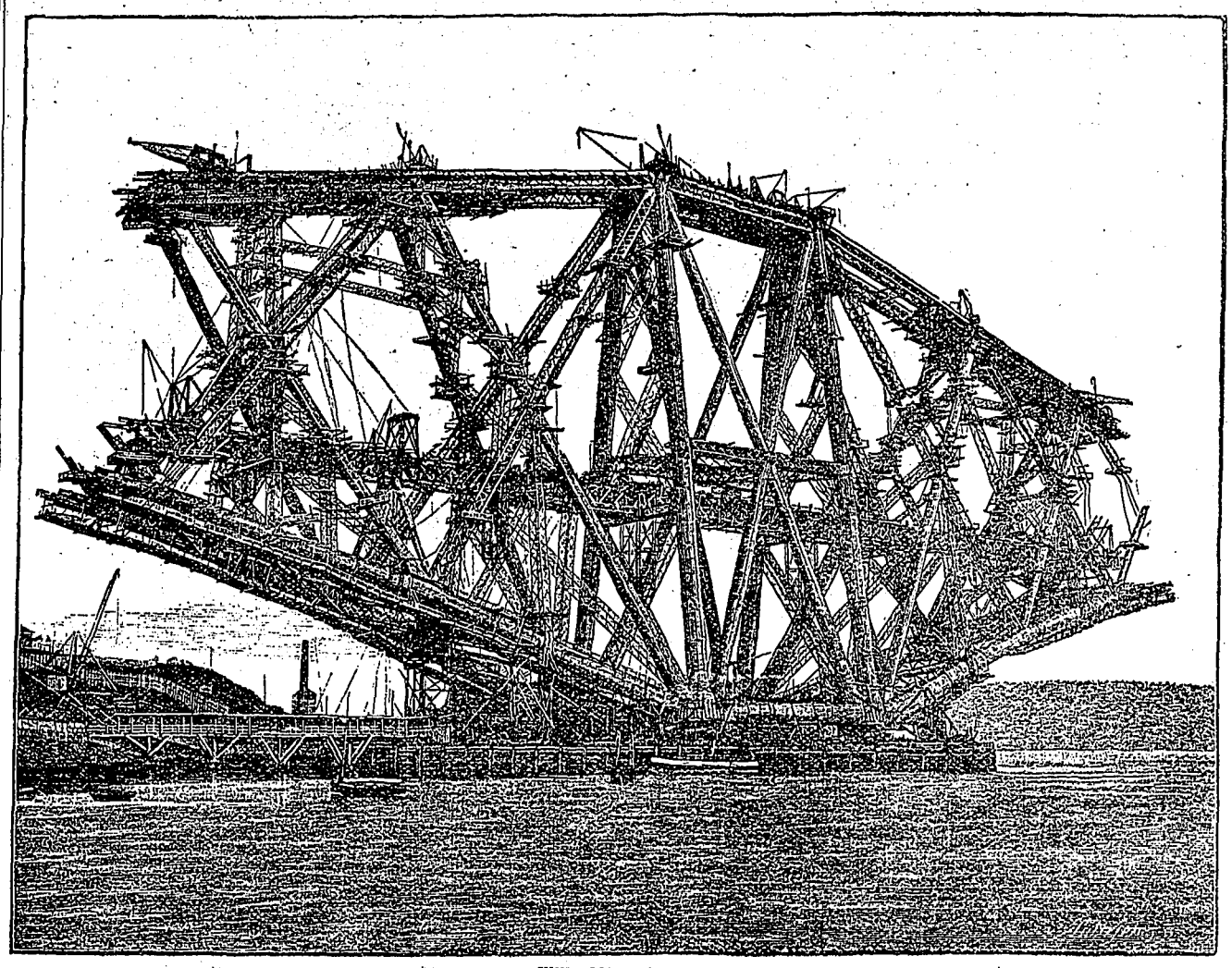


FIFE MAIN PIER.

THE GREATEST BRIDGE IN THE WORLD.

The Forth Bridge, which is at present being constructed at Queensferry, bids fair, when completed, to be one of the wonders of the world. It will be of special interest to Canadians, as we have two bridges built on the same principle here; the new railway bridge across the Niagara river, and the new Lachine bridge, one span of which, that over the steamboat channel, is also on the cantilever principle. Already, says Alexander Small, in an account of it in an English paper, it has attracted thousands of visitors, not only from all parts of the United Kingdom, but also from foreign countries. Queensferry is a small town on the Firth of Forth, nine miles west from Edinburgh.

In bridging the Forth, the problem to be faced by the engineers was to devise a *structure to cross that immense* distance of one and a half miles with only one support; viz., that afforded by the island of Inchgarvie. Of course, in the shallow water, piers could be built in the ordinary way; but for a space of 1,700 feet or so, on either side of the island, the channel was too deep to allow of this being done. In addition *to this, the bridge required to be of such a* height as to permit of the unrestricted passage underneath of vessels of all classes.

To Mr.—now Sir John—Fowler was allotted the task of furnishing the design.

The bridge, as now being erected, is 2,700 yards in length; that is, rather more than one mile and a half. At each side of the *Forth the bridge is carried out—until* deep water is reached—on a series of piers built of solid masonry, faced with blocks of Aberdeen granite. Over the deep channel, the bridge extends in two half-arches of 650 feet each, and two great arches, of 1,700 feet each. To sustain these great arches, three gigantic towers of steel are erected, resting on granite piers embedded in the solid rock. These piers are 340 feet in height, above high water mark; and the arches are 150 feet high in the centre, and are formed on what is called the "cantilever" principle. A "cantilever" simply means a bracket; and a cantilever bridge is formed by two brackets united by a central beam.

In forming the two large spans of 1,700 feet, it will be noticed that the brackets do not meet, but are joined by a great central girder, which is about 500 feet in length. This pier is 150 feet above high water. Further, it will be observed that arms project from the tops as well as from the bases of the towers. These arms suspend the lower brackets and central girders, and tend to strengthen and stiffen the whole structure. Each of the three great towers consists of four gigantic hollow *tubes of steel, twelve feet in diameter at* the bottom, and tapering towards the top. The brackets and suspending arms are constructed of similar tubes. The part of the bridge which carries the railway is made of steel girders; and all the various parts are united to each other, to the others parts of the bridge, and to the ground, by such an *innumerable quantity of struts and ties,* lattice-bracing and anchoring chains, for the purpose of giving strength and stability at every point, that the bridge, as now being erected, presents to the eye of the ordinary spectator a mass of details whose complexity is utterly bewildering.

A popular idea of the principle on which the bridge is constructed may be obtained in a very striking way, from what has been termed by Mr. Benjamin Baker, C. E. (Sir John Fowler's able coadjutor), a "living model," and which he thus describes:—"Two men sit on chairs a little apart, with their arms extended and supported by sticks grasped in their hands, and butting against the chairs. These represent the towers and double cantilevers, the sticks being the under members and the arms the upper-members. The central beam or girder is represented by a short stick, slung from the near hands of the two men. In the actual structure the men must be imagined to be 340 feet high—the height of the golden cross on St. Paul's Cathedral; the chairs to be placed a third of a mile apart; the pull on each arm being 4,000 tons; the thrust on each stick, 6,000 tons; and the weight on the legs of each chair 25,000 tons."

Each tower is founded upon four columns *of solid masonry, brought up to high water* mark, and resting upon the solid rock or boulder clay. The foundation of the Fife Tower was laid in the usual way, with the aid of a coffer-dam, which is simply a vast tub or casing of wooden piles, from the centre of which the water is pumped out, so as to leave a clear space *for working. Diamond drills and other* ingenious machines were employed in cutting away the rock.

But at the Garvie and Queensferry Towers the water was too deep to allow of this method being followed, and the foundations were laid by means of what were practically huge diving-bells. Iron caissons, seventy feet in diameter, were constructed on shore and floated out. The bottoms of these caissons were set up seven feet above the lower edge, and this under space—70 feet in diameter and seven feet *high—was filled with compressed air,* and formed the chamber in which the workmen carried on their labors. The upper and larger chamber of the caisson was weighted with many thousands of tons of stones, etc., and thus the huge structure sank into the required position as the workmen proceeded with the foundation. *Where the bottom was composed of mud,* the mud was diluted with water sent down in a stream through the caisson, and blown out by the pressure of the air; where it was hard and rocky, it was cut or blasted. When the proper depth was reached, the whole of the caisson was filled with concrete; and on the solid, compact mass, the masonry of the pier was reared. The working-chamber of the caisson was lighted by electricity, and supplied with fresh air by a pumping-engine.

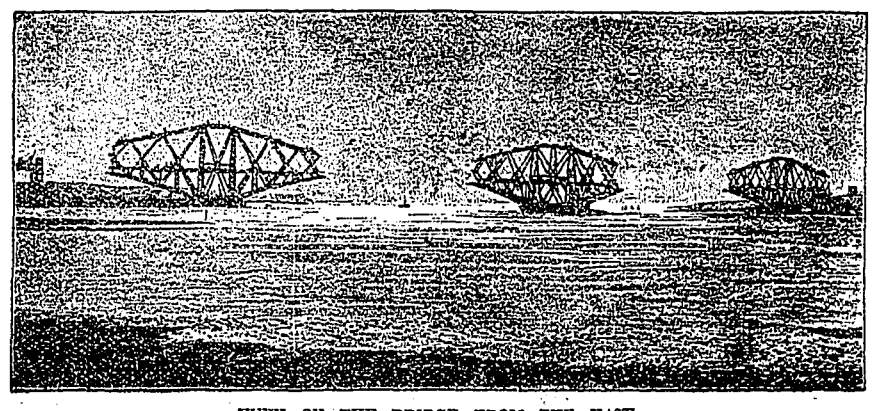
But the erection of the superstructure was of course the greatest achievement. The projecting arms of the cantilevers had to be built out over the deep channel, without any possible support from scaffolding or temporary staging. To one who has watched the progress of the bridge hitherto, it seems as if the huge arms had just slowly grown out to meet each other. This has been achieved by making each bit of the bridge, as it was built, serve as the scaffolding for the next bit. The work, too, has been carried on in such a way that, throughout its whole course, the mass of steel erected on one side of each of the three towers exactly balances the mass on the other side, and thus perfect equilibrium has been maintained. So successful have been the operations hitherto, that although 30,000 tons of steel have been erected, not a single plate or bar has been lost or injured during even the very wildest gales.

The steel plates required for the construction of the massive tubes alone would, if placed end to end, reach a distance of 42 miles. Some faint idea may be thus gathered of the amount of steel required in the work. The steel has been supplied, for the most part, by the Steel Company of Scotland; but, with the exception of the rolling of the plates, every part of the work has been done on the spot. This has necessitated the erection of extensive work-shops and offices; and these, together with the houses required for the accommodation of the great army of workmen, contractors and engineers and their staff, have transformed the little town of Queensferry into a hive of industry. The worshops are capable of turning out 1,500 tons of finished girder-work every month. More than half a million has been spent on buildings, railways, steamboats, and other "plant." In a large shed the designs of each section of the bridge are drawn in full size, with chalk, on the wooden floor. In the carpenter's shop wooden models of every part of the structure are framed. In the vast smiths' shops, where furnaces blaze and steam-hammers make a fearful din, all sorts of machines may be seen at work. Here plates of steel are being bent by hydraulic pressure to the proper radius; there their edges are being planed or cut by knives that go through the solid steel as if it were cheese. In another place millions of rivets are being made or millions of rivet-holes drilled—the latter by a special hydraulic rivetter, devised by Mr. Arrol, which can do the work of 200 men. In a yard outside the workshops, the various plates are put together, so that every part may be seen to fit properly; they are then numbered, and taken apart, and stacked, ready to be floated out and re-erected in the permanent structure.

From three to four thousand men are generally employed on the works. There are quite a large number of Associations for the social welfare and moral improvement of the workmen, including an Accident Fund, Sick and Benefit Societies, a Forth Bridge Institute, with Reading Rooms, etc., a Christian Fellowship Association, a Gospel Temperance Meeting, a Literary Society, Savings Bank, and drawing classes.

Unfortunately, a great number of accidents, many of them fatal, have attended the progress of the works. The greater number of these have certainly been due to the carelessness of the workmen. Others, again, have been due to the fatal curse of intemperance; and the engineer records with much sorrow that a licensed house, which holds out its evil allurements in the vicinity, has been the cause of ruin to not a few of the workmen. Clear heads and steady hands are needed for all kinds of successful work, but are imperatively necessary when the workmen are carrying on their hazardous operations at the giddy *height of 150 or 300 feet above the sea,* and are taken up and down in iron cages, dangling in the air from wire ropes.

Mr. Arrol, the working-partner of the contractors' firm, is a splendid specimen of a self-made Scotchman. Many ingenious labor-saving appliances have been devised and constructed by him. Lately he was presented by his workmen—who look upon him as a friend as well as a master—with his bust in marble.



VIEW OF THE BRIDGE FROM THE EAST.