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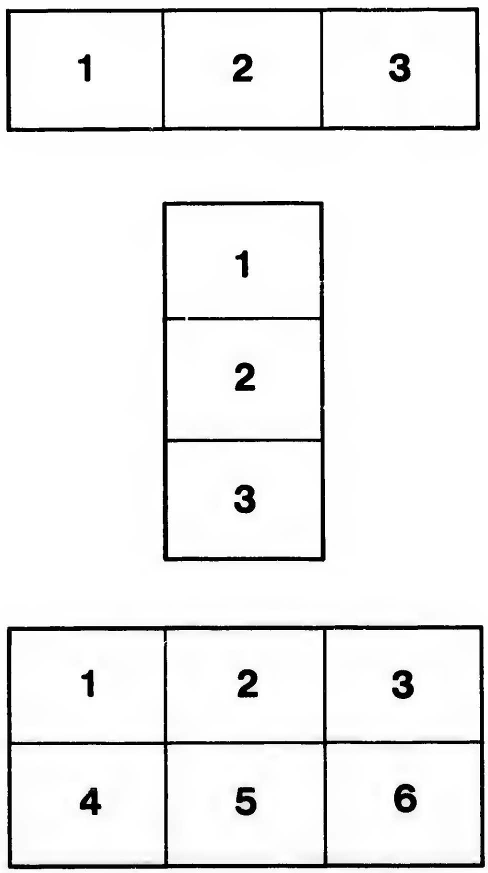
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AMERICAN

VERSUS

ENGLISH METHODS

OF

BRIDGE DESIGNING.

REPRINTED FROM THE "JAPAN MAIL."

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BRIDGE DESIGNING.

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PREFACE.

The letters which are collected and published in the following pages appeared, at intervals during 1885 and 1886, in the columns of the *Japan Mail*. The task of rescuing them from comparative inaccessibility in the files of that journal, and presenting them as a whole to scientific readers, was undertaken for several reasons, of which the principal is that the discussion they embody throws unusual, perhaps unprecedented, light on the difference between American and English bridges and on their comparative merits. The controversy was provoked by a review—which also appeared in the *Japan Mail*—of Mr. Waddell's *Memoir;* a work prepared chiefly for the benefit of Japanese readers, the majority of whom are, of course, strangers to the contents of the English press. For their sake, therefore, the desirability of reprinting the letters in pamphlet form strongly presented itself. Unfortunately, the discussion is not without evidences of a spirit which looks out of place in the context of scientific enquiry. But to expunge these traces of rancour would have disturbed the continuity of the argument, and they have consequently been suffered to remain as blemishes too common to be serious. There is much to be said still on the interesting subject of American *versus* English bridges, and one may venture to hope that it will be said without greatly disturbing national conservatism. Mr. Waddell has made a good beginning, for which impartial men generally, and Japanese students in particular, will be grateful to him.

EDITOR *Japan Mail.*

Tôkyô, March 27th, 1886.

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AMERICAN VERSUS ENGLISH METHODS OF BRIDGE DESIGNING.

(FROM COLUMNS OF THE "JAPAN MAIL.")

(July 16th, 1885.)

REVIEW.

A System of Iron Railroad Bridges for Japan. By J. A. L. WADDELL, C.E., B.A.Sc., Ma, E. Published by the Tôkyô Daigaku, 1885. A.D.

PROFESSOR WADDELL'S work on Iron Railroad Bridges for Japan forms the eleventh memoir issued by the Tōkyō University. In issuing this memoir the University has taken a step in an entirely new direction; for hitherto the memoirs have been confined to the treatment of general science, whilst this one is on an essentially technical subject. Professor Waddell occupies the Chair of Civil Engineering in the University.

The work is divided into two parts bound separately; the first, containing the text, and the second, tables and plates.

Part I. consists of 258 pages, and is divided into twenty-four chapters, exclusive of a Glossary and an Index.

Part II. contains twenty-four tables, twelve plates and thirty diagrams of stresses and sections.

Chapter I. consists of an introductory letter addressed to the civil and mechanical engineers of Japan. It explains the author's object in writing the treatise; insists on the necessity of a system of iron railroad bridges built upon thoroughly tested scientific principles instead of the rule of thumb methods by which the present Japanese bridges are designed, and maintains that the American system of bridge designing is immensely superior to that of the European.

Chapter II. gives tables of the sections of bridge iron rolled by the principal manufacturers of Europe and America.

Chapter III. contains a list of the different portions of bridges built according to the author's system. It is intended to assist the engineer in making out bills of iron.

Chapter IV. is descriptive of the bridges treated, and the connections of the various portions.

Chapter V. treats of the floor system proper (*i.e.* the ties, rails, and guard rails) and of a re-railing and a ditching apparatus. By means of the last two devices perfect safety is insured to bridges against constantly recurring accidents, such as the running off the line of an engine or a car. *If a car or a locomotive were off the line when it reached one of the present Japanese bridges, the structure would be doomed.*

Chapter VI. consists of "General Specifications" which treat in a concise manner of all the various steps to be taken, and limitations to be made, in designing, erecting, and maintaining any bridge.

Chapter VII. is on live and dead loads and wind pressures. In connection with Table I., it gives the total weight of iron and the dead load for any single track truss bridge measuring from sixty to three hundred feet span, and indicates how the corresponding quantities are to be found for double track bridges.

Chapter VIII. gives an analysis of stresses in trusses, and methods for finding the same. The causes of stresses in trusses are—

1° uniform live load;
2° dead load;
3° engine excess;
4° wind pressure indirectly;
5° wind pressure directly;
6° curvature of track.

Chapter IX. treats of stresses in lateral systems and sway bracing. The effect of inequality of loading in double track bridges receives due attention. This is a point hitherto uninvestigated as far as we are aware.

Chapter X. is on rivetting, and shows how rivets should be proportioned for bending and bearing rather than for shear.

Chapter XI. treats of the proportioning of main members of trusses, lateral systems, and sway bracing.

Chapter XII. is on proportioning track stringers, plate girders, and floor beams.

Chapter XIII. is on the proportioning of pins.

Chapter XIV. is on the proportioning of other details.

Chapter XV. is on double track bridges.

Chapter XVI. is on economy in the construction of a bridge. It shows how to choose the best number of spans for any bridge, and the best number of panels and depth of truss for any span. It treats of how to design a bridge so that it may be quickly and cheaply erected.

Chapter XVII. shows how to make out bills of materials and estimates of cost. It gives a table of the probable cost of all single track bridges for Japanese roads for spans ranging from 60 to 300 feet.

Chapter XVIII. illustrates as an example how to design all the parts of a single track bridge of 168 feet span; and concludes with bills of iron and timber.

Chapter XIX. gives all necessary directions for making working drawings.

Chapter XX. illustrates an approximate method of designing any single track bridge without making the usual calculations. Its office is to serve those who have not received much technical education, and to act as a check on the designs of engineers.

Chapter XXI. shows how to prepare order bills and shipping bills, also how to mark the iron so as to facilitate erection.

Chapter XXII. treats of methods of erecting and maintaining bridges

Chapter XXIII. contains a mathematical discussion of the effects of a braked train upon the bottom chords of pin-connected bridges, showing that under the worst possible circumstances, the author's bridges have in this respect a large factor of safety.

Chapter XXIV. is a recapitulation of the steps, in bridge designing, following which is an addendum containing the results of some investigations made by the author subsequent to the preparation of the treatise.

Eight pages are devoted to the Glossary and eight to the Index, both being intended to facilitate the use of the book in designing.

Most of the plates are drawn on the scale of an inch to a foot. They illustrate everything needed by a designer who is entirely unacquainted with the subject of bridges.

From the thirty diagrams of stresses and sections can be found the correct sizes of all the main parts of any bridge that will ever be required on Japanese roads according to the present system.

That the bridges of the treatise and those in use in Japan are fundamentally different will be apparent to every technical reader of the work; and it is to be hoped that the Japanese engineers will not be slow to appreciate the difference.

They are not asked to adopt a new and untried system of bridges, or the ideas of a mere theorist, for Professor Waddell is acknowledged both in England and America as an authority upon bridge construction. In proof of this we quote the following from the leading technical papers of these countries, which, as will be seen, have reference to another book of his, published last January by Wiley and Sons, of New York, entitled "The Designing of Ordinary Iron Highway Bridges."

The London technical journal *Engineering* has the following notice of the book in its issue of April 24th :—

> This is a work of a class practically unknown in our own country, but which English engineers would do well to imitate. There is no recognised standard type of road bridge in Great Britain, although thousands of such bridges have been built since the introduction of railways. The Railway Clauses Act of 1845, fixes the minimum spans and headways, and the Board of Trade requirements limit the maximum stress upon the metal; but in all other respects the young engineer is free to indulge his fancy, and as a result some extraordinary examples are scattered about this country. . . . . . Within the limits which the author has set for himself in the present work, his treatment of the subject may be regarded as not merely satisfactory, but exhaustive. He has aimed at producing a treatise upon bridge designing rather than one upon stresses, which we think, will materially conduce to the usefulness of his work in this country, where students are, as a rule, more familiar with stresses than with practical details.

An eminent technical writer in America, A. J. Du Bois, writes :—

I congratulate you on the book. It is just what the student needs and the only book which covers the ground of practical designing at all adequately. It covers it admirably, too. In connection with a good work on strains—as the author intends it to be used, it leaves nothing to be desired for a full and thoroughly valuable practical and theoretical course—except a similar work by the same author in the same spirit upon Iron Railway Bridges. . . . . . . I never looked over a work with more genuine satisfaction. It will be as useful in the office as in the class-room. The whole matter is presented in detail, clearly and fully in the Text, and when the student takes that in and understands it, the Tables alone are all he needs to refer to in actual designing. There is an immense amount of labour in these Tables, and altogether it is the most valuable work on the subject I ever saw. If more engineers would write more such books, we would'nt hear so much about "Theory" and "Practice." I feel as if I owed a large debt of gratitude to Mr. Waddell, for this is just what I have been wanting a long time. If our students don't get a good useful grip on designing now, it will be their own fault entirely. Mr. Waddell has energy and industry to match his ability. I have been impresed by the careful painstaking thoroughness of the book and the man.—*Engineering News and American Contract Journal*, February 14th, 1885.

We strongly recommended this book to students and engineers desirous of learning the art of bridge designing. The extensive practical experience of the author in the construction of highway bridges has led him to keep always in view economy as well as stability, so as to design a safe and durable structure at the minimum cost. Hence the results of his patient labor embodied in this book will be sure to prove of great value to the technical public.—*Engineering News and American Contract Journal*, March 21st, 1885.

The general plan of this book is radically different from that on which numerous works on bridges and roofs have hitherto been prepared. While almost numberless treatises on the theoretical part of bridge construction have appeared during the past few years, somewhat to the perplexity of students and young engineers, it is not too much to state that not one of a really practical nature has preceded Professor Waddell's work. Questions of construction and design have received most rational and masterly treatment at his hands. Professor Waddell has brought to bear on this work the benefit of an accumulated experience both as a practical engineer and as an instructor in two technical schools of the highest standing, and his book is probably the most valuable contribution to the literature of iron bridge building which has yet appeared.—*The American Engineer* (Chicago), February, 13th, 1885.

The book will be found of the greatest value to county commissioners, and all others who have to make contracts with builders of iron highway bridges, as it gives complete and easily comprehended data for making estimates of cost, and for determining whether designs or completed structures will endure the strains to which they will be subjected.—*The Railway Age* (Chicago), March 5th, 1885.

The work is replete with valuable information, systematically arranged and well digested, and will, no doubt, soon take a prominent place as a book of instruction and reference.—*Toronto Mail*, March 7th, 1885.

It is well known that very many of our present highway bridges are defective both in design and workmanship, and a person devoting years of time to the study and writing up of these important structures merits the thanks of the whole travelling public in general and that of engineers, bridge designers, and constructors in particular.—*Montreal Daily Witness*, February 28th, 1885.

The book here reviewed is based upon the same general principles as the one on highway bridges, the principal differences between the two classes of structures being in the floor systems.

The truss stresses in railway bridges are somewhat more complicated than those in highway bridges, but the difference between the finished structures is more in quantity than in disposition of material. If Japanese engineers can accept the class of structures treated of in "The Designing of Ordinary Iron Highway Bridges," as the above quotations would show them to be warranted in doing, they may also safely accept the bridges designed and treated in "A System of Iron Railroad Bridges for Japan."

Professor Waddell tells us in his introductory chapter that he came to Japan some two and a half years ago, hoping not only to be at the head of a large department, but also to be able to occupy his spare time in attending to practical engineering work; but that he found there was no work in the country for foreign engineers; and, what was worse, that there were never more than a dozen students in the Engineering Department of the Tōkyō University; and that as he was unwilling to depart from Japan without leaving behind him some professional record of his stay, he has devoted a twelve-month of his spare time to the preparation of this work.

We are sure that neither the Japanese Government nor the foreign public will be slow to appreciate the conscientious motives which have led to the production of Professor Waddell's work. And we trust that its sale in this country will be large, and that its author will be encouraged by the success which his two works meet with to give the public the benefit of the results of the study and investigation of his future, as he has of his past, career.

(August 4th 1885.)

CORRESPONDENCE.

IRON RAILROAD BRIDGES FOR JAPAN.

TO THE EDITOR OF THE "JAPAN MAIL"

SIR,—Having read in the *Japan Mail* of the 16th inst. a review of Professor Waddell's work on Iron Railroad Bridges for Japan, issued by the Tōkyō University, and having seen the book, I congratulate Professor Waddell on the energy, the industry, and the immense amount of labour required for compiling such a work.

Professor Waddell advises the Japanese to substitute for the present style of bridge-designing that expounded in his book, which is essentially American. He tells us that the United States of America lead the world in bridge building, and that the fact is undisputed even in Europe. He tells us that American bridges are lighter than English bridges which, being made of low-priced iron, require a great amount of it. He tells us that American bridges can be erected with the least possible amount of labour, and *that* unskilled labour, and he adds that all bridges in this country have grave errors. Concerning the cost per lb., he puts the American at $4\frac{1}{2}$ cents, and the English at 4 cents, but he informs us that American manufacturers are underselling the English by three or four £ sterling per ton. He expresses his willingness to give his opinion as to what shops in America do the best work. This he should be able to do, as he is consulting engineer for the firm of Raymond and Campbell, Bridge-builders of Council Bluffs, Iowa.

As regards prices of iron in America and England, this is the first time I have heard of English iron being undersold by American to the extent of three or four £ sterling per ton, and also the first time that I have heard that English iron is so inferior to American. If the American bridge-builders lead the world, what is to be said of all the great engineers and bridge-builders in Europe, many of whom were in practice before America adopted iron-bridges to any notable extent; and what is to be said of the great number of bridges erected in Europe and Asia? I have little knowledge of any of these having been designed or manufactured in America. The longest span in Japan is 150 feet. This bridge, indeed, came from America, and was ordered by the American Engineer of the railway in Yesso. It is not stated how many days it took to erect, but a few seconds sufficed to bring it down into the river.

The bridges on the railways built by English engineers in Japan are of the most simple design, and the drawings were passed by Dr. Pole, a well-known engineer and calculator. Professor Waddell declares himself horrified "by the absolute lack of lateral bracing," and says that the bridges "are wholly unfitted to resist the stresses produced by a whirlwind." But as there no whirlwinds in Japan, what could be the use of building bridges to resist them? He also comments on the grave fault of "the absence of a guard rail or any arrangement to prevent a derailed car or locomotive from going through the bridge." The reviewer, speaking of these apparatus, says: "By means of the last two devices, perfect safety is ensured to bridges against constantly recurring accidents, such as the running off the line of an engine or a car." These kind of accidents are only too common on American lines. Many of our friends who often travel from San Francisco to New York have experienced the annoyance of delays caused by derailed locomotives and cars, and by bridges giving way. The Japanese roads on the English system are so constructed as to reduce to a minimum the chances of derailment, and the many millions of miles run on these roads go to prove the excellence of the system, for in no case has an accident occurred.

Professor Waddell is well aware of the strict rules and regulations laid down by the British Government with reference to all details of railways. I quote the following remarks from a well-known member of the American Institute of Civil Engineers, Mr. Fernie:—"There is happily in America no Government control to hamper or interfere with railroad engineers, either in regard to the materials which they employ or to their designs. They are at liberty to exercise their ingenuity in construction, disposition, strength, and choice of materials; and the competition between rival companies is so great that the pressure put on railway companies in England to adopt improvements in not required in America."

Our young Professor is certainly candid in expressing his opinion on the works of older and more experienced men and is not troubled with any mock modesty when striding to the front in all the glory of official print to do battle with that many-headed dragon, the British and European Railroad Bridge Interest. He claims the title of Hercules, conveying thereby a gentle hint of his own prowess, and a neat insinuation of certain stables which require his superhuman strength to cleanse.—I am, Sir, your obedient Servant,

NOT A BRIDGE BUILDER.

Tokyo, August 1st, 1885.

(August 12th, 1885.)

SIR,—Your issue of 4th inst., containing a criticism of my treatise on "A System of Iron Railroad Bridges for Japan," by a gentleman who is "Not a Bridge Builder," has just reached me. Although several books and papers, to which I would like to refer, have been left at home, I will endeavour to answer him, taking up the various objections in the order in which they were raised.

The first item is the cost of bridge iron, in which he makes me appear to have contradicted myself by first stating it to be $4\frac{1}{2}$ cents per pound in America and 4 cents in England, then saying that American manufacturers are underselling the English by three or four pounds sterling per ton. The last statement is not mine, but was made by an American engineer in a letter to me received after the MS. had been sent to press: this is clearly indicated in the foot note on p. 10. The fact was a surprise to me, for I had always considered English iron to be cheaper per pound than American iron. The authority, however, cannot be doubted; for the writer of the letter is Wm. H. Burr, C.E., engineer to the Phœnix Bridge Co., and author of two standard works on engineering subjects. My interpretation of the statement is that English manufacturers cannot afford to bid as low on bridges of American design as can American manufacturers, the reason being that the latter are used to the work and have all the appliances. Plate girders, I acknowledge, can be built more cheaply in England than in America.

Next, as to the quality of English ironwork. I can give no opinion as to the quality of workmanship on bridges in England, not having been in that country for a number of years; but, if I am to judge of English ironwork by the specimens on the Japanese railways, I can unhesitatingly condemn it. Ironwork of as poor quality may be found in many of the cheap highway bridges of the United States, but no first-class American manufacturer would allow such work to pass out of his shop. In the Arakawa and Karasugawa bridges of the Tôkyô-Takasaki Railway the bottom chords are so warped and twisted that to make the floor beams bear on both sides of same, shims or filling pieces of $\frac{1}{8}$ or $\frac{1}{4}$ inch iron had to be used: and there are open joints in the top chords that even paint will not hide. Concerning these points, I refer to Mr. Takanobu Kônô, the engineer who erected both bridges, and to Mr. Mouri, engineer in charge of the railway.

Concerning the quality of American ironwork, let me quote from my book p. 78. "The several pieces forming one built member must fit closely together, and when rivetted shall be free from twists, bends, or open joints. * * * * * * Abutting joints in truss bridges shall be in exact contact throughout," etc. If the ironwork does not comply with these specifications, it is not accepted.

The next and worst point of offence to your correspondent is my statement that the Americans lead the world in bridge building. Being a Britisher myself, I surely can make such a statement without arrogance. His retort that there are many great engineers and bridge builders in Europe, who were in practice before America adopted iron bridges to any notable extent, is truly characteristic of a conservative Britisher. Does he think that the world is standing still? Not one of the bridges of those days is to be compared with the bridges of to-day; they are inferior in everything except massiveness. Think of comparing the tubular bridges at the Menai Straits and Montreal with the Bismarck and Plattmouth bridges across the Missouri and the great cantilever at Niagara! As well compare an old three-decker to one of England's latest made and fastest ironclads!

In treating of iron bridge construction it is necessary to ignore all structures built over fifteen, or at most, twenty years ago; for the science has been developed gradually. In England, where the funds at the command of engineers were practically unlimited, the tendency was to make bridges very strong, regardless of weight and expense: for instance take the bridge over the Ouse, near York, the Leith Docks Swing Bridge, for a long time, if not still, the largest swing bridge in the United Kingdom, and all of the numerous plate girders exceeding sixty feet in length. In America, on the other hand, where money was scarce and the amount of work to be done was great, the tendency was to make bridges light and cheap, too often at the expense of strength. This accounts for the facts that most of the old English bridges are excessively heavy, and that many of the old American bridges are not strong enough to carry the greatly increased engine and train loads of the present time.

As the study of bridge designing has continued, English engineers have endeavoured to reduce the weights of their bridges, and American engineers to increase the strength of theirs. But as progress is much more rapid in the United States than in conservative England, the American engineers have pushed ahead in bridge building, leaving their English brethren far behind.

Is it heresy for a Britisher to make such a statement? I think not. Did not England's representative technical periodical, *Engineering*, state not long since in reference to the Suakim-Berber Railway, that it would be well for English engineers to go to America to learn how to build railways rapidly? They spent three months in building twenty miles of comparatively level road, while in the wilderness of the North-West of Canada five hundred miles were built in a single season working from one end of the line; and ten miles were laid in one day.

Your correspondent says that he has no knowledge of any of the great bridges of Europe and Asia being manufactured in America. His knowledge is correct: until lately, America has had enough bridges to build for herself, but now she sends iron bridges to some of the British colonies and to the States of South America. It may not be long before some of them will be found in India, and I think that ere many years bridges of the American type will be manufactured and erected in England.

Let us see how first-class American railroad companies (and there are railroads in the United States that will compare favourably in every respect with the best in England) get their bridges built. First they employ the services of an acknowledged expert in bridge designing to prepare general specifications: then these are submitted to half a dozen of the principal bridge companies, who make tenders for the work. The contract is generally let to the lowest bidder who has furnished satisfactory diagrams of stresses and sections and drawings for each structure.

Then the company employs an expert inspector, who makes a specialty of this business, to remain in the shops, while the ironwork is being manufactured, during which time he makes numerous tests of small sample bars, and an occasional test, to rupture, of a full sized member, any material not coming up to the required standard being rejected. In many cases all the tension members are tested far beyond their working strength but within the elastic limit.

As an example of a grave error in a large modern railroad bridge of, I believe, English design and manufacture, let me call your attention to a letter from Professor Kernot, of the University of Melbourne, which appeared in *The Engineer* of June 5th. The structure referred to is the Hoogly Bridge of, I think, four hundred feet span, with curved upper chord. Professor Kernot points out, that by this curvature the intensity of stress in the end panel of the upper chord varies from zero on one side to twice the average on the other, thus making the bridge only half as strong as calculated. No American engineer of any standing would make such a mistake. That this style of bridge with the curved upper chord is not uncommon in Europe, can be seen by glancing over Mr. Edward Hutchinson's treatise on "Girder-making."

Next, in regard to the 150 feet span on the Yezo Railway. I have been told that it was purchased ready made from a Pittsburgh manufacturer, having been built for an American road and rejected because of bad workmanship and inferiority of design. I cannot vouch for this statement: my knowledge of the bridge being simply hearsay. If it be true, it is but one of the examples of how badly the Japanese Government has been treated by foreign manufacturers and business men.

The statement of your correspondent that Dr. Pole approved of the drawings for the present Japanese bridges is valueless when contrasted with the list of errors in design that I have given on pp. 5, 6, and 7. Grave faults are there clearly indicated: and, if your correspondent wishes to convince the public that the Japanese bridges are perfect, the *onus* of proof lies with him.

A parallel instance of technical authority was the condemnation of the great Forth Bridge by Sir George Airy, who is supposed to be posted in bridge building. He betrayed the grossest ignorance of some of the most simple matters in bridge designing, and showed himself a quarter of a century behind the age.

Your correspondent appears to lay stress upon the fact that "the bridges on the railway built by English engineers in Japan are of the most simple design." He here exposes the weak point of the designers and the designs: because the proportioning of a first class railway bridge is a complicated matter, and involves more considerations than the designers of the Japanese bridges ever dreamed of.

As an evidence that my opinion concerning the Japanese bridges is of at least some value, I refer you to p. 145 of my treatise, where I state that the spans in this country are altogether too short, considering the sudden rises and the immense volumes of water in the mountain torrents. The book was hardly issued before an undeniable proof of my statement was furnished by the Karasugawa Bridge near Shinmachi, a pier of which was destroyed by a flood. If the waterway had not been so obstructed by the piers (*i.e.* if longer spans had been employed) the accident would not have occurred.

Your correspondent's suggestion that lateral bracing is not required because there are no whirlwinds in Japan is quite amusing, and indicates his ignorance of the subject of wind pressure. Does he think that in a typhoon the winds blows steadily in one direction?

Your correspondent will find that on p. 7 I have acknowledged the excellent condition of road-bed which is maintained on Japanese roads, nevertheless the liability of a rail breaking always exisjs, and such an accident is almost sure to produce a derailment. If I am not mistaken, there have been derailments on the Japanese roads, though no serious accident has resulted therefrom. The fact that derailments are uncommon is no reason for not providing for their occurrence.

If one should take place as a train is upon or approaching one of the Japanese bridges, nothing could save the structure; because the sleepers are so small and so far apart that they could not possibly carry the derailed wheels. The longitudinal wooden stringers on the Kobe and Otsu Railroad afford no better protection against loss of bridge by derailment than do the sleepers.

I would like to ask your correspondent if the British Government has done any more concerning the regulation of the strength of railway bridges, than to limit the rolling loads and intensities of working stresses. You will see by the quotation from *Engineering* in your issue of the 16th ult. that this is all that the Board of Trade has done for highway bridges.

If the gentleman who is "Not a Bridge Builder," instead of indulging in such bombast as that contained in the last paragraph of his communication, will read the *remaining twenty-three chapters* of my book and expose what he may consider objectionable in my designs, he will act to better advantage; one cannot write a review or express an opinion of any value concerning a book by reading merely the introductory chapter.

I have expected to meet with opposition to my views from English engineers in Japan, so if any other member of the profession would like to express his opinion thereon, I hope he will not refrain from so doing for fear of wounding my susceptibilities; because I am not troubled by tender feelings any more than by "mock modesty." Moreover, I feel fully equal to defending any views advanced in my book; but at the same time, if proven to be in the wrong, you will find that I am quite ready to acknowledge my error.

In a few months there will probably be some reviews of the treatise in the European and American technical papers; and, as my competency to treat the subject of bridge designing appears to have been doubted by your correspondent (perhaps by others also), I will see that you are informed of what kind of reception it meets.

With many apologies for occupying so much of your valuable space, and thanking you for your favourable review of my book.

I remain, very respectfully yours

J. A. L. WADDELL.

Nikko, August 6th, 1885.

(August 22nd, 1885.)

SIR,—Your issue of August 4th is just at hand. I notice a letter to your paper by "Not a Bridge Builder" in which a misleading statement occurs: "The longest span in Japan is 150 feet. This bridge, indeed came from America, and was ordered by the American Engineer of the railway in Yesso. It is not stated how many days it took to erect it, but a few seconds sufficed to bring it down into the river."

The bridge in question was made in England for the Philadelphia Bridge Company and was designed for a standard gauge railway. It was purchased by the American Engineer for the Poronai Railway.

The following quotation from the *Japan Weekly Mail* of December 2nd, 1882, gives a succinct account of the accident occuring to the bridge alluded to:—

"In the autumn of 1881, under the direction of the Japanese Engineer, three piers were built in Toyohira River. The tops of the coping-stones of the piers were located four feet above the highest observed high water mark at this part of the river. During the month of April (1882) one span of 50 feet and one of 150 feet were placed on these piers. These iron spans were built for the Philadelphia Bridge Company, and were designed for a standard guage (U.S.) line. The 150 feet span weighed about seventy tons, and rested on bed-plates on the one pier and roller plates on the other. As soon as the bridge was in position, all trestle and other supports had been removed from the stream in anticipation of the snow-floods. At the time the river began to rise most of the massive oak stringers and guard-rail timbers had been bolted in place, and in a few days the bridge would have been tracked.

"Previous to April 28th, the sky had been clear for some time. The hot sun had caused the immense banks of snow on the foot-hills and mountains about the Toyohashi to become much softened and honey-combed. During the night of the 27th and the morning of the 28th a strong warm wind prevailed. About three p.m. (27th) the rain began to fall and the quantity steadily augmented. The high wind and the torrents of rain continued their action until 10 a.m, of the 29th. At 5 a.m. of the 29th, the Police bells aroused the few who had been able to sleep. The bulk-heads of the canal had given away and the upper part of the town

(Sapporo) was in danger. The Toyohashi was a raging, muddy, destructive agent studded with floating timber, bush-wood, up-rooted trees, and other débris. In spite of the efforts of the men placed on the 150 feet span to fend off and to push under the drift, it steadily accumulated under the bridge and on the current side of the bridge. During the early morning the track and all the banks for nearly half a mile on each end of the bridge had been swept away, thus leaving the piers and bridge isolated in the broad stream. About 12 (noon) o'clock the bridge was buoyed up from the coping stones, and on the mass of drift materials it floated from the piers. The men on the bridge when it moved from the piers succeeded in reaching the upper works of the fifty feet span which had remained firm. The east end of the moving span encountered firm resistance about 200 feet below its pier, at which time the other end swung down the stream. When the bridge, still keeping its form, went under, it was turned partially on its side and soon became filled with drift and sand. It was estimated by the Japanese engineer present that the current near the centre of the span moved at the rate of 26 feet per second. After the flood had subsided it was found that the coping stones of the piers had been three feet and seven inches under water.

"The piers, not having been injured, have been built up to a new level. The bridge having been removed from the bed of the river was found to have had very few parts ruined, though many of the links and rods were bent and twisted. During the past month (Nov. 1882) the links and rods have been straightened, parts of the bridge have been re-riveted and re-adjusted, and a few parts replaced by material from Tôkyô. It is now expected that the bridge will be in position again in January, 1883."

The bridge was tested the last week of December, 1882, and found acceptable. It has been in use since. No repairs have been needed, painting excepted, since it was replaced. Coal-trains of from fifteen to eighteen cars (eight tons of coal per car) pass over the bridge at from half to three-quarter speed daily.—I remain, Sir, yours truly,

AN AMERICAN.

Sapporo, August 12th, 1885.

[We have before us a photograph of this bridge as it now stands. It is a handsome, solid-looking structure.—ED. *J.M.*]

(*August 31st, 1885.*)

SIR,—In your issue of the 12th instant, Mr. Waddell, of the Tokio University, refers the public to me as responsible engineer for the alleged flaws in the details of the Arakawa and Karasugawa Bridges. I decline to be so referred to. I was not the chief engineer responsible for the erection of those bridges; but, as far as I know, they are safe and satisfactory. Mr. Alexander, of the Imperial College of Engineering, Tokio, has advised me to defend myself and countrymen from Mr. Waddell's attack, which I cannot do better, perhaps, than by publishing his letter, in which I concur, and which I enclose. Please print it following my own.

Yours respectfully,

TAKANOBU KONO.

Imperial Government Railway Office,
Takasaki, 28th August, 1885.

Imperial College of Engineering, Tokio,
20th, August, 1885.

T. KONO, ESQ., M.E.

DEAR KONO,—In the *Japan Daily Mail* of 12th Aug., Mr. Waddell, of the Tôkyô University, has a letter in which he refers to you by name in quite an unprofessional way and indirectly lays a grave charge against your character.

Here is the quotation:—

"In the Arakawa and Karasugawa bridges of the Tôkyô-Takasaki Railway, the bottom chords are so warped and twisted that to make the floor beams bear on both sides of the same, shims, or filling pieces, of $\frac{1}{4}$ to $\frac{3}{4}$ inch iron had to be used: and there are open joints in the top chords which even paint will not hide. Concerning these points, I refer to Mr. Takanobu Kono, the engineer who erected both bridges, and to Mr. Mouri, engineer in charge of the railway."

This accuses you as responsible engineer for the erection of the bridges, and of having passed work which he there and in the whole spirit of the letter implies is unsafe.

The whole letter is insulting to European and Japanese engineers, and to the common sense of the public. I think you ought to defend yourself and your countrymen. My reason for so advising you is, that you are one of our most distinguished graduates in Civil Engineering, with a technical education any foreign engineer might envy, and that I know you are quite competent to make all the calculations for the most modern engineering structures, even when so complicated that Mr. Waddell, myself, and most foreign engineers, might be inclined to evade them, by supplying their place from our own practical experience or that of the profession.

Write a letter, addressed to the Editor of the *Japan Mail*, saying whether you were the responsible engineer for the erection of those bridges or not: that you are sorry Mr. Waddell should have so far forgotten the etiquette of the profession, to say the least of it, as to refer the general public to you in respect of alleged flaws in the details of these bridges, which flaws, though of a trifling character, he leads the public to believe render the bridges unsafe, thus asking you to endorse and publish what would be your own shame and criminal negligence.

You are at perfect liberty to ask the Editor of the *Mail* to print this letter along with your own.

I am, dear sir, Yours sincerely,

(Signed) THOS. ALEXANDER.

(September, 5th, 1885.)

SIR,—Your issue of yesterday containing Mr. Kōnō's letter has just reached me. I am both surprised and grieved that my statement in your issue of the 12th ult. could have been so misinterpreted. My intention was far from throwing any blame on either Mr. Kōnō or Mr. Mouri, both of whom I esteem personally and as engineers. If Mr. Kōnō had been sent the whole paragraph in which I referred to him he could not have misinterpreted it. It related entirely to the question of the *quality of the ironwork* on the Arakawa and Karasugawa bridges, and did not concern those structures in any other particular. The whole paragraph is as follows:—"Next, as to the quality of English ironwork. I can give no opinion as to the quality of workmanship on bridges in England, not having been in that country for a number of years; but if I am to judge of English ironwork by the specimens on the Japanese railways, I can unhesitatingly condemn it. Ironwork of as poor a quality may be found in many of the cheap hghway bridges of the United States, but no first-class American manufacturer would allow such work to pass out of his shop. In the Arakawa and Karasugawa bridges of the Tôkyô-Takasaki Railway the bottom chords are so warped and twisted that to make the floor beams bear on both sides of same, shims or filling pieces of ½ or ¼ inch iron had to be used; and there are open joints in the top chords that even paint will not hide. Concerning these points, I refer to Mr. Tananobu Kōnō, the engineer who erected both bridges, and to Mr. Mouri, engineer in charge of the railway." Now can anyone so interpret the above so as to cast a slight upon either of these gentlemen? I referred to them simply as prominent Japanese engineers, who will give an honest opinion upon the quality of the ironwork in the bridges mentioned. If either of them object to my having so referred to him without permission, I hope he will accept my apologies for the same. As for any accusation for responsibility in having passed the work—that is both untrue and absurd. Mr. Kōnō was given the various portions of the ironwork with instructions to erect the bridges, with which instructions he complied. Can any man with common sense blame him because the ironwork would not go together without warping and twisting? He did the best he could under the circumstances by inserting filling pieces beneath the floor beams. Such deficiences in workmanship would be sufficient to cause the rejection of the bridge in either England or America, if the railroad company could afford the time to wait for another bridge to be manufactured; but the Japanese Government cannot wait a year or more for another structure, so content themselves provided that the bridge can be erected and that it name sufficient sectional area in the principal parts to resist the calculated stresses.

It is not because of poor ironwork that I have condemned the present Japanese bridges; in fact, that consideration was not mentioned in the introductory chapter of my treatise. *The faults are in the designs,* and these are not the work of Japanese engineers, but of foreigners.

Let me here distinctly state that in no particular do I consider the Japanese engineers responsible for the faults of design that I have pointed out; in proof of which let me quote the following from the introductory chapter of my treatise:—

"It will now be necessary for me to criticize the railroad bridges of this country, aud I hope you will excuse me for so doing. I have little hesitation in expressing my opinion thereon, knowing that the designs are not yours, but are the work of some of the present and former foreign employés of the Railway Department."

Does not a perusal of the second part of the communication in yesterday's paper suggest that the responsibility is being shifted from the foreign to the Japanese engineers, and that one of the former does not care to take up the question?

As for my letter being "insulting to European and Japanese engineers, and to the common sense of the public," I cannot view it in that light. In plain words the affair stands thus: I have stated that the present Japanese bridges are badly designed, and explained in what particulars; also that the designs are the work of foreign engineers.

If anyone wishes to contradict the statement, the burden of proof lies with him. Moreover, I have prepared a complete system of iron railway bridges, which I offer to the Japanese engineers. By reading my treatise they can see whether the bridges of my designing are superior to those in present use or not, and can accept or reject them accordingly. If any foreigner wishes to prove that present Japanese bridges are better than those of my designing, let him read the treatise thoroughly and show in what way they are better in a letter to the *Mail*. I am quite ready to enter into a discussion professionally, but wish it to be clearly understood that I will not descend to the use of personalities nor take any notice of such in any communication.

Yours respectfully,

J. A. L. WADDELL.

Nikko, September 1st, 1885.

[Without entering into the question of designing, we must say that we think Mr. Waddell's meaning was misconstrued by Messrs. Alexander and Kônô. Mr. Waddell's letter, as we read it, did not reflect at all upon Mr. Kônô's work, but only on the nature of the material with which he was required to work.—ED. *J.M.*]

(*September 9th*, 1885.)

SIR,—My attention has been drawn to an Editorial Notice in the *Japan Mail* of a book written by Mr. J. A. L. Waddell, and a letter from him, dated August 6th, in reply to a criticism signed "Not a Bridge Builder," in the same paper. The book itself has also come into my hands. Its title is a size too large for it. On the cover it is described as "A System of Iron Railroad Bridges for Japan." A bridge of this sort consists of two parts, the girders, and piers or abutments which carry them. It is impossible to consider a bridge otherwise than as a whole, if a proper opinion as to what is suitable for given circumstances is to be arrived at. This book deals with one-half the subject only, the girders, and it is the other half, the piers and foundations, which present the greatest difficulty in this country. Therefore we have not before us a "system of bridges" at all.

The cover next informs us that the author, like a good many other people who come to Japan, has written a book, that he is a member of no less than four American Engineering Societies, mostly local, and that he belongs to the junior grade of the Institution of Civil Engineers in London. This position he attained the year before last. Had he been able to show that he had held a responsible situation for five years he would have been eligible for the higher grade. As he did not obtain it, one must suppose his experience did not justify his doing so. Whether he has had any practical experience at all he does not tell us, but he does inform us that he holds two appointments at present. Taken together they explain a good deal of what follows.

He is "Consulting Engineer" to an American bridge building firm, and he is a Professor of Engineering at Tôkyô University. As to the latter position, he tells us in his preface that he has never had more than a dozen students at a time. I must be excused if I am somewhat personal, because in weighing opinions it is necessary to consider whose they are, and with what authority they are delivered. Mr. Waddell, too, in his letter invites criticism, and says there is no fear of wounding his susceptibilities because "he is not troubled with tender feelings any more than with mock modesty." I believe him, and I take him at his word.

The book consists of eleven pages of preface, followed by about thirty pages of reprints of manufactures' price lists. The latter is useful material, but from its nature not original. Thence to the end of the first volume is technical matter involving calculations, &c., into which it is not necessary to enter. Certainly any discussion on this part would be out of place in a paper of general circulation, and merely wearisome to the public. Therefore I limit my remarks to his letter and his preface. This I am aware, is what he objects to in "Not a Bridge Builder's" dealing with the subject. That writer noticed the preface only, to which Mr. Waddell replied that "one cannot write a review or express an opinion of any value concerning a book by reading merely the introductory chapter." That is undeniable. But, when the preface is much more important than the book, it is perfectly fair to comment on the preface, as showing the spirit in which the book is written; and for this, as much as for any other portion, an author must be held responsible.

The first volume is supplemented by a second, of tables and drawings, which again are not of general interest. Probably they owe their origin to the black-board in the class-room.

The whole work is a treatise on the American method of girder building, as compared with the English, and many differences in the methods used are pointed out. There have always been such differences, and no doubt always will be; the conditions of the two countries differ widely, and so what suits the one does not suit the other. As regards girders, the Americans have used a greater depth in proportion to length than has been taken in England, and from this change almost all the others have followed. But as I believe the Americans are now reducing depths, while the English are increasing them, the two types are becoming similar. Such matters have often been discussed by engineers of the two countries; always, till Mr. Waddell took pen in hand, in a fair and courteous manner. For really there is nothing to quarrel about in the fact that each country knows what is best for itself; on the other hand, each can learn and is learning from the other. For myself, I should be ashamed to denounce American engineers, or American methods, because these were not what I had been accustomed to.

Mr. Waddell takes a different line. Addressing the Japanese engineers, he says of the bridges in this country: "I have little hesitation in expressing my opinion thereon, knowing that the designs are not yours, but are the work of some of the present and former foreign employés of the Railway Department;" and again, "The trouble with most English bridges, and consequently with those of this country, is that they are designed by railroad engineers, who have not made a special study of bridge designing, and are therefore *incompetent* to do the work entrusted to them."

Here we have a sweeping charge of incompetency made against English railway engineers as a body, on the false ground that they do not make a study of bridge-work. Coming as it does from a professor in so small a way of business, it is a mere impertinence; one that American engineers of good standing would probably be the first to regret.

Mr. Waddell is evidently ignorant of the fact that the designer, whom he tells us, is in America employed by the manufacturer, is in England, either a man in private practice, or else he is on the staff of the railway office. Most large railways have several men in their employ who are competent to design, and do design, any girder work that is wanted. What he tells his readers is *not* a special study, is, with very many men, I do not say with all, a matter which they take especial pains with, as it leads to advancement.

It is just a case where American and English habits differ. By all means let the Americans follow the course which they prefer One reason for its not being followed in England is, that the designer may be an independent person without bias towards the contractor. Certainly in England he never has to use his education as a means for advertising the contractor's wares.

Mr. Waddell's tone as regards English engineers is unfortunately fairly represented by the two passages I have quoted; he writes in a bitter spirit of depreciation all through. For American methods, and his own especially, he can not say too much. He tells his readers, in his own idiom, that "he has not an axe to grind." It looks very much as if he had. He says on page 10: "I have no objection to giving any of you individually my opinion as to which shops in America do the best work." No doubt. The shops would feel grateful, and might even allow their gratitude to take a practical form. As Mr. Waddell is leaving Japan, his advice on this subject, if it is ever asked for, would certainly ensure him a warm welcome on the other side the Pacific, from the parties who derived benefit from it.

Leaving his comparisons between English and American girders, and turning to his denunciations of the bridges in this country, we find him, as might be expected of an outsider to the Department, not acquainted with what is being done, exceedingly weak in his facts. I am not disposed to correct them for him, but I may notice that where on page 5 he writes:—"The first grave error to which I would call your attention is, that both for economical and prudential reasons the spans are too short. the superior limit being 100 feet." Well, that used to be the limit;

it is not so now: more than a year ago girders over 200 feet in span were indented for from England, and they will soon be here.

Then again, he attempts to make a great point of the absence of a guard rail, that is a second metal laid alongside the one on which the train runs, on the bridges. There is a very good reason, unknown to him, but known to those whose business it is to know, for believing that in this country such a rail would cause danger and not prevent it. However, Mr. Waddell goes so far as to say, "if derailment of a train should take place as it is on, or approaching, one of the Japanese bridges, *nothing could save the structure*." This attempt to raise a scare fails, because the very thing he mentions happened with a carriage on March 23rd, 1884, between Suita and Osaka. No one was hurt, the permanent way was virtually uninjured, though the train passed over the Kansaki-gawa bridge, 13 spans of 100 feet girders.

So the facts are awkward for Mr. Waddell, as indeed they are all through.

If the bridges made on the English system had not been well and solidly constructed they would not have stood the wear and tear of traffic all these years, nor would they have resisted the heavy flood pressures they have been exposed to, especially this summer, without injury. There they stand, and they do their work, none the worse for it. In the face of this, it is no use for Mr. Waddell to theorise and vapour about their not standing.

He is wrongly informed about the cause of failure in the Karasugawa bridge recently. The bridge had only just been constructed, and I do not include it in what I have said above.

Mr. Waddell asserts that, if an American engineer were sent to inspect and pass judgment on a Japanese railroad truss bridge, he would condemn it before getting within a hundred yards of it. Of course he might, but if he did he would be a very silly fellow. Any man must be so regarded who commits himself to an opinion without examining what he has to report on.

Even after reading Mr. Waddell, I decline to think so hardly of American engineers.

Mr. Waddell tells us his typical man would condemn the bridge because it would blow over. A bridge that has stood ten or a dozen typhoon seasons and declines to go over, if it does not upset itself, at all events upsets the Professor's theories on the subject.

Only once, and that by accident, is Mr. Waddell amusing. One hears from him, for the first time, that Sir George Airy, who, as Mr. Waddell says, when writing about the Forth Bridge "betrayed ignorance," is a "technical authority." He is nothing of the sort. Most men of science know that Sir George Airy is not an engineer, but an astronomer. He was the English Astronomer-Royal for ever so many years. His mistake about the Forth Bridge was precisely the one which Mr. Waddell is making now; that is, he interfered in matters outside his own department and in charge of other men. He made nothing by it, neither will Mr. Waddell. But there were two excuses for Sir George, which do not apply to his imitator; one, that he was a very old man, and a good deal is conceded to age; the other, that he was, as a man of science, of world-wide fame.

I have not time or inclination to follow Mr. Waddell any further. I hope I have shown that the alarm he tried to cause about the guard rails on the bridges is needless. That is all that really concerns the public.

I do not intend to be drawn into a newspaper correspondence. If Mr. Waddell desires to obtain notoriety, I do not. Therefore I shall take no further notice of him. But I could not pass unnoticed his tone, or his motives, in writing about English engineering works.

There is no one else here to take him up, and if I failed to reply, the public might suppose no reply was possible. If any remarks I have made are disagreeable to Mr. Waddell, he must remember that I write in self-defence. Let him keep to the work he is paid for, and teach his dozen or half-dozen of students all he can. Let him attend to his own duties and leave his neighbours to attend to theirs. I, for one, have as little disposition to annoy him or interfere with him, as I have to submit to any annoyance or interference on his part.

I am, Yours faithfully, C. A. W. Pownall, M. Inst. C.E.

Kobe, September 4th, 1885.

(*September 10th, 1885.*)

Sir,—I am glad that Mr. Waddell has apologised to Mr. Kōnō for referring the public to him without his permission, and for not sending him *the whole paragraph* in which he did so. In my opinion the apology is ungracious, as the expressions "If either of them object," "who will give an honest opinion," reflect upon the authenticity of Mr. Kōnō's letter and the honesty of the very decided opinion he has given. This, you must see, is very unfortunate, for if the foreign teachers here do not treat the gentlemen holding the degrees of their colleges with the marked respect which is due to them, how can it be expected that the Japanese authorities will respect them? As Mr. Kōnō was a pupil of your own for some years, when we were colleagues, you surely know his hand, and could testify to the genuineness of his letter.

The challenge thrown out to me individually in the paragraph beginning, "Does not," I cannot take up, as I do not wish to insult the public with a parade of private professional knowledge, nor could I give a professional opinion without being asked to do so by the proper authorities, besides being allowed the time from my arduous duties for making the necessary inspection of the bridges in Japan, for making plans and calculations, and for consultation with other members of the profession.

As to Mr. Waddell's pamphlet, which he calls a treatise, on one kind of American bridge—that sold by Raymond and Campbell, to whom he is consulting engineer—I may say that I have offered him every facility in my power to have the subject brought legitimately before my students and graduates, that they might learn, in the indifferent way that such a thing can be learned from a book, the practical details of one American bridge.

I have myself taught my pupils the scientific theory of American trusses, following Dr. Maurice Levy's "Statique Graphique," which I in part translated for their private use, first correcting some errors and considerably extending the investigations, my corrections and extensions both being accepted by Dr. Levy for his second edition. If any one will get that eminent engineer's work or a private copy of my pamphlet, and putting a wet towel round his head, carefully read it, he will, if he can follow the mathematics, see the grave scientific defects of American designs.

Notwithstanding their scientific defects, the American professional engineers justly claim for their style of trusses many practical advantages which can only be really known to them and in part to those French engineers who have visited America to make them a special study, just as the grand advantages of English girders to resist shocks, heavy, swift, and incessant traffic from the excessive resilience due to their massiveness can only be appreciated by English engineers long in practice. These things cannot be demonstrated or settled by book work, but only in each case by the general concensus of opinion of that part of the profession with the necessary experience.

Two of our graduates in Civil Engineering have, with our encouragement and at their own expense, gone to America and are there in practice in Railway Work. They will see such structures themselves, and will, I grant Mr. Waddell, see or rather learn in a slight degree some of the practical points in which his and other American designs are superior, and others in which they are inferior, to European designs. On the other hand, by the liberality of the Government many of our graduates have continued their studies in Germany, England, and bonnie Scotland for periods of three or four years. These gentlemen instead of "accepting or rejecting them," the one or the other system, will, I have no doubt, like all liberally educated professional men take what is proved by experience to be good in both, and adapting it to the circumstances of their own country inaugurate a *Japanese System of Bridges for Japan*, do which Mr. Waddell's work would have honourably added its quota had it been allowed to carry its own weight, and not been marred by the omission of "proposed" in the title and by the amazing self-conceit of the author in his preface, and by his unwarranted wholesale attack upon the foreign engineers who have executed admirable works already in Japan.

It may especially interest your Japanese readers to hear the curious partial corroboration in "Matheson and Grant's Engineering Trades Report" for last half year, of certain statements made in the course of this correspondence as to the gradual conversion of English engineers to the adoption of American trusses, and as to the exportation of American iron to Australia, though a very different reason is assigned. Here is the quotation: "It has long been known to English Engineers, and the opinion is now being rapidly adopted in the United States, that the light and cheap American bridges, with pin connections, are neither stable nor permanent enough to justify their use, but at present there are political influences in New South Wales, which favour greatly the importation of railway material from the United States."

I am, yours, &c., THOS. ALEXANDER.

Kobu Dai Gakko, September 7th, 1885.

[Of course Mr. Kōnō's letter was genuine. Surely this has never been intentionally questioned.—ED. *J.M.*]

(September 16th 1885.)

Sir,—Your correspondents' letters in issues of the 9th and 10th inst. should have received attention ere this, had not various matters connected with my work prevented.

With difficulty I will endeavour to sift from the mass of personalities in Mr. Pownall's letter the few technical points that it contains, and will discuss them in the order in which they appear.

First, he objects to my calling the treatise referred to a "system of bridges," because I do not treat of foundations. In engineering literature the two subjects will generally be found treated separately; and in America at least, the two classes of work are very often done upon the same structure by different contractors. The bridges of my "system" may be placed upon any of the ordinary foundations.

Perhaps I should not have been found incompetent to treat the subject of foundations; for the last piece of work upon which I was engaged before leaving America was the making of the plans and superintending the putting in place of the foundations for a large railway bridge, the total length of which is half a mile, and the maximum height from water surface to rails one hundred feet.

The subject of foundations will be found well treated in a number of standard works, to which, undoubtedly, many of the Japanese engineers have access: moreover, even had I wished to introduce the subject into the "Memoir," I could not have done so, because of want of space, the size of the book having already far exceeded the usual limit.

In his first paragraph Mr. Pownall has struck the key-note to the reasons for some of the principal faults in the Japanese railroad bridges. He says "A bridge of this sort consists of two parts, the girders and piers or abutments, which" etc.

Herein lies one of his errors: he considers only the *girders* of the superstructure, and omits entirely the necessary lateral systems in his designs. Indeed, I doubt that the consideration of wind pressure ever entered the calculations of stresses in the existing Japanese bridges.

Next, let me ask Mr. Pownall, if Mr. Benjamin Baker, who is regarded in America as one of the highest English authorities upon bridges, was not an associate member of the Institution of Civil Engineers when he wrote his standard treatise upon "Long Span Railway Bridges."

Allow me to correct a statement of Mr. Pownall's. Chapter II. contains tables of sections of bridge iron rolled in Europe and America, not *price lists*. This chapter, though not original, is necessary, because Japanese engineers have not access to many of the original tables.

Mr. Pownall asserts that the succeeding chapters of the "Memoir" are of much less importance than the introduction. The part of the book thus slightingly passed by is the first treatment, that has yet appeared, of the *actual designing* of railroad bridges in all their details. Moreover, a large portion of this treatment has already appeared in my work on Highway Bridges, and has met with the almost unqualified approval of the principal engineering periodicals of England and America, as you have shown by quotations therefrom in your review of the "Memoir." My reputation as an engineer and technical writer is not, therefore, likely to suffer from attacks such as that of Mr. Pownall. There is one point, though, that I must not fail to notice, even if it does come under the head of "personality": I refer to the insinuation that I am in the pay of the American maufacturers. It is utterly untrue in every respect. Even my connection with Raymond and Campbell cannot be so interpreted, for they design and erect, but do not manufacture bridges: they stand in relation to the work in the same position as does the Japanese Government.

The drawings in Vol. II. do not "owe their origin to the black-board in the class-room," but are the result of five years of study, research, and practice in the designing of bridges.

Mr. Pownall cannot be better informed concerning American engineering work than I am, nevertheless he tells your readers that the Americans are reducing the depths of their trusses. On the contrary, American engineers have determined the most economic depths, and employ them whenever practicable.

Concerning the proper limiting length of span, Mr. Pownall has changed his mind within the last two years; nevertheless my statement that the limiting length is one hundred feet is perfectly correct, for there is no existing span longer than that on any of the Japanese railroads excepting the Poronai. I am curious to know whether the glaring defects of design in the one hundred feet spans will appear in the new two hundred feet spans; for the importance of such errors increases very rapidly with the length of span.

If the new bridge on the Utsunomiya line be erected before I leave the country, I will make a journey to see it, and will, if you so desire, send you my opinion thereon.

I can explain how the derailed carriage passed over the Kansaki-gawa bridge. On the Kobe and Otsu Railway the rails are supported by wooden stringers to which they are spiked. These stringers are, say, fourteen inches or more in width. Now if a *carriage* be derailed while passing over the bridge, the traction of the preceding car will cause the derailed wheels to keep close to the rails: and, if luck befriend the train, it may pass over the structure without having the derailed wheels deflected from the track more than half the width of the stringer. But if the *locomotive* be derailed, there is nothing to prevent it from running off the edges of the stringers and destroying the bridge. On such bridges as the Arakawa and Karasugawa, where the rails are supported by small cross-ties or sleepers, spaced at least thirty inches from centre to centre, a derailed car would have no chance whatsoever of passing over the structure, much less would a derailed locomotive.

I am glad to be informed that derailments on Japanese lines of road are possible; the gentleman who is "Not a Bridge Builder" led me to infer that such an occurrence is impossible, and that it is folly to provide for it.

I should be pleased to be informed how an inner guard rail of the same height as the main rails could "cause danger and not prevent it." Surely the conditions in this respect in Japan cannot be very different from those in America, where inner guard rails are common.

Next let me inform Mr. Pownall that the fact of certain bridges having "stood the wear and tear of traffic" even for years has in many cases caused such a secure feeling that sad accidents have resulted therefrom—witness the Ashtabula horror and another incident in Scotland, of which I shall have occasion to speak farther on.

The fact of having stood for years is no proof whatsoever of sufficient strength: it merely shows that the necessary combination of favourable circumstances for the destruction of the bridges has not yet occurred. The now nearly obsolete term "factor of safety" or as it has been aptly termed "factor of ignorance" is responsible for weak structures withstanding for years all the stresses to which they are subjected, then suddenly collapsing.

Mr. Pownall very coolly omits the Karasugawa bridge, when he refers to the durability of the Japanese bridges; merely because it was recently constructed. He says that I am misinformed about the cause of the failure, but does not state what the cause was. I can state it in a few words. The damming up of the water by the close piers and the embankment caused an eddy which undermined one side of the foundations of one of the piers. Had the waterway not been so obstructed, the accident would not have occurred.

Mr. Pownall's remarks concerning the Japanese bridges having "stood ten or a dozen typhoon seasons," instead of proving that they are strong enough to resist the proper allowance of wind pressure, merely show that the requisite wind pressure for destruction has not yet struck the bridges.

It is a well known meteorological fact that the maximum wind pressure in any great storm acts at one time over a very limited area, so the chances of any bridge escaping destruction by any one storm are very good.

Concerning Sir George Airy, my statement, although amusing to Mr. Pownall, was nevertheless correct; for I have been informed by an eminent English engineer that he (Sir George) many years ago was referred to concerning most of the important bridges then being built in England, in order that he might check the calculated stresses and pass judgment upon the designs.

Finally, Mr. Pownall advises me to attend to my own work and let his alone. It is true that if I had done so all the discussions of the last six weeks would have been avoided. But it happens that my specialty is bridge designing, and seeing before me specimens of very inferior designing of bridges on the Japanese roads, have I not a right to express a professional opinion thereon? When an engineer erects any structure, he places himself in the same position in respect to criticism as does an author in writing a book, so he need not feel offended or insulted, if someone takes advantage of the opportunity to express an opinion adverse to the work.

Now as the foreign engineers who have hitherto taken part in the discussion refuse to criticize my work on rational and technical grounds, preferring to indulge in vague reference to the great mental capacity requisite to a comprehension of the subject, and in personal attacks, it behoves me to state as clearly and as simply as possible the faults that I find in the Japanese railroad bridges. I have done so already in the "Memoir;" but, as very few of your readers have seen the work, a repetition will not be out of place.

But first a word in respect to the great mental capacity referred to a few lines back. It is the opinion of most American engineers that to design a bridge a man requires plenty of good, sound common sense rather than a profound knowledge of mathematics. It is true that without a thorough, practical knowledge of this subject no man can be an engineer; but on the other hand, a great ability to understand and use profound and complicated mathematics will not constitute a man an engineer; in fact it nearly always indicates an incapacity to deal with the practical parts of the profession.

The three dangers to which the present Japanese bridges are subject are washout, destruction by wind, and derailment. In respect to the first, my prediction has already been fulfilled.

To the second the bridges are liable at any time, although it may be years before a sufficiently great pressure will strike one of them; but when it does, being utterly unprovided with either sway or side bracing of any kind, the structure must succumb. In respect to the third, the danger is ever on the increase, because the life of the best of rails is limited; and, when a broken one on or near the approach of one of the bridges derails a locomotive travelling at the usual speed, there will be a wreck that is liable to cause the loss of many lives.

In addition to these, there are the following faults in the construction that indicate very clearly a want of practical and theoretical knowledge in designing.

1°. The web struts are weak even if their sectional areas be excessive, owing to the fact that they are formed of two flat bars with trussing between. Trussed bars as struts were long ago tested in America and condemned.

2°. The thickening of the eyebars at the eyes by rivetting a plate on each side weakens the bars, indicating a want of either strength or economy.

3°. The stay plates of the top chord might as well have been omitted for all the good they can do. *They are placed three feet apart and have one rivet through each end.*

The object of stay plates latticing or lacing is to make the two sides of the member so connected act together instead of separately.

Supposing the top plate to be omitted (as it sometimes is) and to be replaced by stay plates similar to those described, would the two valves of the chord act together or separately?

The answer to this may be that the top plate is not omitted. True, but if it were, the injurious effect of using such stay plating would only be doubled.

4°. The trough shape of the bottom chords tends to collect rain water and to rust away the iron. I saw water standing in the bottom chords of a bridge on the Kobe and Otsu Railway long after it had ceased raining.

5°. The connecting plates at the joints in the top chords are so small that there are not enough rivets to transfer the stress past the joints. This is not a point of vital importance, provided that the abutting ends are in contact throughout, which I stated in a previous paper they are not.

6°. There is a want of economy in using so many panels in the trusses and so many floor beams. A smaller number of larger floor beams would weigh much less and be more rigid.

7°. By resting the floor beams on the bottom chords, the inner sides of the latter take up nearly all, if not all, of the weight when the beams are loaded. This causes a distortion of the chord section and an overstraining of one side of the same. This overstraining is carried to the panel point where it causes an overstraining of the inner diagonal ties, which in turn tends to twist the top chord and to cause an unequal distribution of stress on the web struts, an inequality that the trussing is not well calculated to overcome. Again, the supporting of the floor beams between the panel points produces a bending upon the lower chords, greatly increasing the range of working stress, and necessitating, if the bridge be well designed, an increased sectional area.

If anyone be sufficiently interested in the subject, I shall be happy to explain how the most serious of the faults just mentioned may be corrected without interfering too much with the traffic, and without incurring great expense; but until requested to give my opinion upon this matter I prefer to remain silent.

I can scarcely believe that the structures on the Japanese roads are fair specimens of English bridges, although the drawings were passed by Dr. Pole. The Board of Trade, I believe, specifies that all bridges be proportioned to resist a wind pressure of fifty-six pounds per square foot of exposed surface. This has not always been complied with, as was shown by the fall of eleven spans of the Tay Bridge, a structure of such evidently inadequate design that its failure was predicted several months before the occurrence by a student at a meeting of the Rensselaer Society of Engineers.

In respect to the letter in your issue of the 10th inst., I have nothing to add to your foot-note thereto.

This bridge discussion has reached unusual limits, and I fear that both you and your readers are getting as tired of it as I am. As I have pretty clearly stated my opinions in this letter; and as, if there be any answer, it is liable to be of a personal nature, it is quite likely that this will be the last time that I shall trouble you on the subject.

Yours respectfully,

J. A. L. WADDELL.

Tôkyô, September 13th, 1885.

(October 6th, 1885.)

SIR,—My attention was called yesterday for the first time to the correspondence which has been going on on this subject in your paper, or I should before now have written to protest against Mr. Waddell's imputations on my father's engineering ability. But let me premise that Dr. Pole is not responsible for the design of any bridges on the railroads here, except those of 100 ft. spans on the lines north of Osaka, and the New Dokungo-yama bridge on the Yokohama-Tôkyô line. It is to these therefore solely that I shall refer in what follows.

Mr. Waddell says, "I can scarcely believe that the structures on the Japan roads are fair specimens of English bridges, although the drawings were passed by Mr. Pole." With reference to this statement, allow me to inform Mr. Waddell that the drawings for the bridges which I refer to were not merely "passed" by my father, but actually made under his own eye, and in accordance with his own personal instructions. He alone is responsible for their design, though it is probable that in designing them he endeavoured to assimilate them, so far as he thought desirable, to the type which had already been introduced into the country before his connection with the lines. But of this I cannot now speak positively.

Mr. Waddell also says, "I doubt that the consideration of wind pressure ever entered the calculations of stresses in the existing Japan bridges." I can set his doubt at rest at once with regard to the 100 ft. span bridges, which he accuses of showing such "glaring defects of design," by assuring him that this point received most careful attention from my father. I was at the time in his office, and well remember the wind calculations being gone into minutely.

Now, notwithstanding Mr. Waddell's disclaimer, it must be obvious to every candid observer, that he has, as Mr, Pownall has hinted, been singularly ready to volunteer his criticisms—how much more to publish his denunciations and disparagements—on the existing railway bridges in Japan. Had he been requested by the Japanese Government to report upon them, there might have been some excuse for him, though many right-minded engineers would have hesitated before consenting to do even this: but, that he should impose upon himself this task unbidden, and carry it out in the spirit in which he has done so, seems to argue unusual confidence in his own attainments.

Göethe says:—"The man who loudly denounces, I always suspect," and certainly, in the present case, Mr. Waddell has given good grounds for a suspicion that he has an ulterior object in view in thus rushing into print.

He objects to this being made a personal matter. But I should like to ask him how he can deny that it is purely such. When one engineer criticises and passes a condemnatory judgment on the work of another, the first question an outsider asks is: "*Who* is this who undertakes the office of censor? What is his position as an engineer as compared with that of the man whose work he pulls to pieces? Is he a competent authority to deal with such a matter?" Until these questions are answered, it is impossible to know what weight to give to his opinions and criticisms; and it is in order to enable your readers to answer these questions, that I take upon me the uncongenial task of comparing Mr. Waddell with Dr. Pole, in order that the public out here (were this to occur in England, it would be treated with the silent contempt which it deserves), and especially those Japanese who are likely to be misled by Mr. Waddell's statements, may be able to judge which of the two is the better able to design railway bridges and whose opinion on the subject is likely to be the more correct.

Now, on looking at the title-page of Mr. Waddell's book, the first idea that would suggest itself to the mind of an engineer of any standing or experience would be that he had before him the work of a tyro. It is to be supposed that here, if any where, the author gives us all the information regarding himself of which he is proud. There are some six lines or so of "titles," only two of which, however, are worth *anything at all*, and one, at least, of which a respectable engineer would hesitate to print after his name. I do not know what the custom may be in America, but in England I doubt whether a fourth-rate engineer in a provincial town would be silly enough to publish on the title-page of such a work that he was consulting engineer to a Bridge Co. (By the way, perhaps Mr. Waddell can explain to his own satisfaction, how a firm can design and erect bridges without *manufacturing* them, or at least, which amounts to the same thing, *being responsible* for their manufacture. And although he may not be "in the pay" of this company, which no one said he was, can he deny that he receives pay from it? If so, he is the first "Consulting Engineer" I have heard of who does his work gratuitously.)

Further, Mr. Pownall has drawn attention to the fact that Mr. Waddell has not had five continuous years of practical experience as a Civil Engineer in responsible charge of engineering works. After Mr. Pownall's statement, Mr. Waddell would certainly, if he had been able to do so, have made this plain, instead of giving the evasive answer which he has done.

Now, I challenge Mr. Waddell to deny to my father a position as a Civil Engineer, or as a man of science, among the foremost 100 in the world. If I were to confine myself to English Engineers, I should probably put him among the first 20, but as I desire to include other countries as well, I put the limit at 100. I may be biassed, but I can honestly say that none of the greatest living English engineers or those who have died within the last decade or so—I mean such men as Hawkshaw, Hawksley, Bateman, Bramwell, Barlow, Bazalgette, Siemens, Gregory, Coode, Harrison, Brunlees-Bidder, and many others whose names are on my lips,—would be ashamed to have had (as many of them have, in fact, had) my father's name coupled with theirs in any engineering work. His re-election year after year for a period of 20 years or more on the Council of the Institution of Civil Engineers is sufficient guarantee for this, and his present position as Hon. Sec. of that Institution is proof positive of the respect with which he is regarded by the leading members of his profession.

I omit all reference to the other honours to which, as a man of science in respect to other matters, he has attained, as they do not immediately concern the point at issue:—

> Titles of honour add not to his worth
> Who is himself an honour to his title.

My father's reputation for bridge designing, and his experience of work of this nature, whether theoretical or practical, was gained probably long before Mr. Waddell was in his cradle. And for a beginner (as I take Mr. Waddell to be) to presume to pull to pieces the work of an engineer who has reached, undeniably, the foremost rank in his profession, reminds one strikingly of Landseer's picture of "Dignity and Impudence."

Now we are brought to this problem. Which of these two gentlemen is likely to be correct in his method of designing bridges? If Mr. Waddell is right, then Dr. Pole's design shows "glaring defects." If my father's experience and ability have not been over-estimated by his fellow engineers in England, Mr. Waddell's grand denunciations are worth just simply nothing at all. And with his denunciations must go his whole system of bridges for railroads in Japan or anywhere else.

Unless I am very much mistaken, this attack on English engineers will cost Mr. Waddell more than he bargained for. I mistake the spirit of the Council of the Institution of Civil Engineers, if they will pass over with impunity such wholesale denunciations of English engineers by one of their Associate Members. Mr. Waddell *may* have to strike out of his long list on the title-page of his work, one of the only two titles of which he has any right to be proud.

It will be said that this letter contains very strong language, especially as it comes from a clergyman. But the meekest has a right to be indignant under such circumstances. No doubt, I lay myself open to Göethe's suspicion, and it may be true that I have a bias towards one side. I should not be my father's son if I had not. But I would simply ask your readers to judge whether I have not good cause to be indignant.

I certainly shall not condescend to any controversy with Mr. Waddell as to my father's reputation. I have stated what I believe to be the facts as to their comparative positions in the engineering world, and even allowing for the unconscious exaggeration of bias, if any there be, I think most readers will agree with my statement that the two gentlemen ought not to be spoken of in the same breath.

My father is, of course, not infallible, and it would not be surprising if, in the course of his 50 years and more of professional career, he should have made a few mistakes and miscalculations (though I do not know of any such). But that he is incompetent to design a 100 feet span iron girder bridge, which shall not show such "glaring defects" that an ordinary engineer would condemn it without even properly examining it, is "altogether quite too exquisitely and supremely" ridiculous. And however persistently—however emphatically—Mr. Waddell may re-iterate his charges, the accusation will always continue to bear on its face its own refutation.

Yours truly, G. H. POLE.

23, Concession, Osaka, 22nd September, 1885.

(*October 8th, 1885.*)

SIR,—The accompanying paragraph, clipped from the columns of "interviews" in the issue of August 21st of the *New York Semi-Weekly Tribune*, may be of some interest to readers of the discussion lately carried on in the *Mail*, under the above caption:—

Ex-Minister Osborn, who has just returned from Brazil, gave me the other day an important piece of information affecting American inventors. We were discussing the trade between the United States and Brazil when he said:—"Our principal export to Brazil is flour. But they take our manufactured products also to a considerable extent. Iron bridges are a large item. They can buy iron cheaper in England, but they regard American engineering as superior. The iron bridges made here are lighter in weight which makes up the difference in price, and fully as serviceable, besides having superior construction. I regard that as one of the triumphs of protective tariff, that the genius of our inventors is stimulated so that we compete with the world with the advantage on our side. What is true of iron bridges is true of locomotives. The American locomotives are constructed so that they have room for play on the wheels required on new and necessarily uneven road-beds. The English locomotives are built for the old and solid road-beds that course the British Isles. They are not adapted to new roads at all; so ours have the preference. They have been obliged in England to pattern their engines after ours, in order to find foreign sale, as we were taking their trade in Australia and other colonies. That speaks well for inventive genius in America."

I am, Sir, yours, &c., AN AMERICAN.

Tôkyô, October 5th, 1885.

(October 9th, 1885.)

SIR,—It seems almost superfluous to point out the weakness of Mr. Pole's letter. It is not an argument, but a pathetic appeal to the public to respect the reputation of his father. No one but an over-sensitive son would have supposed this latter to be necessary. The time has gone by, however, when important questions in science can be settled by a mere appeal to authorities. The issue is not whether Dr. Pole's reputation as an engineer is greater than mine, but whether the "glaring defects" of design which I have pointed out in the Japanese bridges really exist. It is not a question of who "is *likely* to be correct," but who *is* correct. This is a matter to be settled by solid scientific reasoning alone. The facts and principles involved I have gone into at length in my book. Even had I known of Dr. Pole's close connection with Japanese bridges, I could not, on the merits of the case, have written other than I did.

Into these merits of the case not one of the writers of the letters in the *Mail*, attacking my book, has dared to enter. An open scientific discussion is apparently the very last thing which my opponents desire. They know that it would make patent to the world the radical deficiences of the old English system of bridge building. As for your correspondent's threat—is it not rather a gross imputation on his father's honour? Dr. Pole's standing, as an engineer and a gentleman, would render it impossible for him to stoop to such an act of injustice and spite.

Yours respectfully, J. A. L. WADDELL.

Tôkyô. October 7th, 1885.

[Surely this discussion has continued long enough. We have published a number of letters—so many that our readers must be quite weary of the subject—and yet, as Mr. Waddell says, the point at issue is as far as ever from a settlement.—ED. *J.M.*]

(October 9th, 1885.)

SIR,—It is pleasant to find that Mr. Waddell is not going to have all his own way, and walk over the course alone.

I would have addressed you earlier on this subject, but the matter was so confined to technicalities that I thought the general public would not care about any more of it, and I shall endeavour to dispense with them as far as possible, avoiding useless twaddle.

My experiences in Iron Bridge building date back to the "Britannia tube." The "Conway" had already been tried as a test or confirmation of the designer's ideas, with perfect success.

There can hardly be said to be any system of *English* or *American* bridge designs as such. Before building the Saltash Bridge, Brunel gave great attention to the subject, and his ideas have not been much improved upon to date in any country.

All the bridges (iron) in the world of any size could be counted on the fingers in the year 1849, and, taking the life of an ordinary bridge at 300 years, it is too early to form opinions as to stability, &c., when but very few have been erected in 50 years.

England, until quite recently, had but very few bridges of size; indeed, there are no rivers to bridge over, save tidal ones with cheap water carriage and easy foundations—but there are some fine viaducts with no foundations to speak of.

It is a manifest absurdity to compare bridges designed and constructed in England or designed for construction abroad—in Egypt, India, the Colonies, &c., with bridges designed for construction in the States and American Republics generally. For the following reasons: First, all railway bridges erected in the British Islands have to be under state supervision and come up to a certain standard of strength. As a rule transit is cheap, as well as skilled labour, whilst timber is dear. Experience shows that the most suitable superstructure as well as the most economical, is some form of "girder" according to span, plain, lattice, bow, chord, inverted, or direct suspended, &c., weight of material being generally taken to stand the lateral pressure of the moderate gales of the home latitude, whilst special provision is made in the case of tropical climates. Secondly, bridges designed in England for erection abroad are made to be put together by unskilled labourers, who frequently cannot count more than five without the use of both hands—and not one in a hundred has any conception of numbers above twenty. None can either read or write. Hence the necessity for some simple form that will stand rough usage and can be launched over the piers from the banks without any scaffolding, &c. "Girders" again, are dragged to the spot by mere strength. Some of the best railway bridges in India, and largest in the world at the time, were so placed in position. Thirdly, in the States and Canada there is no such thing as unskilled labour—every man can read, write, and count even up to a thousand without using his fingers; use an axe, saw, hammer, &c.; and hence greater liberties can be taken over design than can be allowed where the superstructure has to be put in position by men who never saw a piece of iron larger than a plough point, which they carry in their hand, and make a new plough every time they have occasion for one.

After all the superstructure of an iron railway bridge is of comparatively little moment; it is the foundations first, and piers after, that are of most importance. With these the designer has but little to do, and the local engineer everything; he has to watch day and night and carefully surmount every fresh difficulty as it arises—most frequently without much regard to original designs, provided that he keeps his span distances correct.

As a rule the original designer of an iron bridge seldom sees the creation of his brain after it is in place—and it is but seldom that he takes note of circumstances that may occur once in the world's history, such as the cyclone in Calcutta in 1864, when the "bore" came up with a tidal wave. The cost of any erection by way of bridge that *might* stand such a shock would be so great as to render the work impossible.

On the other hand, I will give an instance of a stone bridge designed to withstand extraordinary pressure.

Somewhere about the time that King John had to sign the Charter, an Eastern potentate—Babu, or "one of that crowd," gave an order to his engineer to built him a bridge at Jaunpore to stand well, and I presume as he had no intention of paying himself for the work, he did not go into the question of dollars or their prototype. The bridge was built, and it is to be presumed gave satisfaction, for it carried me safe over, a few years ago. Mark the foresight of the old engineer: he found out that the river, every hundred years or so, overflowed its bank to an enormous extent—and must have calculated that the cost of building a bridge above flood level would be more than his patron cared to squeeze for a mere bridge at least: so he made his piers and arches strong enough to allow the flood to pass through and *over* the bridge. I now come to the modern engineer. He designed his bridge and out it came, and looked so nice—until one fine day shortly after its completion, the "hundred years or so" run out, and down came the flood over the old Mogul's Bridge, and away went railway, foundations, piers, girders, and all.

When the flood had partially subsided I was asked to attend the survey, and we found the old stone bridge perfectly intact, only the metal and part of the parapet washed in heaps, but the bridge was good to stand another 1,000 years. Of the iron bridge we had some difficulty in finding enough to hold a survey upon.

The Japanese engineers are no fools, and do not need to be taught what kind of superstructure suits their own climate; and instead of picking holes in their work it would be to say the least more charitable on Mr. Waddell's part to correct their faults, if they have committed any, a little more gently, giving credit where credit is due.

I am, Sir, yours truly, T. R. GREEN.

No. 40, Yokohama, October 7th, 1885.

P.S.—If you think another letter on bridge *experiences* would interest your readers, I shall be glad to send one without reference to "Railways in Japan."

T.R.G.

(*November 9th, 1885.*)

We found ourselves wading chin deep in an iron-bridge controversy the other day, but dry land could never be discerned while the danger of being swamped by correspondence grew momentarily imminent. A Civil Engineer, Mr. Benjamin Baker, has been reading a paper on this subject before the British Association, in the Section of Mechanics, and we turn to his demonstrations with a feeling of relief that somebody is capable of discussing the behaviour of iron beams and girders without drifting into personalities. The *Spectator* says of Mr. Baker's essay :—" He showed, as the result of careful and long-continued experiment, that the power of an iron bar to bear weight is no test of its strength to endure weight in motion. It dislikes above all things intermittent weight. When five-minute trains are run over girders they can hardly be made strong enough, and even slow and unfrequent movement wears out the resisting power. The usual theory is that a bridge is safe if it can bear three times the heaviest weight ever placed upon it ; but this is by no means the case if the weights move, and such a bridge would break down rapidly under the passing of twenty trains an hour. Many English bridges are unsafe, from this cause or from defective construction ; and Mr. Baker added on the latter point a suggestion which would delight a Hindoo. American ironfounders, he said, adopted a type of bridge or other work and adhered to it, instead of trying all sorts ; and it was found that, from practice and the observation of faults, their bridges grew better and better. That is what the Hindoo workman has been saying for two thousand years or so, without getting much attention."

(*November 17th, 1885.*)

SIR,—I am very much dissatisfied with the discussions on " Iron Railroad Bridges for Japan," and, as I do not wish the Japanese to have a false idea of the real value of what has been written, I consider it necessary now to express my opinion about it.

As far as I know, most of the opponents are not civil engineers, and not capable of understanding the merits of the controversy. Consequently, they seem to have looked only at the introductory part of Mr. Waddell's work. Yet they undertake to criticize the work !

Some of them believe that a young man ought not to have liberty to discuss the work of an elder, and say that Mr. Waddell, a comparatively young engineer, has not ability enough to criticize the work of engineers much older than himself, and one of whom has obtained a wide reputation in engineering. Of course, no one will deny that old men must be respected; nevertheless, a young man ought to have liberty to criticize the work of the old, especially when we remember that a man is supposed to know much more than his grandfather did; and by this way only the modern sciences are to be advanced. If there be really any faults of design in the Japanese railroad bridges pointed out by Mr. Waddell, he ought to be entitled to say so, more especially as he tells us how to build bridges that have no such faults.

In the *Engineering and Mining Journal*, I read, a few days ago, the following in regard to the adoption in England of an American process of smelting lead, and this has some relation to the matter. "This is another recognition of the fact, which is becoming more and more generally known, that in practical metallurgy, as well as in many other branches of engineering, this country is leading the old world. The high prices of labour and supplies, and the intelligence and practical genius of our people, have made them quick to test and to adopt improvements for effecting economies, and our superiority is due to a total disbelief in the worship of precedent, which paralyzes in a measure the progressive instinct among European engineers, and makes it difficult to secure the introduction of improvements there."

It seems to me that Mr. Waddell's critics are Englishmen, as is natural, because his book attacks the English system of bridge designing. The American system of bridge designing and the English system are totally different, and any one who has read the book through must see that either Mr. Waddell's system is right, and that the English is entirely wrong, or *vice versâ*. Of course, the Americans will say that theirs is right, so we cannot accept the last letter by an American which you published, except as a biassed opinion. To decide the matter impartially, we must find out the opinion held by the best English engineers, and I will now quote the following from the Presidential address of Mr. Benjamin Baker, who was elected as president of the Mechanical Section of the British Association. He is, in fact, the highest English authority on bridges. He writes thus: "It is an open secret that nearly all the large railway companies are strengthening their bridges, and necessarily so, for I could cite cases where the working stress on the iron has exceeded by 250 per cent. that considered admissible by leading American and German bridge-builders in similar structures. In the case of old bridges the variance in strength is often partly due to errors in hypothesis and miscalculation of stresses. In the present day engineers of all countries are in accord as to the principles of estimating the magnitude, but not so in proportioning the members, to resist those stresses. The practical result is that a bridge which would be passed by the English Board of Trade would require to be strengthened five per cent. in some parts, and sixty per cent. in others before it would be accepted by the German Government, or by any of the leading railway companies in America."

Further on he says:—

"In one respect the practice in America tends to the production of better and cheaper bridges than does our own practice, and it is this:—

Each of the great bridge-building firms adopts by preference a particular type of design, and the works are laid out to produce bridges of this kind. It is an adage that practice makes perfect, and by adhering to one type, and not vaguely wandering over the whole field of design, details are perfected, and a really good bridge is the result. Engineers in America, therefore, need only specify the span of their bridge, and the rolling load to be provided for, with certain limiting stresses, and they can make sure of obtaining a number of tenders from different makers of bridges, varying somewhat in design, but complying with all the requirements. With us, on the other hand, it is too often the privilege of a pupil to try his 'prentice hand on the design for a bridge, and it is no wonder therefore that many curious bits of detail meet the eye of an observant foreigner inspecting our railways."

Further on he says, in speaking of suspension bridges of steel :—

"In this, as in many other engineering matters, Americans have given us a lead. America is, indeed, the paradise of mechanics."

Now Mr. Waddell has said nothing more than this, in his address to us Japanese Engineers, and the part of it which seems to have given most offence to his opponents is this :—"The trouble with most English bridges, and consequently with those of this country, is that they are designed by railroad engineers who have not made a special study of bridge designing, and are therefore incompetent to do the work entrusted to them."

Now, I cannot see why this should be objected to, any more than what Mr. Baker says about "the privilege of a pupil to try his 'prentice hand on the design for a bridge." What Mr. B. Baker says confirms Mr. Waddell's criticisms of the Japanese railroad bridges.

Knowing the design of our bridges to be wrong, is it not our duty to construct no more such bridges, but to build them according to the scientific method which Mr. Waddell teaches us?

I am very sorry to hear that somebody has questioned Mr. Waddell's motives in writing his book, and has attributed to him pecuniary motives.

For my part, I feel sure that Mr. Waddell's object in writing it is to benefit the civil engineering profession in our country, and I think it would be unjust for any of us to doubt his good faith.

Yours very truly,

A JAPANESE ENGINEER.

Tôkyô, November 13th, 1885.

(January 26th, 1886.)

SIR,—I thank you very much for your kindness in publishing some time ago my opinion on "Iron Railroad Bridges for Japan." Many Japanese engineers have been very much interested in the discussions on our bridges. They say that it would be of great benefit to our country if the subject were discussed technically, omitting personalities. By this way, not only should we obtain information as to the better kind of bridges, but also would be enabled to procure more economical structures. As the extension of the railway is going on rapidly throughout the country, the total saving of expenditure by the adoption of the better bridges will be considerable.

In one of his letters, Mr. Waddell said that, if desired, he would be willing to express his opinion how to correct the defects of our railway bridges. But as no one has made this request, I now ask Mr. Waddell whether he will have the kindness to give us his opinion.

My last letter was written in order to show your readers what is the opinion of an eminent English engineer: this one will give the opinion of an eminent German engineer, Mr. Charles Bender, who published lately a treatise on "Principles of Economy in the Design of Metallic Bridges."

In the preface he says:—"The system of competitive design, combined with competition prices, has produced in the United States the most economical and the most serviceable form of a single-span bridge. But there are other forms, such as arches, cantilever-trusses and arches, and for the greatest spans, stiffened-wire suspension-bridges, of which the merits and proper proportions are less generally known, and outside of the United States the question as to the most economical form of truss is not yet everywhere settled."

In the fifth chapter he says:—"The strains calculated under the supposition that plate-girders are homogeneous beams, or that the joint-points of skeleton-structures are mathematical hinges, are termed primary strains.

Those strains which arise from the fact that the joints are more or less rigid, or which are caused by the gravity-lines of the members of a structure not meeting in the mathematical joint-points, are termed secondary strains.

These strains are caused by flexures of the members which in the calculation of the primary strains were supposed to remain straight lines.

These moments of flexure may not amount to any considerable percentage of the moments of flexure of the whole structure, and yet they may cause considerable additional local strains.

The correct intersection of gravity-lines of the members can be secured, and this principle should not be neglected in the lateral and transverse wind-bracing or in the attachment of the floor beams.

The secondary strains arising from rigid connections are unavoidable, and the question arises how great they may be, how they can be diminished, and how they must be provided for."

* * * * * * * * * * *

"We cannot enter into the subject, but we shall state the principles of the theory of secondary strains:—

The more nearly the structure is designed to contain the minimum volume of material, or, what is the same thing, the less the sum of deflections of its joint-points, the smaller the secondary strains must be.

Hence the good rule to use the greatest practicable depth of truss."

* * * * * * * *

"The longer the distance between connecting points the smaller the secondary strains will be.

Hence the good rule to use long panels and not to shorten artificially the members by inter-riveting the web-members where they cross each other.

The more nearly the tensile members are made to resemble mere flexible strings the more easily can they be bent without great strains; the less, therefore, the flexures of the compression-members will be. The flexures of these members are desired to be as small as possible, because they have great moments of inertia or are very stiff, and hence would receive great strains. And since these members must be safe against crippling, flexures would be more dangerous to them than to tensional members. The narrowness of ties, however, has a certain limit below which their own secondary strains again increase.

The practice of using eye-bars is advantageous as regards reduction of secondary strains, also because at the joints eye-bars are stronger against flexure than in their shanks, and much more so than broad, thin riveted ties. Eye-bars are attached in their gravity-lines, whilst this is not the case with the angles serving as diagonals of lattice-bridges.

It is good practice to build the end-posts and compression chords of trusses as continuous unhinged members, for otherwise the pins will receive not inconsiderable torsional moments causing additional strains, and because nothing is gained by hinging those members together. The pins, when the bridge is once freed from the false-works, do not admit of rotation, because the secondary moments in a properly designed structure are not strong enough to overcome friction.

The secondary strains of pin-jointed structures arise only from movable loads.

Also, a part of the secondary strains of riveted structures may be assumed to have vanished by the settling of the structures during the removal of the false-works or under the test-loads. But if the rivets are very numerous and are well driven at the joints of such structures, the head friction may be sufficient to keep the joints rigid.

The author calculated the secondary strains of a 100-foot Whipple truss, 20 feet deep, with panels 20 feet long. The maximum secondary strain was 8 per cent. of the admissible pressure of the top-chords near the centre. These members could easily have been reinforced by using sufficiently long and strong joint-plates. The secondary strains of the eye-bars were quite insignificant.

The secondary strains of riveted structures were calculated to be much greater. For triangular girders 32 to 100 per cent., for quadrangular 10 to 24 per cent. in the top-chords were found.

Of a triangular, all pin-jointed girder, of which the tensile members are built of broad flats with eyes riveted thereto, secondary strains up to 66 and even 172 per cent. were calculated at some points. This bridge of 118 feet span consists of 9 panels, it is 12.5 feet deep, and was built in South Germany."

* * * * * * * *

"On the contrary, deep, long-panel, pin-jointed structures with eye-bars as tensional members are almost entirely free from secondary strains. They are the best and the most economical structures, provided that the principle of central intersection of gravity-lines is not only applied to the main girders, but also to the lateral and transverse bracing, and to the attachment of the floor. Without this condition being fulfilled, or, at least, duly considered, they lack more or less the lateral stiffness required."

I have quoted nearly all Chapter V., as the subject of secondary strains has almost hitherto received no attention. As Mr. Bender says, in the Whipple truss the secondary strains are small and easily provided for. For this reason, secondary strains are not probably mentioned in "A System of Iron Railroad Bridges for Japan." However, in the introductory chapter, something is related in a quotation from Mr. Boller, the conclusion being as follows:—

"The riveted system has of necessity so many imperfections of design, of workmanship, and material, in contrast with the above [pin-connected], that, to obtain anything approaching equal strength on the same specification, it should only be used with a higher factor of safety. It is probable that this difference is not less than 20 per cent.; so that when a pin bridge is called for, having a factor of five, a riveted bridge cannot be considered as approaching the same strength unless it is proportioned with a factor of six. The fact that a riveted bridge is stiff or that its deflections may be small under a test, is no evidence of strength, which last depends upon other considerations than those applying to stiffness."

The bridge described by Mr. Bender built in South Germany is similar to our 100 foot girders. Its span is, however, 118 feet, the depth of the girders is a little greater than that of ours, and the number of panels is 9. Mr. Bender found out the secondary strains of this bridge to be 66 and sometimes 172 per cent, of the primary strains. Certainly the secondary strains of our bridges would be much greater. As the existence of these secondary strains was never taken into account, the failure of these bridges is merely a question of time, though they stand now on account of the use of the factor of safety.

On pages 39 and 40, Mr. Bender states: "Only very lately in Germany an approach was made to the Whipple truss with inclined end-posts, and in fact outside of the United States the perfection of this most serviceable, and very economical truss, which can be adapted to by far the greatest number of different localities, even yet is not sufficiently appreciated.

"We shall see that the Whipple truss presents almost the maximum attainable economy of the varions types of single-span-truss. For small openings, up to about 150 feet, the Pratt truss, but with Whipple's inclined end-posts, diagonals intersecting only one panel, seems to be the most appropriate structure."

According to the investigation of Mr. Waddell, the economic limit of length of the Pratt system for the single track bridges is 170 or 180, and probably ten or twenty feet less for double track bridges; above these spans, the Whipple system would be advantageous. Thus the two authors' conclusions are not much different.

On page 55, Mr. Bender states: "None of these forms is of pronounced practical value. It is, however, good that they were once thoroughly examined, and that we now know that greater economy than is offered by the Whipple truss can hardly be obtained.

"We have seen that the principle which the late Professor Culmann, the originator of graphical statics, has already pronounced in the first edition of his work, namely, that equidistant chords lead to the greatest economy, is almost absolutely true.

"And, having arrived at this result, it will be well not to continue to devote so much valuable time to special investigations of those and similar forms.

"Let bridge-engineers and students rather direct their attention to subjects new and of greater usefulness. Of such subjects, as in all branches of engineering, there is an ever increasing abundance."

This agrees quite well with Mr. Waddell.

On page 165, Mr. Bender states :—

"The task of the bridge-builder should not be considered ended when he has given the necessary vertical strength and stiffness to a structure. On the contrary, his problem is then only half solved. A bridge of which the vertical trusses are simplified at the expense of the scientific attachment of the floor, or by introducing eccentric and loose lateral and oblique or transverse bracing, is a more or less dangerous piece of work.

It is at the points of lateral connections where strains, arising from the rigid connections of the posts with the floor-bearers, and secondary strains arising from eccentric attachments of wind-members, are met with. These may cause moments of torsion as well as of flexure. Besides, the wind diagonals participate in the annihilation of chord strains, and their assistance may be considered in spans of some considerable length."

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"As regards the maximum wind pressures to be specified, it may be remarked that, though the frequency of hurricanes depends on the nature of the country in which a structure is located, nevertheless storms of the greatest severity in the course of time may be expected anywhere; and unless a structure is specially protected, either by mountains or by buildings, or because its axis runs in the direction of the most dangerous storms, it must be designed to meet the strongest hurricanes."

These few remarks of Mr. Bender are in confirmation of the statement made by Mr. Waddell in regard to the absolute lack of lateral bracing in our railway bridges. I am very sorry to say that the discussions have been carried solely by reference to authorities and without original contributions to our knowledge of the subject. But this cannot be avoided.

We can easily judge the value of the memoir by the favourable reviews that appeared in the technical papers, and we thank Mr. Waddell very much for the trouble of writing such a valuable treatise.

With respect, I remain Sir, yours faithfully,

A JAPANESE ENGINEER.

Tôkyô, January 22nd, 1886.

(January 7th, 1886.)

SIR,—I beg to add my contribution to the discussion of the above question in your pages.

I am an Englishman and have never been in America. I do not know any American engineers. I have seen only one bridge of American construction, and that a small one. My professional training has been under English engineers, and any bias that exists in my mind is naturally in favour of English ways of doing things. Nevertheless, I am convinced that American bridges are far in advance of the usual English type of shallow lattice girder.

I have been led to this conclusion first, by mathematical investigation; second, by numerous experiments upon models of card board, wood, or iron, which I have tested and broken down.

My first objection to the English type of bridge, of which we have many examples in Australia and particularly in New South Wales, is that the main girders are too shallow. Our bridges are usually 150 feet span in the clear, and the main girders are only 12 feet deep in the older bridges and 15 feet in those erected during the last two years. Comparing one of our main girders 12 feet deep with one of American type 22 feet deep, I find that, with each part made the exact theoretical size under British Board of Trade Rules, the American girder will contain less iron than the English in the ratio of 63 to 100, or 37 per cent. of saving in material.

Secondly, in the English bridges as we have them in Australia, there is a large excess of material over what is required by calculation in certain parts. Did this excess obtain throughout the whole girder it would simply mean a stronger bridge. But this is not so; excess occurs in certain parts only, while the rest is only the theoretical size. This element of waste is seen in the huge and unscientific "end boxes" which are so common on English lattice girders, and also is the minor diagonals of closely latticed girders which for practical reasons have to be made much stouter than calculation requires. In American bridges the metal is concentrated in a smaller number of bars of massive section and which can be designed much more closely in accordance with the requirements of the theory. Thus not only are American girders theoretically more economical, but the practical excess of material above what theory requires is much less than in the other form.

Thirdly, the upper chord of a girder, being in compression, tends to bend sideways, and so evade its duty, especially if it be comparatively long and narrow. This tendency was very apparent in my experimental models. It is met and most effectively provided for in American deep girders by a system of horizontal bracing binding the two top chords together into a most efficient horizontal truss. Unfortunately all our English girders are so shallow that the funnel of the locomotive rises some feet above the top of the girder. Hence this most vital bracing is either omitted altogether, or is carried out in a costly and imperfect way consisting of a series of complicated arches rising above the engine funnel.

Our bridges stand. I cannot deny that; but all my actual experiments lead me to look upon them with more or less misgiving as by no means possessing that margin of strength against hurricanes and other contingencies which is desirable. A bridge ought to be laterally braced against wind and vibration at rail level and also at the top chord, as the American bridges are. Ours unfortunately can hardly be said to be braced at all at the top chord, while at rail level many of them are so weakly braced as not to calculate out properly for 10lbs. per square foot wind pressure—while American bridges by good makers are always made safe at 30lbs.

Again, as to intensity of stress; good American bridges never go above

5 tons per square inch in tension or 4½ tons in shearing—while in some of the Australian bridges the bottom chords are exposed continually to 7 tons per square inch in tension, and the rivets to the same in shear. Finally, in English bridges, or bridges designed locally by English engineers I have frequently found gross errors, arguing either great carelessness or lamentable ignorance. Some of these errors were even so serious that when pointed out they led to the alteration or condemnation of the structure. Some of them are referred to in the pamphlet I forward. Others will be found mentioned in the engineering journals (in *Engineering* 6th June, 1884, 10th October, 1884, and *Engineer* 5th June, 1885). Though I have looked through very many published plates of American Bridges, I have never found any such errors as those referred to, but, on the contrary, have been uniformly struck with the intelligence and skill displayed by the designer.

Yours, &c.,

W. C. Kernot, M.A.,
Professor of Engineering.

University of Melbourne, 2nd December, 1885.

(*February 1st, 1886.*)

Sir,—The following, taken from a late number of the *Engineering News*, of New York, may not be out of place after the very interesting, but rather heated, discussion, on the relative merits of the British and American systems of bridge building which has lately attracted the attention of your readers :—

American Bridges in English Colonies.

The last number of *The Engineer* (London) contains the following :—" An English engineer, well known in railway circles, says that American bridge builders are, for bridges of all ordinary sizes, completely cutting the English builders out of the market for Canada and other colonies, and that this is chiefly due to the baneful effects of the Board of Trade rules, which, instead of improving, have caused the depreciation of our bridges, by the use of the common materials which will stand only four or five tons tensile or compressive strains."

It is possible that our contemporary has just learned that our bridge building firms are cutting English builders out of colonial markets not only for bridges of all "ordinary sizes" but many of extraordinary sizes. They have only themselves to thank for their Board of Trade rules. The past great cheapness of their raw material has enabled them to substitute weight of metal for the scientific adaptation of sizes and shapes in use with us ; for a long time their products found sale under the name of British solidity of construction. But now that pig-iron, Bessemer rails, and refined iron in bars are only $4 to $5 per ton, and common iron only $5 to $6 cheaper in England than here, and they are met with such statements as those lately made by Baker, that members of some English bridges would require strengthening to the amount of 60 to 160 per cent. before being up to American standards, there is no doubt about the cutting of their trade.

The editor of the *Engineer* should not have allowed the implication contained in the sentence "for bridges of all ordinary sizes" to have appeared; for as long ago as the building of the Inter-colonial Railway, Clarke, Reeves & Co. got all he long and ordinary spans, the English builders securing only girders and str ictures not requiring trussing.

Very truly yours, AN AMERICAN.

Yokohama, January 30th, 1886.

(*February 5th 1886.*)

SIR,—Professor Kernot's letter on "American versus English Bridges," which appeared in your issue of January 17th, throws considerable light upon the subject. In a personal letter to me, received a week or ten days ago, he treats the same topic, entering much more into detail. As a great portion of its contents will be of interest to many of your readers, and will clear up in the minds of the Japanese any lingering doubts which they may have concerning the superiority of the American over the English method of bridge designing, and as Professor Kernot has kindly given me permission to use his letter as I may see fit, I quote therefrom the following :—

"These [referring to copies of the *Japan Mail*] I have read with great interest, as I find you are engaged in a struggle very similar to one that I have been carrying on for some years, and are experiencing the same kind of unfair and unsatisfactory opposition.

"Fighting is unavoidable in this present world; but if we fight, let us fight fair. There is very little satisfaction in a contest carried on with a man who will not abide by the rules of the game. What has irritated me beyond measure is the way in which my opponents play fast and loose with scientific investigation. They are exceedingly glad to bolster up their opinions with a mathematical formula, but let that formula be used against them and at once it is 'mere theory.'

"About three years ago a tall iron viaduct for road purposes was constructed from a design prepared by two of my pupils. This structure was placed in a very sheltered spot. Its overturning wind pressure was about ninety pounds per square foot, of which sixty pounds were due to direct stability and the rest due to the friction of the cylinders in the ground and other collateral sources of resistance.

"A comparatively trifling failure took place in the masonry abutments, and a public scare arose. Mr. W. H. Greene, the engineer of existing railways, a gentleman of great experience and receiving £1,200 per annum from Government, was called in to report. He first of all proposed a fearfully costly reconstruction of the abutments, and then proceeded to discuss the lateral stability of the iron piers, &c.

"He calculated that they would resist fifty-six pounds wind pressure, and thereupon *condemned them as dangerous.*

"I protested publicly, and so did my pupils, pointing out that our railway rolling stock has less than half the resistance to wind than the bridge and has never suffered though constantly running in infinitely more exposed positions. I also pointed out, and you in your book [The Designing of Ordinary Iron Highway Bridges] do the same, that the overturning of a road bridge by wind would be a far less serious affair than the destruction of a railway train—but without avail. He simply ignored us and insisted on the alteration.

"The local body interested then called in an elderly engineer, who had for many years been chief engineer of roads and bridges to the colony of Victoria. He, in a most vaguely worded report, carefully avoided all calculation, but insisted on the bridge being strengthened.

"I then proposed to have large models made of our bridge and of one of the railway bridges and tested, and offered to pay all expenses if ours, slight as it looked, did not exceed in lateral resistance Mr. Greene's more massive structures. But it was no use—there was no reply.

"Mr. Rowand (the second authority) then set to work to alter and strengthen (?) our bridge. He took a year to think over his plans and then set to work. The result was simply amazing.

"He spent hundreds of pounds in propping up the piers, and, when the abutments had failed, he introduced new spans. These were so horribly designed that, though most expensive to construct, they were only half as strong in respect to carrying loads as the original structure. This was due to a local weakness in one vital bar. I pointed it out in a letter to the local council, and they sent my letter on to Mr. Rowand. He denied the weakness, and said that I was a theorist and unworthy of credence.

"I at once publicly offered to make a bridge fifty per cent. stronger than his with the same iron and no more work, and proposed to have models made one-fourth full size and tested to destruction, and offered to pay all expenses if I failed to beat him by fifty per cent., provided he paid if I did. As usual, he preserved a discreet silence.

"I, however, referred the question to the Editor of *Engineering* and he (see *Engineering* 10/10/'84, p. 335) of course decided in my favour. I took care that this decision was made public, and Rowand had not a word to say.

"I omitted to state that the masonry that failed in the first instance was executed in the face of a written protest from the original designers.

"Now this is just a sample of the way in which I am constantly coming into collision with the leading engineers of this and the adjoining colonies. I find their work to present serious weaknesses, and I point them out. They never attempt to meet me fairly—they never criticize my calculations in detail or attempt to show a flaw in my reasoning—they simply call me a theorist, and when I challenge them to a public test of large-sized models they have nothing to say.

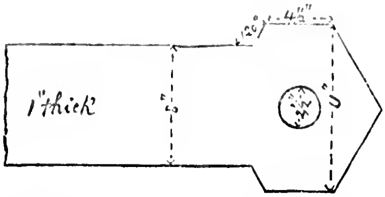
"Heaven knows I don't want to quarrel with these gentlemen. I can admit their great experience, and can appreciate their administrative skill, but when they produce the most absurd designs—when they load ordinary iron with a tension of over ten tons per square inch and risk people's lives upon it, I am bound to protest.

"As an extraordinary example of ignorance in a slightly different direction take this specification of iron. 'The whole of the wrought iron used shall be of good quality capable of bearing compression equal to sixteen tons per square inch, or a tensile strain of twenty tons per square inch without decreasing or increasing more than one 625th part of its length.' Now, will you believe that an iron viaduct costing for ironwork more than £70,000 has just been completed near Melbourne under the above specification?"

So far, from Professor Kernot's letter, and before going farther it will be well for me to make a few remarks for the benefit of your non-professional readers. First, as to Mr. Greene's condemnation of the bridge because a wind pressure of fifty-six pounds per square foot would overturn it, if not anchored to the piers, I would state that braced piers in America are proportioned for a wind pressure of thirty pounds per square foot when loaded with light box cars, and forty pounds when not loaded, the condition being stipulated that neither of these pressures produce tension in the windward posts of the piers; so, according to American practice, the structure condemned had a surplus of strength.

Next as to the specifications; if any one interested will consult my "Highway Bridges," pp. 25 and 26, or the Memoir, pp. 79 and 80, he will see what elaborate tests of materials are required by American engineers, and how crude and inadequate are those just quoted.

But to return to Professor Kernot's letter—he says—"Now what do you think of this for an eye-bar?



There are hundreds of them in one of our largest structures, and each has to endure a working stress of forty tons. At what distance would your typical American engineer condemn it—100 yards or 100 miles?

"The only conclusion that I can come to is this, that our leading engineers don't grasp the first principles of bridge designing, and that they are ashamed to own their ignorance. They get on tolerably well when following precedent, when copying existing structures, but fail utterly as soon as they attempt anything original.

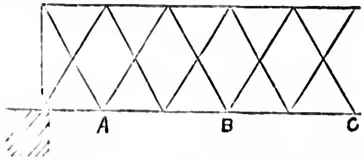
"Some time since I caused much stir by making some experiments on iron models and publishing the results. I send several copies of the pamphlet, and the only thing that will astonish you will be that such absurd designs as some that I experimented on should ever have been made. It seems almost beyond belief, but is nevertheless strictly and absolutely true, that Design A (see pamphlet) was worked out with most extreme care and deliberation by three of the most experienced and highly paid engineers in Australia, and yet by a most simple modification I gained nearly four-fold strength with less material and far less workmanship, as in Case B.

"Model C represents one of many hundreds of girders made to the design of Mr. Brunlees, who not long ago was President of the Institution of Civil Engineers in London.

"It is horribly bad.

"Three girders of type C are used in each span—they contain nearly the same iron as two of type G (designed by two of my pupils) and realize less than one third as much strength. * * * * *

"We have near Melbourne two bridges arranged as below:—



with cross girders at A B C only, so that one set of diagonals has to carry all the load, and the other, though equally massive, has nothing to do.

"In New South Wales there are a great many road and railway bridges of 120 to 150 feet span, and all of the type you object to. The road is on the bottom chord, and the top chord is either altogether unbraced or is braced (?) with a complicated arch at each end and at the middle. The top chord is made of the same section as the bottom chord, and its length is usually about sixty times its extreme width."

Before quoting any more from Professor Kernot's letter a few remarks from me will not be out of place.

The eye-bar illustrated is without exception the worst that I have ever seen: it excels in stupidity of design even those in the Japanese railroad bridges. The compressive stress per square inch at the eye is found by the proportion.

$$2\tfrac{1}{2} : 8 : : 5 : x$$

to be sixteen tons, almost three times as much is allowed in American practice.

A section through the c[...] the eye shows an increase of area of about six per cent. ab[...] the bar, while according to experiments made in America it [...]e about fifty per cent.

If we assume that [...]e but one pair of bars at each end of the pin—the most favourable assumption—the bending moment on the pin will be forty inch-tons, which will produce a stress of about 58,400 pounds per square inch on the outer fibres—nearly the ultimate strength of the iron.

In daring to criticize the work of the Past-President of the Institution of Civil Engineers, Professor Kernot shows that he has even less reverence for so-called high engineering authority than I had, when I unwittingly condemned the faulty designs of the eminent Dr. Pole.

For unparallelled ignorance and stupidity on the part of the designer the triangular truss illustrated bears off the palm. It is almost incredible that any man with common sense could put in a whole system of triangulation, when it is impossible for it to do any work whatsoever.

As for the arches to connect opposite top chords, they are almost useless for adding either strengtn or rigidity to the structure.

Professor Kernot continues:—"Thus you see we have examples of almost every possible error in bridge designing, and all in bridges designed by most eminent and experienced men, members of the Institution of Civil Engineers, etc.

"My great trouble is that these bridges *don't tumble down*—so long as they stand I have the greatest difficulty in getting people to believe me;—'you unreasonable man, can't you see that the bridges stand; what more do you want.' And the way they stand is most wonderful.

"We have bridges for foot passengers and road traffic in which a dense crowd would load the iron in vital parts to fifteen tons per square inch; and they have stood for many years. To account for their not falling down has been my greatest difficulty. I think, however, that the following considerations explain it.

"1.—They are never loaded with anything approaching their full load. This is especially true of road bridges. A bridge of 150 feet span, twenty feet wide, *might* be loaded with one hundred tons weight, were a dense crowd to assemble upon in; but, as a matter of fact, the chances are that it will never have more than ten or at most twenty tons on it at once. The big load is perfectly possible, but in the highest degree improbable, especially in localities where there is but little population.

"2.—Though five tons per square inch is no doubt a judicious limit to the stress imposed on the material, it is nevertheless a fact that fairly good metal will stand many hundreds or perhaps thousands of repetitions of a stress of ten tons per square inch before failing.

"Thus you see the bridges may stand for many years, and yet may fall at any moment.

* * * * * * * * *

"The facts are very plain to see. With very few exceptions all our leading engineers are men who have never really mastered the first principles of statics. They were educated forty years ago, and their education comprised no real mathematical training. They design their structures partly by copying existing works and partly by guess-work. Owing to a favourable combination of circumstances they have escaped disaster. The margin allowed under ordinary rules to cover imperfections of materials and workmanship has in reality served to cover errors of design; and the heavy loads ostensibly provided for have rarely, if ever, come upon the bridges.

"For a younger man, a so-called theorist, to rise up and accuse them of incompetency is very rough indeed, and they find a ready escape by crying 'experience,' 'the bridges stand, and that proves they are right.' The non-mathematical public, bewildered, know not which to believe. 'Professor Kernot is a very clever man, and talks well, but we prefer to trust our old experienced friends'—'theory is all very well, but practice is another thing,' and so on. Then I make experiments on models, and people say, 'Very nice, indeed, but we haven't much faith in experiments on toy models'; and my last resource, experiments on full size girders, is out of the question on account of expense.

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"Still I produce some effect. The railway foot bridges are now of a better form than they were; and even those engineers who indignantly deny the justice of my criticisms, nevertheless tend in their late designs to avoid the features I most violently oppose."

I have quoted at length from this letter of Professor Kernot in order to let Japanese engineers see into what egregious errors it is possible for English bridge designers to fall. They will not now be liable to be misled by such statements as that in a letter which you published in your issue of September 10th last year—" * * * * * * * just as the grand advantages of English girders to resist shocks, heavy, swift, and incessant traffic from the excessive resilience due to their massiveness can only be appreciated by English engineers long in practice." "A Japanese Engineer" showed pre· · clearly in his first letter that at least one eminent English engineer, Mr. Benjamin Baker, most decidedly does not believe in the "grand advantages" claimed by your correspondent.

In the last paragraph of the same correspondent's letter there is a quotation from the trade circular of Matheson and Grant, that at the time I was not able contradict, although perfectly convinced of its fallacy. It read thus,—"It has long been known to English engineers, and the opinion is now being rapidly adopted in the United States, that the light and cheap American bridges, with pin connections, are neither stable nor permanent enough to justify their use, but at present," &c.

I enclosed the circular in a letter to an eminent American bridge engineer and asked him if there were any truth in the statement about pin connected bridges coming into disfavour in the United States. He replied, "It is utterly untrue. Never have pin connected bridges stood higher in the opinion of American engineers than they do to-day." He informed me also that at the time he wrote his firm was negotiating with a large English firm for the sale of a great quantity of American rolled eye-bars.

Your readers can judge from this how much of Messrs. Matheson and Grant's trade circular it is advisable to believe.

Would it not be well for the manufacturers of English bridges to accept the advice given by the Editor of the *Mechanical World* (Manchester) to the manufacturers of English locomotives, viz:—"There is no question that for very many countries the American type of engine is far superior to the English, and there is no real reason why this class of engines could not be built as well and as cheaply in this country as in the United States. If, as is quite possible, the working details are not known by the office staff of the factory, would it not pay to obtain for our use a few good draughtsmen or other gentlemen from the States, throughly conversant with all details of construction, and familiar with American practice."

Such a course of action would be far more judicious than a blind adherence to precedent, and a continued, unreasoning denial of the superiority of American methods of designing and manufacturing bridges.

"A Japanese Engineer" in his second letter has asked me to give my opinion as to how the principal faults in the Japanese bridges may be corrected. Before leaving this country I will do so in a letter to the *Mail*. It is not practicable to comply with his request in this letter, for I fear that I have already exceeded the space which you allot to correspondence.

Very respectfully yours, J. A. L. WADDELL.

Tôkyô, January 29th, 1886.

(*February 18th, 1886.*)

Sir,—As the bridge discussion has taken a new start, it may be well to clear up every point concerning it. With one exception, I have already done so, and will now clear up that. I should have attended to this matter before but for two reasons; first, I did not think it worth while; and second, I did not have the necessary books for reference.

In Professor Alexander's letter, which you published on September 10th, there appears the following:—

"I have myself taught my pupils the scientific theory of the American trusses, following Dr. Maurice Levy's 'Statique Graphique,' which I in part translated for their private use, first correcting some errors and considerably extending the investigations, both being accepted by Dr. Levy for his second edition. If anyone will get that eminent engineer's work or a private copy of my pamphlet, and, putting a wet towel round his head, carefully read it, he will, if he can follow the mathematics, see the grave scientific defects of American designs."

Having lately been questioned as to the existence of these "grave scientific defects of American designs," I procured a short time ago a copy of Professor Alexander's pamphlet, and discovered at a glance *the grave practical defect of Dr. Levy's hypothesis.*

But first a word as to the pamphlet. Its title is "Analysis and Comparative Advantages of the Fink, Bollman, and Warren Sytems of Trussing;" but on glancing through the work I see that the Quadrangular or Pratt truss is also treated.

It took me a very few minutes to come to the conclusion that the book is a great waste of time, mathematics and "wet towel," having been written by a man, who, although a good mathematician, is evidently ignorant of the principles of bridge designing; for he has based his investigations, as I will show presently, upon an entirely false assumption.

The principal object of the pamphlet is to compare the Bollman and Fink trusses with the Warren, the conclusion being arrived at that the latter is superior to the others. Of course it is; and it would be even if it cost three times as much; but it needs no complicated mathematics to prove this. Both the Fink and Bollman trusses were long ago abandoned in American practice, and most of the latter type have been taken down, although there are a few left on the Baltimore and Ohio Railroad.

That they are utterly lacking in rigidity, owing to the unequal stretching under load of the long and the short ties, anyone who has ridden over that road will readily acknowledge. The Fink trusses are not much better. It is as obviously unfair to call these typical American trusses, as it would be to judge English bridges by reference to the old tubular girders only. Surely Professor Alexander cannot be ignorant of this. Although he does state that the bridges of my treatise are of one kind only—that sold by Raymond and Campbell, to whom I am consulting engineer—it is nevertheless a fact that American engineers have adopted the Pratt and Whipple as the characteristic American trusses, and that trusses of any other type are now-a-days very seldom built in the United States.

As far, then, as the pamphlet relates to the contrasting of English and

American bridges, we must consider only the comparison between the Warren or Isoceles and the Quadrangular or Pratt trusses, the former being presumably the English type, although formerly by no means uncommon in the United States.

Dr. Levy's calculations in comparing these two trusses show an economy of *three* per cent. in favour of the Warren, but he adds:—"We do not pretend to say that these figures rigorously represent the volumes of the trusses when all pieces are designed to meet *all* the requirements which experience dictates, but they fairly represent their merits relatively." Do they? Several other investigators, among whom are Bender and Cleeman, show by very similar calculations that the economy is in favour of the Quadrangular truss. None of these investigations are to be depended on: they are all based on false assumptions; and Dr. Levy's is by no means the least faulty of all these incorrect applications of mathematics.

His error is simply this—he assumes that the intensity of working stress for all truss members is a constant, or as Professor Alexander translates it: "Suppose the material to be of uniform strength f lbs. per square inch to resist either tension or thrust, then the proper sectional area of any piece will be found in square inches by dividing the stress in lbs. which it bears by f."

Now in point of fact this value of f in actual practice varies from 1.5 tons to 5 tons, so the assumption that it is constant is very crude indeed. The writers, who so employ it, argue that the error thus involved affects equally all the trusses that they compare; but this is far from being the case when contrasting the Warren and Pratt types.

This investigation is by no means a new one to me, for nearly three years ago I treated it in a paper entitled "Economy in Struts and Ties," the concluding paragraph of which read as follows:—"To recapitulate: our investigations show that, for the ordinary bridges met with in an engineer's practice, the most economical inclination for the strut is a batter of one in five or one in six, but that the saving obtained by its use is such a small percentage of the total cost of the bridge that it is scarcely worth while to depart from the usual Pratt or Whipple trusses; and that the latter are decidedly cheaper than the Warren girder."

Now these investigations were made in a thoroughly practical manner by preparing a number of actual designs for four characteristic cases, taking into account not only the varying intensities of working compressive stresses, but also the weight of all details and the difference in price per pound for finished struts and finished ties. By this means the comparison was reduced to a basis of dollars and cents, the only true method of determining economy in design.

Now to show the incorrectness of Dr. Levy's reasoning, and consequently of that of Professor Alexander, let us take the case of an ordinary span, say one hundred and sixty feet, and proportion for it two through trusses, an Isoceles and a Quadrangular, then compare their weights and cost first by using a constant value for the intensity of working stress, according to Dr. Levy, with a uniform price per pound for the iron, and second, by a close approximation to the total weights including details, using the proper intensities of working stresses according to the formulæ and tables of my books, and making the correct allowance for the difference in price of strut and tie iron. To be perfectly fair there should be the same number of panels in each truss, and the most economic depth in each case should be used. The common number of panels employed in America for a 160 foot span is eight; and, English opinion to the contrary, this gives a greater economy than does any larger number. The economic depth for the Pratt truss of this span and number of panels I have proved by actual design to be twenty-four feet; that for the Isoceles is somewhat less—perhaps twenty-one feet.

A check upon the correctness of the assumed economic depths can be had after the calculations are finished by noting whether the total weight of the web is about equal to the total weight of the chords. That this is a condition of economic design can be demonstrated by mathematics based on fairly accurate assumptions: moreover, I have proved its approximate correctness from the weights of over one hundred trusses actually designed.

In order to save time and trouble we will assume a depth of twenty-one feet for both the Isoceles and Quadrangular trusses, although such an assumption will militate against the latter.

Let the live load per lineal foot of the truss be assumed to be one thousand pounds, and the corresponding dead load six hundred pounds, of which one third is supposed to be concentrated on the top chord and two-thirds on the bottom chord. The panel live load will then be ten tons (of 2,000 pounds) and the panel dead load six tons, of which two tons will be concentrated above and four tons below. The stresses in all the main members of both trusses will then be as given in Tables I. and II. The lengths of the members in these tables are those from panel point to panel point. The value of f assumed is four tons, but as this quantity affects the results in both cases in the same proportion, it might have been taken at any other value. Where two stresses of opposite kinds can occur in the same panel or in the same member their amounts are added together. This method agrees with the old American practice; and, although improved upon of late years, it is correct enough for the present purpose, and affects both truss weights to almost the same extent. In the next comparison a more accurate method will be used.

TABLE I.

ISOCELES TRUSS.

MEMBER.	STRESS IN TONS.	LENGTH IN FEET.	STRESS BY LENGTH. ÷ *f*.
Top Chord Length 1	53.333	2 × 20	
Top Chord Length 2	91.430	2 × 20	2,590.510
Top Chord Length 3	114.288	2 × 20	
Top Chord Length 4	121.907	1 × 20	609.535
Bottom Chord Length 1	27.142	2 × 20	
Bottom Chord Length 2	72.859	2 × 20	
Bottom Chord Length 3	103.335	2 × 20	3,219.100
Bottom Chord Length 4	118.574	2 × 20	
End Web Strut	63.156	2 × 23¼	
2nd Web Strut	46.813	2 × 23¼	
3rd Web Strut	31.855	2 × 23¼	
4th Web Strut	+ 18.282 − 3.878	2 × 23¼	
End Tie	60.940	2 × 23¼	3,735.345
2nd Tie	44.597	2 × 23¼	
3rd Tie	29.639	2 × 23¼	
4th Tie	+ 6.094 − 16.066	2 × 23¼	
Total Comparing Volume			10,154.490

TABLE II.

QUADRANGULAR TRUSS.

MEMBER.	STRESS IN TONS.	LENGTH IN FEET.	STRESS BY LENGTH. ÷ *f*.
Top Chord Length 1	91.428	2 × 20	
Top Chord Length 2	114.288	2 × 20	
Top Chord Length 3	121.907	2 × 20	
Bottom Chord Length 1	53.334	2 × 20	6,400.070
Bottom Chord Length 2	53.334	2 × 20	
Bottom Chord Length 3	91.428	2 × 20	
Bottom Chord Length 4	114.288	2 × 20	
Batter Brace	77.335	2 × 29	1,121.358
Post 1.	29.750	2 × 21	
Post 2.	17.500	2 × 21	496.125
Post 3.	6.500	1 × 21	34.125
Diagonal 1	56.965	2 × 29	
Diagonal 2	38.332	2 × 29	
Diagonal 3	21.405	2 × 29	1,782.137
Diagonal 4	6.214	2 × 29	
Hip Vertical	14.000	2 × 21	147.000
Total Comparing Volume			9,980.815

Table III.

ISOCELES TRUSS.

Member.	Intensity.	Section in sq. in.	Equiv. Length in feet.	Corresponding Weight in lbs.	Wt. of Details.	Total Weight.	Value in $.
Top Chord 1	—	19.50					
Top Chord 2	3.602	25.38	40	10,215	3,405	13,620	681.00
Top Chord 3	3.602	31.73					
Top Chord 4	3.602	33.84	20	2,256	752	3,008	150.40
Bottom Chord 1	5.000	5.43					
Bottom Chord 2	5.000	14.57					
Bottom Chord 3	5.000	20.67	46	9,872	—	9,872	394.88
Bottom Chord 4	5.000	23.71					
Web Strut 1	3.150	20.00	46.5	3,100	1,033	4,133	206.65
Web Strut 2	2.850	16.43					
Web Strut 3	2.485	12.82					
Web Strut 4	2.262	9.46	46.5	7,[illegible]87	4,858	12,145	607.25
Web Strut 5	—	8.30					
Web Tie 1	5.000	12.19					
Web Tie 2	4.750	9.39	52.5	4,930	—	4,930	197.20
Web Tie 3	4.500	6.59					
Total weight and value						47,708	2,237.38

Table IV.

QUADRANGULAR TRUSS.

Member.	Intensity.	Section in sq. in.	Equiv. Length in feet.	Corresponding Weight in lbs.	Wt. of Details.	Total Weight.	Value in $.
Top Chord 1	3.602						
Top Chord 2	3.602	90.96	40	12,128	4,043	16,171	808.55
Top Chord 3	3.602						
Bottom Chord 1	5.000						
Bottom Chord 2	5.000						
Bottom Chord 3	5.000	62.48	46	9,580	—	9,580	383.20
Bottom Chord 4	5.000						
Batter Brace	2.759	28.03	58	5,419	1,806	7,225	361.25
Post 1	2.694	11.04					
Post 2	2.227	7.86	42	2,646	1,764	4,410	220.50
Post 3	—	5.10	21	357	238	595	29.75
Diagonal 1	5.000	11.39					
Diagonal 2	4.667	8.21	64	5,235	—	5,235	209.40
Diagonal 3	4.333	4.94					
Diagonal 4	—	2.25	68	510	—	510	20.40
Hip Vert	4.000	3.50	48	560	—	560	22.40
Total weight and value						44,286	2,055.45

In Tables I. and II. the stresses given can be relied on as correct, having been checked by another engineer. These stresses for economy of space are not repeated in Tables III. and IV., although used in computing the third column in each. It will be noticed that in Table III. two intensities are wanting. The reason is that the members in these cases were not proportioned by using ordinary intensities. In the first case, although the smallest possible section (two 12″ channels and a ⅜″ × 20″ plate) is used, there is an excess of area and consequently of strength. This is unavoidable in the Warren or Isoceles truss.

In the second case the member has to resist both tension and considerable compression, so has to be designed for both. The sectional area used, viz., 8.3 square inches is about what most American engineers would employ.

There is one more peculiarity in Table III., viz., the manner of proportioning strut 4, which has to resist a tension of 3.878 tons in addition to a compression of 18.282 tons. The latest American method is to add to the larger stress eight-tenths of the smaller and proportion the strut to resist a compression equal to the sum.

In Table IV. there are also two intensities wanting. In the first case there is an excess of strength, although the section is as small as good practice will allow. The second case is that of the counter-ties, which are proportioned with an allowance for initial tension to provide for the stress caused by screwing up the adjusting nuts.

In both tables the equivalent lengths for tension members in the fourth columns are found by adding three feet to the length of each rod to allow for the weight of the eyes; and in the case of counters, two feet more for the weight of the adjusting parts. The fifth column in each table is filled out by multiplying together the numbers in the third and fourth columns, and multiplying the product by ten-thirds.

The sixth column was filled out by empirical rules taken from my own practice, viz., that the weight of the details (stay-plates, lattice-bars, connecting plates, rivet-heads, &c.) for top chords and batter braces is equal to one-third of the weight of the two channels and cover plate; and that for the other web struts the weight of the details is equal to two-thirds of the weight of the two channels. These rules were derived from the average results of a number of designs, and are quite accurate enough for present purposes. In computing the last column, strut iron was assumed to cost five cents per pound, and iron for tension members four cents per pound. In reality the difference is a little greater, so the assumption made is in favour of the Isoceles truss.

Let us now look at the results of our calculations, first dealing with Tables I. and II. In place of finding as Dr. Levy does a saving of three per cent. in favour of the Isoceles truss, we discover that *by using his own incorrect method* there is a saving of one and seven-tenths per cent. in favour of the Quadrangular truss. Perhaps this difference is due to Dr. Levy's having used the greater stress instead of the sum of the stresses in those diagonals which are subject to both tension and compression. Let us see. In Table I. we have $(3.878 + 6.094)\ 46.5 \div 4 = 115.925$, showing still a slight saving in favour of the Quadrangular truss. Evidently Dr. Levy's mathematics are at fault. It is an old saying that "mathematics cannot lie"; but experience has shown that it, like a well known historical work, can be manipulated so as to prove nearly anything one wishes.

Referring now to Tables III. and IV. we see that, when both trusses are properly designed and the weights of the necessary details are included, there is a saving of seven and seven-tenths per cent. in favour of the Quadrangular truss; and that, when the difference in cost of the struts and ties is considered, this saving is increased to eight and eight-tenths per cent. Let us now investigate a little concerning the economic depths of both trusses. For small changes in depth the weight of the web is directly and the weight of the chords inversely proportional to the depth. Dividing up the weights of both trusses between the chords and web we find by trial the economic depth of the Isoceles truss to be 23.5 feet, and that of the Quadrangular truss 24.5 feet, the resulting minimum total weights being respectively about 47,414 and 43,700 pounds, increasing the saving in weight by the use of the Quadrangular truss to eight and a half per cent., and the saving in cost to about nine and a half per cent.

The preceding investigations have been made with the greatest possible fairness, and the calculations have all been checked by another engineer.

The span is an ordinary one, and the loading nearly that for one of the Japanese single track bridges. To simplify calculations the loads were taken in round numbers, and no engine excess was used. Had the latter been employed, the result would have been still more unfavourable to the Isoceles truss, for the effect thereof is greater on the web than on the chords, and it is in the web that the Isoceles truss requires more material than the Quadrangular. Besides this matter of economy, there are two particulars in which the Warren girder is inferior to the Pratt and Whipple. The first is that when the oblique struts are long and slight there is an injurious bending on them due to their own weight. The second is that oblique web struts do not permit of the use of brackets or vertical sway bracing, except in the case of unusually deep trusses of double cancellation. Dr. Levy unconsciously points out the difficulty into which European bridge designers have gotten themselves. On p. 28 of Professor Alexander's translation he says, "But we cannot vary *n* (the number of panels in half the span) at pleasure because it is fixed between certain limits by practical considerations. For the booms must not be too long, because, besides bearing direct stress, they act as beams in transmitting the load upon them to their ends."

The booms should never act as beams, then long panels can be employed; and it has been acknowledged by everyone who has practically investigated the subject that the greater the panel length up to a limit of at least twenty-five feet, the greater the economy of material.

I have investigated, by making actual designs, the effect of loading the bottom chord between panel points and have found that it always demands an increase of iron for equal strength. As for loading top chords between panel points—anyone who knows anything whatsoever about bridge designing would not think for a moment of so doing; for the stress upon a loaded strut increases with the perpendicular distance between the middle point of its axis and the straight line joining the centres of ends of same. How absurd then it is to increase this distance by transverse loading !

Finally, to show what impracticable ideas of bridge designing both Dr. Levy and his translator are possessed of, let me quote from p. 31 of the translation a couple of lines:—" It is to be remarked that for bridge girders the most favourable ratio of the depth to the span lies between the limits from $\frac{1}{8}$ to $\frac{1}{12}$ or from $\frac{1}{10}$ to $\frac{1}{12}$."

Anybody at all posted in modern practice must know that the economic depths are almost twice as great as above stated. I have investigated this subject systematically in a paper on "Economy in Highway Bridges," published in the *Proceedings of the Engineers' Club of Philadelphia*, by making over one hundred actual designs, and have conclusively shown that the economic depth varies from one-fifth of the span for spans of one hundred feet to one-seventh of the span for spans of three hundred feet.

This subject of economy in bridge trusses, although a favourite one with mathematicians, is altogether too complicated to be handled by pure mathematics; and it would be greatly to the advantage of the engineering profession if chronic mathematicians were to let bridge designing and kindred subjects alone.

Yours very respectfully,

J. A. L. Waddell.

Tôkyô, February 13th, 1886.

(February 23rd, 1886.)

Sir,—I see that my small letter has come in for a large share in Mr. Waddell's last two letters, clearing things up as he calls it. He might have, among other things, cleared up why he calls it a "discussion," seeing it is entirely one sided and that no Englishman took up the merits of the case. The English letters merely commented on the want of courtesy in Mr. Waddell's preface. My own letter was to prevent my ex-pupil from being publicly put in a false position, though I mentioned Dr. Levy's book as antagonistic to Mr. Waddell's, and gave a quotation from the trade list of Matheson and Grant directly the converse of what had been stated.

This letter is written to put those parties, Dr. Levy and Messrs. Matheson and Grant upon their feet again, in the eyes of the Yokohama public; as they have been "cleared up" in the most unscrupulous way. In fact it has been stated that Matheson and Grant are liars in a mercantile sense upon the authority of a respectable anonymous firm of merchants in America. I would point out to the public that Matheson and Grant are a respectable English firm, whose business dealings are open before the public, and suggest that the opinion of the American anonymous firm may be worthless or worse.

An amusing little imaginary biography of Dr. Levy is given as a good mathematician, implying that he is no engineer. Allow me to correct this by saying that Dr. Levy has long been Engineer-in-Chief in the Department of the Seine, and that he is more than a good mathematician; that his scientific papers on scientific engineering and physics to the Academy of Sciences place him in the very foremost rank of scientists. Mr. Waddell gives the public a little garbled account of what is Dr. Levy's classical work. He says that Mr. Levy's work is a waste of time, especially that referring to the Bollman Truss, because he (Mr. Waddell) admits without proof that the Bollman is bad, especially in want of stiffness, and yet I shall point out by-and-bye that there are signs of the Bollman Truss being born again, and for the purpose, of all others, of stiffening a less stiff brother. Then follows a definition, the first, of American and English bridges as rectangular and isosceles respectively, and a dissertation on the three per cents., with a parade of figures. Then he *asserts*, that Levy's hypotheses are all wrong, and then he *proves it, practically and experimentally* as he says, and conclusively as he no doubt thinks. This is the manner. He "designs" a hundred or so bridges from his book, and don't let any one think this is a Herculean task, for he told me he could design one in half-an-hour; and from these he finds certain conditions give practically the most economy of dollars, and as these conditions differ from Levy's and the practice of French Engineers, they are all wrong. Now this practical way sounds a most satisfactory method of implying that the hundred or so bridges were built and tested till they were broken in the order assumed. But really the whole reasoning is in a circle, for it is this. The "designs" are after all made from the author's own hypothesis and formulæ more or less obscure, but guaranteed by him to be the only genuine article. After all, then, we have nothing practical nor experimental at all about it, but only the obscure hypothesis of a colonial engineer and Professor in a second-rate Engineering School in Tôkyô, against those of a celebrated engineer, Professor à l'Ecole Centrale, Paris.

Allow me to give an account of what Dr. Levy's work is. Before him Rankine and Stoney found the conditions of economy of material for uniform strength, dividing the problem into two parts from the difficulty presented by the treatment *in toto*. They found economy of booms to resist bending and of braces to resist shear, and averaged the conditions. Mr. Waddell mentions an essay of his on the economical slope of braces, a copy of which I have, and which is a very creditable school-boy paper suitably presented to a small local society. This essay is not at all comparable to Stoney's work. It is not general at all, for though working out a few exercises in detail to a few variations of conditions may give the economy in a certain order, it simply proves nothing generally nor conclusively.

Dr. Levy attacks the problem less perfectly treated by Stoney, and takes the whole conditions in as far as it ever will be possible to do so. He takes both the dead-weight into account and a rolling load, which is a far safer and more satisfactory way of taking the live load than that of so many lbs. per foot, for in the concentration of the moving load and in its transits the whole crux of the strains on the braces lies. He uses three variables, one determining the shape of the triangles, another the number in the span, and the third the ratio of depth to span. He assumes that the sectional area of each piece is to be made proportional to the direct *maximum* load that can come upon it for every possible position of the load, and, by the most beautiful and skilful analysis, finds an expression for the total volume of material in the truss containing these variables. The hypothesis of the section of each piece being proportional to the greatest load that comes on it is perfectly just, in spite of Mr. Waddell's opinion. For a truly scientific method must aim at taking in all the conditions of load as actually rolling on many wheels, the speed, and, as we now know, the frequency, as far as can possibly be done, and yet admit of general treatment. Mr. Waddell's uniform load is not a scientific substitute for the actual load, and he is forced into using *different* factors of safety for different members (or factors of ignorance as he calls them, or factors of wilful oversight as I might suggest), hence his 1.5 to 5 tons. Neither is his arithmetical treatment of a few tentative cases at all worthy of scientific recognition. Neither are they of the value they might be as an arithmetical example, because he employs great gaps between the crossbearers to suit his own preconceived ideas, and leaves the wheels to jump across or be carried across by auxiliary trusses, whose volumes for increasing values of the gaps soon swallow up the apparent economy in the main truss. His suggested refinement of adding the positive and negative recurring strains is not demanded, as in large bridges there is sufficient time for the piece to recover itself from one strain before the other is made, which is quite warranted by the practical evidence obtained by the Committee of the British Government, and if Dr. Levy had chosen to do so, it would not make an appreciable difference in the tabulated results. Dr. Levy goes on to prove that the value of the variable for shape (the other circumstances remaining the same) which makes the volume least gives an isoceles triangle, but that the value which makes it rectangular is only 3 per cent. above it. Next he tabulates the ratio of depth to span to make the volume a minimum, keeping to those two shapes and corresponding to a range of value of the number in span including all suitable numbers. Now the ratios of depth to span which give minimum value of material are exactly those employed in England, Germany, and France, and, what is of greater importance, it agrees with the ratio of depth to span which gives the most suitable stiffness to the bridge, a quality of greater importance than strength even. So that, in deliberately taking greater depths in ratio to span, the three following grave scientific errors are made: the loss of economy of material, if each piece were sectioned to resist the direct thrust only; the still greater loss of material in stiffening the long struts which are thereby rendered longer still, and a want of uniform stiffness, there being too much stiffness as a whole and too little stiffness from bay to bay. The last being most serious if the load move swiftly and occasions a series of shocks as the loaded wheels cross each transom, which can be distinctly heard by one standing under any girder as a succession of blows. These blows produce impulsive strains of the braces giving unknown but large stress on them, or more simply tear and wear.

By Mr. Waddell's own allowing, the Americans have thrown over their own complicated inventions, and are now making rectangular trusses, so that it is evident that what Mr. Pownall said is the case, that American designs differ principally in excessive depth and in pin connections. If Mr. Waddell will read the remainder of Dr. Levy's work, he will see the grave objections to pin joints.

One thing I would like to point out, is the entirely wrong use that is made of what Baker said about English railway companies strengthening their bridges. Our bridges in England and more especially in Scotland, we admit, have a lavish amount of iron put upon them. It was fortunate that it was so, for, when the traffic increased in weight, and more especially in swiftness, they were still quite substantial. Baker has struck a new key-note, really a physical one; namely, that *frequency* of transit, an increase from a 15 minute to a 5 minute service, demoralises even those substantial bridges which writers in Germany, where they design on the same principles but carry out the most extreme economy, have flouted as far too strong. The future engineering of bridges to carry heavy swift, *incessant* traffic, is only going to begin; Mr. Waddell's pamphlet on undue economy is not in the new direction, but an over refinement of the old. Designing which gives prominence to extreme economy of dollars with only sufficient strength, in putting stiffness in a second place and resilience (the resistance to shocks and directly proportion to the weight), in the third place, puts resistance to this new kind of fatigue, that Baker has brought to light, in the fourth. It is easily handled, however; any lad fresh from college can make it show well, and it appeals to the purse. The economy is, however, false, and all the excessive complicating of the design till it is like a spider's web is only the afterthought to remedy in some measure defective stiffness, short livedness, and inefficiency except for loads "that crawl between heaven and earth." It will likely prove that, for heavy, swift, incessant traffic the heavy riveted plate girders, riveted as they are on the Clyde, if not the tubular bridges, will be the truest economy after all.

I read the other day in a scientific paper everyone must have seen, that "soundness" was to the scientific man what "respectability" was to the business man; without it he could not get even a hearing. I submit that Mr. Waddell's preface and discussion and manner of settling everything his own way by quotation from his former letters or his books or their reviews or what he said at some society, his wholesale condemnation of both practical engineers and mathematicians, his recourse to public newspapers posing as a martyr, obscure his real work, and render the whole "unsound," that is, not scientifically respectable.

I also read that the future stiffened suspension bridge, the Albert Bridge being pioneer, is to include the despised Bollman system, the chain being only to hold up the weight of the rods and keep them from sagging.

One thing I had nearly forgotten, the dictum that no boom should act as a beam, although only a few lines above it exception is taken to a piece which bends under its own weight. I reverse the dictum: every boom acts as a beam for its own weight, and this alone soon fixes an inferior limit to the number of bays in a bridge. Further, something *must* carry the rolling loads over the gap from cross-bearer to cross bearer. If it is done by independent strings they soon develope into bridges themselves if the gaps inordinately increase. Further, there is no objection whatever to the lower booms themselves doing part of this bridging across if suitably designed; on the contrary, it is rather economical.

In Scotch law there is a remarkable middle sentence between conviction and acquittal. For myself, I am quite proud to be classed with Dr. Levy and fall with him and Rankine, Stoney, and many German names, but conclude that Mr Waddell's attacks and vituperations amount to a "Not proven."

I quite agree with Mr. Waddell that neither mathematics nor book-work of any kind are conclusive in Engineering, but I include his book as no more practical nor experimental except by his own assertion, and much less general and more crude in its mathematics and incomplete in its treatment than many others. In fact in my former short letter I said so. It is the case, however, that students of engineering must be taught on "sound" bases and the general principles, and not supplied with a sort of quack doctor's cure for all diseases guaranteed by the vendor. They must also be taught mathematics, even although a little of that article is emphatically a dangerous thing. Bazalgette, in his presidential speech at the meeting of the Engineering Section of the British Association for the advancement of science, although himself the most practical and experienced of engineers, said the training of an engineer was first mathematical, second mathematics, third mathematics.

I hope this letter will conclude the correspondence, as Mr. Waddell long ago said he was tired of it, as I am sure the public are also, and as in the second of his last two consecutive letters he says he has cleared up the last remaining point.

I am, &c., THOMAS ALEXANDER.

February 20th, 1886.

(February 27th, 1886.)

SIR,—There are a few points in Professor Alexander's last letter that require comment.

First, the designs to which he refers were not made according to my own hypotheses, but in accordance with the best American practice In the Memoir it is plainly stated that my system is essentially American; moreover it has been so accepted both directly and indirectly by the leading technical periodicals of the United States in their reviews. In proof of this let me quote the following from *The American Engineer* of January 21st:—

"This work ought to prove valuable to Japanese engineers, illustrating, as it does, the American system of bridging so much in detail that any engineer with the slightest knowledge of iron work, should be able with its aid to meet ordinary cases at once.

"There is probably nothing published in this country covering the same ground in such a practical manner.

"The progressive spirit so manifest in Japan of recent years, with such aids at hand, can scarcely fail to adopt the American system for the railway bridges of that country."

The time required to design a truss varies from half an hour to four or five hours according to the length of span—the one hundred cases required over three hundred hours.

Professor Alexander appears to insinuate that I do not use concentrated loads in designing my bridges; but, if he will look at the Memoir, he will find that in this he is mistaken.

One might interpret him to say that I do not distinguish between live and dead loads; but I do more than this by dividing the dead load between upper and lower panel points. The uniform live load of one thousand pounds per lineal foot, that I used in the examples in my last letter, was not only concentrated at panel points, but was assumed to be an advancing load when calculating web stresses. Moreover, in the Memoir I make an allowance for shock equal to twenty-five per cent. of the calculated live load stresses in proportioning the floor system.

The "different factors of safety," *i.e.*, as I prefer to express it, "the varying intensities of working stresses," are used by all American engineers, and, if I am not mistaken, by the leading engineers of Germany.

The use of long panels gives an economy not only in the trusses, but also, Professor Alexander to the contrary, in the floor system. Thus in a one hundred foot span, as now built in this country, there are eighteen moderately heavy floor beams and two rows of light iron stringers: while, according to my designs, there are four heavy floor beams and two rows of heavy stringers. *For the same strength* the latter method requires less iron and offers greater resistance to shock, because each piece is much heavier. For the same reason the parts of the web in American bridges are heavier and therefore better calculated to resist the shock of "heavy, swift, incessant traffic" than are the corresponding parts in English bridges.

The leading engineers of both Germany and America provide for both "positive and negative recurring strains."

The stiffness of a bridge, other things remaining constant, increases directly with the truss depth; for stiffness and deflection under load are inverse functions of each other.

One would think from Professor Alexander's letter that rectangular trusses are not of American origin. On this point let me quote from Bender's "Principles of Economy in the Designing of Metallic Bridges," p. 38:—"The modern quadrangular trusses, or girders with parallel chords and upright posts, were orginated by American engineers."

The "stiffness from bay to bay," that Professor Alexander very properly states to be necessary, is amply provided for in American bridges by well proportioned, substantial, yet economical floor systems; and undue vibration of the structure as a whole is prevented by horizontal and vertical sway bracing, thus making these "spider's web" bridges stiffer, stronger, lighter, better, and cheaper than bridges of the English type.

Professor Alexander has advanced many opinions that are in direct variance with those of Baker and Bender, obtained from their practical experience and investigations, and with those of Professor Kernot deduced from actual experiments.

Professor Alexander is truly a hard man to convince.

Perhaps the following extracts from the leading editorial of *The Engineer* of January 1st, an authority that he is not likely to dispute, will change some of his opinions; for they show that his views and those of the highest English editorial authority are diametrically opposed.

The italics in what follows are mine:—

"Protection abroad has encouraged manufactures in many countries which were our best markets; but, with minor exceptions, these countries are still unable to compete with us in price. The result is that some of these countries, and notably within the past few years the United States, devote their energies to the production of the really good instead of the cheap, and in the sale of these they have succeeded much abroad and not a little in England itself. 'The best is the cheapest,' is an old cry, and is one which may be successfully used by a competing country in countries where people have grown tired of the cheaper English goods, and proved that cheap may be dear. 'English' was synonomous with good, but the race in the rapid acquisition of wealth amongst the ever increasing number of English manufacturers caused the lowering of prices, and to some extent the unnecessary lowering of quality. Prices were lowered more rapidly than improved methods lowered the price of production. English makers thus brought themselves to the level of successful attack by others; an attack doubly successful at a period when faith in the quality of English goods had begun to lose its hold."

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"To go to much larger things it is the same in bridge work. If an English maker is asked to tender for a girder not quite of the sort he has been accustomed to make, he immediately wants to charge more, because the designer has presumed to make a change which he thinks will give him a little trouble; or he refuses to tender. An American, on the contrary, will not object to a design simply because it is new, and does not suit the present arrangement of his drilling, punching, and shearing machines, but will immediately begin to think out the simplest way to suit himself and his plant to the job. Witness the numerous bridges recently built and building in Canada and elsewhere. Some of these are actually being built of Scotch open-hearth steel, the duty on which is as much as it would be on the bridge; yet the bridges are being made by Americans. The bridges are partly rivetted and partly pin bridges. They are made in American shops, and put together in their places. Tension bars have pin holes drilled in them, which are within a fiftieth of an inch of their proper distance centre to centre, though 40 feet to 50 feet apart. Some English builders would not like this exactness, but it is absolutely necessary in a pin bridge well designed, *and not having in it a great unnecessary weight.*"

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"There is one question concerning bridge structure and bridge material upon which action should at once be taken by the proper authorities. We refer to the Board of Trade rules with reference to wrought iron and steel bridge structures. In the commencement of this article reference has been made to the decline of English bridge work where American builders have any chance of competing. Indirectly it may be fairly contended that this is to some extent the result of English Board of Trade rules for railway bridges. The rules, as they now stand, are not only perfectly useless for securing safety, but they indirectly put a premium on bad materials. This, taken with the fact that a Board of Trade inspection of a bridge must remain a farce so long as these rules are in force, places the public safety completely in the hands of the bridge engineer or of the resident engineer or inspector representing the engineer on the work. A bridge that would be passed by the English Board of Trade would require strengthening 5 per cent. in some parts and 60 per cent. in others before it would be passed either by the German Government or by the leading bridge building companies in America, *and yet it is known that most of the German or American bridges have a lighter appearance than our own.*" * * * * *

"There is no reason, except honesty, for putting good material into a bridge, and unscrupulous men will say common material is good enough when anything will pass the Board of Trade. There is no doubt that this feeling actuates bridge building to a considerable extent: *it encourages the continuation of unsatisfactory design and workmanship*, and a result of years of working under this rule is that a system has grown up which it will not be easy to leave, and a disinclination to any but the good-enough policy is sufficiently widespread to make it really difficult for any engineer to get bridges built which are out of the ordinary run." * * * * *

"In one recent case, which is typical of many, an engineer had designed bridges at considerable trouble, but, to suit the custom of the bridge makers' trade, he had to submit to an increase in weight, which changed his bridges from economical to ordinary bridges in this respect. He also endeavoured to work more on the German system of using lattice girders under 100 feet span, as well as above that; but the difficulty of getting light lattice girders built with sufficient care, *instead of with that rough-hedge carpentering in iron which is about the quality of most plate girder work*, was so great that he had to give it up, and return to the heavy ugliness of the plate girder. He had tried to get larger bridge girders made without plate work, and with greater depth, necessitating long tension bars, but the difficulty which has been experienced in getting these long bars made sufficiently accurately to length, so that one might not be sagging while its neighbour was being stretched under undue load, is so great, that he will have to give up the attempt *unless he makes his sections much heavier than is necessary except to cover bad workmanship.* Now, this sort of thing is a daily-acted fact, but the chief American and Canadian bridge builders are accustomed to make lighter bridges, AND THERE IS NO FINER WORK DONE IN THE WORLD THAN THAT THEY TURN OUT AT THE PRESENT TIME."

* * * * * * * * Hundreds of bridges have been made during the past few years for Canada, and we h[illegible] made hardly any, if any of them, although much of the material has gone from our shores, and paid as high a duty as it would have paid if our men had been paid the money to work it up into bridge forms. *We lose trade in all directions by the stubbornness and inertia of our manufacturers*, and it will probably be a

long time before we can make many of the proprietors, foremen, and workmen in our bridge and girder yards understand that *something more of the nature of an instrument of precision than a sledge hammer and drift* may be used without great expenditure either of time or money in girder constructing; and that with suitable designs the drilling and boring machine may have to take the place of a blunt shearing machine, and punching machine with blunt punch and blunt edged die.

The rule to which we have been referring was useful in its day, and was adopted by the Board of Trade upon the recommendation of civil engineers. The Board is therefore not to be blamed for it, and steps ought at once to be taken by the Board to obtain the opinion of civil engineers *who are amongst the leaders in modern practice; not of those who, though eminent as engineers, are beyond that age which admits alteration to be necessary in any rules they have long been accustomed to work with.*"

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"IN ALL CASES OF BRIDGE DESIGN DIFFERENTIAL FACTORS SHOULD BE USED INSTEAD OF A SLAP-DASH ALL-ROUND FACTOR, WHICH IN SOME PARTS OF A BRIDGE IS TOO HIGH, AND IN OTHERS AS MUCH TOO LOW."

The foregoing evidence, coming as it does from the highest English authority, is so conclusive that I will rest my case thereon, and will trouble you after to-day with no more letters on "Iron Railroad Bridges for Japan."

Will you kindly add one more to the many favours that you have done me by inserting the appended letter to the Japanese engineers? It was promised some time ago.

And now, Mr. Editor, allow me to most sincerely thank you for all the courtesy that you have shown me during this discussion, and for the large amount of valuable space which you have given it in your colums. Although it has undoubtedly been somewhat uninteresting to many of your readers, it will eventually prove of value to the Japanese engineers and other gentlemen connected with the Railway Department.

Yours very respectfully,

J. A. L. WADDELL.

Tôkyô, February 24th, 1886.

TO THE CIVIL AND MECHANICAL ENGINEERS OF JAPAN.

GENTLEMEN.—Having promised during the course of the bridge controversy to explain, if requested to do so, how to correct the principal faults in the Japanese railway bridges, and having been so requested by one of your number, I now proceed to comply.

In my letter of September 13th I stated that the three great dangers to to which the railroad bridges of this country are subject, are washout, destruction by wind, and derailment. To prevent the first nothing can be done unless the embankment has been carried too close to the stream, in which case a portion of it should be removed and replaced by trestle work or short spans.

The second danger can be averted by attaching at right angles to the planes of the trusses several pairs of 4″ × 5″ angle-irons to the underside of the lower chords by means of single octagonal intermediate plates. These angle-irons, which are to be rivetted together into T form, should project four and a half or five feet outside of each truss, and a side brace of a single angle-iron should extend from each end to the top chord as shown and described in the Memoir. Four or five such pairs of angle-irons should be used for a one hundred foot span, and the positions for their attachment should be chosen where there are no splices in the lower chords.

In addition to these transverse struts there should be diagonals of single angle-iron attached by rivets to the under side of the bottom chords close to the connections of the transverse struts. As these diagonals may be relied on to resist both tension and compression, if made of sufficient sectional area, only one will be needed per panel of wind bracing. Care should be taken to make the connections very strong, and rivets should be used unsparingly provided that the holes therefor do not too greatly weaken the bottom chords.

The side braces thus provided at once strengthen the top chords by reducing the ratio of length to least diameter, and prevent the overturning of the trusses when subjected to heavy wind pressure.

The third danger, viz., that from derailment, may be entirely avoided by adopting the arrangement of ties and guard rails together with the rerailing and ditching apparatus described in the Memoir.

In the letter before mentioned I indicated weakness and inferiority of design in the Japanese railway bridges in seven other, but minor, particulars.

The first, viz., weakness of the web struts, owing both to their section and to the trussing employed, can be corrected with considerable difficulty by rivetting along the outer edges of the bars, frames composed of light angle-irons latticed together. These cannot extend to the eyes of the bars, but as there is more iron near the ends than in the body of the strut, stiffening will not be required there.

The second point, viz., the thickening of the bars at the eyes, although indicative of very crude ideas in designing, is not of vital importance; which is well, for it is an evil that cannot be remedied.

Third, the stay plates of the top chord and batter braces should be taken off and replaced by a system of lacing bars with a wide stay plate (say 8″ or 10″) on each side of each panel point and as near thereto as possible.

Fourth, if water lodge in the bottom chords, a small hole should be drilled through the plate at the deepest part of each pool.

Fifth, the smallness of the connecting plates of the top chord cannot well be corrected; by relying upon abutting ends (which first-class American specifications do not allow) the chords in this respect may be considered as not dangerous.

The sixth error, too many panels, is a fundamental one; and, of course, cannot be corrected. It affects the economy of design, but not the strength of the structure.

Seventh, the supporting of floor beams between panel points cannot be avoided in the present Japanese bridges; but the method of so doing may be so improved as to do away with the very objectionable torsional effect that I have pointed out; it will necessitate, however, either a slight raising of the grade or the lowering of the trusses a few inches. If under each end of each floor beam there be placed a small pin, say $2\frac{1}{2}''$ or $2\frac{3}{4}''$ in diameter, having its axis horizontal and lying in the central plane of the truss, and if proper bearings both on the under side of the floor beam and above the chord be provided, the object will be accomplished. Each bearing could be made of two pieces of angle-iron rivetted to a plate bent into channel shape, so as to form a double T. The head of this T would be rivetted to the upper side of the bottom chord, and the pin would pass through holes bored in the two stems. Another plate bent into channel form should be rivetted to the under side of the floor beam at the end, and a hole should be bored through the vertical flanges thereof. In order to reduce the thickness of the bent plate, the circumference of the hole might cut into its web about an eighth of an inch. By this means the load on each beam will be applied in the central planes of the trusses, and the objectionable torsional effect will be avoided. The pins will hold down the floor beams in case of an upward wind pressure.

These improvements have been merely sketched out, but the description will be sufficient to enable you to make the changes should you ever find them necessary. It is not likely that such troublesome and expensive improvements will be attempted until the bridges show signs of failure; and then it might be better to replace them by entirely new structures. I would, however, advise the immediate use of the lateral system and side bracing described and the adoption of my arrangement of ties and guard rails.

The bridges should be watched carefully to detect signs of failure according to the system described in the Memoir. When the rivets begin to work loose, and when any members show the slightest evidence of bending, then look out for disaster.

It would be a very wise precaution if the Railway Department would so alter the time schedule on the Tôkyô-Yokohama Railway as to avoid having trains meet on the Kawasaki bridge. Two benefits would result therefrom; first, the structure would last longer, and second, if an accident should occur, it would involve the loss of one train only.

These few remarks will, I hope, close the bridge discussion.

That both it and the Memoir may in the years to come prove of real, practical benefit to our profession in this country is, Gentlemen, the earnest wish of

Yours faithfully, J. A. L. WADDELL.

Tôkyô, February 24th, 1886.

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