soon after they were put into use; the whole apparatus has had to be discarded at all the stations at which it was in use.

The following statement gives a comparative summary of the working for the year compared with 1898 :—

	Year ending December 31st, 1899.	Year ending December 31st, 1898.
Miles open at close of year	1,990	1,990
Capital cost	£20,930,573	£20,222,263
Average cost per mile	£10,518	£10,162
Capital entitled to interest	£20,800,212	£20,027,299
Gross earnings	£2,792,975	£2,953,090
Working expenses	£1,830,321	£2,012,390
Net earnings, belonging exclusively to the Cape Government	£962,654	£940,700
Working expenses to earnings, per cent.	65·5	68·1
Net earnings to capital, percentage	£4 12s. 7d.	£4 13s. 11d.
Train miles	7,958,434	8,905,378
Earnings per train mile	7s. 0·2d.	6s. 7·6d.
Working expenses, per train mile	4s. 7·2d.	4s. 6·2d.
Earnings, per average mile open	£1 404	£1,495
Working expenses, per average mile open	£920	£1,019
Locomotives, number	475	489
Coaching vehicles, number	645	590
Goods and live-stock vehicles, number	6,670	7,046
Other kind of vehicles, number	742	762
Passengers carried (inclusive season tickets), number	11,006,870	10,013 432
Goods carried, tons	1,261,038	1,507,600
Population (white), approximate	458,000	449,000
Miles of line open per 1000 of white population	4·34	4·43
White population for every mile open	230	223

The engineer-in-chief reports that the fracture of fish-plates continues high, but can be attributed to the heavy weight per axle of the engines and the high speed. The breakages occur principally in the lighter type of the 60 lb. road. The angle or wing fish-plates, which have been put into the road at various places, have so far proved to be a success, and they will be adopted in place of the present type. The number of broken fish-plates found in the road during the year totalled 11,391. Of these 2907 were of light section and 8484 of heavy section.

GREAT NORTHERN RAILWAY.—NEW RAILWAY AT NOTTINGHAM.

By R. F. BENNETT, Construction Department, G.N.R.

No. III.

CLOSE to the canal bridge previously described is the bridge over the London-road. It is a steel girder bridge of 50ft. span, on the square. Here, again, the platform of the London-road Station has to be carried over the bridge. Four main girders were employed, two for carrying the up road, and two for carrying the down road, the two inner were spanned by cross girders projecting in the same way as the bridge over the canal. The flooring is composed of steel trough plates §in. thick, and ballast plates are put along the main girders to keep the ballast away from the web.

It has been found that one of the principal causes of the deterioration of girders, which is now giving so much trouble, and is likely in future to give still more, is the contact of the ballast with the web plates. Those who have to do with the maintenance of bridges find that the girders generally corrode at the junction of the ballast and the web. The ballast gets wet and keeps the web in a state of rust, and gradually the latter gets pitted and finally eaten away. This action is specially rapid where ashes ballast is used. The Great Northern and other companies in all new bridges fix guard plates so that the ballast is kept away from the girders; and it is hoped by this means to add considerably to the life of the same. A sloping cover is put from the top of the ballast plate to the web of girder, so that any rain that may beat in is led away to the asphalted flooring, and thence to nearest drainage.

After London-road is passed there is a long range of fifteen arches, about 35ft. in height; the arches are of similar character to those already described, and do not call for further attention. As it is a rather long range of arches, it was thought best to build cross walls in the centre span, to act as a bastion or steadying pier.

After this range of arches is passed the canal is crossed again by a lattice girder bridge of 123ft. span. There are three girders of N type to be used, with cross girders on top of same, bracketed out so as to form a curve parallel to the rails on the top. The rails are carried on longitudinal rail bearers, and the flooring consists of §in. bent steel plates, the usual vertical and longitudinal wind bracing is provided, and the bearings for the main girders are similar to those shown for the former bridge over the canal previously described. This bridge is shown in Fig. 4, page 258. After this bridge comes another range of four arches, when Leen side is crossed by a similar lattice girder bridge to that just described.

After another range of four arches the line passes over a back street called Popham-street; this road is crossed very much on the skew, and although the square span is only 25ft., the skew span comes out to 57ft. 4½in. The bridge consists of three longitudinal web girders. The outside girders being bracketed out to carry the curved parapet. The flooring consists of pressed trough plates covered with asphalt and the ordinary ballast with loose road on top.

Again passing over a few arches, the line crosses another back street called Malt Mill-lane. Here, owing to the curve and the skew, the girders differ in length, the west girder being 56ft. 1in. in span, and the east girder 63ft. 4in. This bridge is shown in Fig. 11, and will be seen to consist of two plate girders bracketed out more or less for an open parapet on the curve. The cross girders are placed 12ft. apart, and it will be noticed that only the two in the centre span between the main girders, the remainder having one end resting on the abutment. It will also be noticed that on account of the curve the centre bay between the cross girders is radiated, the cross girders being 12ft. 8in. apart at the outside of curve, and 11ft. 4½in. on the inside; by this means all the other cross girders could be put parallel, which is a great advantage to the flooring. This consists of pressed steel troughing on top of the cross girders, jointed on the top of each cross girder to facilitate erection. The last steel span is that over Narrow Marsh, close to the junction with the Great Central Railway. The bridge here consists of three main girders, 39ft. 11in. span, with troughing between. The bridge almost touches that belonging to the Great Central over the same road, and special provision had to be made in the parapet where the two girders meet at an acute angle; there is nothing, however, unusual in this bridge, and it does not call for further attention.

It will be noticed that all the steel bridges over the main roads at Nottingham have open parapets instead of the usual heavy plate screens, which are insisted on by most local authorities. These open parapets were agreed upon in consultation with the city authorities. They give the bridges a much lighter appearance, and it is very doubtful if the effect on the horses is so injurious as when the plate screens are used. A horse will not be so frightened at anything he is able to see and understand, as he will if he can hear a locomotive and only see the chimney. The traffic has been running over these bridges for some time, and no report has been received as to the horses being frightened. The appearance of bridges, especially lattice girder bridges, would be much improved if the wise example of the Notts City Council was more generally followed.

As previously stated, a new station had to be put at London-road, as near the existing terminal station as possible. The platforms themselves are on the viaduct, but the station buildings, which are of handsome design, are on the street level, with large cabyard in front. They are built up against the south face of the viaduct, and the booking-hall is in front of one of the arches, and measures 30ft. by 23ft. 6in., with four windows for booking, the booking clerk's office behind being 30ft. by 15ft. There are ample cloak-rooms and parcel offices, with a large parcel stores under one of the arches, so as to provide for the large quantity of luggage which is now left at the stations. The booking-hall opens direct into the arch behind, which is lined with glazed bricks. A hydraulic lift, capable of raising 10 cwt., is provided for the luggage, worked by pressure obtained from the Corporation mains. From the archway is a wide staircase leading up to the platform. The stairway is also lined with glazed bricks, and opens on to the covered platform. The usual waiting-room accommodation is provided on the platforms. The whole is covered in by a handsome hipped covering, the ridges at right angles to the platform, the ends facing the rails.

The covering is carried on cast iron columns; the roofing is of mild steel throughout, and glazed; the bays are 18ft. centres. A photograph is given on page 259 which shows the roofing very well.

On page 258 are given four photographs. Figs. 1, 2, and 3 are described in our issue of August 31st, and Fig. 4 is alluded to in the present article.

The whole of the brickwork of the viaduct was built in lime mortar in proportions of 2 of sand to 1 of blue lias lime, except the parapets, which are in cement mortar. The general foundations are all in cement concrete; the backing in the spandrils of the arches is in lime concrete in the proportion of 5 of gravel to 1 of lime. The specification and tests for the cement are as follows:—"The Portland cement shall be of the best quality, and shall be obtained from manufacturers approved by the engineer. It shall have a specific gravity of not less than 3·10, and be so finely ground that it will all pass through a sieve of 900 meshes per square inch, and leave upon a sieve of 5776 meshes per square inch a residue not exceeding 10 per cent. When made into pats, the neat cement shall stand immersion for twenty-four hours in a hot water bath maintained at 113 deg. Fah. without cracking, and test briquettes of neat cement after being immersed seven days in cold water shall be capable of resisting a tensile stress of 350 lb. per square inch before fracture, and increase not less than 25 per cent. in strength after being immersed for twenty-eight days. Any cement failing to stand these tests will be rejected, and shall be at once removed from the works."

The specification for concrete was as follows:—"The lime concrete shall be formed of clean gravel, or good hard broken stone, of not more than 1½in. cube, and sand, well mixed with freshly-burnt ground lime, as hereinafter specified, in proportions by measure of 3 of gravel or broken stone and 2 of sand to 1 of lime. The cement concrete shall be formed of clean gravel, or good hard broken stone of not more than 1½in. cube, and sharp, clean sand well mixed, as hereinafter specified, with Portland cement of the quality aforesaid, in the proportions by measure of 5 of gravel or broken stone and 2 of sand to 1 of Portland cement. In the cylinders the proportion shall be 3 of gravel and 2 of sand to 1 of Portland cement. The proportions shall be ascertained by proper gauges to be provided by the contractor; and the materials shall be thoroughly mixed on a clean wooden platform. The sand and cement shall be first mixed together with water, and turned over until reduced to a paste. They shall then be cast upon the gravel or broken stone, which shall first be well wetted, and the whole turned over until thoroughly incorporated, water being added as required to bring it to a proper consistency. The concrete shall be lowered in skips, and carefully deposited at the bottom of the foundations, and shall in no case be thrown from a height. When deposited it shall be spread by hand, and thoroughly pumned, and brought up in layers not exceeding 1ft. in thickness, the top being levelled to a uniform surface before the brickwork is commenced."

The specification for the steel used in girders and flooring was also as follows:—The steel and wrought iron used in girders and flooring shall be of such strength and quality as to be equal to the following tensile strains, and to indicate not less than the following percentages of contraction of the tested area at the point of fracture, and of extension in 10in.:—

	Tensile strain per square inch. Tons.	Percentage of contraction.	Percentage of extension in 10in.
Steel plate, angles, tees, and rivets { not less than	28	45	20
Steel plate, angles, tees, and rivets { nor more than	32	—	—
Wrought iron plates, angles, and tees with the grain	22	10	7
Wrought iron rivets, straps, and bolts	23	25	—

The steel used for girders shall be capable of being bent double on a radius of the thickness of the specimen, without showing signs of fracture. All rivets, both steel and iron, shall be capable while cold of being bent double without signs of fracture.

The Parliamentary powers for the above were obtained by Mr. Richard Johnson, late engineer to the Great Northern Railway, and the work was carried out under the supervision

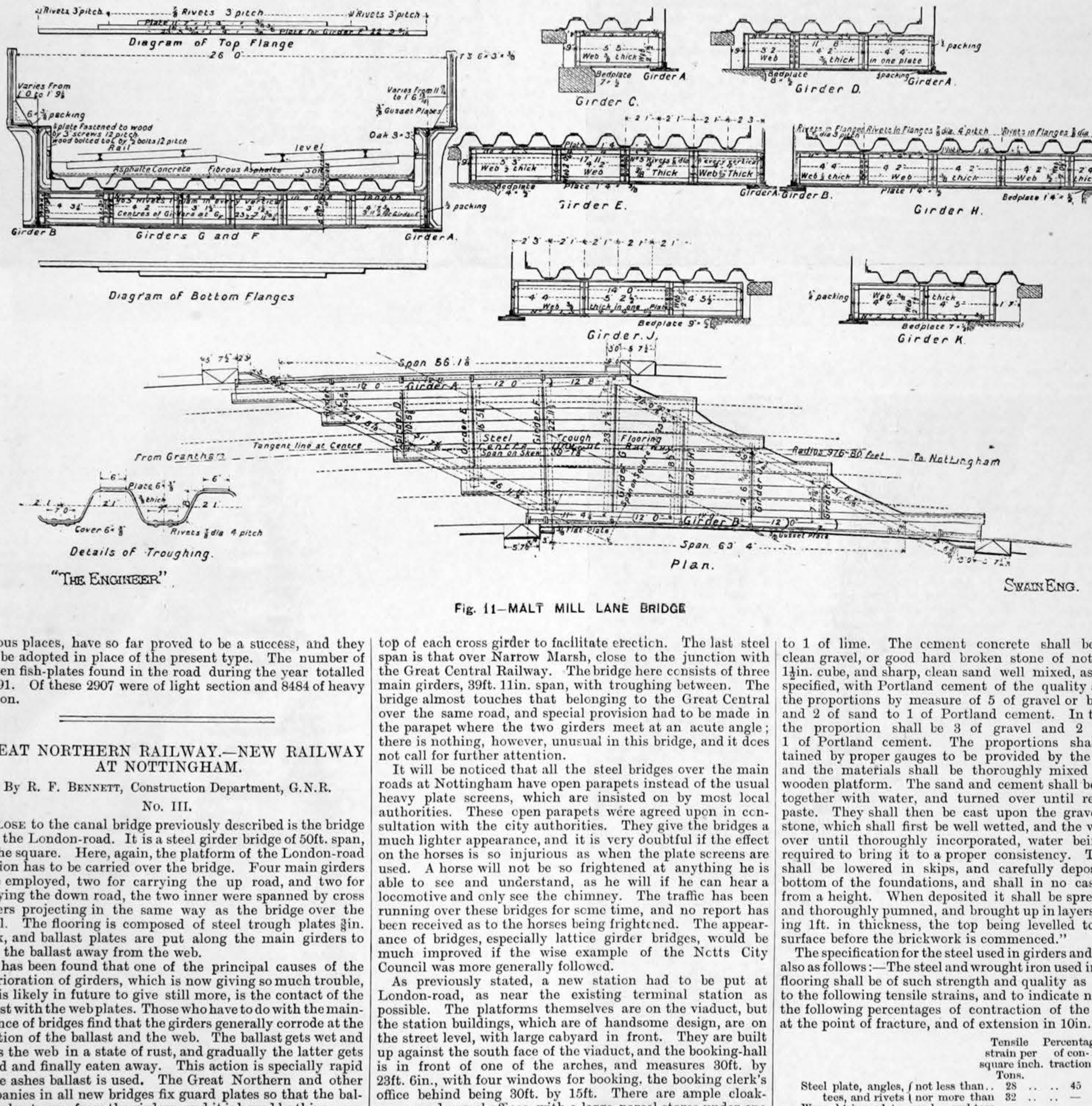


Fig. 11—MALT MILL LANE BRIDGE

GREAT NORTHERN RAILWAY—NEW LINE AT NOTTINGHAM

(*For description see page 257*)

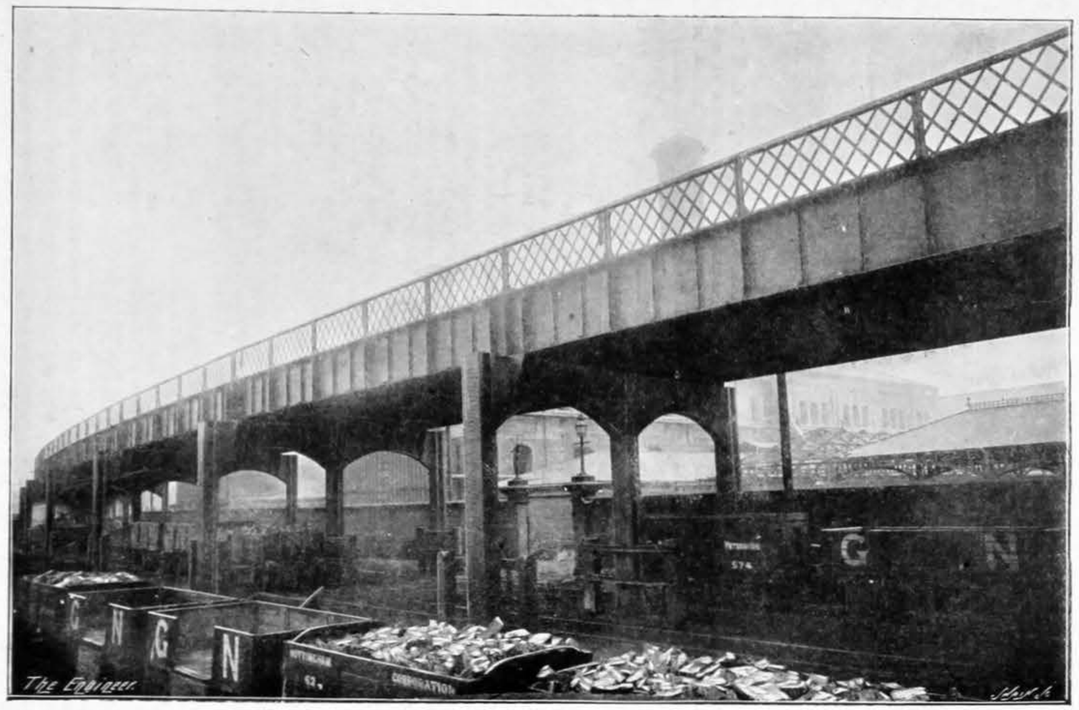


Fig. 1 GAS WORKS SIDING VIADUCT

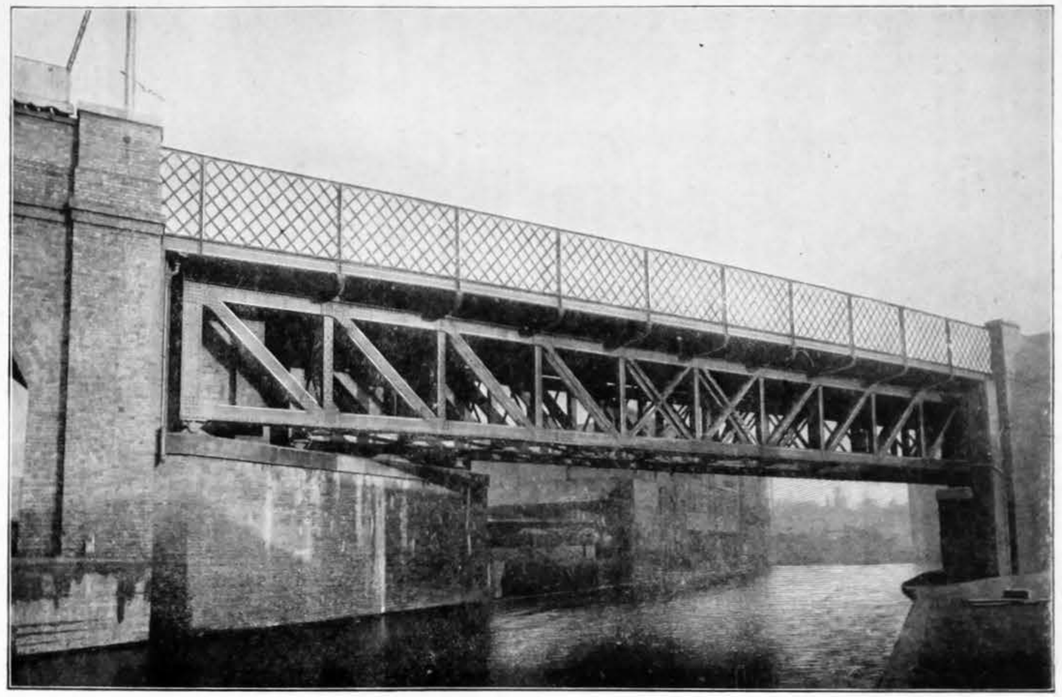


Fig. 4—BRIDGE OVER CANAL

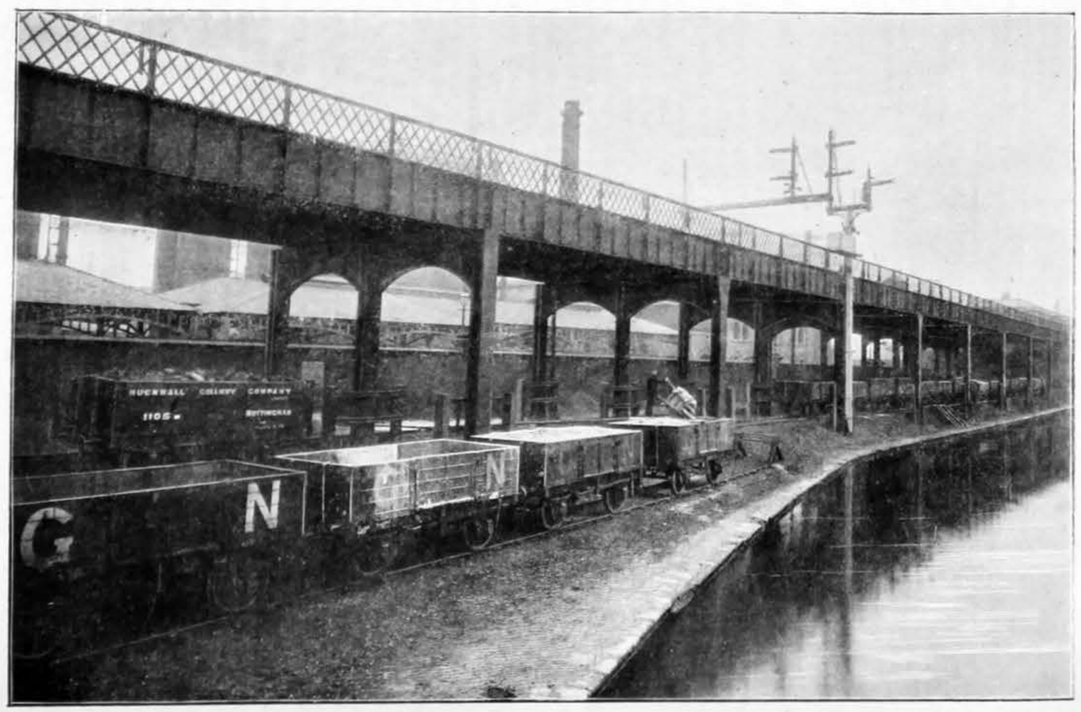


Fig. 2—GAS WORKS SIDING VIADUCT

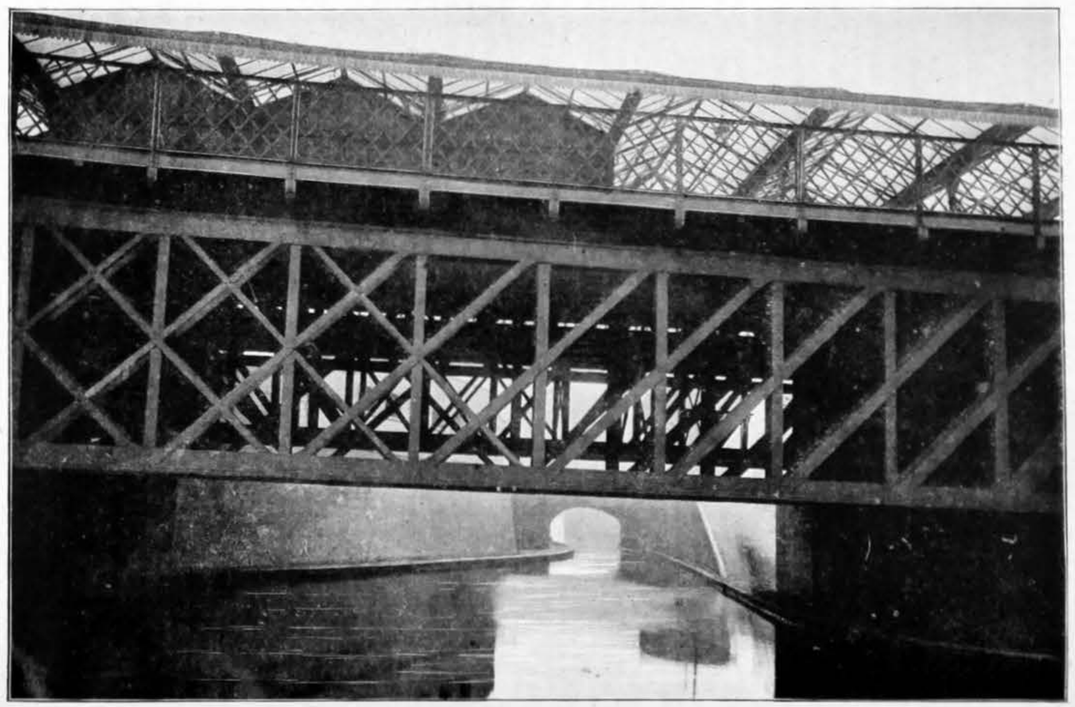
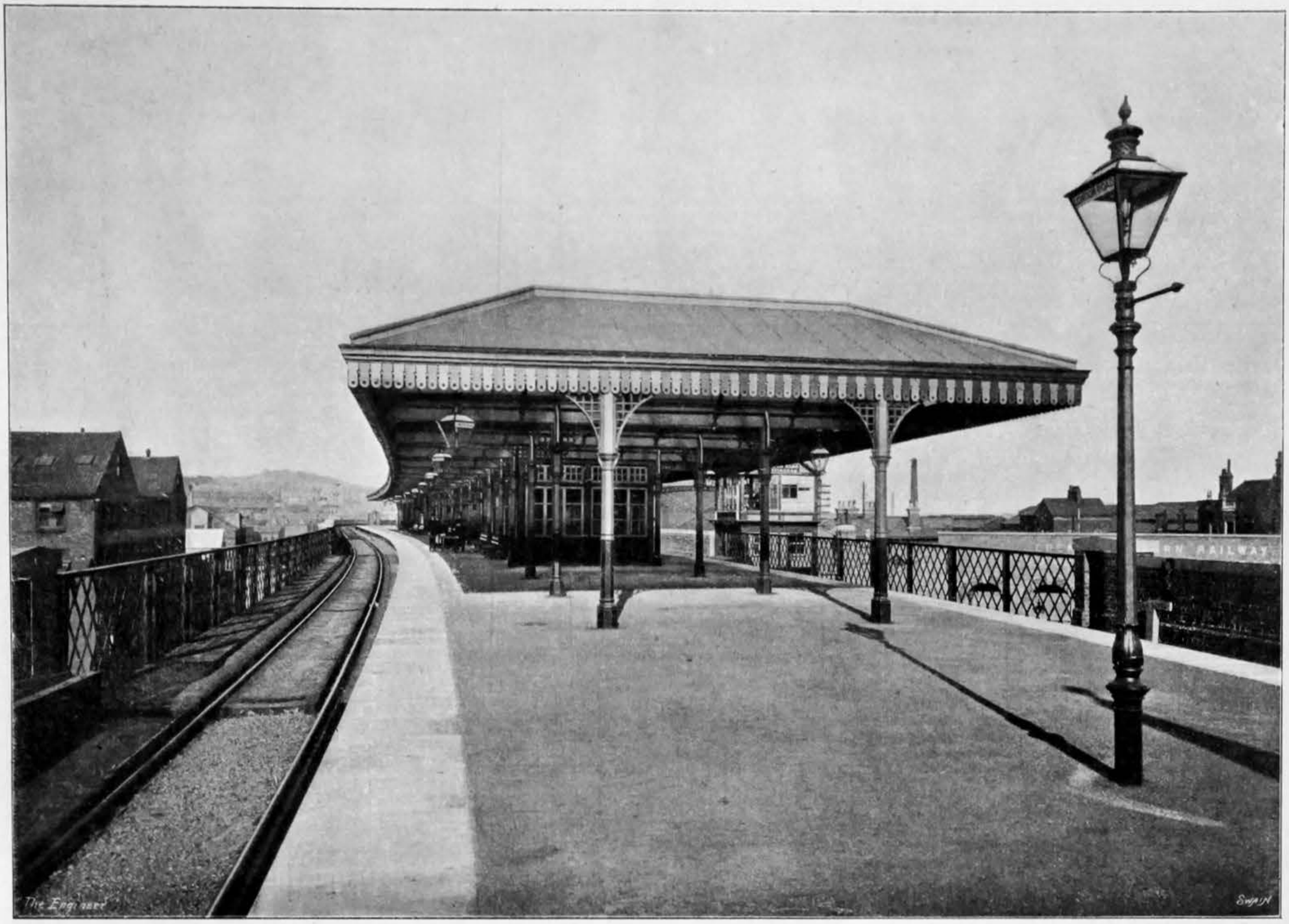


Fig. 3—PART OF GIRDER OVER CANAL BASIN

GREAT NORTHERN RAILWAY—LONDON ROAD STATION, NOTTINGHAM

(*For description see page* 257)



of Mr. W. H. Sadler, M. Inst. C.E., the chief assistant for construction, Mr. V. B. Hunt being resident engineer. The contractors for the general work were J. D. Nowell and Sons, of Westminster. The steelwork was constructed and erected by the Patent Shaft and Axletree Company, of Wednesbury.

visional Order to supply Glasgow generally, as also did the Corporation, but the company withdrew in favour of the Corporation application, which was duly sanctioned by the Board of Trade. Subsequently the Corporation agreed to purchase the company's undertaking for £15,000, and on 1st March, 1892, it entered upon possession. The supply on the high-tension overhead system having only Board of Trade sanction till August, 1893, the Corporation proceeded forthwith to lay down a central generating station for low tension

stations during the night or early hours of the morning, when both plant and mains were under easy load, and to discharge them during the two or three hours of the afternoon or evening maximum load, the discharge current, of course, going to feed the local districts around each sub-station.

Following upon this, the Committee turned their attention to the question of suitable sites for entirely new works—one