	2½ in.	3¼
Bevel gear on cross shaft	24	19.08	2½ in.	3¼

COUNTERWEIGHT SYSTEM

While the operation of the bridge by rack and pinion is extremely simple, the counterbalancing of the span in all positions is, at first sight, more involved. The arrangement of the counterweight system is shown in Fig. 2. Upon the tower or bent, is carried a rocking counterweight truss *ABC*, supported by the trunnion pin *D* at the top of the tower. The rear end of the truss is attached to the lower part of the counterweight, *E*, while the forward end is attached to a vertical hanger *F*. The lower end of the hanger is attached to the bridge span at *G*, and its upper end is attached to a link *H-J*, whose rear end is attached to the upper part of the counterweight *E*. Part of the weight of the link is carried by a vertical strut *K*, pivoted to the link and to the trunnion pin of the truss at *D*.

Thus the counterweight, truss, hanger and link form a jointed frame, which is so proportioned as to meet the requirements for perfect balance as follows: (1) That for all positions of the lift span the sum of the moments of all the forces about point *D* (the trunnion at the head of the tower) must equal zero; (2) the moment of the counterweight about the point *A* (at the counterweight end of the rocking truss) must be equal and opposite to the combined moments of the lift span, hanger and link about the point *C* (at the bridge end of the rocking truss). With this system the bridge is balanced in all positions, and the main trunnion reaction on the post of the tower or bent is constant and always vertical.

This type of bridge lends itself especially to cases where a fixed span has to be converted to a draw span. These cases may arise from the development of navigation on a stream crossed by a fixed bridge, or by the shifting of the navigable channel from the original draw span to one of the fixed spans (as sometimes occurs).

Arkansas River Bridge

The second case (or the possible necessity of shifting the draw span from its original location to another span of the bridge) is represented by a combined railway and highway bridge over the Arkansas River near Pine Bluff, Ark. This bridge will carry a steam railway and electric railway (on one track), with two roadways and two sidewalks, outside of the trusses. It will have six through-truss spans of 245 ft. and an end span of 140 ft., besides long trestle approaches. As built, the first 245-ft. span will be a lift span on the Strauss system, with towers carried by the piers and the end panels of the adjacent spans. The lifted weight will be 500 tons. The maximum lift is 50 ft., giving a clear headway of about 60 ft. above high water.

Should the channel shift from its present location, the towers and the operating and counterweight mechanism can readily be moved to any one of the other spans. To provide for such a change, the towers are so made that they can be disconnected at the top chords and moved along these chords which would serve as a track. To facilitate this also, the counterweights are made in blocks of such size as to be handled by one man, so that they can be removed and replaced readily when it is necessary to shift the towers. That such a movement is not improbable is shown in an article on drawbridges by C. E. Smith, in our issue of Jan. 23, 1913. This referred to two other bridges over the Arkansas River in which provision is made for the shifting of the navigable channel, and the article referred also to the advantages of the vertical-lift type of drawbridge under such conditions. The Roemheld Construction Co., Chicago, has the contract for the Pine Bluff bridge.

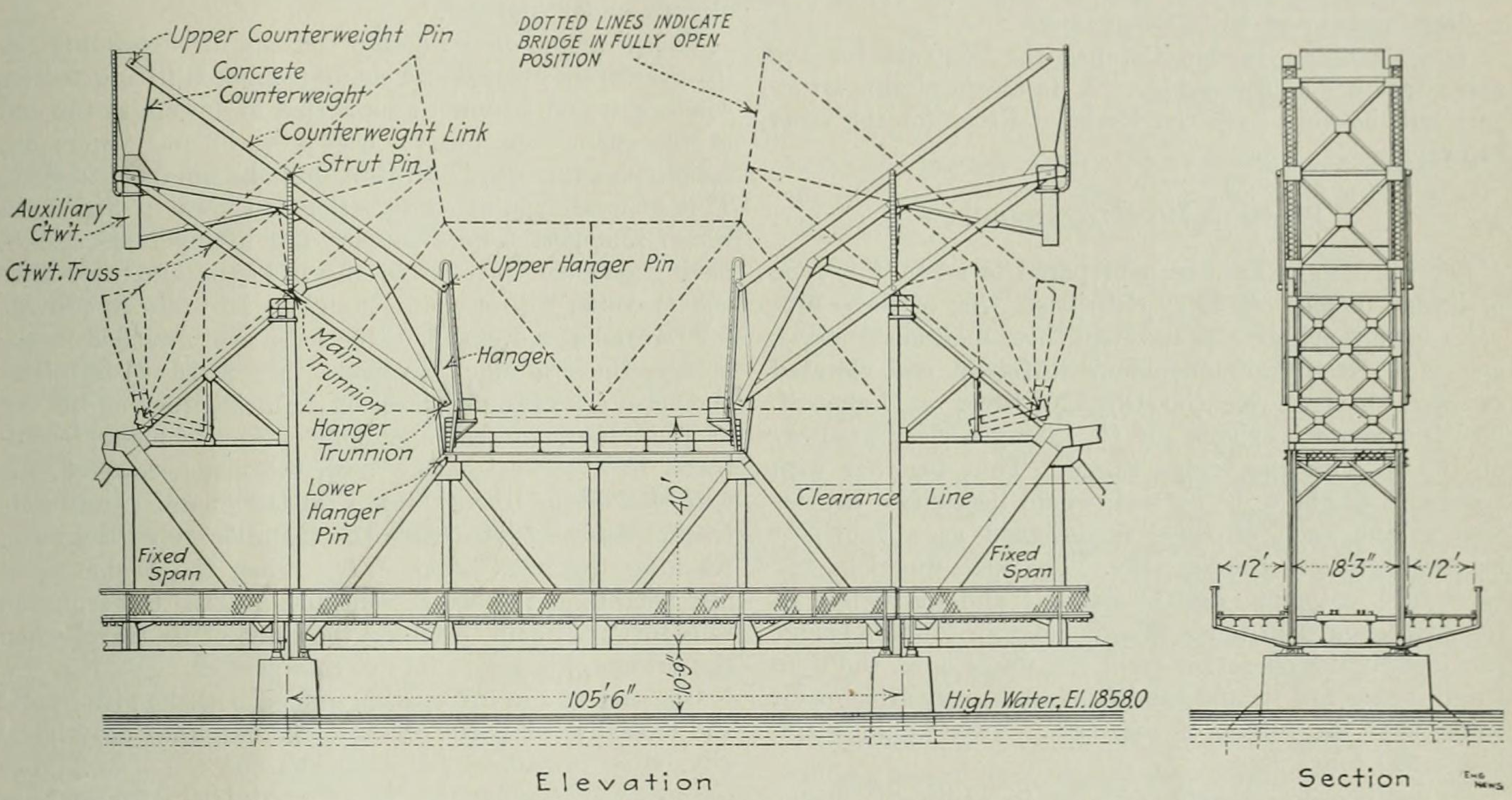

FIG. 3. DIRECT-LIFT SPAN OF COMBINED RAILWAY AND HIGHWAY BRIDGE OVER THE FRASER RIVER; GRAND TRUNK PACIFIC RY.

(Strauss Bascule Bridge Co., Designer, Canadian Bridge Co., Contractor.)

Steilacoom Creek Bridge

This direct-lift bridge is to be built to carry the Northern Pacific Ry. over Steilacoom Creek, near Tacoma, Wash. It will be a double-track riveted pony-truss lift span of 96 ft., with trestle approaches. An unusual feature in this case is that the towers are connected by overhead struts, for the reason that they are carried only by the piers and cannot be braced from the trestle. The lift in this case is about 43 ft. 6 in., giving a clear headway of 50 ft. with the bridge raised. The lifted weight will be 155 tons. The American Bridge Co. has the contract for this bridge.

Fraser River Bridge

For the channel span of the combined railway and highway bridge to be built by the Grand Trunk Pacific Ry. over the Fraser River near Fort George, B. C., the Strauss direct-lift system has been adopted. This lift-span, shown in Fig. 3, will be a 100-ft. riveted through-truss span, with towers supported on the piers and adjacent fixed spans. It will carry a single track line and two 12-ft. roadways. The weight of this span will be about 200 tons. Its lift will be about 40 ft., giving a clear headway of 50 ft. when raised.

The Canadian Bridge Co. has the contract for the superstructure of this bridge. A duplicate of this structure will be built over the Nechako River for the same railway.

Proposed Modified Designs

Several designs have been prepared to adapt this type of bridge to meet special conditions. One of these provides for a much greater lift than those mentioned above, and is a design for a double-deck (street and elevated railway) bridge over the Chicago River at Lake St. The lift would be about 104 ft., giving a clear headway of 120 ft. with the bridge raised. This, together with the great weight to be carried, would necessitate heavier towers, and each of these is designed as a four-post braced tower on cylinder piers. The span would be 244 ft. c. to c. of piers (200-ft. channel) and the weight of lift span about 930 tons. Another design for this bridge provides for its operation from one tower only, the span length being 218 ft. and the lifting or hanger attachment being near the center of the span. This would weigh about 660 tons.

In another design, proposed for the 12th St. bridge over the Chicago River, the counterweight trusses form part of a suspension system, from which the live load is carried. The connections at the hangers would permit their movement without disengagement from the suspension truss. This design is said to be specially adapted for bridges of ornamental character.

In bridges with the floor high above water level, yet not sufficiently high for navigation, the counterweight system may be mounted beneath the level of the lift span. The same arrangement may be applied also for canal bridges, where space is limited and the lift is small. In this latter case, the counterweight system is arranged to be mounted in masonry pits below the ground, with the counterweight trusses placed at right angles to the line of the bridge. For such bridges, stairs may be erected on the abutments to provide for foot traffic while the span is raised.

Finally, for short plate-girder lift spans, a design has been made which dispenses with towers, each trunnion being mounted on a single post, braced from the pier. In this design, the hanger attachment is made at the bottom flange of the girders.

A Vertical-Lift Drawbridge without Cables

The vertical-lift type of drawbridge has received a considerable amount of attention within recent years, as noted in a preceding article, but while the existing bridges are operated by means of cables, we describe herewith the design of a vertical-lift bridge which is supported and operated without cables or chains. This type of bridge is said to be particularly adapted to and economical in cases where the height of travel or lift is not great, although it can be applied where the lift is as high as 150 ft. The design described below was developed by the Strobel Steel Construction Co., of Chicago, which controls patents covering the general design and specific details, and we are indebted to the engineers of the company for information, as well as for drawings showing different applications of the design. One bridge of this type is already under contract.

The principle of the design consists in suspending the lift span from pivoted and counterweighted lifting trusses which move on trunnions supported by towers at the end of the span. On the vertical posts of the towers are racks engaging with operating pinions on the lift span. This general type of construction is shown in Fig. 1, in which four-post towers support the lifting trusses *A-B*, having one end pivoted to the lift-span and the other end provided with a counterweight. In order to provide for the radial movement of the lever arm attached to the bridge, the trunnion-bearings *C* are fitted with rollers and have a horizontal travel on a track girder at the top of the tower, so that the point of attachment *B* will travel in a vertical path. With the bridge lowered, the trunnion of the lifting truss is at the forward end of its track. As the bridge rises the trunnion rolls backward, reaching the limit of its travel when the bridge is at mid-height; as the bridge continues to rise, the trunnion rolls forward again, reaching the limit of its travel when the bridge is lifted to its extreme position.

One end of the lift span is guided both longitudinally and laterally, while the opposite end is guided only laterally, thus providing for expansion of the span. The operating mechanism is mounted on the lift span, and has bevel-gear connections to a longitudinal shaft which carries the operation pinions.

In Fig. 2, this vertical-lift system is shown as adapted for cases where an existing fixed span must be converted into a movable span in order to provide for navigation and where the adjacent spans must not be loaded by the lifting apparatus, but the weight must be carried directly by the piers. This is effected by carrying the lifting truss *A-B* on a vertical bent *C*, on each pier, and braced to the adjacent span. In this case, however, no longitudinal movement of the trunnions is practicable and the trunnions are carried in fixed bearings at *D* on top of the posts. The necessary longitudinal travel to compensate for the radial movement of the lever arm is provided, therefore, at the point of attachment of the arm (or lifting truss) to the lift span. At this point an additional member *E* is built upon the bridge truss, and carries beneath it a track plate *F*, against which bears the roller *G* at the end of the lifting truss. The operation will be understood readily from the dotted lines, which show the curved path of the rollers and the vertical path of the bridge.

In the designs shown in Figs. 1 and 2, the lifting apparatus is provided at both ends of the bridge. A modified design in which the bridge is operated entirely from one end is shown in Fig. 3. In this design, also, the operating machinery is carried upon the tower instead of upon the bridge. In this case, the bridge in moving vertically has a longitudinal and horizontal movement, swinging in a vertical arc due to the radial movement of the arm of the lifting truss. This truss *A-B* has a fixed trunnion on the head of the tower at *C*, and a pin attachment to the lift span at *B*. To hold the span in a horizontal position while moving, the end of the bottom chord of the span is attached to the controlling strut *D-E*, the rear end of which is pivoted to the tower. Thus, as the lifting truss rises, the bridge is suspended from the pin *B* at the end of the top chord and supported longitudinally by the pin *D* at the end of the bottom chord.

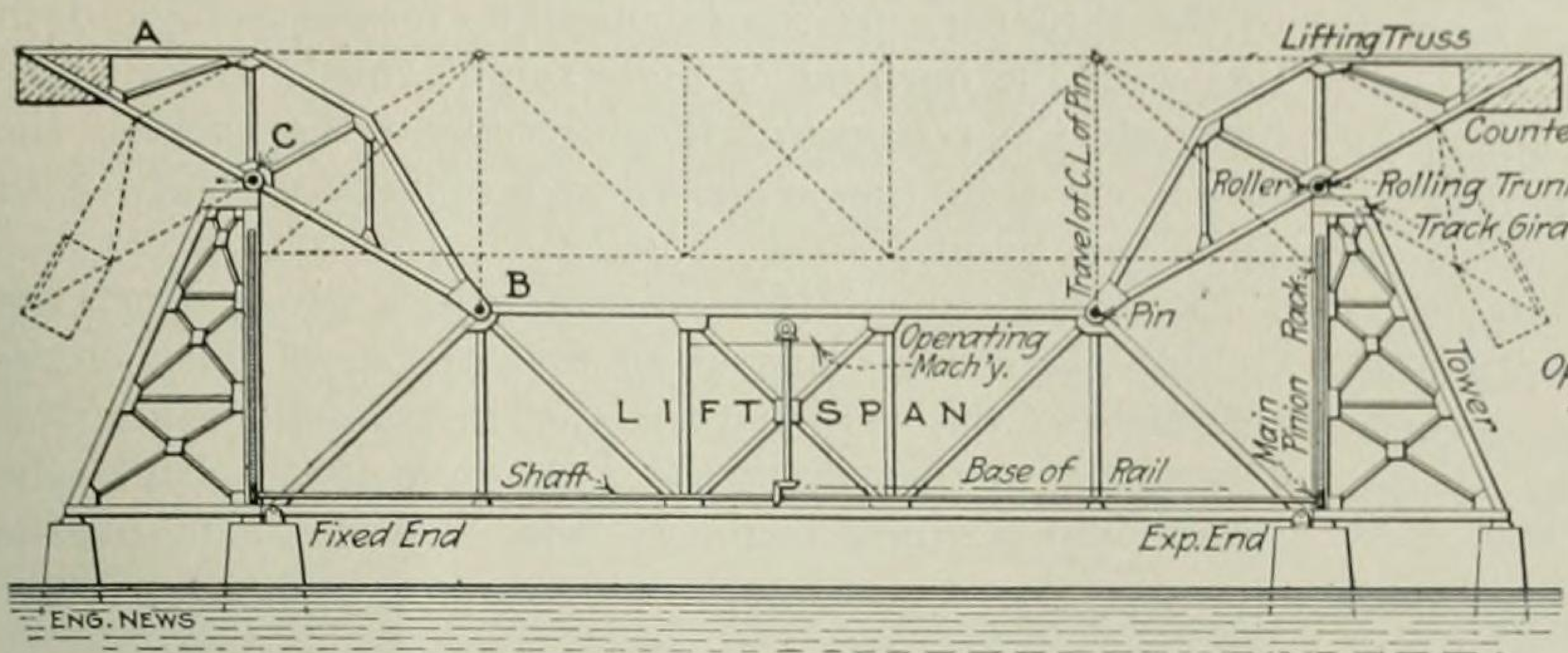

FIG. 1. DESIGN OF VERTICAL-LIFT DRAWBRIDGE WITHOUT CABLES

(Strobel Steel Construction Co., Chicago.)

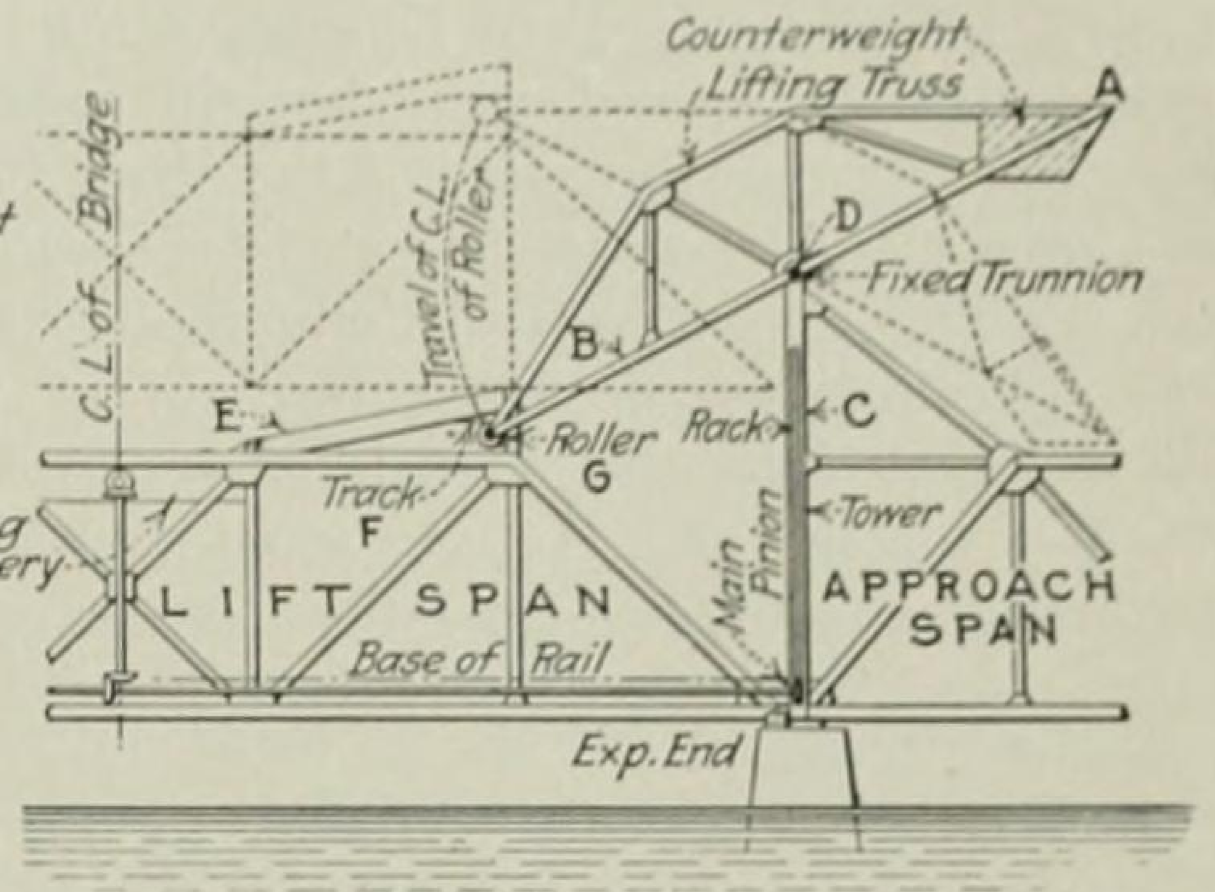

FIG. 2. VERTICAL-LIFT ARRANGEMENT (STROBEL SYSTEM) AS ADAPTED FOR CONVERTING A FIXED-SPAN TO A DRAW-SPAN

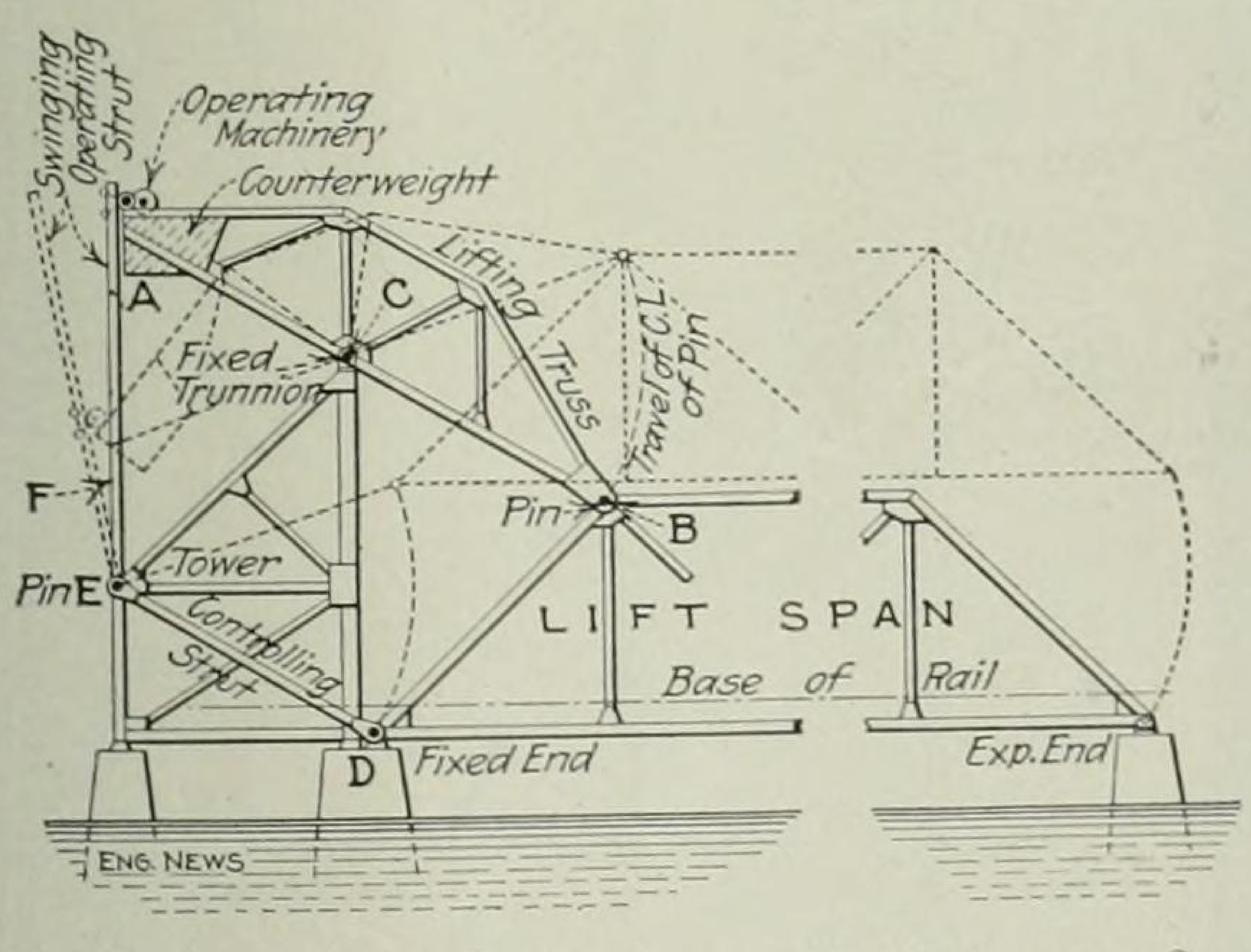

FIG. 3. VERTICAL-LIFT ARRANGEMENT FOR OPERATING A BRIDGE FROM ONE END (STROBEL SYSTEM)

The operating mechanism is different from that of the other designs. It is carried on the counterweighted or tail end of the lifting truss, at *A*, and serves as a part of the counterweight instead of adding to the weight to be lifted. The pinion engages with a rack on a vertical operating strut *F*, which is pivoted to the rear post of the tower. As the bridge rises, the pinion rides downward on the rack, the strut swinging outward to accommodate the curved path of travel of the pinion, as shown.

An alternative arrangement proposed is to put the trunnion bearing of the lifting truss at *E* and to attach this truss to the bottom chord of the lift span, while the controlling strut would be pivoted to the head of the tower and the top chord of the lift span. In other words, the positions of the lifting truss and controlling strut in Fig. 3 would be reversed. A second alternative is to replace the controlling strut by a second lifting truss, which would be somewhat similar to the arrangement employed for the Frederick Bridge at Dresden, Germany.

A LONGITUDINAL-MOVEMENT DRAWBRIDGE

The temporary removal of a fixed span (to provide for infrequent navigation) by a derrick car which raises the bridge and runs it back longitudinally, is familiar to engineers, and was noted in our issue of Jan. 23, 1913. It is not generally known that designs were made some time ago for the regular operation of a drawspan in this way, the part of the derrick car being taken by counterweighted lifting trusses carried by trunnion bearings on a tower traveling on tracks outside of the line of the bridge girders. By rocking the trusses on their trunnions the bridge would be raised clear of the abutments, and the towers would then be run back sufficiently to carry the bridge clear of the opening. This design was invented and patented by Mr. Strobel, and is worth mention here, although the design has not been carried into practice.

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The West Virginia Public-Utility Law which goes into effect soon provides for four commissioners, each with an eight-year term of service and a salary of $6000. The commission is given jurisdiction over the usual common carriers, over gas and electric companies, telegraph and telephone companies, and over municipalities furnishing gas or electricity. The jurisdiction is specifically extended over car companies, toll bridges and ferries, hydroelectric generating and transmitting companies, water companies, and persons, associations, corporations, or agencies employed in the several businesses noted. The commission also has to perform duties in connection with any workmen's compensation law which may be established. It has the usual power over rates and service, except that it cannot reduce any rates within ten years after the completion of a road or plant below a point which would prevent the owning corporation from making a net earning of 8% on the cost of construction and equipment. The commission is instructed to collect full and complete data on the value of all property owned and controlled by these corporations once a year, and to furnish this information to the Board of Public Works for tax assessments. The new law lays a new tax on public-service corporations by a special license fee proportioned to the value of the corporation's property. This tax is to be distributed so that its aggregate will produce a revenue of $60,000 a year for the support of the commission.

Direct-Lift Span Provides 55-Foot Clearance Over Louisville and Portland Canal

Waterway Improvements at Louisville Include Unusual Type of Vertical Lift Span Raised 40 Feet by Levers on Approach Spans

EXTENSIVE improvements of the Louisville and Portland Canal at Louisville, Ky., carried on by the U. S. Government, have been in progress for several years past and are now nearing completion. They consist principally in widening the canal from 86½ ft. to 200 ft., in building a new lock 600 ft. long by 110 ft. wide alongside of the old locks and in the renewal of the two existing swing bridges crossing the canal. The new lock was described in the Engineering Record of June 26, page 794.

The old swing bridges were originally built about the year 1866, one at the head of the locks and the other at Eighteenth Street over the canal proper at Louisville. The former is being replaced by a swing bridge 275 ft. long spanning both old and new locks, the pivot pier being located between them. The Eighteenth Street swing bridge has just been replaced by a Strauss direct-lift bridge spanning the entire width of the 200-ft. canal. The old swing bridge had unequal arms, spanning 87 ft., the former width of the canal.

Conditions Governing Design

The craft that navigate in the Ohio River at Louisville do not require more than 55 ft. vertical clearance above high-water level. On account of the low vertical clearance required, compared with the length of span, the lift type of bridge was considered best. The invitation asking designs for this structure, as issued by Major J. C. Oakes, Corps of Engineers, U. S. A., in charge of the work, contained the following clause:

"In making a comparison and selection the following are some of the points which will be considered: First cost, probable cost of maintenance and operation, advantages and disadvantages of the type of operating machinery as to the reliability of operation and chances for accidents, and provision for preventing the lift span from falling if any accident happens to parts of the operating apparatus."

First cost, therefore, was only one of a number of factors which were considered in selecting the type of lift here adopted.

General Features of Design

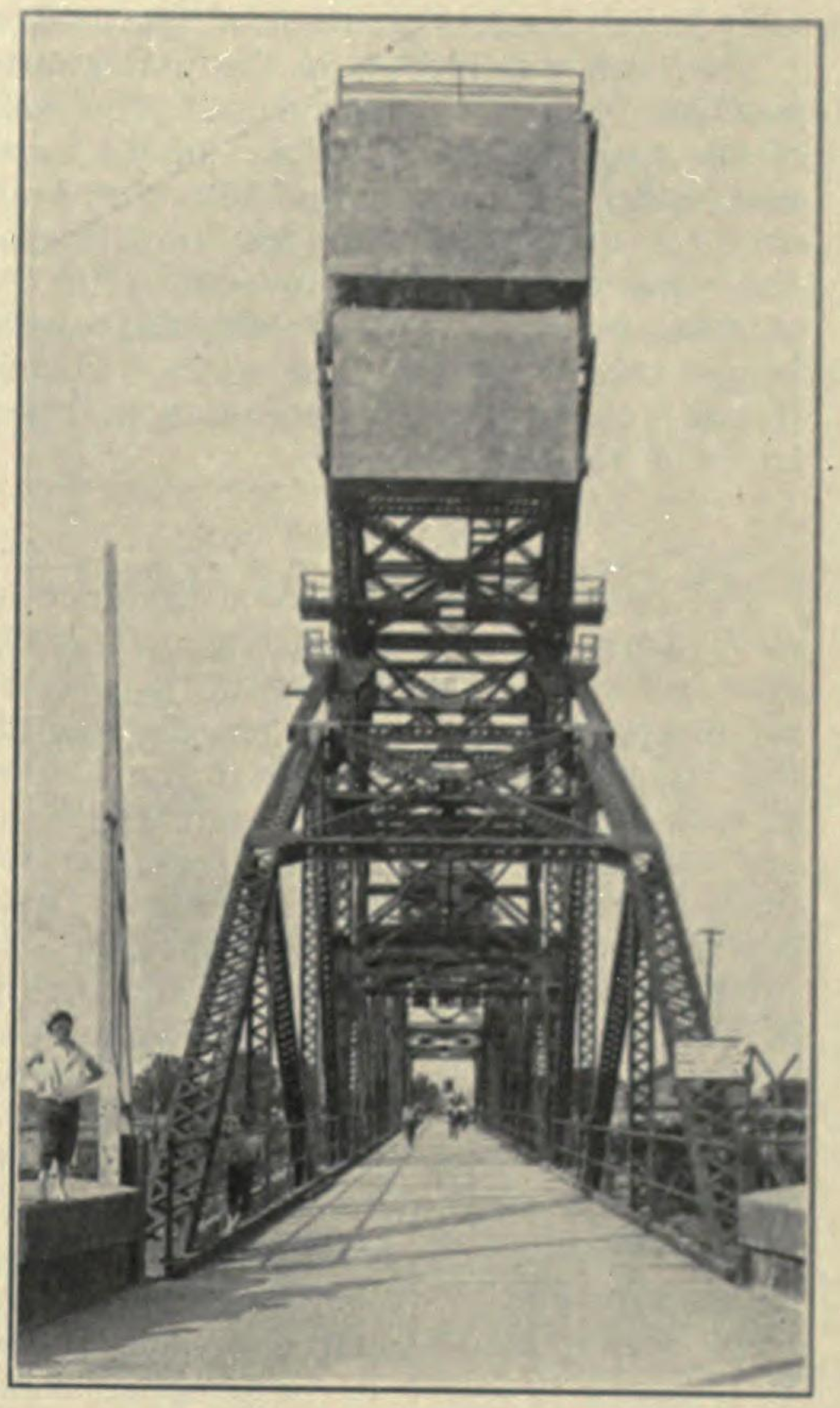
The bridge consists of the main, or lift span, 210 ft. long, and an approach span at each end, 85 ft. and 75 ft. long respectively. The main trusses, which contain eight panels, each 26 ft. 3 in. long, are of the Pratt type with inclined upper chords, and are spaced 18 ft. apart. The approach trusses are spaced 18 ft. 6 in. apart, and the unusual offset top strut to the main column, required to allow clearance for the counterweights, can be seen in the photograph showing an end view.

The existing stone center pier of the old swing bridge has been utilized for the west pier of the lift span, and a new concrete pier, founded on rock, supports the opposite end. Photographic views reproduced herewith illustrate the finished structure. The rectangular pier showing under the center of the span is the old rest pier of the swing bridge, which, together with the old stone canal wall, will be removed when the new wall and widened part of the canal are completed.

The bridge is designed for highway traffic only. The roadway has 16-ft. clear width, the floor system and its supports being designed for a live load of 100 lb. per square foot, or one 15-ton truck on two axles 10 ft. on centers. The trusses are designed for a live load of 100 lb. per square foot of roadway. The usual unit stresses for work of this character were followed in proportioning the members. The specified permissible stresses were allowed an increase of 25 per cent during erection.

Counterbalancing the Lift Span

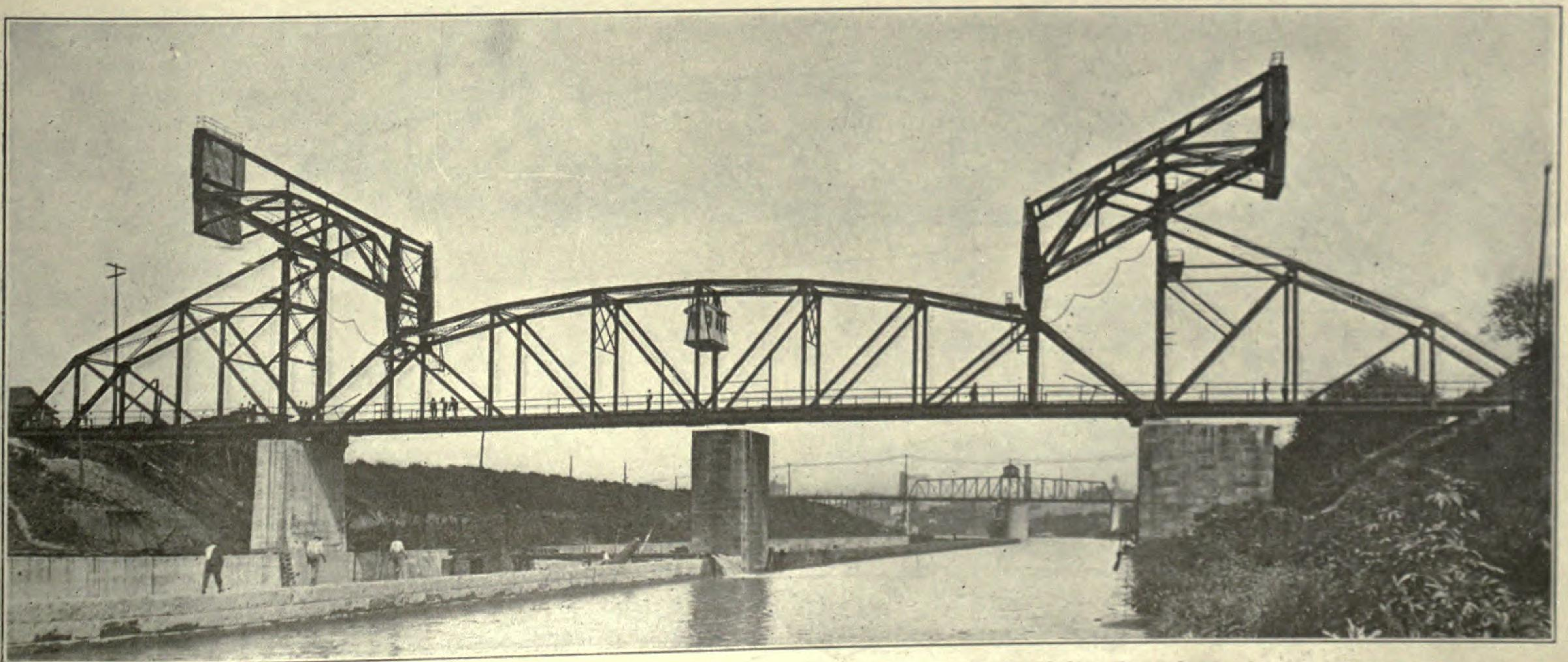
The lift span is counterbalanced by counterweighted crane-like trusses pivotally mounted on the main vertical posts of the approach spans at either end. These counterweighted trusses are provided with a pair



OFFSET TOP STRUTS PROVIDE CLEARANCE FOR COUNTERWEIGHTS

of hangers, pin-connected near their midsections, while the lower extremities are pin-connected to the lift span, and their upper extremities are pin-connected to a member termed the "counterweight link," the rear extremity of which is pin-connected to the counterweight.

The concrete counterweight itself is so connected to the rear extremity of the counterweight trusses that the four main pin points form a parallelogram. By virtue of this parallelogram and the connecting hanger the main span and center of gravity of the counterweight are permitted to move vertically. The lower auxiliary fixed counterweight balances the weight of the hanger and brings the center of gravity of all the dead-load forces to the center of the main trunnions at the top of the tower post. The moments of span and counterweight about the main trunnions are ex-



CLOSED POSITION OF NEW DIRECT-LIFT SPAN 210 FEET LONG—CENTER PIER OF OLD SWING SPAN TO BE REMOVED actly equal for any position of the bridge.

The span was erected in the partly open position to permit navigation. The half of the span over the new part of the canal was built on falsework, and the other half, over the navigable canal, was cantilevered out without the use of falsework in the existing canal. The alignment of the new bridge coincides with that of the old, but it was not necessary to maintain highway traffic during erection.

Electric Operation

The span travels a vertical distance of 40 ft. from the closed position to the fully open position. The movement is effected by means of electric operation, the operating pinions, four in number, being located at each corner of the span below the floor, and engaging vertical fixed racks on the inside faces of the tower posts. These pinions are actuated, through shafting and intermediate gears, by two 11 hp. direct-current motors located near the center line of the span and controlled from an operator's house, at the center of the span, suspended from the top chords above the clearance line as seen in the photographs.

One minute is required to raise the span, by electric power, from the closed to the fully open position, and the same period is required to lower it. Emergency hand operation is also provided by two turning levers which can be used at each end in the center of the roadway. Indicators are installed in the operator's house, consisting of white and red incandescent lights showing the various positions of the bridge. The movement automatically cuts out the lifting motors when the span is 6 ft. from the fully open or the fully closed position. However, a spring switch is provided which, if held closed, will render the automatic cut-out ineffectual and enable the bridge tender further to operate the bridge. Safety gates are provided on the approaches, controlled from the operator's house and interlocked with the lifting machinery so that the latter cannot be operated until the gates are closed, and the gates cannot be opened again until the bridge is closed.

The structural steel in the lift span, counterweight trusses and approaches, weighs approximately 250 tons. The operating machinery and trunnions weigh approximately 20 tons. The steel was furnished by the Penn Bridge Company of Beaver Falls, Pa., and erected by the Middle States Construction Company of Columbus, Ohio. The Strauss Bascule Bridge Company of Chicago, consulting engineers, furnished the plans and specifications under the direction of Major J. C. Oakes, U. S. engineer at Louisville, in whose office the contract for construction was awarded in July, 1914. The bridge was completed and first operated June 23, 1915.

Rattler Test for Paving Brick Abandoned in St. Louis

Instead There Has Been Substituted a Standard Sample of One Hundred Bricks by Which Shipments Are to Be Judged

By MONT SCHUYLER
Engineer in Charge, Municipal Testing Laboratory, St. Louis

NO DOUBT the rattler test in all of its various forms has improved vastly the quality of paving brick. It is necessary that a certain strength both against disruption and abrasion should be present in every brick, and this quality, or set of qualities, is, of course, measured coarsely by any method involving rough handling, such as the rattler test undoubtedly is. But that the brick's value as a paving material can be determined with any accuracy by this method is a matter upon which more and more people have reached, first, a doubting stage, and, then, finally, a stage wherein the rattler is considered merely as a method of adjustment between the brick seller and the brick buyer. In other words, the rattler test is not an engineering instrument.

Visual Inspection in Theory as Well as in Practice

Though, as above stated, the rattler has done much to improve the character of brick, and no doubt will in the future maintain a certain position in the paving field, still it is the writer's belief that, as time goes on, less and less attention will be paid to the extreme refinements added during the past few years. The machine will then be used perhaps in conjunction with other machines to determine the presence or absence of certain qualities in the product of this or that factory, the actual acceptance or rejection of brick being based openly, as it is now actually, on visual inspection while brick are being handled from the kiln to the pavement.

While this thesis may be disputed in various quarters, it cannot be denied that many engineers and brick manufacturers are tending toward a gradual abandonment of the rattler. This the writer knows from many conversations with men from all parts of the country.

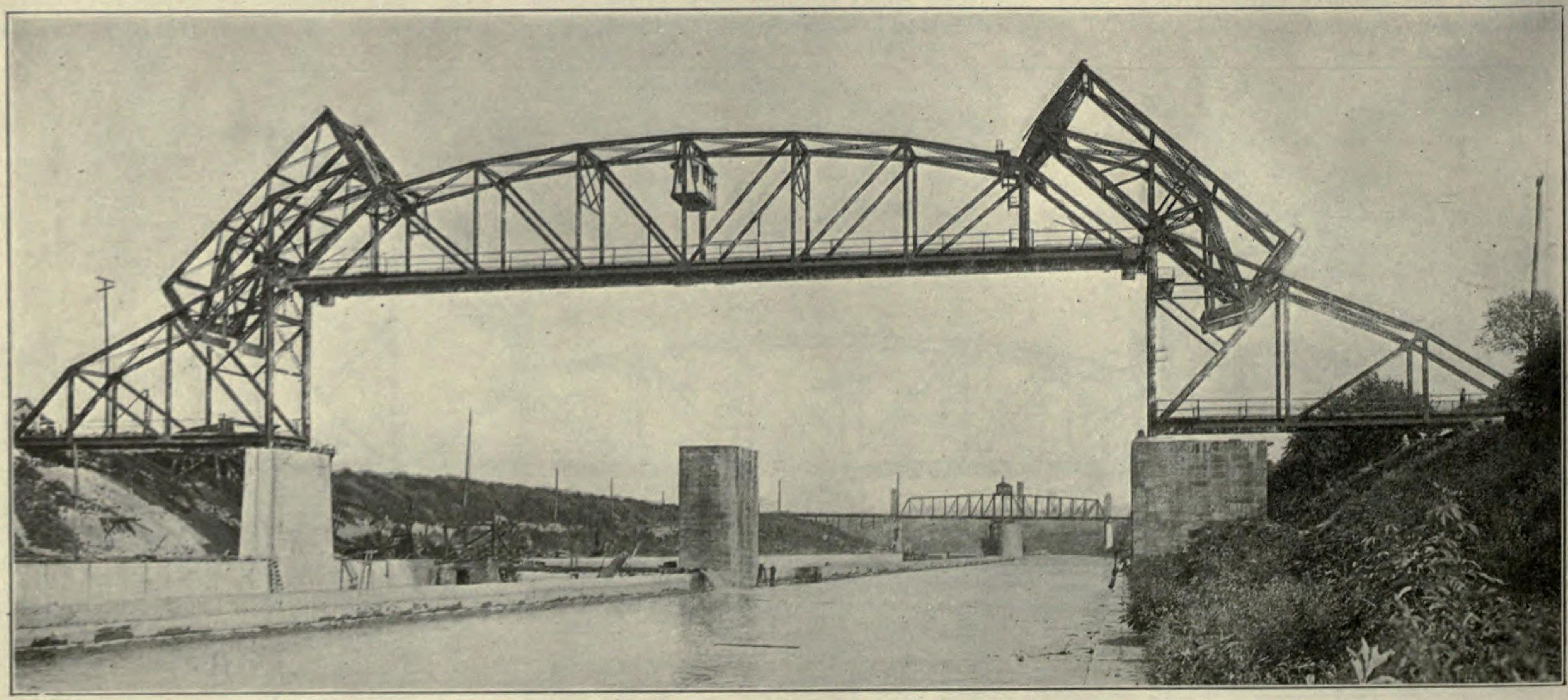
Following out this general tendency the city of St. Louis, in its new specifications, has omitted all reference to the rattler test, placing reliance solely upon the general knowledge of brick extant in that city's construction and testing department. The new specifications, referring to paving brick, read as follows:

Paving Brick

General

"Vitrified paving brick shall be made from suitable shales or inferior fire clay burnt to uniform texture throughout. They shall be thoroughly and uniformly vitrified and annealed, containing neither unfused nor glassy spots, and shall not be salt glazed. They shall be tough and uniformly hard. They shall be free from defects such as laminations, fire cracks, cooling checks, etc. They shall be free from lime or other impurities. They shall be unrepressed, side wire-cut in such a manner that the lugs will be formed during the process of cutting and shall have the ends beveled.

"At least one month before the contractor begins laying the wearing surface he shall submit one hundred (100) specimen brick of the brand he expects to use to the Board of Standardization, unless samples of brick proposed to be used are already on file. The type, the range of burning, the variation in dimensions and the general condition of the brick which the contractor expects to furnish shall be exhibited by these specimens. The president of the Board of Public Service will cull from this lot the brick



DIRECT-LIFT SPAN IN OPEN POSITION WITH CLEARANCE OF 55 FEET—SPAN LIFTED 40 FEET BY LEVERS AND PARALLEL LINKS than one man should. Either the superintendent should be free to help him, or he should have a competent assistant.

The selection of those foremen and mechanics who are not readily picked up at the work, and who are carried by a contractor from place to place, should be made, or at least passed on, by some one person in the main office who is an expert at the business of knowing a man when he has talked to him. No man should be taken on without a personal interview. A fair-sized contracting business can well afford at least one expert of this sort, whose main concern is employing men. Many readers will be able to recall instances where, for lack of such an expert, contractors have suffered from the most ridiculous mistakes made by men sent as competents by the main office.

Having provided a definite man to employ others on each job, a contractor should watch that feature of the work carefully, and see whether each particular man's judgment can be improved. On visiting a contract it is often easier to tell what is wrong than to right it. If the wrong men are employed on one of your jobs, or men picked for one class of work are doing other work for which they are not fit, a little observation will disclose the fact. To set it right, however, may require both tact and patience. Nevertheless, it will not be hard to find men enough in the average executive force who can at least be taught to do this work, if they are not able to do it already.

To interest these men and train them to this way of doing is at the present time the best of business. The man who waits till competition forces him to adopt a progressive measure stays right where he was before his competitors began to adopt it—a little to the rear of the procession and profits.—D. H. Hammond, in The Engineering Record.

Building the Substructure of the G. T. P. Bridge over the Fraser River at Prince George, B. C.

Staff article, prepared from data and illustrations kindly furnished by Mr. E. Stanley Holland, Vice-President of the Bates & Rogers Construction Company, Chicago.

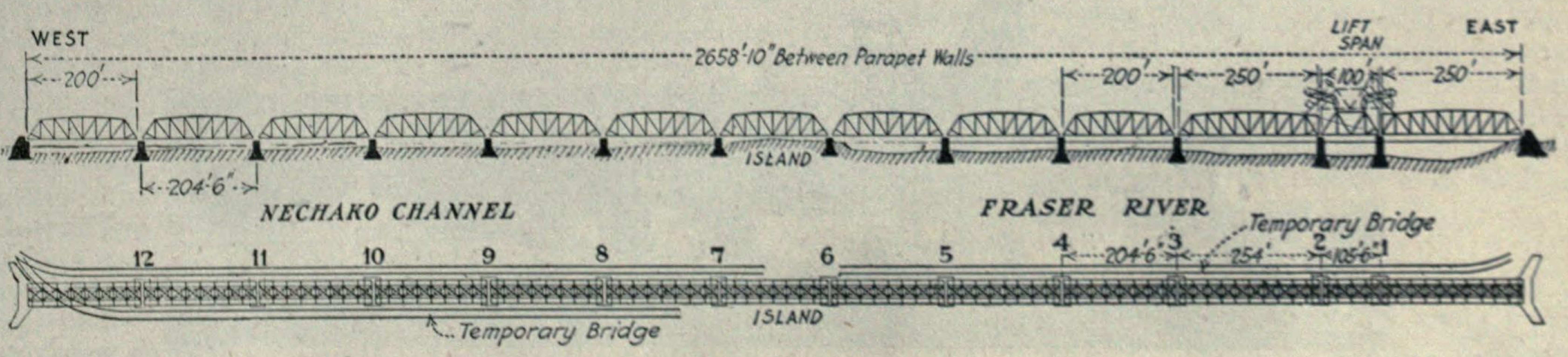
ONE of the interesting features of construction on the Pacific Coast section of the new Transcontinental line of the Grand Trunk Pacific Railway is the bridge foundation work along the Fraser River between Tete Jaune Cache and Fort George in British Columbia. The largest and most important of these structures is over the Fraser River at Fort George—or Prince George, as the new railroad town is named—known as the Fourth Crossing of the Fraser River.

For one hundred and eighty-five miles between Tete Jaune Cache and Prince George, the railway follows the Fraser River through several ranges of mountains, the distance by river being over three hundred miles. The country is wild and rugged and inhabited mainly by Indians and trappers.

In the summer, the melting glaciers and snow turn the Fraser into a deep, swift river. It was not possible for the railway company to maintain a temporary bridge across this river during the entire year, and for this reason it was necessary to construct the substructure well in advance of track construction.

Under these conditions it was necessary to transport all camp and construction equipment and supplies, as well as cement, to the site of the work long before the railroad had arrived. The nature of the country was such that wagon roads were impossible. The only means of delivering this material was by boat or scow on the Fraser River, which is navigable only during the high-water period. Actual construction had to be carried on during the low-water period, which usually begins during September or October and continues until April or May. A number of sternwheel steamers, of the usual type, were operated on the river, but they could not begin to handle the tonnage. For this reason, scows, from 36 to 40 ft. long, and from 12 to 14 ft. wide, carrying 12 to 25 tons each, were floated down the river from the end of steel to the site of the work. They were handled by sweeps at each end, each sweep being manned by two men. In the more dangerous canyons and rapids, pilots and several additional men were put on to assist the crews, but even with this precaution, entire cargos were frequently lost. The average mileage a day for a scow was 50, with a maximum of 70 miles. Notwithstanding the difficulties attendant upon this method of transportation, over ten thousand of a total of eighteen thousand barrels of cement for the Fourth Crossing, as well as camp supplies and almost all of the construction equipment, were taken down the Fraser River in this manner, a maximum distance of over three hundred miles.

During the winter season, a considerable amount of freight was handled by teams travelling on the ice in the river. Freight was handled in this manner for a maximum distance of 150 miles. At one time in



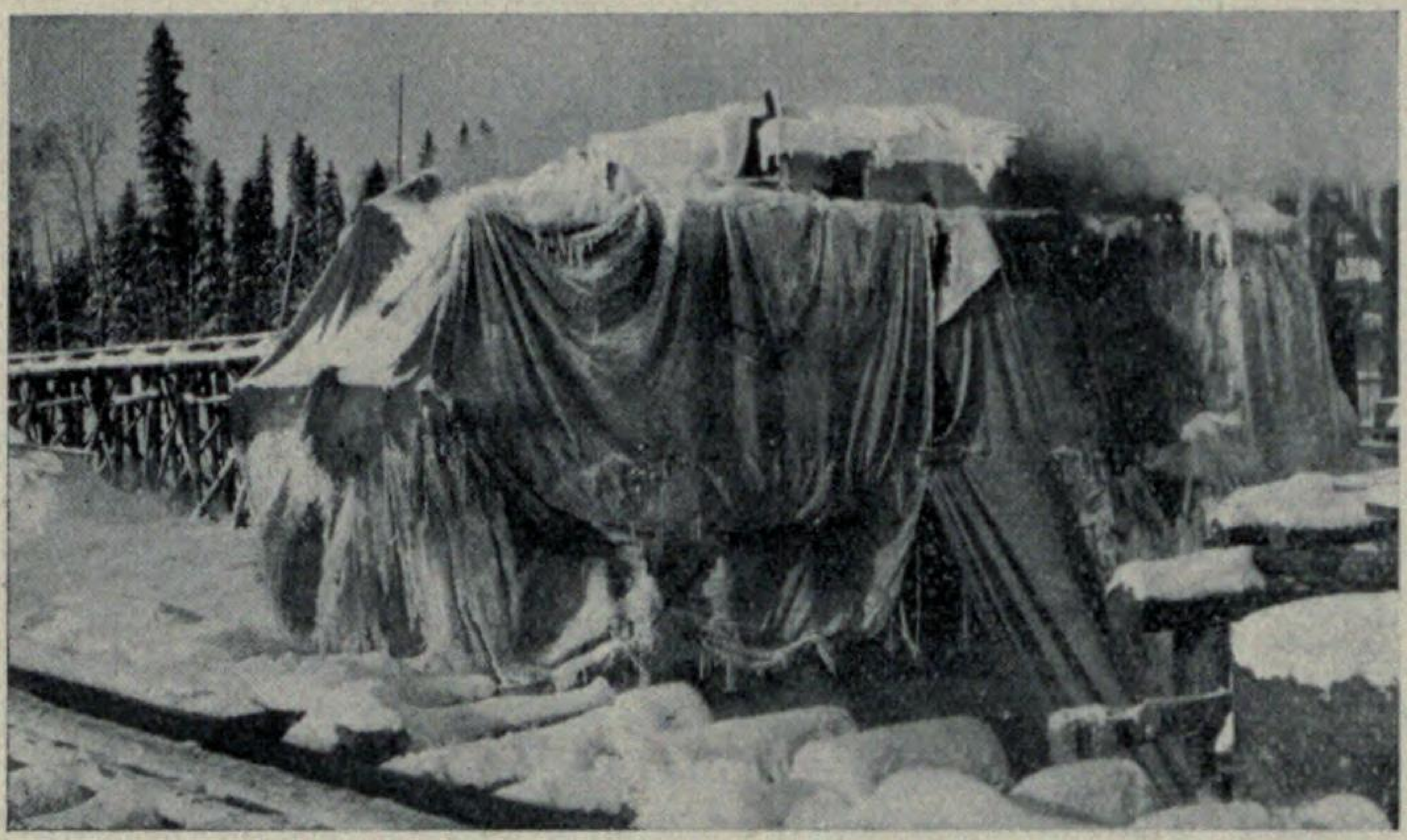
G. T. P. Bridge at the Fourth Crossing of the Fraser River.

mid-winter, when the ice conditions were good, about four hundred teams were hauling equipment and materials. Some two-horse teams would haul as much as seven tons.

After the close of navigation, getting to the site of the work was a difficult matter. Dog teams were occasionally employed, and at some points teams could be used along the railroad company's embankment. Frequently it was necessary for the contractors, superintendents and others to walk one hundred miles or more to reach the work.

The general contractors for the construction of the railroad had a single line telephone system serving all camps along the line. This was a great help, although the single wire was inadequate for the service required.

The bridge at the Fourth Crossing is just below the confluence of the Fraser and Nechaco Rivers. Here the line crosses an island with the deep water channel, known as the Fraser Channel, on the east side, while the Nechaco Channel, an overflow during high-water, is on the west side. The length of the bridge at this point is 2,658 ft. A plan and profile are shown herewith. The contractor's camp was located on the island between the Fraser and Nechaco Channels and accommodated six hundred men. The bunk-houses were frame buildings covered with prepared roofing. The store houses for cement and material were large frame buildings covered wth heavy tarpaulins, of exceptionally fine canvas—made in Scotland. Most of these tarpaulins had been used for protecting cement on the trip down the river. An auxiliary camp to accommodate one hundred men was established on the east bank. This was rendered necessary on account of the great danger, due to floating ice, in taking laborers across the main channel before the contractor's temporary bridge was completed. The establishment of this camp proved very fortunate, for in the spring, when the ice took out a large part of the temporary bridge, the work on the east bank was carried on without interruption.



Method of protecting concrete in severe weather.

A complete day and night organization was maintained during the entire work, each pier of the Fraser Channel having a complete plant as well as an individual crew. A night and day foreman for each pier worked together, shifting the crews every two weeks. Each foreman reported to the general foreman, there being one general foreman for each shift. The general foreman reported to the superintendent, who was located on the work.

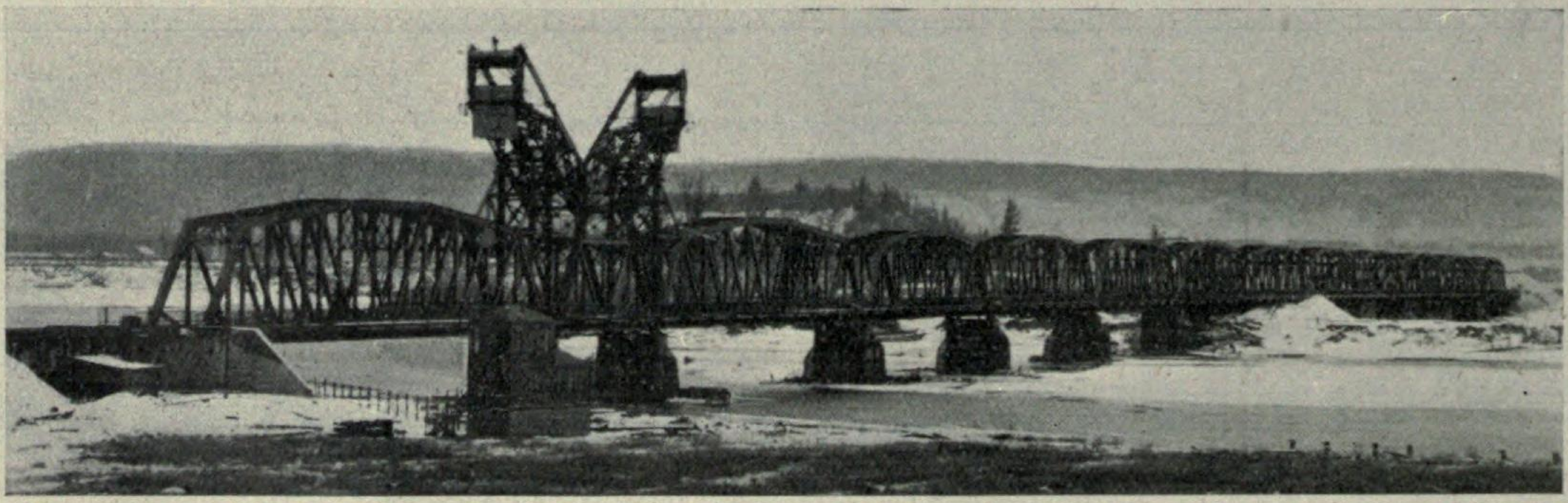
The substructure consists of twelve concrete piers and two abutments all resting on pile foundations. The deepest foundations are at piers No. 1 and No. 2, which were carried 25 ft. below record low water. The average depth of water during the progress of the work was well over 30 feet, requiring 40 ft. steel sheet piles in the cofferdam. Careful soundings taken before the work was started showed gravel with underlying strata of very stiff sandy clay, with layers of quicksand. An exhaustive study was made of the individual pier and abutment sites, and coffer-dams were designed to suit the conditions at each point. Three types of coffer-dams were used—cribs, steel sheet piles and triple lap wooden sheet piles. The coffer-dams were made of sufficient size to allow ample room for the necessary coffer-dam piles, bracing and other timbers. The bracing was spaced to allow of dredging with grab buckets.

Actual work on the shore was commenced in September, 1913, on the east abutment and pier No. 6, the only units then accessible. The temporary bridge, from which all work was directed, was started at this time and carried out as far as navigation laws permtted. Later, when floating ice stopped navigation, it was found difficult to drive the remainder of the bridge, and it was not until January that it was entirely completed. The river, with a current of five to six miles an hour and filled with floating ice, presented a formidable obstruction, not only against the construction of the temporary bridge, but it seriously hindered the construction of coffer-dams.

The general programme of construction for each pier was as follows:

1.—Open dredging was carried as deep as it could be maintained.

2.—The coffer-dams were then built. Where crib coffer-dams were used, they were built and sunk in the ordinary way. For steel coffer-dams, wooden piles



The completed structure.

were driven about 8 ft., centre to centre, around the space to be inclosed. These were carefully lined up and two sets of timbers, 4 ft. apart vertically, bolted on the inside of the piles above water to act as guides for the steel sheeting. Three or four complete sets of waling and bracing were then placed and sunk as deep as possible. The steel sheeting was then set inside the guide timbers, it being driven about 3 ft. as set and the closure made when the last sheet pile was set. After closure, the steel was driven to the full depth required, usually 6 ft. below the elevation required for the bottom of the foundation.

3.—Excavation inside the coffer-dam was continued with dredges, teeth being used on clam-shell buckets when clay was encountered. As far as possible the waling and bracing were sunk as the excavation proceeded. The excavation was usually carried 2 ft. below the bottom elevation required, in order to allow for swell due to driving foundation piles.

4.—When the excavation was completed, the foundation piles were driven and cut off under water by means of a circular saw on the end of a shaft. The penetration of the foundation piling was about 20 ft. below cut-off. The driving was very difficult.

5.—After the foundation piles had been cut off, the concrete was placed under water by means of bottom dump buckets. A 1:2:4 mixture was used. The amount of sealing was figured carefully to prevent floating or "blow-in." The sealing was allowed to set from three to six days, depending on the depth of the water and temperature.

6.—When the concrete was properly set, the coffer-dam was pumped out. As the water was lowered, the bracing was examined, and strengthened or repaired, as necessary. The results in all cases showed first-class masonry.

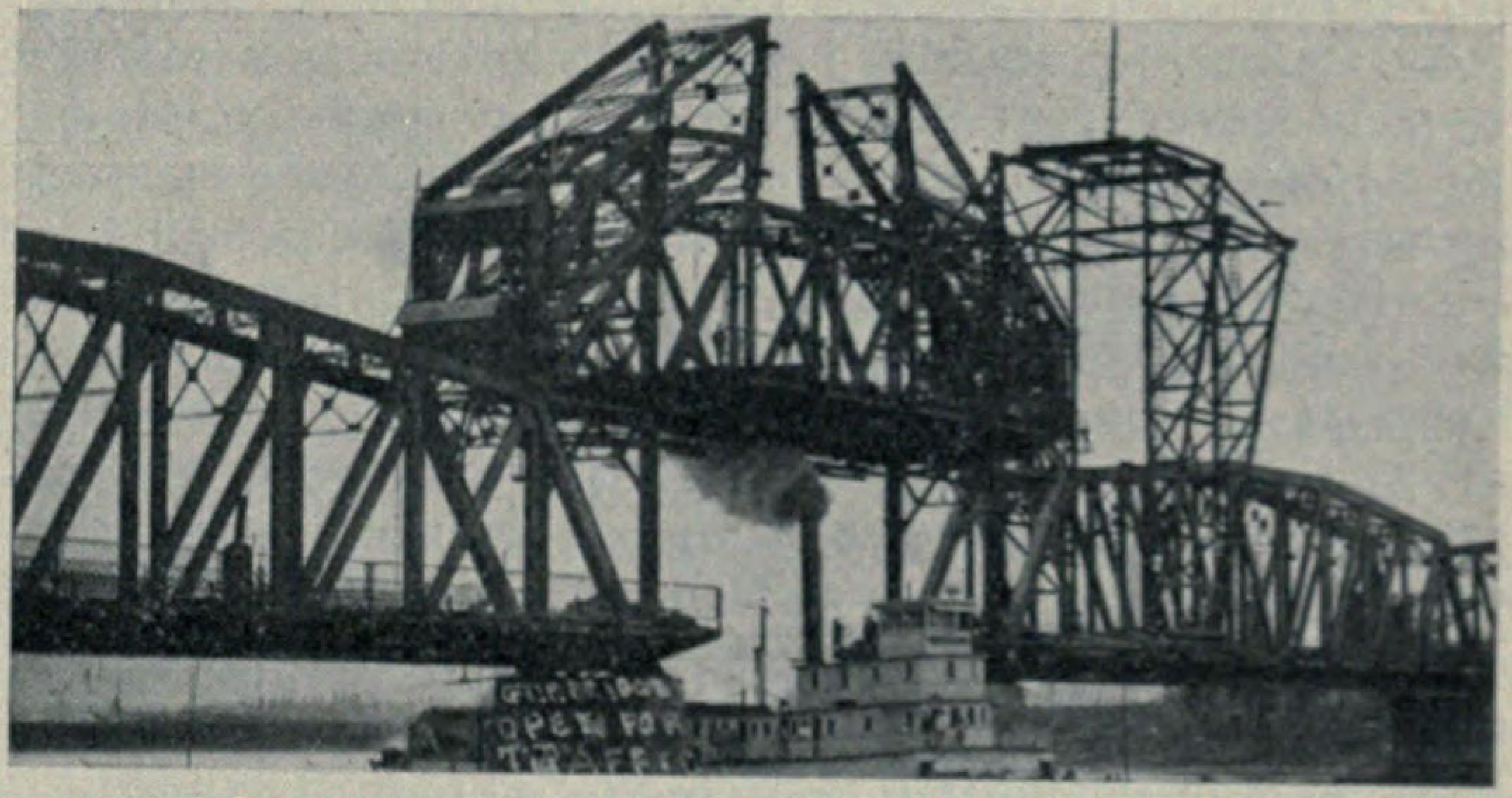
7.—Forms were built and the pier concreted, using a 1:3:5 mixture and taking precaution against freezing, as described later. Piers 7 to 12 are located in the Nechaco channel. Shortly before these piers were built, an ice jam came down the Nechaco River and filled this channel, which previously had been dry, with broken ice from shore to shore to a minimum depth of 15 ft. In building the temporary bridge to serve these piers, it was necessary to excavate through this ice to get a foundation for the framed bents, which were used to support the bridge. It was also necessary to excavate through the ice before starting coffer-dams for the piers.

To prevent the concrete from freezing, the gravel was heated by means of steam boxes. The water was also heated and the concrete was placed in the forms hot. The forms were entirely covered by tarpaulins extending from the top of the coffer-dam to the top of the forms, completely enclosing the pier. Under the tarpaulins, fires were kept in small stoves, or steam heat was furnished from radiators built on the work. Both methods worked well, but steam was more satisfactory and was used where there was an available supply, as this method avoided the danger of fire from the stoves. Heating was continued for three to seven days after the placing of the last concrete and the forms were stripped in from seven to ten days. The results obtained were remarkable: the masonry is smooth and of a uniform color, and there are no indications that frost penetrated anywhere, **although concrete was actually placed at temperatures as low as 35 deg. below zero and temperatures of 50 deg. below zero were experienced while the concrete was setting.**

For the Fraser Channel, two concrete plants were used—one on the island and one on the east bank. Gravel taken from the river was stored close to the mixer. Cement, which had been delivered by scow, was stored at both plants. Concrete was taken from the mixer to the piers in buckets, on cars handled by an endless cable. Buckets were handled from the cars to the forms by the derricks, which had previously built the coffer-dams and made the excavation. For the Nechaco Channel, gravel was obtained from the foundation for each pier and a mixer was set up at each pier, it being moved as the work progressed.

The weekly progress report used was a white print 28 ins. long, showing an elevation and plan of the bridge and a profile of the river-bed. Concrete progress was marked on the elevation and plan, and coffer-dam and pile foundation on the profile. On the print was a table showing the quantities of excavation, coffer-dam piling and concrete for each pier, the table being filled in each week. In addition to this, a monthly report was made for each pier or abutment, showing the progress, materials used and the condition of the work. These graphic reports were made up at the Superintendent's office and forwarded to the main office in Chicago.

The work on the substructure of this bridge was completed on May 20th, 1914. During the progress of the work, the track had arrived and been carried across the river on a temporary bridge, in the maintenance of which serious difficulty was experienced. After the arrival of track and the installation of train service, the conditions of the work were materially improved as it was possible to get supplies within a relatively short time.



The lift span open. This span is fifty feet above high-water mark.

The fourth crossing of the Fraser consisted of two 250-ft. spans, six 204-ft. spans, four 200-ft. spans, and one 100-ft. drawspan.

The amount of work is seen from the followng quantities: excavation (dry), 3,175 cu. yds.; excavation (wet), 15,986 cu. yds.; foundation piling, 3,000 piles; concrete, 14,576 cu. yds.

The Bates & Rogers Construction Company built some twenty or more bridges between Tete Jaune Cache and Prince Rupert (a distance of seven hundred miles) for the Grand Trunk Pacific Railway. Of these the Fourth Crossing of the Fraser was the largest. This company also enlarged and lined with concrete (heavily reinforced) eleven tunnels for the G. T. P. in Alberta and British Columbia.

A mixture which will permit hard steel or iron to be drilled with ordinary drills is made by using 1 part spirits of camphor and 4 parts turpentine. Mix well and apply cold, letting it remain a few minutes before applying the drill. Run the drill slowly with fine feed.