THE VICTORIA JUBILEE BRIDGE AT MONTREAL; GRAND TRUNK RAILWAY.

For some years past there have been rumors current to the effect that the celebrated tubular bridge across the St. Lawrence River at Montreal was to be replaced with truss spans, but these rumors have not generally received much credit. It is now true, however, that the tubular spans are to be replaced with truss spans, and the contracts for the work have been awarded, as already noted in our news columns.

When the Grand Trunk Railway was being built from Portland to Montreal the English projectors saw at once that it would be necessary to build a bridge over the broad and swift St. Lawrence to obtain an entrance to Montreal. The famous engineer, Robert Stephenson, was called in to examine the ground and design the structure, and after an interesting and comprehensive series of investigations and tests he adopted the tubular form of bridge, then already in use for the railway bridge across the Menai Straits. These tubes were of boiler iron and were 16×20 ft. in sectional area, with a simple plate floor and roof instead of the cellular construction adopted in the Menai Bridge. The smoke and gases from the locomotives in this long iron tunnel made the atmosphere very foul, and within recent years, under instructions from Sir Henry Tyler, who was President of the Grand Trunk Ry. at the time, a strip of the plating along the center of the roof was removed, the roof being reinforced by riveting angle irons along each side of the opening. Rust and corrosion (from the products of combustion, damp, and the drippings of brine from refrigerator cars) have made inroads upon the ironwork, and while these did not reach such an extent as to impair the safety of the structure, yet they, in conjunction with the incapacity of the single track bridge to provide properly for all the traffic, led the company to decide upon erceting a new superstructure.

The first stone of the Victoria Bridge was laid on July 20, 1854, and the first train passed over on Dec. 15, 1859. The bridge is 9,144 ft. long, the total length of the ironwork being 6,592 ft. There are 24 piers and two abutments, containing 100,000 cu. yds. of masonry, the thickness of the piers at the water line being 18 ft., except for the two piers of the channel span, which are 28 ft. wide. There are 25 spans, 24 of these ranging from 242 to 247 ft. in length, and the center or channel span having a length of 330 ft. The height from the water to the bottom of this tube is 60 ft., and the bridge has a grade of 1 in 130 from each end to this span. The total weight of iron in the tubes is 9,044 tons, and the area for painting in each coat was 32 acres. The greatest depth of water is 22 ft., and the average rate of the current is 7 miles per hour. The contractors for the old bridge were Messrs. Peto, Brassey & Betts. Fig. 1 is a general view of the bridge. Fig. 2 shows in more detail one of the masonry abutments and some of the end spans, with the iron casings of the ends of the tubes, which form refuges for the trackmen. It also shows the side openings for ventilation, and the traveler used in cutting out the top plating for additional ventilation, while at the right appears one of the travelers used for painting and inspection of the exterior.

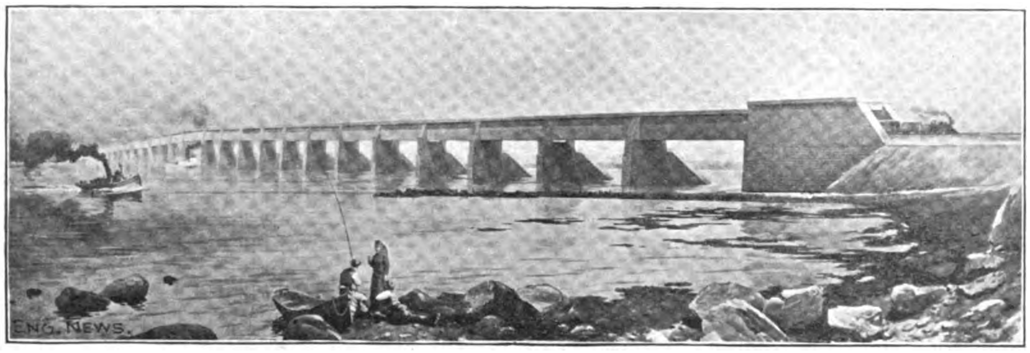


FIG. 1.—GENERAL VIEW OF THE VICTORIA TUBULAR BRIDGE OVER THE ST. LAWRENCE RIVER; GRAND TRUNK RY.

The masonry of the piers is now being extended on the upstream side, to meet the requirements of the enlarged superstructure, but this addition is only above the water table of the cut-waters of the piers, as the present foundations are ample for the new work. The masonry is of limestone ashlar, and the contractor for the extension of the piers is Mr. Wm. Gibson, of Beamsville, Ont. A part of the walls and portals of the abutments of the bridge will have to be taken down, and the upper portions of the piers (at their south ends) are also to be taken down to such an extent as to admit of lengthening the piers as above described. Examination of the masonry showed that the material removed would be unsuitable for use for the external masonry, but it may be employed for the backing. Each course of the new masonry is to be of the same depth as the course of the old masonry of which it becomes an extension, and all the masonry will be built of dimension stone, all faces being pick or hammer dressed. The vertical joints in each course must overlap those in the course below by at least 12 ins. The backing will be of squared or dimension stone, of the same thickness as the face stones. The following is an abstract from the specifications for this masonry work:

The face of the stones forming the ice breakers shall have a 2-in. margin draft all round, and shall be dressed off between to a uniform surface with a point or pick. All these face stones are to be clamped together, both vertically and horizontally, with iron. The horizontal clamps to be 2½ ins. wide, ½-in. thick, 24 ins. long; these are to be turned down 2½ ins. at each end, and embedded their whole length and thickness in the stone. The vertical bolts are all to be 1 in. diameter, and to pass through the horizontal clamps and the vertical joints of the stones, to be let into the course below at least 9 ins. and to be secured thereto by fox-tail wedging.

Coping stones of piers and bridge-seats of abutments, shall not be less than 5 ft. in length, nor less than 30 ins. in width. The top and face of each stone to have a 2-in. tooled margin draft, and to be neatly bush-hammered between. String courses and pedestals to be dressed in the same way as copings. The sides and ends shall be dressed so that vertical joints shall not exceed ¼-in. in width. The ends will be fastened together, on top, by clamps 12 ins. long, 2 ins. wide and ¾-in. thick, let 3 ins. into each stone, two to a joint, and to be placed where directed. The whole of these stones to be set in full Portland cement mortar, made in the proportion of 1 part cement to 1 of sand.

Every stone of the masonry must be set in a full bed of mortar and beaten with a heavy wooden maul until a solid bearing has been secured; the vertical joints must be fully flushed and filled up, using for the purpose "swords" or rammers, and where necessary to insure perfect filling, grouting must be resorted to. Each course must be properly levelled throughout its whole extent.

The mortar must be composed of the best Portland cement, and clean, sharp, coarse and properly screened sand, thoroughly mixed in approved proportions; these will be generally 2 parts of sand to 1 of cement, but they may be varied at the option of the engineer, according to the quality of the material. The cement and sand must be well mixed in a dry state; then enough water must be added to make mortar of a consistency that can be properly handled by a trowel. Mortar must be made in small quantities and only as required. Re-tempering of mortar that has partly set will not be permitted.

The face joints of the masonry must be raked out to a depth of 1½ ins. and pointed with pure cement mortar.

The superstructure of the new bridge, which is to be called the "Victoria Jubilee Bridge," will consist of 24 spans of pin-connected, through, steel trusses, each 254 ft. long, c. to c. of end pins, and one of 348 ft. over the steamboat channel. The trusses will carry two railway tracks to be used by ordinary steam railway trains, as well as by electric railway cars, and the floor beam system will be extended beyond the trusses sufficiently to carry a 10-ft. roadway and a 5½-ft. sidewalk on either side.

The details of one of the 254-ft. spans are shown in Fig. 3. It has parallel chords and inclined end posts, and is divided into two panels of 25 ft. 4¾ ins., c. to c. of pins. The depth of truss is 40 ft., c. to c. of pins, and the width between trusses is 31 ft. 2 ins. c. to c. The top chord is of trough section, 28 ins. deep, having four web plates, a top cover plate and eight flange angles. The pins in this chord are 6, 7 and 7½ ins. diameter. The posts are of I-beams and built-up sections, and the diagonals are eye-bars, with turnbuckles on the counters in the two middle panels. The bottom chord is composed of 8-in. eye-bars, with 7½ in. pins, the thickness and number of bars varying with each panel. The end pins are 8½ ins. diameter. The floor beams are plate girders 66 ft. 3 ins. long, suspended from the pins by I-beam hangers, the girders extending beyond the trusses to carry the roadways and sidewalks. The girders are connected by longitudinal and diagonal brac-

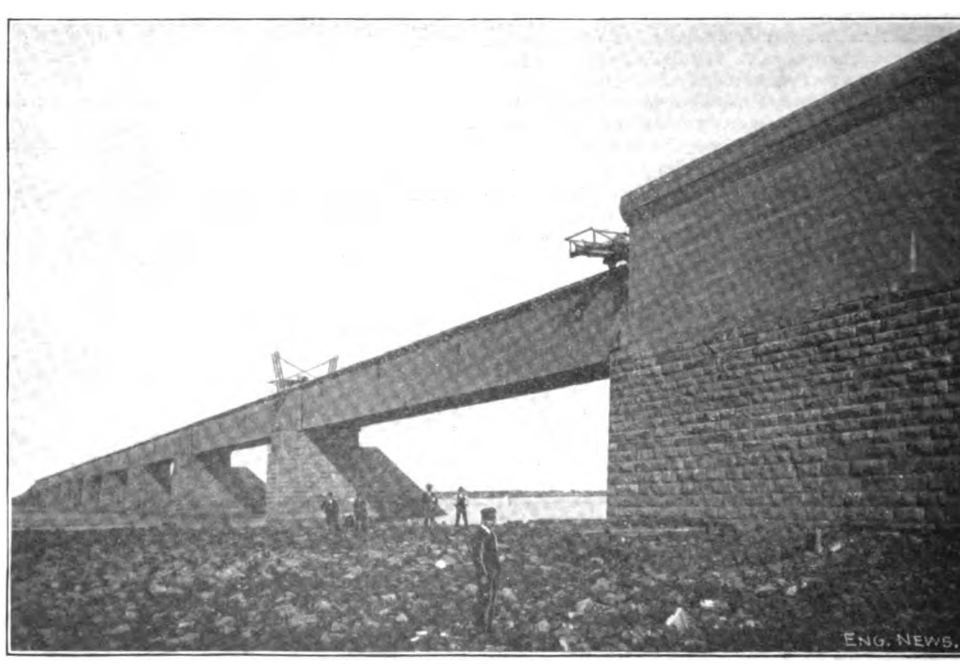


FIG. 2.—VIEW OF ABUTMENT AND END SPANS OF THE VICTORIA TUBULAR BRIDGE.

ing. The trusses will be connected by transverse struts between the top chords, and between the posts, the latter struts being 15 ft. 1 in. below the top chords, giving a clear headway of 23 ft. 1½ ins. from base of rail to the lower struts of the overhead lateral bracing. There will also be the usual horizontal and vertical lateral bracing, as shown in the plan and cross section, Fig. 3.

Upon the central portion of these floor beams are carried eight lines of stringers of 24-in. I-beams, four under each track, 2 ft. 5½ ins. c. to c., the inner lines being connected by vertical diagonal bracing. Across these beams are laid pitch pine ties, 10 x 10 ins., 4 ins. apart in the clear, these ties being long enough to carry both tracks. There will be two tracks of standard gage, 13 ft. c. to c., with a guard timber outside each rail. On each cantilever end of the floor beams will be two lines of 20-in. I-beams for the roadway, and a 15-in. channel on the end of the beam. These carry the roadway timbers, which will be similar to the track ties, but 12 ins. apart. Upon these timbers will be laid a flooring of 4-in. plank for the roadway and sidewalk.

Across each end of each masonry pier (parallel with the bridge) will be laid seven 24-in. I-beams (100 lbs. per ft.), 19 ft. long, the ends of which will be riveted to the end floor beams. On each set of I-beams will be two wall plates 4 x 5 ft., 1½ ins. thick, upon which will rest the shoes of the trusses. The shoes at the expansion end will have nine rockers, 4 ft. 3 ins. long, 3¾ ins. wide, and 7 ins. high, the top and bottom having curved faces. A variation in temperature to the extent of 150° is provided for in the expansion bearings. Between the floor beams carried by the I-beams on the piers, are 15-in. I-beams which support the floor system across the pier.

The channel span of 348 ft. will have curved top chords to the main trusses, but the plans of this span have not yet been finally adopted.

The railway tracks will be used not only for ordinary trains, but also for electric cars, thus affording a more frequent service between Montreal and several small towns on the south shore. These cars will be run between the times of the regular trains, and interlocking switch and signal plants will be installed at each end of the bridge at the junction of the electric railway with the bridge tracks.

The trusses are designed for the following loads:

1.—The total weight of metal in them, amounting to 5,910 lbs. per lin. ft. of span.

2.—The weight of the wooden floor beams, planking, sidewalks, guard timbers, railings, rails and fastenings, etc., amounting, in the aggregate, to 2,800 lbs. per lin. ft. This, with the weight of metal, gives the assumed dead load of 8,710 lbs. per lin. ft. of span.

3.—A moving load in either direction on each of the two tracks, consisting of two consolidation engines and tenders coupled, each weighing 284,000 lbs. on a length of roadway of 54 ft., followed by a uniformly distributed train load weighing 4,000 lbs. per lin. ft. The distribution of the engine loads is shown in the accompanying illustration.

4.—A moving load in either direction on each of the roadways of 1,100 lbs. per lin. ft.

5.—A live load on each footwalk of 200 lbs. per lin. ft.

To provide for wind strains and vibrations in the 254 ft. spans, the bottom lateral bracing is proportioned to resist a lateral force of 450 lbs. per lin. ft. of span, 300 lbs. of this being considered as a moving load and as acting on a train of cars at a line 8 ft. 6 ins. above the base of the rail. The top lateral bracing is proportioned to resist a lateral force of 150 lbs. per lin. ft. of span. For wind strains in the 348-ft. span, 35 lbs. are added in each of the above cases.

The following are some extracts from the specifications:

Bed plates (on masonry) for the trusses are to be made of cast-steel. These castings shall be free from blow holes, true to pattern and of a workmanlike finish. When tested in specimens not more than 2 ins. long, and of at least ½-in. uniform sectional area, it must give the undermentioned results:

Ultimate strength ....67,000 lbs.
Elastic limit ....34,000 "
Elongation in 2 ins.............................20%

All steel must be made by the open-hearth process, and shall contain not more than 0.08% of phosphorus in acid steel, or 0.04% in basic steel, and each kind must be of uniform quality.

All tests for tensile strength, limit of elasticity and ductility, shall be made on samples cut from the finished material after rolling, and shall be at least 12 ins. long, and shall have a uniform sectional area of not less than ½-sq. in. All broken samples must show a silky fracture of uniform color.

When material is to be annealed or otherwise treated before use, the specimen representing such material is to be similarly treated before testing.

Soft steel shall have an ultimate strength of 54,000 to 62,000 lbs. per sq. in., with an elastic limit not less than half the ultimate strength and a minimum elongation of 25% in 8 ins. This steel must bend double, when cold, to close contact without sign of fracture on the outside.

Rivet steel shall have an ultimate strength of 50,000 to 58,000 lbs. per sq. in. and an elongation of 25%, and shall stand the bending test above specified.

Medium steel shall have an ultimate strength, when tested in samples of the dimensions given above, of 60,000 to 68,000 lbs. per sq. in., an elastic limit of not less than half the ultimate strength, and a minimum elongation of 22% in 8 ins.

This steel must stand bending 180° to a curve whose inner radius is 1½ times the thickness of the sample, without cracking on the convex side, either when cold, hot, or after being heated to a cherry red and cooled in water of 60° F.

Eye-bars of 8 sq. ins. of area or less, must elongate 15% in a gaged length of 20 ft.; must show a minimum elastic limit of 30,000 lbs. per sq. in., and develop a minimum ultimate strength of 58,000 lbs. per sq. in. For eye-bars of greater area, not exceeding 20 sq. ins. in section nor 2 ins. in thickness of bar, a reduction will be allowed to a minimum requirement of 56,000 lbs. ultimate strength, 29,000 lbs. elastic limt, and an elongation of 10% in a gaged length of 10 ft.

Eye-bars tested to destruction and fulfilling the above conditions shall be accepted even though they break in the head, if not over one-third of the bars tested break in this manner.

Pins made of either soft or medium steel shall, on specimen test pieces cut from finished material, fulfil all the requirements of the grade of steel from which they are rolled, excepting the elongation, which shall be decreased 5% from that specified.

Pins up to 6 ins. diameter shall be rolled. Pins exceeding 6 ins. in diameter shall be forged under a steam hammer striking a blow of at least 5 tons. The blooms to be used for this purpose shall have at least three times the sectional area of the finished pins.

After pins have been manufactured to diameter, they shall be carefully and uniformly heated to a medium orange color in a closed furnace, and not in contact with the fuel, after which they shall be buried in warm dry sand or ashes until cool.

All pins more than 5 ins. diameter shall be bored through the center.

Punched rivet holes, pitched two diameters from a sheared edge, must stand drifting until the diameter is one-half larger than the original hole, without cracking the metal.

All holes for field rivets, excepting those in connections for lateral and sway bracing, shall be accurately drilled to an iron templet, or reamed while the connecting parts are temporarily put together.

The several parts composing a riveted member shall be so accurately punched and reamed, that upon being assembled, connecting holes shall be truly opposite. If

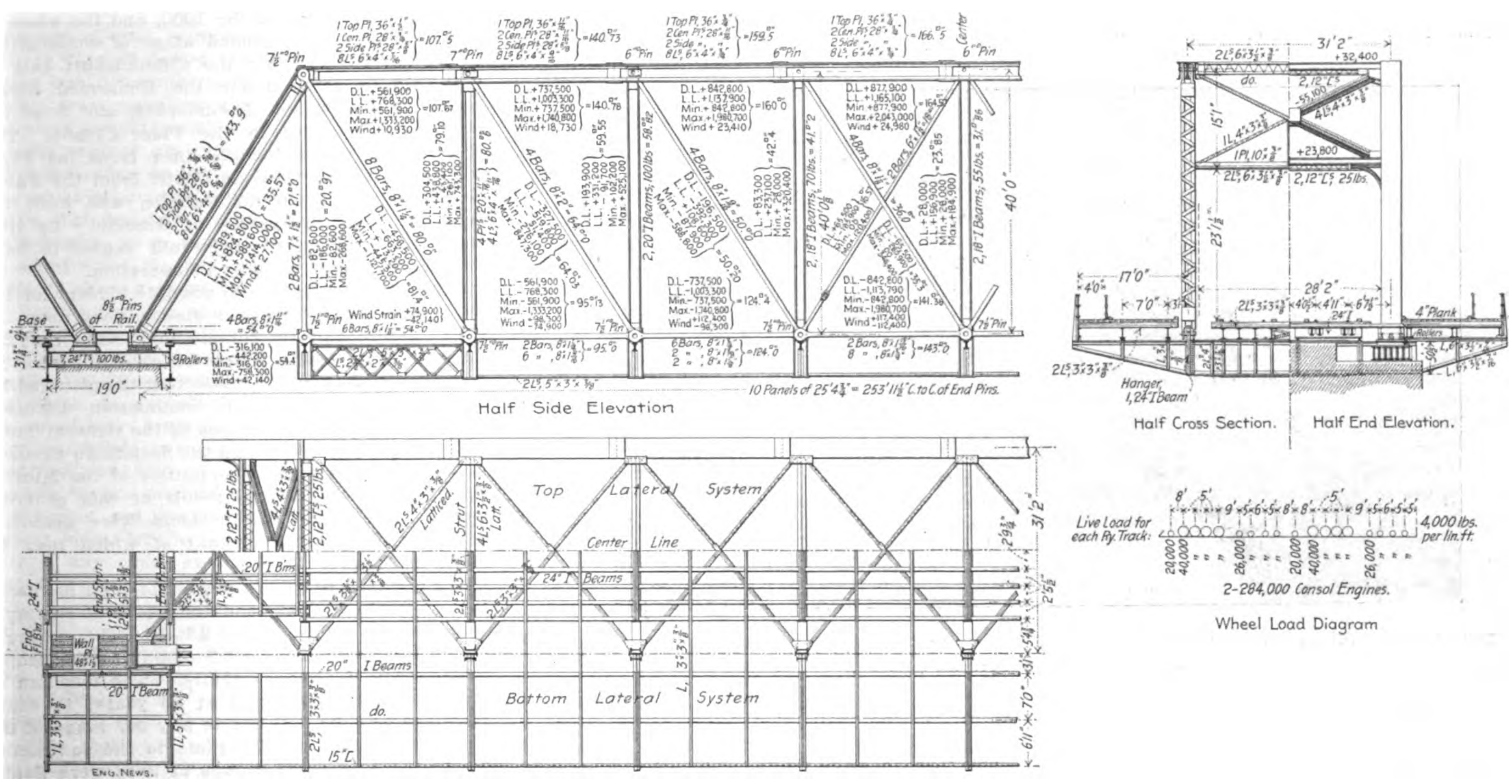


FIG. 3.—DETAILS OF NEW TRUSS SPANS FOR THE VICTORIA JUBILEE BRIDGE.

they are not they may, if the inaccuracy does not exceed 1-16-in., be still further reamed to bring them exactly into line.

The heads of eye-bars and enlarged ends of rods shall be made by upsetting or forging into shape. Welds in the body of the bar will not be allowed, except to form loops of laterals, counters, sway rods or unimportant details.

The eye-bars shall be annealed, and must be perfectly straight before boring, and must be free from all flaws or defects and of full thickness in the necks. Welds in the body of these bars will not be allowed. The heads of these bars must be so proportioned and made that when tested to destruction, the bars shall break in the body of the original bar rather than at any part of the head or neck, and shall be made by upsetting, rolling or forging into shape.

Bars which are to be placed side by side in the structure shall be bored at the same temperature and of such equal lengths that on being piled on each other the pins shall pass through the holes at both ends without driving.

The pins shall be turned accurately to gage and shall be straight or smooth; chord pins up to 4½ ins. diameter shall fit the pin holes within 1-50 in.; for pins of a larger diameter the clearance may gradually be increased to 1-32-in. for pins of 6 ins. diameter and over. Lateral pins shall fit the pin holes within 1-32-in.

The open sides of all compression members shall be stayed by batten plates at the ends and diagonal lattice work at intermediate points. The batten plates must be placed as near the ends as possible, and shall in length be not less than the greatest width of the member, or 1½ times its least width. The size and spacing of the lattice bars shall be proportioned to the size of the member.

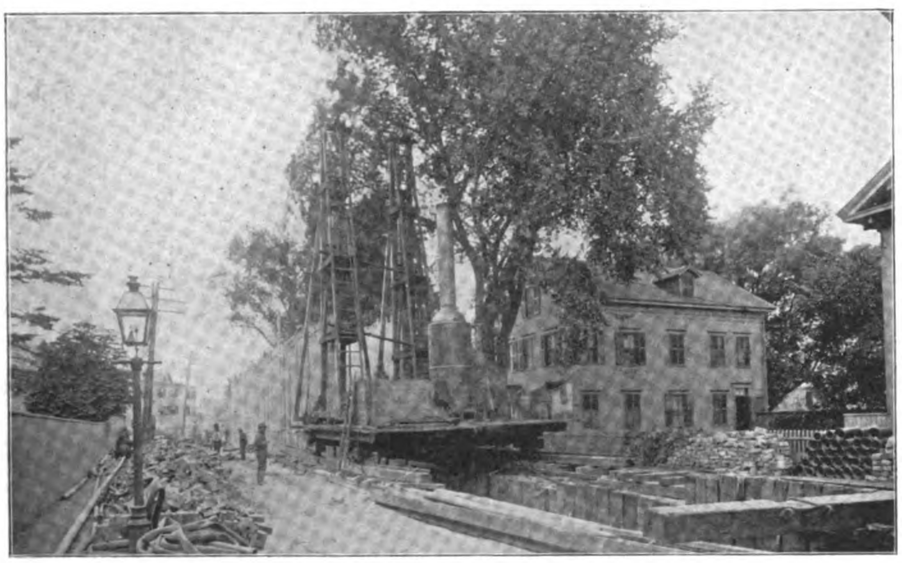
The trusses shall be given a camber, by making the panel lengths of the top chord longer than those of the bottom, in the proportion of ⅛-in. to every 10 ft.

The shop painting will include one coat of paint to all inaccessible parts, and two coats after erection, all other parts being given one coat of raw linseed oil. Pin holes and planed surfaces will be coated with white-lead and tallow. In the field, the structure will be given two coats of paint. All paint will consist of 12 lbs. of pure red lead and 10 ounces of lamp black per gallon of paint, thoroughy mixed with raw linseed oil.

The design of the bridge has been prepared under the direction of Mr. Joseph Hobson, Chief Engineer of the Grand Trunk Ry., to whom we are indebted for blue-prints and specifications, etc. Ten of the trusses are now under construction by the Detroit Bridge & Iron Works, of Detroit, Mich., six by the Dominion Bridge Co., of Montreal, and nine by the Union Bridge Co., of New York city. The whole 25 spans will, however, be erected by the Detroit Bridge & Iron Works.

STEAM PILE DRIVERS FOR DRIVING SHEET PILING FOR SEWER TRENCHES.

The accompanying view shows a steam sheet pile driving apparatus used on the Allen Ave. sewer construction at Providence, R. I. A carriage mounted on wheels and spanning the trench carries two sets of leaders, one set over each line of sheet piling. The hammers are raised in the leaders and the plank used for the sheeting is placed under them and guided by the leaders. After steam is turned on the driving goes on automatically. A letter from the Vulcan Iron Works, of Chicago, Ill., who furnished the steam pile drivers for this machine, states that 150 lin. ft. of 4 and 6-in. sheeting in a 28-ft. trench was driven in ten hours on this work. In our issue of Jan. 28, 1897, we gave some very carefully prepared records of sheet pile driving by steam hammers in the construction of the West Bluff sewer system at Peoria, Ill.



STEAM SHEET PILE DRIVING APPARATUS USED ON THE ALLEN AVE. SEWER, PROVIDENCE, R. I.
Vulcan Iron Works, Chicago, Ill., Builders.

THE DEFINITE PROJECT FOR THE METROPOLITAN RAILWAY OF PARIS.

On July 7 the Municipal Council of the city of Paris adopted the report presented by Andre Berthelot, representing the special Metropolitan Commission, and laying down a definite project for the construction and the granting of a concession for the metropolitan railway of Paris. Without going into the detail of route, some notes upon the methods adopted for building this system will be of interest as abstracted from "Le Genie Civil." The essential features of this project are electric traction, the building of the substructure by the city and the operation of the system by a contractor who shall take charge of the work of equipping the system and furnish the material.

The reasons given for adopting this method of proceeding with the work are as follows: The city can secure the necessary capital for construction at a lower rate of interest than any private corporation, say, 3.3% as compared with 5%; and no private company could raise the capital required, about $40,000,000, without a guarantee of interest by the city. The Municipal Council also believes that the only means of protecting the interests of property holders on the line lie in this direct construction by the city; and for the direction of such work the engineers of the city and the municipal employes are evidently superior to any other agents by reason of their intimate knowledge of the subsoil of Paris, acquired in conducting analogous work. The city, however, does not deem it wise to equip the system, and leaves this work in the hands of the parties securing the concession for operating the lines. The electric installation is relatively new in type, and "the contractor should make the tools which he is supposed to afterwards use." This contractor can then organize his technical operation as seems best to him, without being handicapped by original arrangements over which he had no control; and, finally, to avoid all sources of complaint on his part, the city even leaves in his charge the arrangement of the station approaches. This division of interest in the actual construction not only lightens the burden imposed upon the city, but it also requires the operating party to invest a larger sum in the initial enterprise and to thus increase the guarantee obtained from him.

The total estimated expenditure by the city of Paris for the execution of this metropolitan system is about $35,000,000; and it expects to realize this sum by a loan based upon a tax of one cent per passenger which the operating party engages himself to turn over to the city. This differs essentially from the system of great monopolies conceded to the gas and the omnibus companies of Paris, which are founded upon a division of the profits. The present plan was adopted to avoid a repetition of the frequent legal disputes with the two latter companies. At 3.3% interest on this loan, or $1,100,000 annually, a traffic of 110,000,000 passengers would be required to meet this charge. The city engineers estimate that this figure will soon be reached, and during construction the interest charge will be embraced in the general budget.

The construction will be divided into three stages, and the first stage will include the building of a line from the Vincennes to the Dauphine gate; a circular system along the outer boulevards, and a line from the Maillot gate to Menilmontant. These lines would aggregate 26 miles in length, and eight years are allowed for building them, though the city hopes that one or two of these lines may be completed by 1900, and the whole of them by 1902. The second stage of construction would cover lines from the Clignaucourt gate to the Orleans gate; under the Boulevard Strasbourg to the Bridge of Austerlitz, and from the Park of Vincennes to the Place d'Italie. The third stage would include lines from the Place Valhubert to the Quai de Conti; from the Palais Royal to the Place du Danube, and from the Opera to Auteuil, by way of Grenelle. By 1905 the engineers of the city would expect to have 35.3 miles of this railway in operation.

One month was given to possible bidders for the concession to present their observations upon the plan submitted by the commission. After that the Prefect of the Seine appointed an administrative commission charged with selecting the plans which seemed best to it. This commission discussed matters with representatives of the General Traction Company of Paris and the Societe du Creusot, and also with a special committee of the Municipal Council. As a final result of this congress certain conditions and projects were definitely adopted, the most important of which may be noted as follows:

The distance between tracks has been increased from 1 m. to 1.30 m., and the width of carriages increased from 1.90 m. to 2.10 m. This enlargement was recognized as necessary for the proper installation of electric motors. The duration of the concession was fixed at 35 years; to count from the day the last line in any one stage of the work is handed over complete to the contractor. These three different groups of lines were finally to be handed over to the city in the order in which they were conceded; but the contractor was to remain in control of the whole until the last group was turned over to the city, upon condition of paying for the lines on which time had expired an annual sum amounting to 45,000 francs per kilometre, or about $14,518 per mile. At the expiration of all concessions the city will enter, without any payment, into possession of the whole system, including the necessary plant for operation, electric generating stations, repair shops and depots.

The city reserves the right after 1910, at which date the monopoly of the Omnibus and Tramway Company expires, to take possession of all means of transport in the city. In this case the contractor for the metropolitan system would receive an annuity of 45,000 francs per kilometre, until the nominal expiration of his concessions.

The price of ordinary passage on the system has been lowered to the uniform rate of 3 cts. for the course. But a first-class ticket has been provided costing 5 cts. Up to 9 a. m. the passenger will also be entitled to a return-ticket by paying 4 cts.; and the children of any public school, traveling together in charge of a teacher, only pay 1 ct. fare. The creation of the first-class fare is intended to compensate the operating party for the reduction of fares noted. Under these conditions it is estimated that a traffic of about 130,000,000 passengers annually will be necessary to enable the operator to pay his expenses and recoup the