RAILWAY ENGINEERING IN ENGLAND.

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(Continued from last week.)

The Great Western Railway was opened to Maidenhead, a distance of 23 miles, in June, 1838; to Twyford, in July, 1839; the whole length to Bristol being completed by June 30th, 1841. An important work is the Wharncliffe viaduct, which carries the line over the valley of the River Brent, near Hanwell. It consists of eight semi-elliptical arches, each of 70ft span, with a rise of 17ft 6in. The average height from the ground level is 65ft. It is a fine example of brickwork, and is built throughout as light as possible, compatible with the most economical and effective distribution of material, a point to which Mr Brunel paid the most profound attention. This principle in brickwork forms somewhat of a contrast to the method pursued in the earlier works of the Stephensons, whose fundamental policy was solidity. For example, in the case of retaining walls, Mr Robert Stephenson adopted the curved form, relying upon its shape and massiveness to resist the forward pressure of the earth. On the other hand, Mr Brunel's plan was, in such structures as were subjected to earth pressure from behind, to make them as light as possible, and, in the case of retaining walls, to adopt the straight form, introducing, however, at the back, "sailing courses," which were in reality projecting shelves. The pressure of the earth on these courses increased the weight at the back of the wall; in other words, increased the resistance to forward pressure.

Perhaps the finest example of a brickwork structure is the bridge carrying the railway over the Thames at Maidenhead, a view of which is given The bridge crosses the river, which is at this point about 290ft wide, in two spans of 128ft, with a rise of 24ft 3in. Flood openings consisting of semi-circular arches, one of 21ft span and three of 28ft span, precede and follow the main spans. The radius of curvature of the main arches, which are among the flattest ever built, is 165ft, the line of pressure in each case being diverted in a downward direction by the thrust of the adjacent flat arches, which carry a mass of concrete.

During the construction, when the centering was slackened, the brickwork of one of the arches followed the centering for a distance of 5in at about 15ft, one each side of the crown, and one of the spandril walls cracked, circumstances which at the time awakened the apprehensions of some with regard to the safety of the bridge. This, however, was remedied, and when the time came, years later, for the bridge to be widened, Sir John Fowler decided to carry the extra rails on brickwork, and by so doing preserved the elegance of the structure.

Many other of Mr Brunel's brick and masonry bridges on this railway are of an interesting character, but space will not permit more than a mention being made of the three-arched gothic masonry bridge near Bristol, with a centre arch span of 100ft; the flying bridge near Weston-super-Mare, with a clear span of 110ft, carrying a road across the line at 60ft above the rail level; bridges of the same character used to keep apart the sides of a cutting; and skew ashlar masonry bridges with mechanically correct spiral tapering courses.

Cast-iron as a materials for the construction of bridges was first used in railway work by the Stephensons. Brunel, however, did not make much use of it for this purpose, his objection to it reposing on the fact that repairs necessitated to such structures as a result of frosty weather or other causes were generally excessive. He introduced it, however, in cases where headway was very limited in the form of troughing let into the crown of brick arches. His objections were also probably founded on the fact that at that time sound castings of any large dimensions were not always possible to obtain. Wrought-iron, in spite of its cost, was a material Brunel employed in the larger of his bridges, as examples of which may be cited that carrying the Windsor branch of the Great Western Railway over the Thames, the Chepstow Bridge over the River Wye, and, finally, his last and culminating work, the Royal Albert Bridge over the River Tamar at Saltash. The structure at Windsor is a fine bridge on the bow and string girder principle. It has a span of 202 feet, and a truss of 23 feet in height. It crosses the river in an oblique direction, and a system of diagonal bracing connects the whole of the top of the trusses to strengthen the arched ribs.

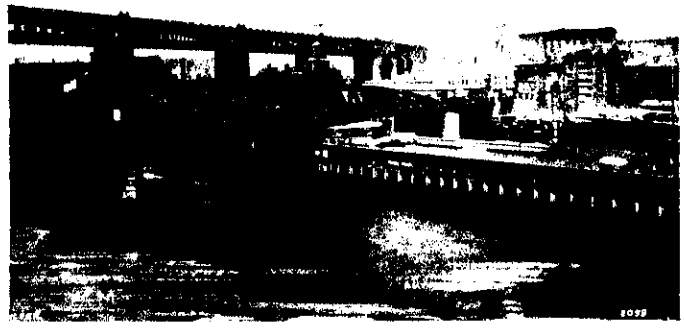
The greatest engineering achievement of Brunel is the Royal Albert Bridge. This is 2200 feet in length and 100 feet high, and crosses the river in two spans of 455 feet each, and on 17 side spans of minor dimensions. The piers are of masonry, that in the centre, on which are cast-iron columns supporting the main girders, being 35 feet in diameter.

Each main span is arched in form, its chief members consisting of a wrought-iron oval tube, 16 feet 9 inches broad and 12 feet 3 inches in height, and two suspension chains falling from the extremities of the tube to a distance corresponding to the rise of the arched tube. The maximum distance between the tube and chains is 58 feet. Upright standards, connected by diagonal bracing, are interposed between tube and chains at 11 points in each truss, the girders carrying the road being suspended from each of these at intermediate points. The total weight of ironwork in each span is 1060 tons, and the cost of the completed structure was £225,000.

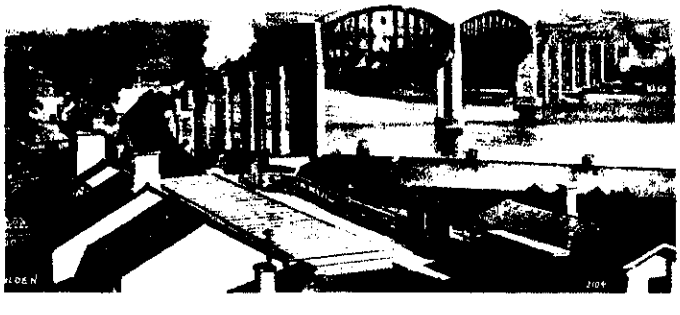
Advantage may be taken here of contrasting with the above bridge the masterpiece of Robert Stephenson, viz., that carrying the railway over the River Tyne at Newcastle, the last link which was to connect, by the East Coast route, the English and Scotch capitals.

The bridge, which is a true example of a bowstring arch without cross-bracing, has six spans, each of 125 feet, which, as in the case of the Saltash bridge, combine both the arch and the suspension principles. The cast-iron arched ribs, four to each span, are arranged in pairs, the inner pair 2 feet 4 inches apart, a space of 6 feet 2 inches, utilised to form a footpath, separating each outer pair.

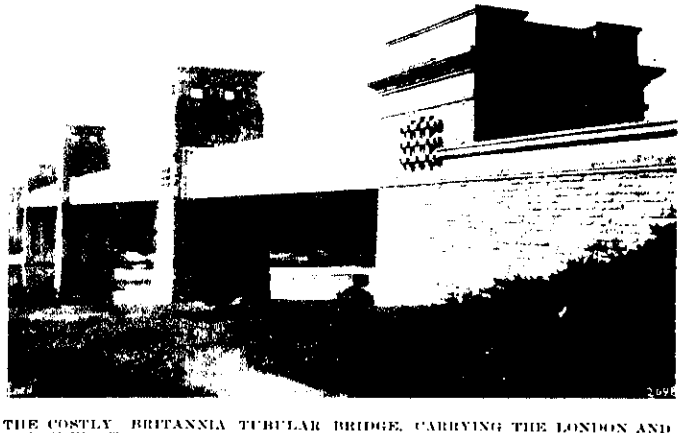
MAIDENHEAD BRIDGE, CARRYING THE GREAT WESTERN RAILWAY OVER THE RIVER THAMES: ONE OF THE FINEST EXAMPLES OF BRICKWORK EXTANT.



THE HIGH-LEVEL BRIDGE AT NEWCASTLE, ONE OF THE GREATEST ENGINEERING ACHIEVEMENTS OF ROBERT STEPHENSON.



BRUNEL'S MASTERPIECE—THE ROYAL ALBERT BRIDGE, CARRYING THE GREAT WESTERN RAILWAY OVER THE RIVER TAMAR AT SALTASH.



THE COSTLY BRITANNIA TUBULAR BRIDGE, CARRYING THE LONDON AND NORTH-WESTERN RAILWAY OVER THE MENAI STRAITS, DESIGNED BY GEORGE STEPHENSON.