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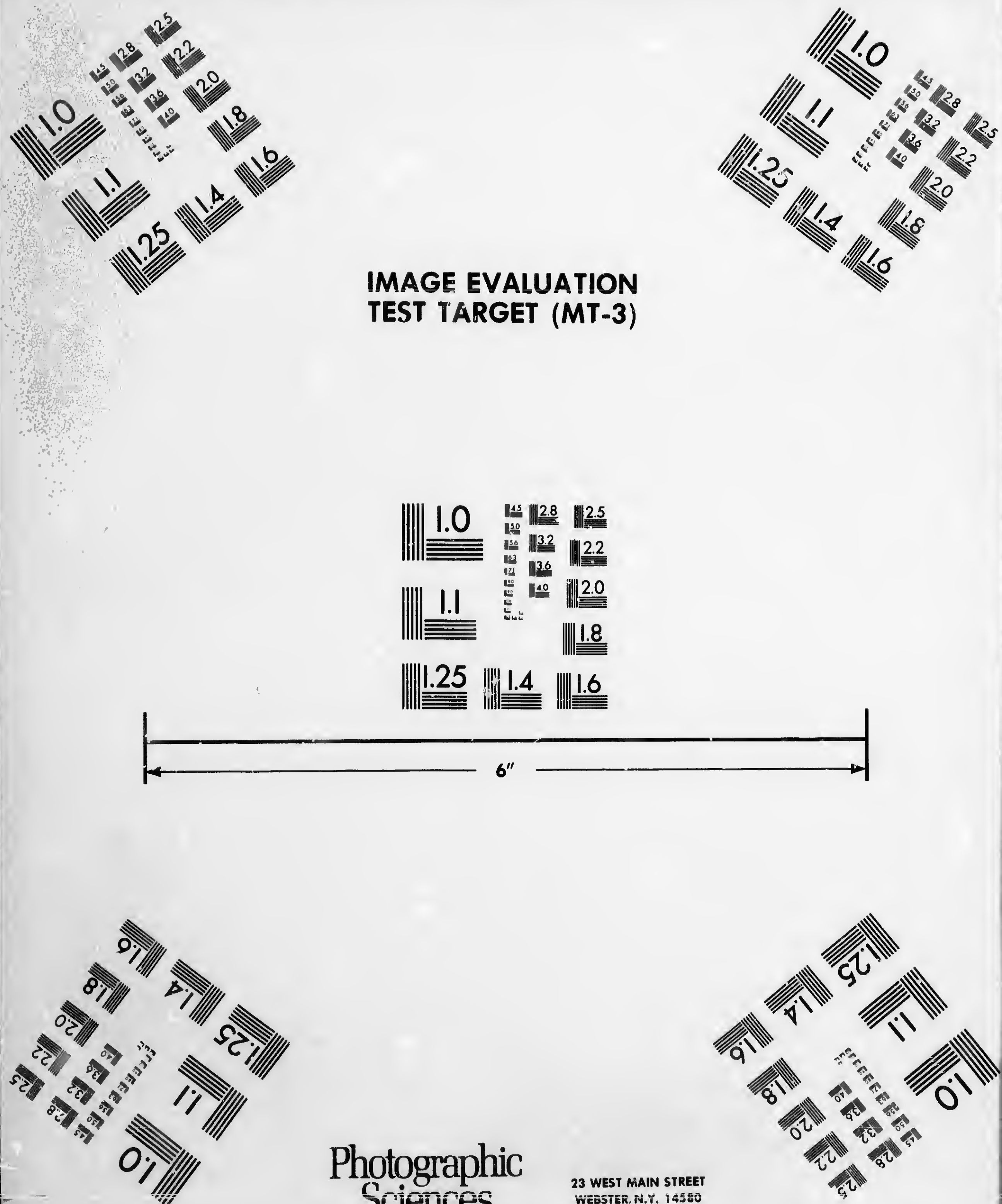

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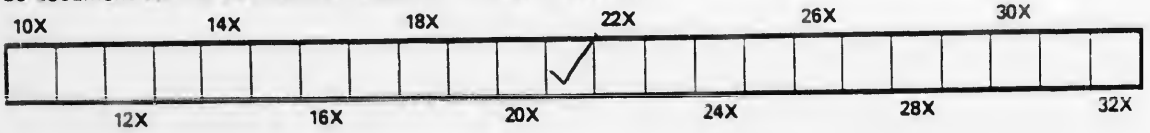

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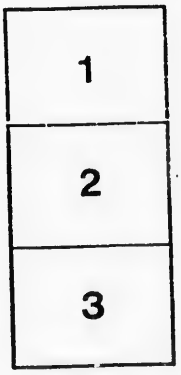

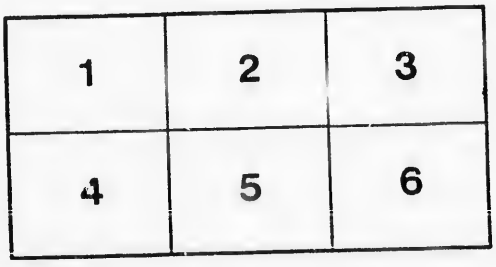

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THE

VICTORIA (ST. LAWRENCE) BRIDGE.

LONDON:
PRINTED BY RICHARD CLAY,
BREAD STREET HILL.

THE

VICTORIA (ST. LAWRENCE) BRIDGE.

[COMMUNICATED.]

THE present autumn will witness the completion of, perhaps, the greatest engineering work of our time: of that great bridge across the river St. Lawrence, of which the Britannia Bridge over the Menai Straits proves to have been but the precursor, as to Americans it will hereafter seem but as the shadow. The Canadians, as may well be conceived, are intensely excited at the prospect of finding their country distinguished by so great a work of science; and throughout the United States the completion of the Victoria Bridge is regarded as an important event in the history of that New World which, since its discovery, has been marked by such rapidity of progress.

It may not be uninteresting, at such a time, to recall the circumstances under which this work was undertaken, and to record, briefly, the history of its construction. There are many, indeed, who will gaze with wonder on the lofty piers and the stupendous tubes of this structure, to whom its peculiar features may scarcely suggest themselves;—yet the greatness

of the conception of this design consists, in reality, less in the size and character of the structure itself than in the objects, — political, commercial, and scientific, which it is capable of effecting.

The primary necessity of a new country is a road. The better the line of communication, the more certain the new country of success. The greatest boon, therefore, that could be conferred upon Canada, was the construction of a Railroad: and those who devised and carried out the project of the Grand Trunk Railway, connecting the different dependencies of the British crown in North America, and passing through the richest parts of both Upper and Lower Canada for a distance of 1,200 miles, must be regarded as great benefactors to the country.

Yet, grand as was the conception of the Canadian Railway, its original design was imperfect. It was not a road through the Province alone which Canada required. It needed, imperatively, a facile communication between the north and south shores of the St. Lawrence;—railway connexion, free from the inconveniences of transhipment, with the United States; and, above all, direct communication with the seaboard of the Atlantic.

A very little consideration of the circumstances of the country will show the imperative character of these requirements. The broad and rapid river St. Lawrence, whilst during the summer months of the year it opens out the whole of Canada to the ocean, for the five winter months completely isolates

the province. Canada, lying to the north of the river thus frozen up throughout its course, is itself commercially as well as physically congealed. During that protracted season no ships can leave or can reach Quebec. With the United States, the communication is, in every sense, of the most frigid character. Up to a very recent period, even intercommunication between different localities of Canada itself was, during winter, maintained with difficulty. To sleigh for 180 miles, as from Quebec to Montreal, was a task attended with no little trouble and with very considerable cost. Of course the transport of goods was impossible. Commercial markets, therefore, were comparatively useless. In fact, the want of means of communication with the outer world, prevented by the frozen state of the great river boundary and highway of the province, deprived the Canadian of nearly one-half of his active existence.

To the Grand Trunk Railway a direct and uninterrupted communication between the north and south shores of the St. Lawrence was also of vital consequence. Inasmuch as a bridge across the St. Lawrence was the key to the whole province, so, in possession of that key, the Grand Trunk Railway would command the whole external intercourse of Canada; whilst, without it, it must remain a mere provincial line. The tide of immigration sets very much into Canada from and through the United States. The whole of that traffic, so important to the Grand Trunk Railway, would

have been lost without the connecting link between Canada and the United States. In the winter season, also, the Grand Trunk Railway kept open, despite snow and frost, by various arrangements and appliances, would command the trade of the province without having to contend with any steamboat competition. To show, by one illustration, the importance of a bridge to the Grand Trunk Railway, it may be mentioned that the Canadian Government contribute the large sum of £50,000 a year to the Steam Ship Company, upon the condition of its opening and maintaining the best direct steam communication between Liverpool and Canada. In the summer months the route can be directed from Quebec; but in the winter that is impossible. Without crossing the St. Lawrence, therefore, the route for which this handsome subsidy is paid could not be maintained, and the Grand Trunk Railway Company and the Canadian community would alike sacrifice the advantages of direct communication between Canada and Europe.

These considerations naturally weighed with increased strength upon the Canadian people and the Directors of the Grand Trunk Railway as that line approached completion. A bridge they saw that they must have; but the question was, could such a bridge be made?

"The rapid river ran deep and wide;"

and there were not a few who thought that to

span it by a bridge would be little better than a temptation of Providence.

The difficulties, indeed, of crossing the St. Lawrence were far from inconsiderable. Its width, even at the most available point, is very formidable; its current is very rapid; its depth not insignificant. Besides this, the navigation of the river, not merely by steamboats and other vessels, but by enormous timber rafts, had to be provided for; so that unusual elevation and unusual width between the piers were required. There was another obstacle, more formidable—far more formidable—than all. In the season the river St. Lawrence presents a field of ice from three to five feet thick. Whilst it is thus frozen, the river rises sometimes as much as twenty feet above its summer level. This rise of water might be provided for; but how was accident to be avoided, at the annually-recurring period when "THE BREAKING UP OF THE ICE" exhibits, in North America, one of the most wonderful operations of nature on that continent?

This "breaking up of the ice" in North America, though welcomed as the harbinger of returning summer, is an event which carries with it no inconsiderable amount of apprehension to the mind of the Canadian. From the extreme thickness of the ice in the middle of the river, little or no effect is immediately produced upon it by the action of the sun. But the banks of the river, imbibing the heat, melt away the thinner portion of the ice which touches them, thereby depriving the main body of

the support it receives from its contact with the land. Then, when a small line of blue water intervenes between the shore and the river ice, the ice begins to move, first slowly, then more rapidly, until the velocity and power of the current, rapidly increased by the melting of the snow, wrenches the ice upwards, and breaks and tears it into fragments, which, larger or smaller, go floating down the river in masses, bearing before them almost everything which they encounter.

Dismal tales are rife in Canada of the fatal disasters which have occurred to life and property by "the breaking up of the ice." The city of Montreal has especially suffered from these fatalities. Before now, the ice has burst into that city and been found sliding down its streets. It has broken into the second-floor windows of dwelling-houses after blocking up the front doors for weeks. It has forced down river terraces and spoilt public and private gardens. Large warehouses, erected without due protection on the banks of the river, have been pushed over by the great moving sheets of river ice, as if they were mere houses of cards. At sudden bends of the river, where the ice meets with obstruction, it piles itself, sometimes, into huge icebergs, from fifty to eighty feet in height. At length, when the river rises, these icebergs get again into its current, and go rolling and sweeping down the St. Lawrence, carrying danger and destruction all before them.

Could any bridge be devised to withstand these formidable difficulties? If possible, how was such a

bridge to be constructed? The Directors of the Grand Trunk Railway, to whom these questions were so vitally important, took a course which will probably be thought to redound greatly to their enterprise and sagacity: they determined to take the opinion of the most eminent engineer whose advice and counsel they could obtain.

The Britannia Bridge across the Menai Straits was opened in 1849, and it was not, therefore, unnatural that in 1852 the Directors should look to Mr. Robert Stephenson as the engineer most competent to advise them. Mr. Stephenson considered the subject of so much interest and importance, that he determined to go out to Canada, personally, for the purpose of dealing with it. He accordingly repaired there at the end of the summer of 1853, and, after examining into the facts, made a public declaration of his opinion, that a bridge across the St. Lawrence was practicable. On the 2nd of May following, Mr. Stephenson addressed to the Grand Trunk Railway Directors a Report, in which he considered the whole question in three branches: first, as to the description of bridge best calculated to prove efficient and permanent; second, as to the proper site; and thirdly, as to the necessity for such a structure. Upon the first point he did not hesitate at once to recommend the adoption of a tubular bridge, as the description of bridge best fitted for a permanent, safe, and substantial structure in such a situation; on the

second point, he was not a little influenced by considerations affecting the flow of the river and "those almost irresistible forces" consequent upon the breaking up of the ice in spring.

As Mr. Stephenson's view of the nature of these forces, and the best mode of encountering them, has not yet, that we are aware of, received publicity, it may be interesting to place them upon record,—especially as we are enabled to do so *with authority*. Mr. Stephenson, on his arrival in Canada, met with numerous alarmists, who could graphically describe to him the effect of the ice, but he met with no one who had in any way measured or calculated the amount of its pressure. In considering the question whether a bridge could be construeted to withstand that pressure, it appeared to Mr. Stephenson to be of primary importance to ascertain really and precisely what that pressure was. This was a question of calculation; though, in the absence of any data, the difficulty was how to calculate it. And here, before the reader proceeds further, he may, perhaps, not without advantage, pause for a moment to ponder on the way to solve the problem —what is the amount of the pressure of ice four or five feet thick in a running stream of a certain inclination, velocity, and breadth?

This problem puzzled Mr. Stephenson himself at first; but it was not long before he hit on an expedient. He first got at the inclination of the river; next at its velocity. He then assumed that the

ice upon that river was what they told him it usually was, from four to five feet thick. He then inquired into the condition of the river, and he found that, about nine miles above Montreal, there was a fall called the Fall of Lachine, which, of course, separated the body of ice above the fall from the body of ice below it. Taking these data, he calculated what would be the pressure of nine miles of ice, from four to five feet thick, lying on a plane of a given inclination, and pressing against the piers of a bridge across the channel. The result of that calculation in figures it would be unnecessary, even if it were possible, to state; but, whatever were the figures, they enabled Mr. Stephenson at once to realize one all-important fact. He arrived at the conclusion that "the almost irresistible force" of this mass of ice would crush or sweep away any ordinary bridge, and that all the suggestions previously made for encountering the difficulty were only likely to result in disaster if carried into effect.

For, up to the period of Mr. Stephenson's Report, great difference of opinion existed in Canada and elsewhere as to the probable effect of the ice pressure. One party held that no bridge whatever could stand against it; another, whilst admitting the difficulty to be formidable, thought timber casings or fenders, such as those in use on the small rivers of Norway and elsewhere, would be an efficient protection for the piers. The proposal most forcibly impressed on Mr. Stephenson was to protect his piers by what is called

a "crib-work;" that is to say, by large masses of timber in front of the piers, crossed and weighted, and as thick or thicker than the ice itself. It was evident, from the first, that this extensive crib-work must be an additional obstacle and impediment to the free navigation of the river, and to the passage of the ice. But, beyond this, Mr. Stephenson's calculations convinced him that such a work would be entirely inadequate to protect such a structure as he contemplated, in such a river as the River St. Lawrence; and that, even if the crib-work stood, it would be subject to such abrasion and wear and tear, from its conflicts with the ice, that it would require to be reinstated at least every two or three years. It was more than doubtful to his mind if such an arrangement would be capable of resisting the ice at all; and if it did not, the capital of the Company would be wasted. Mr. Stephenson, therefore, at once determined that such a work was undesirable; and that such enormous stakes as those at issue could not be left dependent upon the uncertainty of such an expedient.

The abstract methods he had taken to ascertain if any bridge would withstand the almost irresistible pressure of the ice, had not alone convinced Mr. Stephenson that no such projects would avail as those proposed in Canada. They had equally satisfied his mind as to the amount of resistance requisite to encounter the pressure against which it was needful to provide. Knowing what timber would not resist, he equally knew what resistance could be afforded by

substantial masonry. "Cribs" he felt were useless; but there were methods by which the pressure could be resisted independently of "cribs." Mr. Stephenson decided on the adoption of stone piers, to carry the tubes at wide intervals, each pier having, on the side opposed to the course of the stream, large cut-waters of solid stone work, inclined against the current, up which, as it were, the ice would creep, and break itself to pieces by its own weight and pressure. He arranged that these wedge-shaped cut-waters should present angles to the ice sufficient to separate and fracture it as it rose up upon the piers, but at the same time so obtuse as not to be liable themselves to fracture. These piers, therefore, were devised to answer the double purpose of piers and ice-breakers. They exhibit, as now constructed, every indication of massiveness and power to resist pressure as well as of stability to support the superstructure. Experience, indeed, has proved the piers suited for all the purposes for which they were designed. During the four years the structure has been in progress, it has entirely fulfilled all the conditions its originator anticipated; and it has withstood, in the most satisfactory manner, the most violent pressures which have followed the break-up of the ice.

Whilst the piers of this bridge are thus peculiar in their design, in order to meet the peculiar circumstances of the country and the climate of Canada, the superstructure, which creates in America so much surprise, is an elongated repetition only of the design

for the Britannia Bridge. The Victoria Bridge is indeed remarkable for its extreme length, but its several tubes are not so long as those of the Britannia Bridge, and are only otherwise distinguishable inasmuch as that they are the longest tubes yet constructed without the adaptation of the cellular principle. It deserves notice, however, that these tubes, in all their details, were designed, plate by plate and rivet by rivet, in the office of Mr. Stephenson, and were calculated for every strength and strain, and prepared and arranged in all their details, under the sole superintendence and supervision of his relative, Mr. George Robert Stephenson. With such nicety were all the arrangements respecting these plates conducted in this country, that, under the directions of that gentleman, every plate and piece of iron was punched in England before it was sent out to Canada; and elaborate and detailed drawings and instructions were sent by the same hand to show the method of connexion. On the arrival, therefore, of each separate cargo of iron in Canada, little remained to those upon the spot but to fasten together the various pieces, and place them in their order and position as directed.

So entirely, indeed, have the details respecting the tubes been conducted on this side, that it has not only devolved on Mr. G. R. Stephenson to examine the quality of the iron at the iron-works, but to superintend the construction of the plates at the manufactory, and to issue instructions for putting the pieces to-

gether. Upon him has devolved the duty of seeing to the shipment of each tube as it was completed, and of signing the certificates for payments, not alone to the contractors, but also to the resident engineer and other officials in Canada, who were employed and paid under Mr. Robert Stephenson's directions. It is most gratifying that, from first to last, the design has been carried out harmoniously and efficiently by all concerned. Great credit is due to Mr. Alex. M. Ross, who was appointed the resident engineer to superintend the Bridge works in Canada, and who has especially devoted himself to the erection of the masonry; to Mr. Hodges, who, from the commencement, has most efficiently and honourably represented Messrs. Peto, Betts, and Brassey, the contractors, and on whom has devolved the principal responsibility in the execution of the works; as well as to Mr. Stockman, who, in the early part of the present year, went to Canada, accompanied by Mr. S. P. Bidder, to make a full inspection and detailed report upon the works—a duty which was performed in a manner eminently calculated to satisfy the minds of the engineers and of the public.

It is not the object of the present preliminary paper to enter into the fuller statement, which will hereafter be given, of the dimensions of the Bridge, of its quantities, and of the various details connected with its construction. The present object is rather to exhibit the theory upon which it was commenced and carried forward. One remark, there-

fore, in conclusion, is alone necessary. Canada owes this Bridge to one mind — the mind of Robert Stephenson. Had that eminent engineer expressed the smallest doubt or apprehension, the Directors of the Grand Trunk Railway would have shrunk from involving their Company in an expenditure of a million and a half of money to carry a bridge across the St. Lawrence. Until Mr. Stephenson had satisfied the Grand Trunk Company, they would not entertain the idea of constructing such a Bridge; and, unquestionably, Mr. Stephenson would never have satisfied the Company unless he had thoroughly satisfied himself. It was the reliance of the Company on Mr. Stephenson's experience and professional reputation that induced them to commence the Bridge; and having pledged that experience and reputation, Mr. Stephenson, who would have been responsible for failure, is entitled to the full meed of honour and of fame which must hereafter attach to the successful execution of so great a work. He has indelibly inscribed his name on the structure which resists the ice of the St. Lawrence.