24 January, 1928.

ERNEST FREDERIC CROSBIE TRENCH, C.B.E.,
President, in the Chair.

The PRESIDENT, in announcing the death of Major-General Goethals, stated that the following Resolution had been passed by the Council, with which, he felt sure, the members would concur :—

"That the Council record the regret with which they have learned of the death of Major-General George Washington Goethals, who was an Honorary Member of The Institution since April, 1915, and whose great achievement in bringing to a successful conclusion the construction of the Panama Canal earned for him the admiration of the members of this Institution. They desire that an expression of their sympathy be conveyed to his family."

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The following Paper was submitted for discussion, and, on the motion of the President, the thanks of The Institution were accorded to the Author.

*(Paper No. 4638.)*

# "Railway and Vehicular Bridge across Vancouver Harbour, B.C. (Canada)."

By ANDREW DON SWAN, M. INST. C.E.

THIS bridge connects the north and south shores of Burrard Inlet at the Second Narrows at Vancouver, B.C. Before its construction the city and district of North and West Vancouver had no direct railway connection with the rest of the country, except by car-ferry. The building of a bridge at this place had been discussed for about 40 years, but the question of financing the scheme could never be solved.

In 1909 the Burrard Inlet Tunnel and Bridge Company was formed, and the Charter to build a bridge was granted in 1910. An English firm of consulting engineers was retained, and tenders were invited at the beginning of 1914. The work according to that scheme, however, was never proceeded with. Early in 1922 a proposal was made by an American firm to finance and construct a bridge according to their own designs ; and at this stage the municipalities sought the Author's advice on the American proposal and other matters; but after considerable discussion the negotiations with the American firm, as well as the proposals of another, came to naught. The great difficulty was the lack of reliable information about probable foundation conditions on the south side of the Inlet. Practically no money was available to pay for either preliminary engineering, or the taking of borings, or any construction. The various municipalities, however, were prepared to guarantee bonds up to a certain very limited amount. The Author therefore advised that, if it were possible to get a contracting firm to accept payment in bonds, a lump-sum contract seemed most favourable, and that the contract would have to cover all risk of having to carry piers deeper than anticipated if found necessary.

Eventually Messrs. The Northern Construction Company and J. W. Stewart of Vancouver agreed to make investigations of the site at their own expense, under the supervision of the Author's engineering staff.

From the centre of the channel northward the bottom consists of coarse sand and gravel through which borings had been previously taken to a depth of 190 feet, and later, one which struck rock at a little more than 300 feet. It appeared beyond question, therefore, that the north piers would have to be founded on gravel. At the south side of the channel the water was about 90 feet deep and had a velocity of about 7 miles per hour, and as there was only a few minutes of slack water, it was not feasible to obtain borings near the middle of the channel. Various attempts were made to drive piles to carry a boring-platform, but the tide carried them away or broke them off within an hour. To take borings from floating equipment was also impracticable owing to the great length of unsupported casing.

A certain amount of fairly reliable information was obtained by using a heavy probe operated by a pile-driver, and farther inshore, where the current was not so swift, core borings were taken from a platform. In addition, a high-pressure jet-pipe was used at slack water to make additional probings, and some test-piles were also driven.

After work had been carried out for about 5 weeks, it was ascertained that apparently sandstone or other rock existed from the south shore to beyond the approximate site of pier No. 2 (Fig. 1, Plate 5), the rock being overlaid in some cases with 8 to 10 feet of sand, gravel, and boulders. As a result of these investigations the contracting firms already mentioned agreed to take the contract and undertake to sink the piers as far as might be required by the Author as consulting engineer, without claiming any extras.

As shown in Figs. 1 and 2, Plate 5, the work extended from Cariboo Street on the south to Lynn Creek on the north. The original design consisted of a trestle approach from the north shore to pier No. 1, a 300-foot fixed span from pier No. 1 to pier No. 2, a 185-foot bascule span between piers Nos. 2 and 3, a 54-foot tower span between piers Nos. 3 and 4, a 30-foot fixed span between piers Nos. 4 and 4A, a 150-foot fixed span between piers Nos. 4A and 5, and the trestle approach from pier No. 5 to the south shore. Later, however, additional 150-foot steel spans were substituted for the trestle immediately north of pier No. 1.

The bridge carries a single-track standard-gauge railway between the main trusses, with two 10-foot highways, one on each side outside of the truss, and in addition, a 3-foot 6-inch sidewalk on the east side.

The two highways join into a single 20-foot roadway at each end of the steel, so that it is necessary for highway traffic to pass a level crossing once in either direction. The bridge was designed to the Canadian Standard E. 50 railroad loading, whilst the highways were designed for a uniform live load of 100 lbs. per square foot, all members being capable of carrying 15-ton trucks.

In the original design it was intended that all the piers should be constructed of groups of concrete cylinders similar to those used on the construction of the new pier built for the Harbour Commissioners,[1] and the approval of the Board of Railway Commissioners of Canada was obtained for this design. Later, however, pneumatic caissons were substituted for the cylinders in piers Nos. 2, 3, and 4, without additional cost to the bridge company. The design as amended is shown in Figs. 3, Plate 5.

Clearing for the railway embankment from the north end of the bridge to Lynn Creek was commenced in October, 1923. The material was obtained from a pit about a mile distant and conveyed by narrow-gauge railway to the site. In January, 1924, pile-driving began for the trestle from pier No. 1 towards the shore. The piling was impregnated with 12 lbs. of creosote per cubic foot. The piles ranged in length from about 40 to 90 feet and were driven into the gravel about 30 feet. At the outer end four batter piles were driven to each bent to stiffen the structure against the current. A floating pile-driver was used as far inshore as possible, after which a cantilever driver travelling on the trestle previously completed was used up to the junction with the embankment.

The sinking of cylinders for piers Nos. 1 and 5 was then

[1] Inst. C.E. Selected Engineering Paper No. 27, 1925.

commenced. Each cylinder (Figs. 4, Plate 5) was 7 feet in diameter and built up in sections 17 feet 6 inches long, so arranged that when the various sections were bolted together, continuous reinforcement was provided throughout the whole length of cylinder. Each cylinder had an enlarged shoe 12 feet in diameter. The shoe and three lengths of cylinder were built up in the contractors' yard situated about 3 miles from the bridge; when the cement joints had set, a floating pile-driver carrying the cylinder was towed to the site at the bridge, and the cylinder was transferred bodily to the driver on the trestle. All the cylinders for pier No. 1 were successfully placed in position in this manner. After each cylinder had been transferred to the fixed driver, it was lowered to the bottom, accurately set, and thereafter sunk to the required depth by excavating the gravel from the interior by an orange-peel bucket. During sinking operations further lengths of cylinder were added till the required length was reached; each cylinder had a minimum penetration of 30 feet. No filling of cylinders was done until the sinking of the whole group was completed. Thereafter the cylinders were cleaned out by a hydraulic ejector, the final cleaning being done by a diver, and filled to the lower connecting-struts by tremie. The precast struts were then set in position, and further lengths of cylinders were set above them. These were subsequently filled, the filling thus concreting the entire junction and effectively tying the six cylinders together. The whole was capped by a reinforced-concrete slab 6 feet thick, containing about 14 tons of steel.

As the displacement area of each cylinder-shoe was greater than that of the shaft, a considerable depression of the material surrounding the pier took place; and this was refilled with loose rock. Pier No. 5 consisted of three cylinders only, in comparatively shallow water. As the stratum was rock, the area over the pier was first drilled and blasted, and the cylinders thereafter were set into the hole. These cylinders were braced together by precast connections above the level of high water.

The caisson piers consisted of a very heavily reinforced concrete working-chamber surmounted by a watertight coffer-dam. The caisson was constructed on shore and launched into deep water a short distance from the site of the bridge. The working-chamber was poured in position, and about 22 feet of timber coffer-dam was erected and caulked on top of the working-chamber. When this was completed the caisson was launched broadside. A temporary false bottom was built at the bottom of the working-chamber to prevent the caisson from taking too sudden a drop when leaving the end of the launching-ways. This bottom was made of light material, so as to collapse and admit water to the working-chamber soon after launching. The caissons for piers Nos. 2, 3, and 4 were successfully built and launched in this way. As the bottom of the channel was not level at the site of the piers, an artificial bed of bags of gravel was dumped from scows and levelled by a diver. The caissons were towed from the launching-site and sunk in place at slack water, by admitting water to the coffer-dam. As no guiding falsework could be driven at the sites, the positions of the caissons were fixed by two transits operating from a base-line on the south shore. Owing to their somewhat unwieldy bulk and the very short time available during slack water, considerable difficulty was experienced in setting the caissons; the first was sunk and relifted several times before it was finally got into its correct position, a pump having been installed to enable the caisson to be lifted if required.

After the caisson was in place, the shafting and air-locks were erected by a floating derrick, and operations were commenced inside the working-chamber. Caissons Nos. 3 and 4 had one man-lock and two material-locks each. Caisson No. 2 was much deeper, and as the consequently high air-pressure necessitated a long period of decompression, it was supplied with two man-locks. The material-locks discharged at the side, and the man-locks consisted of a straight shaft with diaphragms at intervals fitted with doors provided with valves. Various lengths of shaft or, if desired, the whole shaft, could be used as a lock. The material-shafts were fitted with emergency doors at the bottom.

The concrete forming the shaft of the pier was poured as the work proceeded, in order to provide the necessary weight. The coffer-dams were filled solid to the outside sheeting; and the battered shaft of the pier commenced above this level.

Owing to the impossibility of constructing stagings in the channel, the compressed-air plant and accommodation for compressed-air workers had to be provided on a scow anchored close to the work. This plant carried on its deck two sets of Ingersoll Rand steam-driven compound air-compressors; one of large capacity for supplying low-pressure air to the working-chamber, and a smaller high-pressure compressor for pneumatic tools. This second compressor could, in an emergency, be used to supply low-pressure air to the working-chamber. The air-pressure required varied from about 15 lbs. to a maximum of about 48 lbs. per square inch above atmosphere. Steam was supplied by three locomotive-type boilers, two of which were in general use, the third being a standby. The low-pressure compressor was fitted with a governor which could be adjusted to keep the pressure in the working-chamber constant within a very small range, and this was found to be a great advantage, because rapid operation of the material-locks caused considerable variation in the pressure in the working-chamber, and, unless a reduction of pressure was promptly compensated for by speeding up the air-compressor, it was not possible to keep the floor of the working-chamber dry. The entire compressor plant had a capacity considerably in excess of what it was expected would be required, which was very fortunate, since on pier No. 2, owing to unexpected difficulties, all the power available was utilized.

On the upper deck of the scow a large heated room was provided for the workmen, with hot-water supply, bath-tubs, etc., and arrangements for making large supplies of coffee. A medical lock having two sections was also provided to deal with cases of bends, and a medical doctor was on duty on the scow night and day. During the progress of the work there were numerous cases of bends, none of which, however, was serious, and there were no cases of permanent injury.

Air was conveyed from the compressor scow to the caisson by duplicate sets of flexible hose connected to 4-inch supply-pipes passing through the shafts of the pier and fitted at their lower ends with non-return flat valves. The scow was very heavily anchored, with all moorings in duplicate, because, in addition to the rapid current, there was considerable danger of collision with passing vessels.

The foundation for the caisson at No. 4 pier consisted of a low-grade sandstone which could be lightly blasted without damaging the caisson. After the caisson had been sunk 7 feet into the sandstone it was found that the quality of the rock did not improve; but test-cubes cut out of the rock gave unexpectedly high results, none of them failing at a pressure of less than 100 tons per square foot. Accordingly the caisson was not sunk deeper.

The concrete was mixed on a floating scow, which carried a concrete-mixer, elevating-tower, spouts, gravel- and sand-bunkers, and cement-shed. A stiff-leg derrick was mounted to fill the bunkers from supplies brought alongside.

Before the working-chamber was concreted, the material-locks were changed for concrete locks into which concrete was introduced direct from the spout of the floating mixer. The upper door of the lock was then closed and air was admitted from below; when the lower door dropped, the concrete was dumped down the vertical shaft on to the floor of the working-chamber. It was found that very little separation took place as a result of this drop; and, further, the concrete was almost completely remixed during the handling on the bottom. The process of concreting was carried on in two stages; concreting was stopped about 18 inches from the roof and the concrete was allowed to set; work was then started again and carried on with a wet mixture until the bottom of the shafts was reached, when the air was automatically cut off, after which concrete was dumped in the open shafts to a considerable height above the working-chamber, relief-pipes which had been installed in all corners of the working-chamber being opened to enable trapped air to escape and to allow the concrete to fill as much of the working-chamber as possible. After the concrete had set and shrinkage was completed, the working-chamber was grouted through the relief-pipes, grout being forced down under pressure until it came up all the pipes. Before concreting was started, considerable sections of the concrete web walls supporting the roof of the working-chamber were cut away to assist in the free flow of the concrete.

The process in the case of the caisson of No. 3 pier was practically the same as in the case of No. 4, but 4 or 5 feet of loose sand was removed before the rock was encountered. This pier was carried to a considerably greater depth than pier No. 4, because, being at the side of the bascule opening, it was liable to be subjected to severe shocks in the event of collision. The maximum air-pressure in caisson No. 3 was a little more than 30 lbs. per square inch.

Caisson No. 2 was far the most difficult part of the whole work. This pier stood in about 90 feet of water at high water, and was also at about the point of maximum current. It was necessary to have four sections (88 feet) of coffer-dam built above the concrete working-chamber before the caisson could be set. When ready to be towed to the site, the caisson was drawing about 60 feet of water, and after several unsuccessful attempts it was set in its correct position. The day after, however, it took a considerable list, and was very much out of plumb by the time the locks were got in position and it was possible to get into the working-chamber. This list was due to uneven settling of the bed of sandbags, but it did not take long to get the caisson levelled, and sinking was then proceeded with in the ordinary way.

It had been anticipated that rock of much the same grade as that on which the other two caissons had been founded would be met with close to the surface. However, the caisson was sunk 16 feet before rock was encountered, the material passed through being a good grade of hard-pan, overlain by sand. At about elevation +2·5 rock were first met with on the south-west corner of the caisson, and it was thought that in a short time rock would crop out over the rest of the bottom area. This rock at the south-west corner was harder than that met with in caissons Nos. 3 and 4, and required fairly heavy blasting for its removal. The sinking was continued, but the area of exposed rock on the floor of the working-chamber did not increase, and it appeared that the caisson had landed on the edge of a vertical cliff of rock. Sinking was continued, but the heavy blasting necessary to remove the rock from the south-west corner eventually began to shatter the concrete wall of the working-chamber, and when about elevation −2·5 had been reached it was considered that if further blasting were proceeded with serious damage might be caused to the working-chamber. Sinking was accordingly stopped when the cutting edge was about 20 feet below the original surface, and four wash borings were put down in the floor at various points where no rock was visible, in order to ascertain whether there was any possibility of meeting rock above an elevation to which it was practicable to sink the caisson. The depths to which the borings were put down ranged from 12 to 20 feet, and in no case was rock struck. By this time the air-pressure was nearly 45 lbs. per square inch, the working-shifts had been reduced to about 50 minutes each, and the men had been spending an hour or more in decompression. It was evident that it would be impossible to sink the caisson even a further 20 feet, because in order to do so it would be necessary to do a great deal more blasting along the south side of the area, which the concrete wall was evidently in no condition to stand; and, further, the air-pressure would have been considerably over 50 lbs. per square inch. It was decided, therefore, to attempt to increase the base area of the pier so as to compensate for the lower bearing-capacity of the hard-pan, as compared with the rock, by extending a footing outside the walls of the working-chamber. A test was first made to determine the bearing-capacity of the hard-pan, by means of a hydraulic jack working from the roof of the working-chamber. Practically no settlement took place until a loading about double that for which the caisson had been designed was reached, but this was not considered a sufficient margin of safety for so high a pier, especially under the peculiar condition of being on solid rock on one side; because the slightest settlement on the hard-pan would have thrown the top of the pier a considerable distance out of line to the north.

Eventually it was decided to enlarge the base of the pier where no rock was present. In order to do this, excavation was carried below the cutting-edge level about 3 feet and was tunnelled out beyond the cutting edge also for a distance of about 3 feet. This work was carried out in short sections, and as each section was completed it was filled at once with rich concrete. As the cantilever projection of concrete would not be strong enough to be of any value alone, it was reinforced with 15-inch by 5-inch rolled steel joists projecting 2 feet 6 inches beyond the cutting edge. The inner ends of these beams, which were about 5 feet long (this being the greatest length that could be got through the material-locks), were anchored by steel rods passed through holes in the beams and tied back into the remaining concrete of the working-chamber. The concrete required for this underpinning was taken through the material-locks in the ordinary buckets, and, as these only held 4 or 5 cubic feet, the process was extremely slow. Eventually this underpinning work was successfully completed, though it took considerably more time than the whole of the rest of the sinking of the caisson and was exceptionally difficult. In order to keep the bottom of the excavation dry, the air-pressure had to be maintained in excess of the hydrostatic pressure at cutting-edge level; consequently a considerable leakage of air took place, and it required all the excess capacity of the air-compressor plant to maintain the required pressure. Frequent blow-outs occurred as a result of large holes developing between the outer walls of the caisson and the material through which it had sunk. When this happened the air-compressor was unable to maintain the pressure, and the water immediately rose to the cutting-edge level. It was then necessary to locate the point of leakage and stop it with bags of clay before the excavation could be again dried and work proceeded with.

As the hard-pan was of very good quality, it was not found necessary to support it with timber, except in one place where numerous blow-outs had occurred, and it was only with great difficulty and after many failures that this last section was successfully excavated and filled with concrete. A feature which retarded this work considerably was the very short shifts which the men were working, the air-pressure being about 46 lbs. per square inch. Further, at this time all the experienced general foremen were suffering more or less from bends, and were not able to spend as much time in the working-chamber as they would have liked, the supervision having to be largely in the hands of the "shift bosses." Great credit is, however, due to the contractors and their staff, and this difficult operation was only successfully completed because of the able way in which everyone tackled the job under very dangerous conditions.

When the whole of the underpinning had been completed, there was a concrete wall all round the working-chamber, supporting the caisson, and the centre of the area was then excavated far enough to get a satisfactory bond between the centre concrete and the outside wall. This centre portion was then cleaned, and the remainder of the working-chamber was filled in the usual way.

During the process of sinking the caissons, regular observations were taken, and the actual position of the cutting edge was plotted each day. In order to do this, definite points were set on the top of the caissons, the positions of which were checked daily by transits from the base line. A plumb line was taken down one of the man-shafts to a definite point on the lower door, and the position of this point was established with relation to the points on the top of the caisson. The engineer then went into the working-chamber, carried the point on the lower door down to floor-level, and established the position of the corners of the working-chamber relative to this point. This process enabled an accurate check to be kept of the position of the cutting edge, regardless of whether the caisson was plumb or not. Care had, however, to be taken that the observations were made at a period when the caisson was not actually sinking, since, were it moving during this process the results would be valueless. If the checking showed that the caisson was tending to drift in any particular direction, heavy raking shores were set in position, which tended to throw the caisson in the opposite direction the next time it dropped. By this means it was found possible to control the movement of the caisson within very close limits, and none of the piers was more than a few inches out of its correct position when finally founded. After the working-chambers were filled, each pier-shaft was completed inside the coffer-dam, the distance between piers being directly checked with a piano wire. Pier No. 4A consisted of two standard cylinders, which were connected to pier No. 4 by means of reinforced-concrete struts, and braced to pier No. 4 and to each other by sets of diagonal bracing. These cylinders were sunk by compressed air instead of by the open method used on the other cylinders. Each cylinder was built as before and set in position, and one of the material-locks used on the caissons was then bolted to the upper end, making the entire cylinder practically a working-chamber. This lock had necessarily to be used for both men and materials. The cylinders were sunk by means of pneumatic tools and by firing light charges to a depth of 5 feet below the surface of the rock, which was then cleaned up. The air was then taken off, and the cylinder was filled by means of a tremie.

While the piers were being constructed, certain lumber and other interests occupying sites above the Second Narrows commenced to raise objections to the construction of the bridge, on the ground that they would be put to heavy extra expense in the towing of logs, the handling of ships, etc. Before the commencement of the works the Author had advocated strongly that two 150-foot steel spans should be substituted for the trestle work on the north end of the bridge, so as to enable some dredging to be carried out and so compensate for the obstruction caused by the piers and, if possible, reduce the current for vessels passing through the bascule opening; but no funds were available at that time to carry these recommendations into effect. After lengthy proceedings, and after a local board of inquiry had gone into the matter, it was recommended that the two additional spans should be constructed and that the entire structure should be raised 5 feet so as to give greater clearance for small craft passing underneath.

Funds were voted by the Government to pay for the additional cost of the two steel spans and the raising. Work was accordingly started on two additional cylinder-type piers, and the bridge-level was raised by adding concrete pedestals 5 feet high to each pier already constructed. In view of the increased height, two additional cylinders were sunk so as to strengthen pier No. 1; and the lower bracing was filled in solid, while an additional set of diagonal bracing was added between piers Nos. 4 and 4A. The railway embankment and trestle at the north end had also to be raised. There was then a clearance below the bridge of 22·2 feet at high water.

The bascule span was erected on piers Nos. 3 and 4 with the moving leaf in a vertical position. The fixed spans were all assembled and riveted on a temporary trestle on the south shore. The erection-trestle was so designed that the completed spans could be skidded out far enough from the shore to enable scows to be moored underneath. They were eventually floated off, guided across, and placed in position on the bridge-piers. The first 150-foot span was floated into place on the 6th March, and the last on the 26th August, 1925. The spans were taken across the Inlet by means of hoisting-engines on the scows, operating on wire ropes attached to the piers on which the particular span was to be landed. No tug-boats were used for this operation, but navigation was closed for a short time while the spans were in transit. All the spans were floated into position without mishap. The last part of the steel erection to be completed was the bascule leaf, since, owing to the great height this work took considerable time. The concrete counterweight for the bascule span weighs approximately 1,000 tons. The bridge is operated by two 440-volt, three-phase, 60-cycle, alternating-current motors of 100 HP. each, made by the Lancashire Dynamo & Motor Company. Auxiliary and standby operation is provided by a 70-HP. four-cylinder "Buffalo" petrol engine, control being provided by a friction clutch. The electric motors are able to open and close the bridge completely in about 1 minute 15 seconds, whereas the petrol engine requires about 12 minutes.

The electric motor shafts and countershaft are fitted with solenoid brakes, and when the bridge is operated by the petrol engine these brakes must be held off, control being by a hand-operated screw brake. Locking-mechanism is provided at the end of the bascule leaf, the bolts of which are inserted or withdrawn by a 5·3-HP. electric motor. The locking-gear is interlocked with the main control in such a manner that the main motors cannot be started unless the lock is withdrawn. In the case of a power failure, when the bridge has to be opened by the engine, hand-gear is provided for withdrawing the locking-bolts.

Power is delivered at the bridge at 2,200 volts, and two sets of outdoor-type transformers at pier No. 5 step this down to 440 volts for power and 110/220 volts for lighting. All electric wiring on the bridge is carried in conduit, but on the approaches both high- and low-tension wiring is carried on poles. Traffic gates and gongs, electrically operated and interlocked with the bridge-operating mechanism, are provided to keep traffic off the bridge when the bascule span is about to be opened.

As a considerable amount of shipping passes the bridge, signalling and navigation lights are necessary. Each pier is illuminated by a white flood of light at each end, and in the centre of each span except the bascule span there is a red light on each side; all these lights are fixed and in operation continuously through the hours of darkness. The bascule span carries a red light at the centre on each side, which is automatically extinguished when the leaf is fully opened. For the purpose of signalling to approaching vessels, daylight signal-lamps, having a visibility in bright sunlight of 2 miles over an arc of 15 degrees, are installed, one red and one green light on each side of the bridge. These lights are normally extinguished. When a vessel signals for the bridge to be opened, the operator replies by switching on the red light on the side from which the ship is approaching, thus indicating to the ship that her signal has been heard and the bridge is about to be opened. When the bridge is fully open, the operator switches out the red light and switches on the green one, indicating to the ship that she can pass through the span. If two ships approach simultaneously from opposite directions, the operator signals as already described to the one which he proposes to accept first and signals to the other by a series of flashes on the red light, indicating that her signal has been heard but that she will be delayed. If the operating mechanism fails and prevents the operator from opening the bridge, he signals to approaching ships with a series of flashes on the red lamps. A ship going with the tide is always given the right of way over one going against the tide. A complete system of highway lighting has also been installed through the entire length of the bridge and its approaches.

The spans and trestle work are at present provided with a timber deck consisting of 3-inch diagonally-laid planking, with a 2-inch longitudinal wearing surface. A 20-foot concrete roadway was constructed from both ends of the bridge to the nearest paved streets of North Vancouver and Vancouver City.

The original contract included a railway bridge across Lynn Creek consisting of three 60-foot steel spans. As, however, Lynn Creek is subject to heavy floods and exceedingly rapid rises of water-level, and as the bed of the stream changes quite frequently, it was decided to erect a single 150-foot steel span instead of the three smaller spans. The piers were constructed of mass concrete carried 15 feet below ground-level.

The bridge was opened for traffic on the 7th November, 1925, and 45,000 automobiles and 125,000 persons crossed it during the first month.

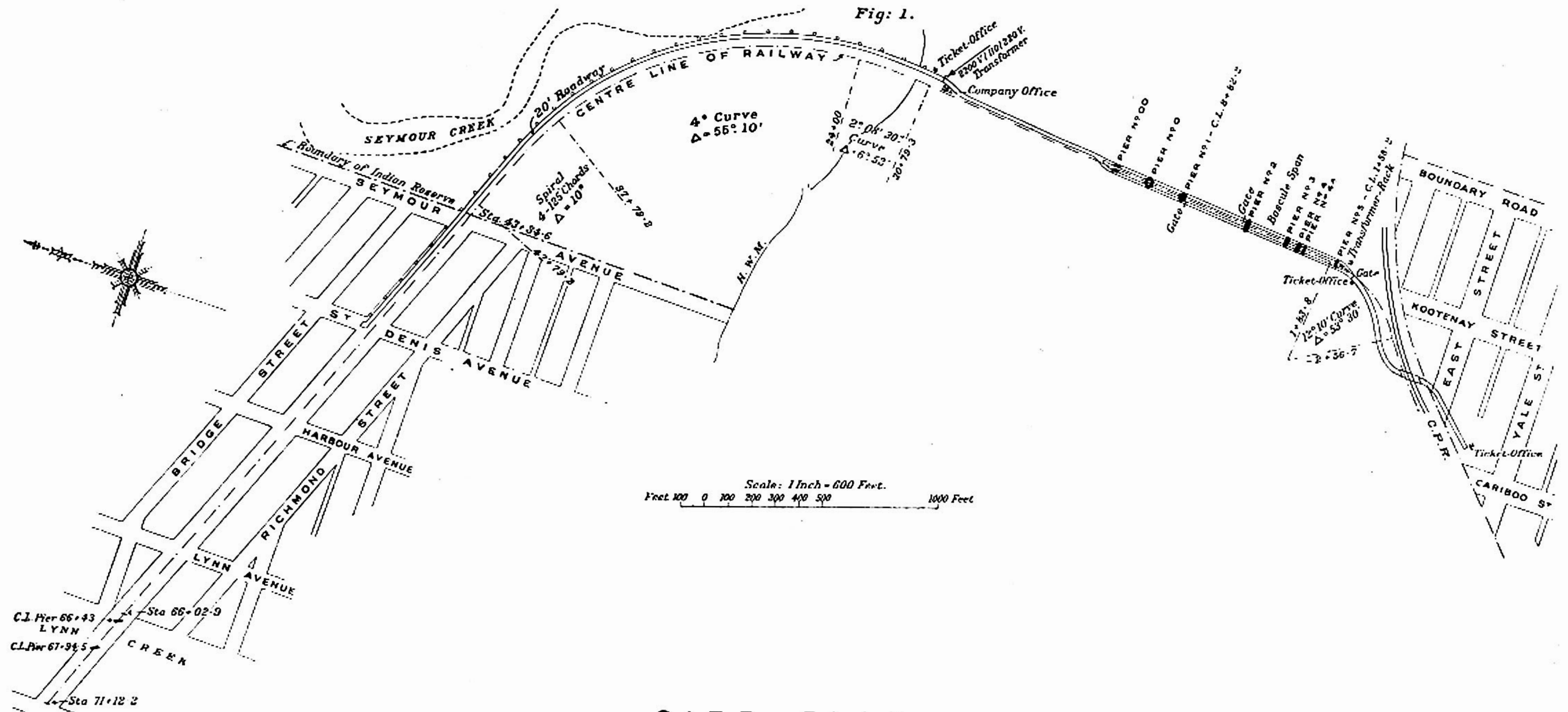
It is intended to connect the present railway terminus at Lynn Creek with the Pacific Great Eastern Railway.

As already mentioned, the contractors for the work were the Northern Construction Company and J. W. Stewart of Vancouver, their Chief Engineer being Mr. Wm. Smaill, and Superintendent Mr. C. A. Leighton. The contract for the structural steelwork was sublet to the Dominion Bridge Company of Canada. The Author was Consulting Engineer for the work, and the Resident Engineer was Mr. E. H. James, Assoc. M. Inst. C.E., assisted by Mr. T. W. W. Parker, Assoc. M. Inst. C.E., and Mr. A. L. Harvey, Assoc. M. Inst. C.E., to all of whom the Author is exceedingly indebted for the manner in which they carried out their duties under, at many times, very difficult and dangerous conditions.

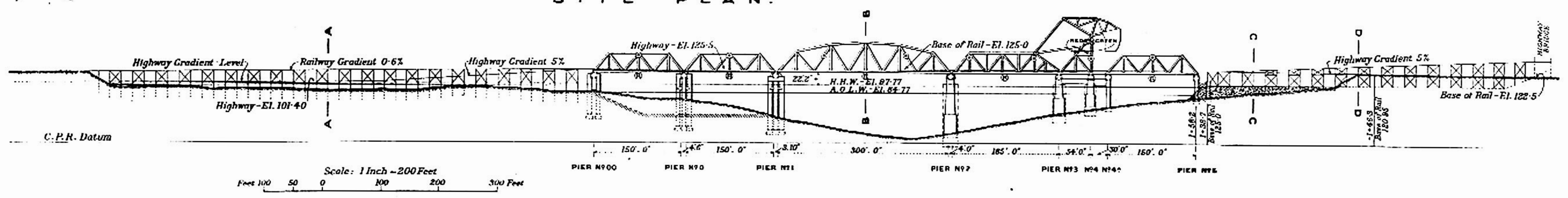
The Paper is accompanied by nine tracings, from some of which Plate 5 has been prepared, and by sixteen photographs.

# RAILWAY AND VEHICULAR BRIDGE ACROSS VANCOUVER HARBOUR, B.C., CANADA.

Fig. 1.



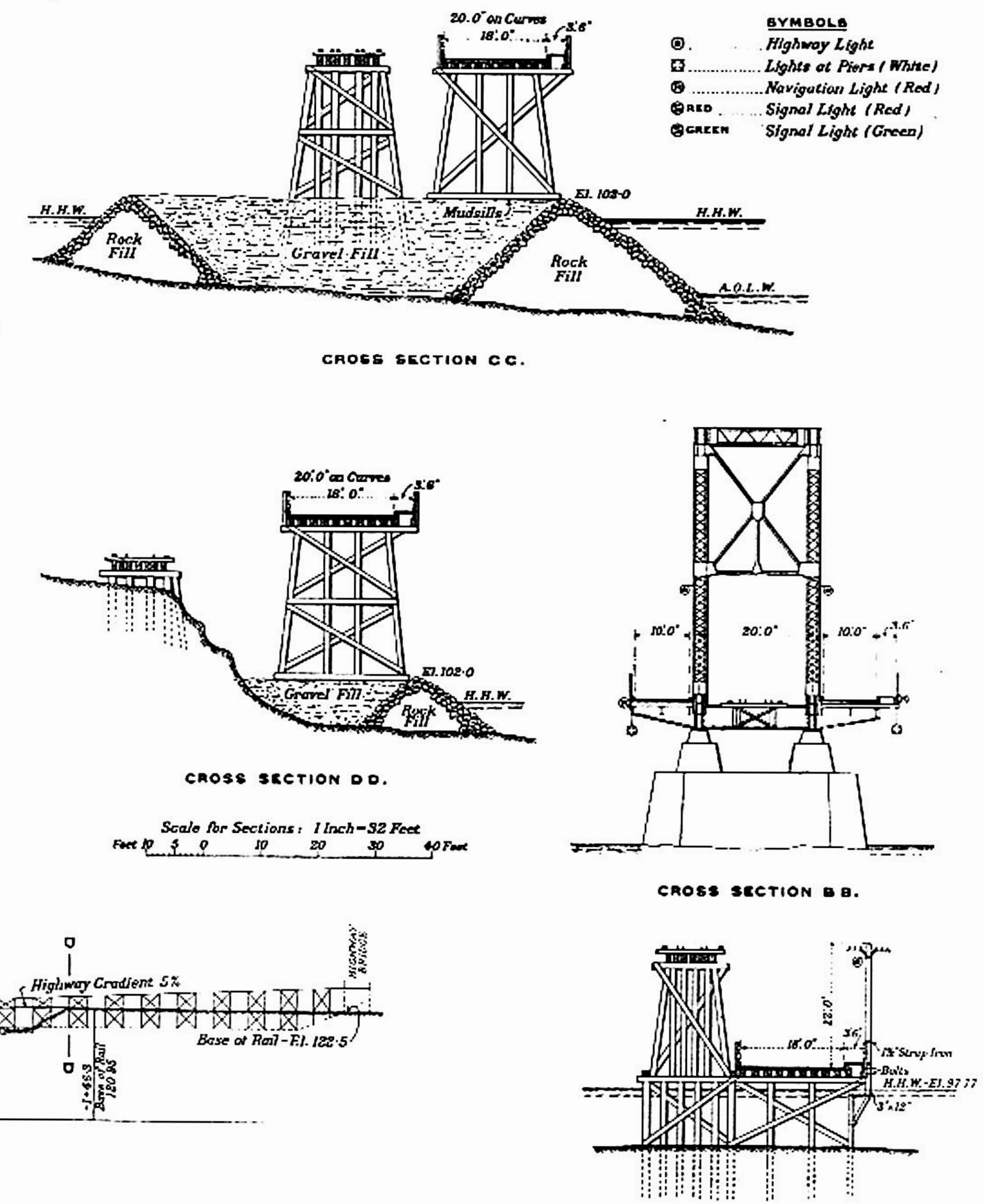

SITE PLAN.



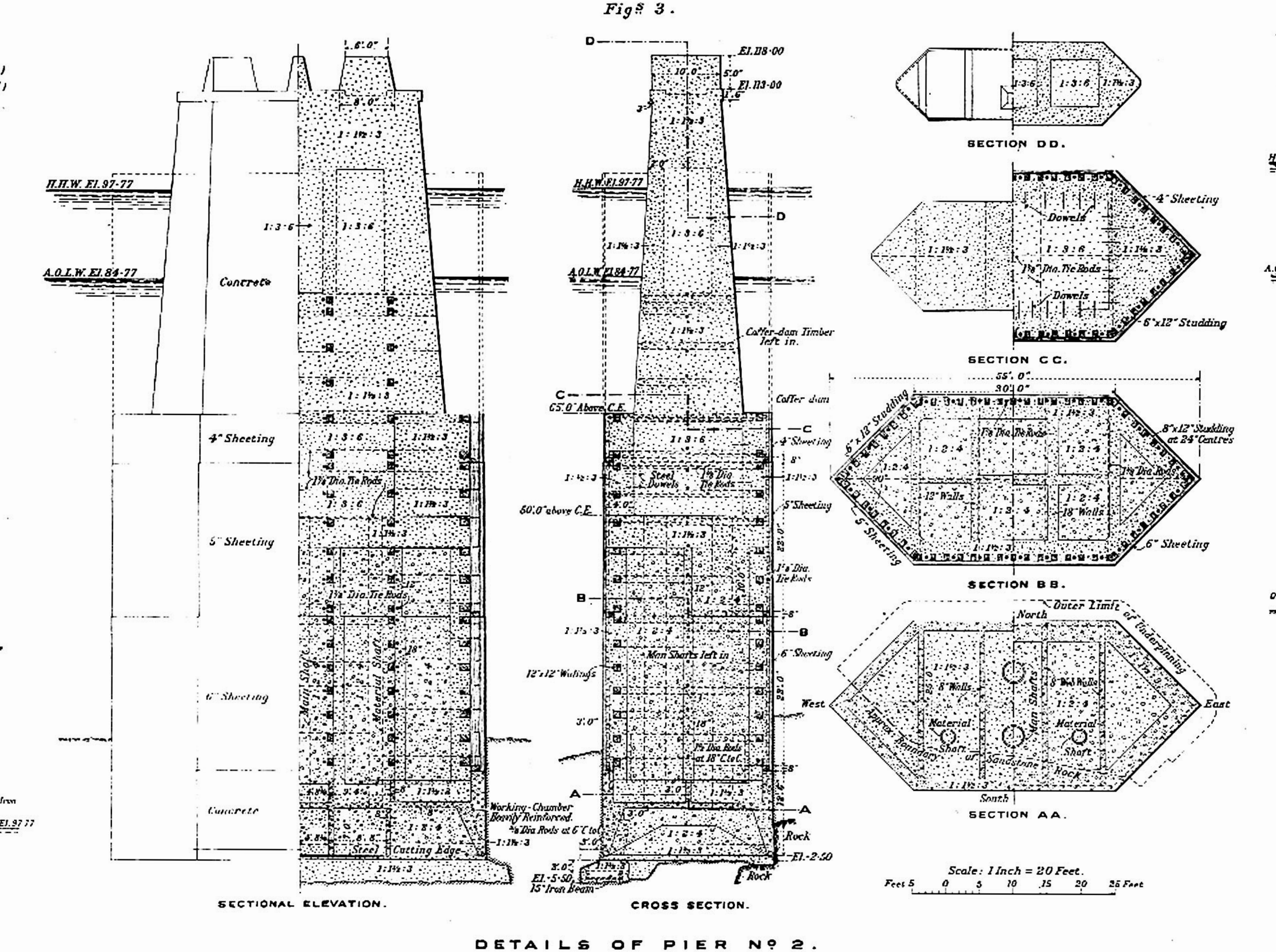

ELEVATION.

GENERAL ARRANGEMENT OF BRIDGE.

Figº 2.

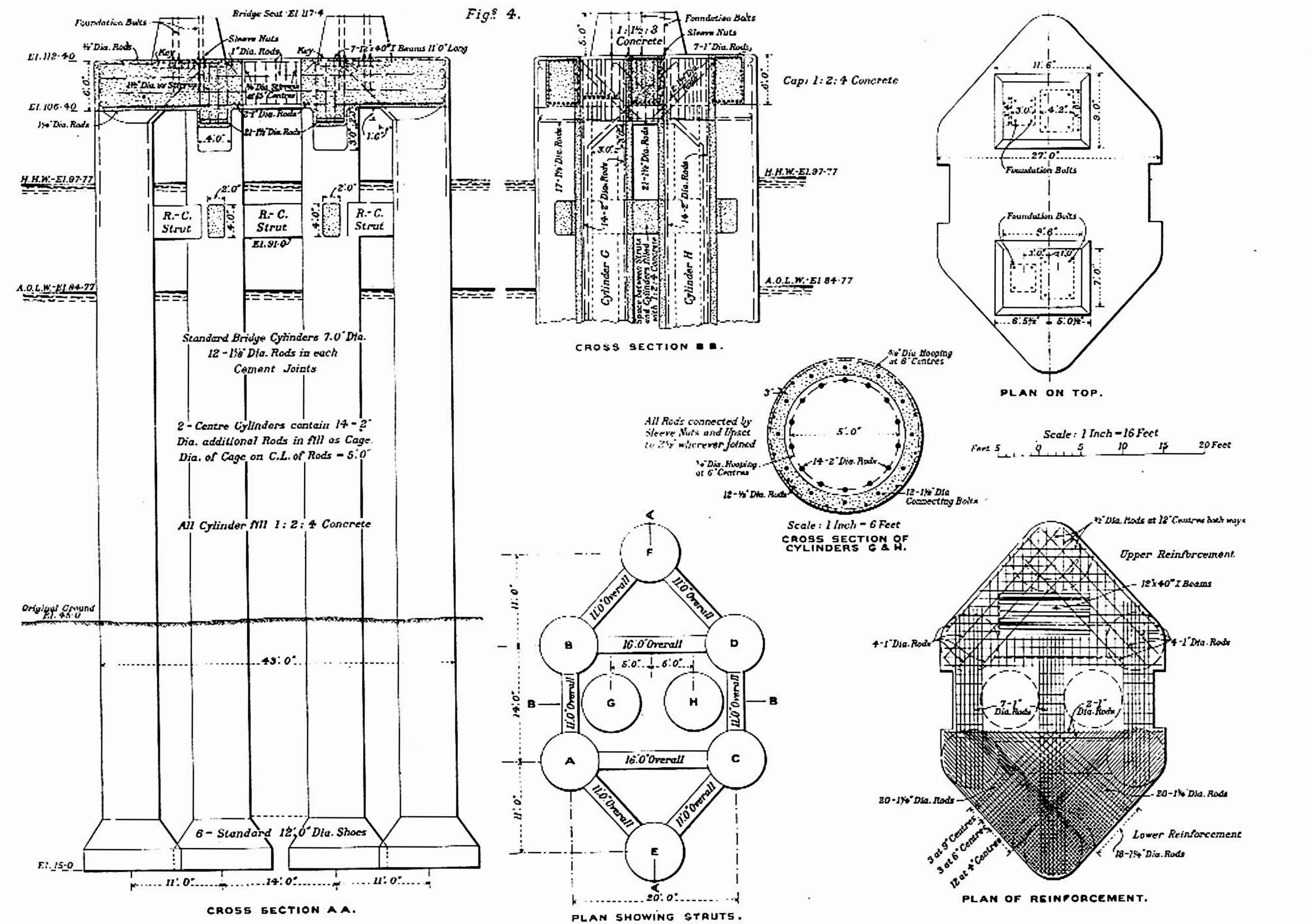



Figº 3.




DETAILS OF PIER Nº 2.

Figº 4.




DETAILS OF PIER Nº1.

A. D. SWAN.