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“Erection of the Nairne Viaducts, near Adelaide,
South Australia.”

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THE construction of the railway between Adelaide, South Australia, and Melbourne, Victoria, was commenced, at the Adelaide end, in the year 1879. The viaducts described in the following Paper occur in the first portion of the line, and span two deep ravines, close together, situated in the very rough country met with in the Mount Lofty Ranges, about 8 miles from Adelaide.

On this part of the line there occur, in succession :—a tunnel, 17 chains in length, in which the formation-level is 200 feet below the surface at the deepest part ; an open cutting of about 1 chain in length ; No. 1 Viaduct, 360 feet in length and 106 feet in maximum height from surface to formation-level ; a shallow bank, not quite 2 chains in length ; and No. 2 Viaduct, 260 feet in length and 78 feet in maximum height. Crossing the viaducts, the line is on a curve of $10\frac{1}{2}$ chains radius, the curve extending from 2 chains inside the tunnel north of No. 1 Viaduct to 10 chains into a deep cutting at the south end of No. 2 Viaduct.

At the Garden Palace Exhibition, opened in Sydney, N.S.W., towards the end of 1879, one of the most interesting engineering exhibits was one span of a road-bridge to be erected over the Shoalhaven River by the Edgemoor Iron Company of Philadelphia, U.S.A. Taking advantage of the presence of Mr. Onward Bates, M. Inst. C.E., the Company's Engineer, in Australia, Mr. H. C. Mais, M. Inst. C.E., then Engineer-in-Chief of South Australia, invited him to submit a design for the viaducts. After some slight alterations made by Mr. Mais, the design and strain-sheets were submitted and agreed upon, and a contract was entered into for the supply and erection of the ironwork. The whole of the ironwork and erecting-gear was on board ship in New York Harbour within 30 days of the receipt of the plans and specifications at the Company's office in Philadelphia.

No. 1 Viaduct is made up of twelve spans of 30 feet, whilst No. 2 Viaduct consists of eight spans of 30 feet, and one span of

20 feet at the south end, Figs. 1, Plate 5. Each alternate bay is braced longitudinally as well as transversely, so as to form virtually a rigid column. For the intermediate bays the main girders span the 30-foot opening from one such rigid column to the next. Pier 1 of No. 1 Viaduct, and Piers 5 and 8 of No. 2 Viaduct, unlike the other piers, consist of hinged posts, allowing a rocking motion in the direction of the length of the viaducts. Each leg of each pier stands on a separate concrete base, as shown in Figs. 1, Plate 5. These and the concrete abutments had been built by Government day-labour before the arrival of the ironwork, as they formed no part of the work contracted for, although included in the design.

The ironwork was shipped in 30-foot lengths, or even greater lengths in the case of diagonal braces, so that little riveting or bolting was necessary after getting the pieces into position. The material having been carted to the spur between the two viaducts, a wooden-framed crane, having a fixed horizontal overhang of about 32 feet, was erected at the south abutment of No. 1 Viaduct. The legs of Pier 11 were swung into position, and the transverse bracing was fixed without securing the base-plate by any holding-down bolts. The horizontals are small lattice-girders, and the diagonals are 1-inch and $1\frac{1}{8}$ -inch tie-bars with adjustable screws, Figs. 3, Plate 5. The main girders for this bay were then placed in position, and were secured by temporary drift-bolts. The crane was then run forward on four wheels of small diameter, which were narrow enough to pass between the rivet-heads of the top member of the main girders. It was securely fixed to the girders when the main verticals of the crane were just over Pier 11, so that the outer ends of the horizontal arms were over the line of Pier 10. The work was then carried on as in the first bay, with the addition in this case of the longitudinal bracing, before proceeding with the next bay, and meanwhile the riveting of braces, fixing of buckle-plate decking, etc., were going on in the first bay. These operations were repeated till the whole viaduct was completed. The fixing of the holding-down bolts at the base of the pier-legs was the final operation, holes being drilled by hand in the concrete bases through the holes in the base-plates. The design was extremely simple in character, although very effective, and lent itself to this simple and rapid method of erection without staging.

A notable feature of the structure is the complete accessibility of the parts for examination and painting, so that with ordinary care in maintenance it should last for years, unless the weight per

axle of the locomotives should be materially increased, when new and stronger cross-girders would be required. To prevent damage should an engine or carriage leave the rails, a longitudinal balk of timber, 12 inches by 6 inches, is bolted to the sleepers (which are spaced 2 feet apart, centre to centre) 10 inches from the face of the upper rail, the top corner being faced with 3-inch by 3-inch by $\frac{7}{8}$ -inch angle-bar. Between the foot of the rail and this balk an iron plate, 6 inches by $\frac{3}{4}$ inch, is fixed on the sleepers. On the inner side of the lower rail an iron plate, 8 inches by $\frac{3}{4}$ inch, and a steel guard-rail $4\frac{1}{2}$ inches in height are fixed, Fig. 2, Plate 5.

The contract price for the supply and erection of ironwork was £40 per ton for a little over 250 tons, the girders weighing 138 tons and the legs 112 tons. The concrete bases and abutments, including excavation of foundations, cost £3,480, thus bringing up the total cost to £13,490. As the total length of deck is 620 feet, the cost per foot run was not quite £22.

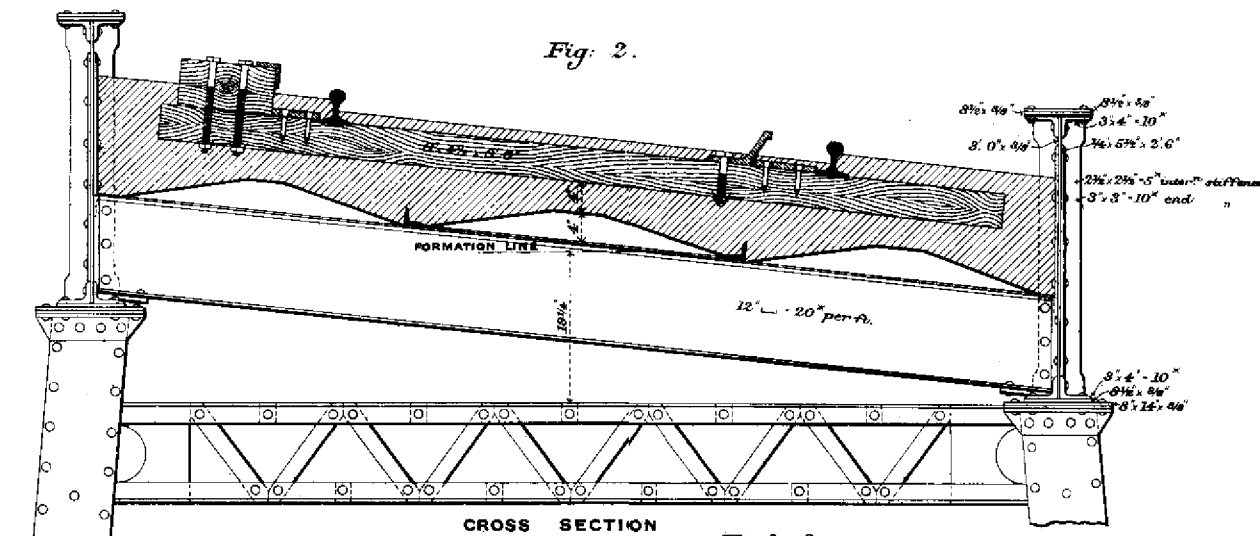
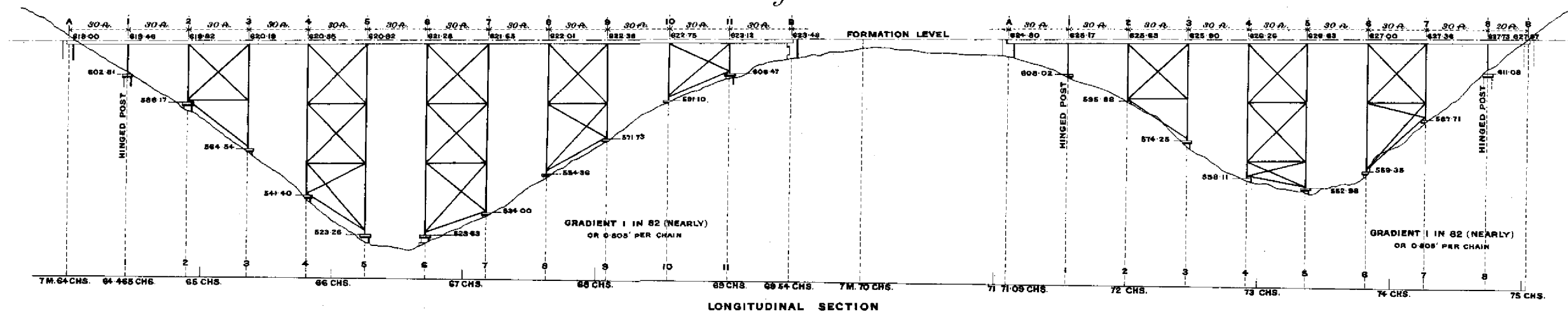
The setting-out of the concrete bases, which had to be done very accurately, was rendered extremely difficult by the rough nature of the country, the slopes, especially at the tunnel end of No. 1 Viaduct, being so steep that steps had to be cut to enable the workmen to climb up and down, while it was almost impossible to set up an instrument at all. When the ironwork was finished everything was found to be absolutely correct. The setting-out was done partly by Mr. J. Stirling and partly by the Author, who were assistants to the late Mr. P. Galt, Resident Engineer. Mr. R. C. Patterson, M. Inst. C.E., Deputy Engineer-in-Chief, acted as Inspecting Engineer throughout the construction of the railway, and gave special attention to these viaducts.

The present Engineer-in-Chief, Mr. A. B. Moncrieff, M. Inst. C.E., recently reported that the viaducts have been used for public traffic for 19 years, and are in first-class condition and perfectly safe.

The Author is indebted to Mr. H. C. Mais, M. Inst. C.E., for particulars of cost and other details given in the Paper.

The Paper is accompanied by three photographs illustrating the method of erection of the viaducts; and by three tracings, from which Plate 5 has been prepared.

Fig¹.



PLAN

RADIUS 650 FEET

