The Author. was the case at home. The remarks of Sir Benjamin Baker upon the Britannia Bridge were of especial interest. Mr. Fairbairn, whilst condemning the use of chains as a permanent auxiliary support for the tubes, had yet admitted their possible value as a temporary aid in the construction, and this consideration, apart from Mr. Hodgkinson's advice, might have warranted the carrying up of the piers to their present height. Without altering the design of the masonry, he had endeavoured in *Figs. 52* to show, in the one case (B), what might have been the appearance of the bridge had auxiliary chains been employed, and in the other (C), its possible appearance had the employment of the chains never been suggested. It was perhaps fortunate, all things considered, that the bridge had been left in its present state, as the presence of the chains, although creating a by no means ugly impression, could scarcely be reconciled with the type of girder to be supported. On the other hand, had the piers been built as in *Figs. 52* (C), or more probably been terminated at the level of the lower boom, nothing would have redeemed the structure from taking rank with the very large class of ordinary supported-girder bridges.

Correspondence.

Mr. Bache. Mr. ALFRED BACHE remarked that, where a steeply inclined roadway was carried over a stone bridge, in which the bed-joints of the masonry adhered to the horizontal in the spandrels and face-work generally, it was suggested at page 153 to adopt a neat stepped parapet, in which the courses might retain their horizontality. Such an outline for the parapet, he feared, would present a somewhat bald appearance; and he suggested that, if the gradations were marked by a castellated or embattled outline, instead of by bare steps, the general effect would be enhanced and relieved of stiffness, while the courses would still be kept horizontal throughout the entire length of the sloping parapet. In *Fig. 18* the appearance, he feared, would hardly be improved by increasing the height of the land arches. The objection to the present design seemed to him to be the apparent weakening of the abutments by the occurrence of the existing land arches just where the thrust of the main arch seemed to come. If the land arches were carried up higher behind the spandrels of the main arch, the apparent

weakening of the abutments would seemingly be aggravated thereby. The land arches, presumably a necessity, appeared indeed to form the one objectionable feature in what looked otherwise an admirable design. The Brooklyn Bridge [1] was referred to in the Paper as an example of a rigid suspension bridge presenting a satisfactory appearance. It would be of interest, he thought, if a sketch of it could be added to the illustrations accompanying the Paper, in order that the Author's eulogy might be fully appreciated by those who did not carry this particular bridge in their mind's eye. No view of it seemed hitherto to have been included in the Institution "Proceedings," notwithstanding the renown of its river span of 1,595½ feet. Among the lofty viaducts in iron and steel which were carried over deep valleys on built-up metal piers, it might not be out of place to recall one of the earliest and most elegant in this country—namely, the Crumlin Viaduct,[2] near Newport, Monmouthshire, carrying the Great Western Railway between Pontypool Road and Tredegar Junction across the valley of the River Ebbw in seven spans of 150 feet each at a maximum height of 200 feet. The main girders were Warren trusses, each 14½ feet deep. The piers were built up of hollow cast-iron columns braced in tiers, and tapered upwards with a batter which gave the impression of stability combined with lightness. The whole structure, completed in 1856, presented a welcome appearance of harmonious design, and stood out in highly pleasing and artistic contrast with its romantic surroundings. Regarding the Menai Suspension Bridge as almost outside the pale of æsthetic criticism, the Author added that the appearance of the land arches was especially acceptable from their exceeding beauty of proportion. A contrary opinion had been expressed half a century ago respecting the pyramidal piers and the arches, in the following words [3]:— Mr. Bache.

"If this masonry merits attention on account of its bulk and height—for the piers are 153 feet high—it cannot be said to do so on account of any tasteful disposition; as a piece of architecture it contrasts strikingly with the simple and elegant stonework of Fribourg Bridge. . . . The curve of the chains, at all times a beautiful object to the eye, lends to it a grace which makes it an orna-

[1] Minutes of Proceedings Inst. C.E., 1877, vol. li. p. 296; and 1883, vol. lxxii. p. 9.

[2] Minutes of Proceedings Inst. C.E., 1880, vol. lxiii. p. 189.

[3] "Dynamics, Construction of Machinery, Equilibrium of Structures, and the Strength of Materials," by G. Finden Warr, pp. 221 and 223. London, Robert Baldwin, 1851.

Mr. Bache.

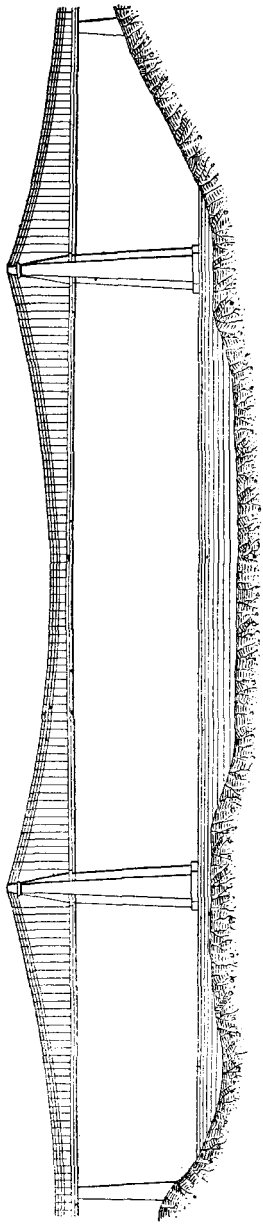


Fig. 53.

ment to the noble strait and its charming woody banks; to this effect however the side arches add nothing, as, like the pyramids, they are by no means pleasing or well formed."

Applying however the principle laid down by the Author for the first of the two alternative ways in which a truly æsthetic result might be achieved, it seemed to Mr. Bache that the land arches were wholly redundant, and that the elegance and beauty of proportion of the structure as a true suspension bridge would be enhanced by their absence. The length of the longest roadway, over the four land arches on the Anglesey side, was not more than half the main span of 580 feet;[1] hence the chains, which were strong enough to carry the main span, were strong enough to carry the two side spans also, without the land arches. In the existing structure, where the land arches carried the roadway; the rods which supported the central span lost their suspending function over the land arches, and became tie-rods or holding-down bolts for constraining the chains to keep to the proper catenary curve over the land arches; they thus sustained the same tension as they would have had to do if they had been made to carry the roadway of the side spans. The land arches were consequently superfluous; and the improved artistic appearance of the true suspension bridge, which would be realised by their absence, was illustrated by *Fig. 53*, as contrasted with Fig. 40, Plate 3. The elegance of the Conway Suspension Bridge was not marred by any arches in the approaches at either

[1] Minutes of Proceedings Inst. C.E., 1846, vol. v. p. 32.

end, though obscured by the adjacent tubular railway bridge. A beautiful example, unimpaired either by side arches or by any other incongruity, was the Clifton Suspension Bridge,[1] of 702 feet span, over the Avon at Bristol, which resembled and rivalled the celebrated Fribourg Suspension Bridge [2] crossing the valley of the Sarine in a span of 896 feet. Mr. Bache.

Mr. M. J. BUTLER considered that the Author had laid down with truth and accuracy the principles which should guide an engineer in the design of any structure. Nevertheless he ventured to submit that many of the criticisms made against the lack of the beautiful in engineering construction were not based upon right principles. "The eye seeth only what the eye bringeth the means of seeing," hence a student of the art of the past, when stone formed the chief building material, looking at a modern steel structure with its rectangular lines, was apt to consider the latter an ugly structure. Stone did not lend itself to rectangular construction, and the natural way to utilise the strength of the material was to put in arches of some form of curve: as nearly all natural surfaces were curved it had grown to be almost a maxim that to be beautiful a structure must be of the arch type. Yet to an engineer cognisant of the forces at work, and of the structural arrangements required to resist them safely, the curved surface might be ugly. It would seem that any structure designed on lines of true economy, with the utmost simplicity and with the fewest number of parts, was a beautiful thing. Yet such designs as the Sukkur and Jubilee Bridges illustrated in the Paper were irremediably ugly. The new Inter-Provincial Bridge at Ottawa was by no means a beautiful one, although the site was one which demanded some attention to æsthetics, lying as it did under the shadow of Parliament Hill. The long flat triangular lower chord of the cantilever was the offending member. The general appearance also lacked a satisfactory balance about the great span. The bridge itself was a remarkable and notable one, but it failed in the matter of beauty. Obedience to the old rule, "Decorate your construction, but do not construct decoration," would generally result in satisfactory treatment. Mr. Butler.

Mr. THOMAS C. CLARKE, observed that it had been said by Sir Henry Wotton that the essentials of good building were "firmness, commodity, and delight." The essentials of bridge construction were the same. Firmness was indispensable. The adaptation Mr. Clarke.

[1] Minutes of Proceedings Inst. C.E., 1867, vol. xxvi. p. 243.
[2] *Ibid*, 1881, vol. lxvi. p. 389.

Mr. Clarke. to uses, which Wotton called commodity, came next. The æsthetic quality, which he had called "delight," came from just proportion, first of all, and next from that ornamentation which was derived from the actual construction, modified with elegance, but not departing from truth. It differed greatly from some of the architecture of to-day, which was deceptive, and tried to make a thing look like something which it was not—a humble chapel like a Greek temple, for instance. On the other hand, the soul of an ancient style might be infused into a modern building, as was seen in the Town Hall at Liverpool, which was as fine a specimen of the Greek style as Athens itself could show. Fig. 3 was given by the Author as an illustration of the true treatment, while Fig. 4, was a kind of tailor's architecture with too many trimmings. The Alexander III. Bridge had a graceful outline, and would have been fine if its architect had known when to stop, and had omitted the decorative treatment of its spandrels. Festoons did not belong to engineering construction, as they were merely applied ornamentation, like that on a lady's dress. For bare and unadorned ugliness the Sukkur Bridge surpassed all others, while the Britannia Bridge was one of the finest specimens of bridge architecture in the world. Roman bridges and aqueducts showed both scientific and æsthetic construction. The massive construction of the Roman bridges made them very effective. The long lines of round arches of the aqueducts were not monotonous, and harmonized with the lines of the landscape. The massiveness of ancient architecture gave a great effect of strength, but this style could not be followed in the present time. The modern engineer was governed by considerations of economy, and did not dare to use more material than his strain-sheets called for. The four great columns supporting the dome of St. Peter's were each of them as large as the church of Trinita dei Monti at Rome. An engineer could have carried the weight of the dome by four steel columns 6 feet in diameter, but every one would have cried out in horror at the sight. Perhaps Emerson had had a suspicion of this when he had said that the architect of St. Peter's "builded better than he knew." Engineers said that architects put in too much material, while architects contended that engineers did not put in enough to answer æsthetic requirements. It was what Voltaire called "Le superflu, chose necessaire," that gave architecture its beauty. The most successful union of æsthetic and scientific construction ever reached was found in the northern mediæval cathedrals. It would be an excellent subject for a prize essay for students, to produce from actual measurements and calculations strain-sheets of such

cathedrals as those of Amiens, Rheims, or of Westminster Abbey. Ruskin had once said that machinery was hideous. If so, it was because it was a bare skeleton. A man, a horse and a bird were types of the best-designed machinery, and they had beauty because their skeletons were draped with flesh. A girder-bridge was ugly because it was a bare skeleton. The examples of open-work steel construction given by the Author seemed to show this. Some things, however, could be done. For short spans Nature's method could be followed; a useful skeleton could be built within and covered with concrete disposed in graceful lines. As an example of this he called attention to the Memorial Bridge at Washington.[1] When the span of the arch became too large for this treatment, its own lines, if of due proportion, would give it sufficient æsthetic beauty, as, for instance, the arched bridge at Niagara with spandrel-bracing. Where a level girder-bridge had to be used, the best treatment was to make it as simple as possible, and to concentrate all the ornament on the balustrade and cornice which was near to the eye. An example of such treatment was found in the Girard Avenue Bridge at Philadelphia.[2] Where the requirements were for a long low bridge with no movable draw, the bridge at Geneva near the outlet of the Lake, consisting of many segmental arches, was one of the best examples. If bridges of very long span were necessary, the graceful outline of a suspension bridge, not distorted from its natural curve by bracing, gave the most satisfactory result. If the span was within the limits of cantilever construction, the same curves should be followed, making the central suspended span level, and tangential to the curves, and by no means with an arched upper member. Mr. Clarke.

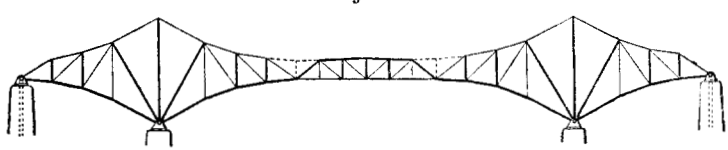
Mr. E. G. Coker remarked that the view expressed by the Author that a pleasing effect in a bridge structure might be produced "in an otherwise distasteful appearance by a judicious application of ornament in such a manner as to hide the bare constructive detail, without at the same time effacing the leading features of the general structural design" did not appear to be a commendable one, as a structure if not beautiful in itself could not be made so by any application of ornament. One of the essentials of beauty in a bridge structure was to attain the simplest and most economical distribution of material which expressed the purpose of the structure. The evolution in the Mr. Coker.

[1] *Engineering Record*, 13 October, 1900.

[2] *Engineering*, vol. xx. p. 379.

Mr. Coker. design of bridges tended to produce a form which satisfied this criterion, and during the last few years this development had been very marked in the design of cantilever bridges. Recent designs by American engineers had shown that some agreement had been arrived at with regard to this type, and although it was probably only a stage in the march towards perfection, yet it appeared to be a great advance upon early work, and to fulfil the condition mentioned above. The characteristic features of recent American designs were illustrated by a diagram for a through bridge, *Fig. 54.* The purpose and design of the bridge were here strongly marked; the break of continuity at the ends of the cantilever arms was emphasized, as it should be; the gradual diminution in depth of the anchor- and cantilever-arms conformed to regular curves which merged into those of the central girder; the balance of the arms was preserved by their equality; and the appearance of stability was assured by massive end piers.

Fig. 54.



Mr. Crowell. Mr. Foster Crowell, of New York, thought it might be admitted that the quality of beauty has not apparently been sought for usually by the bridge designer, but it was questionable whether that had been due so much to apathy and a limited choice of material, suggested by the Author, as to undeveloped conditions of popular taste and appreciation in this regard. As a rule, and confining his remarks to his own country, he thought that the engineer, in designing a bridge, looked primarily at but three things, which were capacity, consistent strength, and economy; and when the structure had been completed, the criticisms and discussions of his brother engineers were directed to these three features only. To point out the ugliness of a man's bridge would be viewed much in the light of a personal attack, and certainly, at the least, would be deemed hypercritical. On this account he considered the Author's temperate and thoughtful presentation of a plea for æsthetic treatment to be both timely and valuable; and his references to the American examples which he included in his comments, and with which Mr. Crowell was familiar, indicated thorough study and accurate observation. It did not follow,

Mr. Crowell.

however, that because an engineer had built a bridge which was ugly from the æsthetic point of view, he had not done what was distinctly the best thing to do under the governing circumstances, nor that he himself was either unaware or disregardful of its short-comings. Moreover, many bridge engineers emphatically refused to consider beauty, in a sensual sense, as a necessary adjunct of design; they claimed that there was such a thing as an intellectually perceived beauty of usefulness, which consisted in the evident application of successful means to an end, and that "whatever looks right is right"; that shibboleth being the engineering equivalent for the old proverb, "handsome is as handsome does." It was needless to point out its error, or to remind members of the profession that such perceptiveness, where it existed, was an educated faculty not shared outside of a limited class. Ruskin's analysis of beauty to the eye, and its effect upon mind and character, was useful as a negative to the proposition, and it was sufficient to turn to any other department in architecture in order to be convinced of its falsity. Yet it probably had no little influence in perpetuating ugliness in bridge design. Finally there was natural conservatism to contend with. In America there were few beautiful bridges, among the larger structures at least, but already there were abundant signs of an awakening by the public to an appreciation of the usefulness of beauty in many ways; and in some of the more recent bridge-designs a disposition had been manifested no longer to ignore the claims of beauty *per se* as an enhancement of excellence therein; public bodies and the press too had begun to demand that bridges should be manifestly beautiful. Happily, in America, the era of redundant, so-called ornamentation, to which the Author had referred, with all its atrocities of added extraneous "decorations," or disguises, or concealments of the real design, was passing away. Such monstrosities were no longer possible, for instance, as the Callowhill Street Bridge over the Schuylkill, in Philadelphia, a 350-foot rectilinear iron-truss, double-decked single span, which was boxed in with sheet iron and painted to simulate cast-iron, so as to appear as a colonnade viaduct; and as if its purpose were to support the upper deck with a heavy stream of traffic whilst its feet stood upon nothing but air, the ridiculous effect was further emphasized by the very pronounced camber of the truss, to which the colonnade conformed. This treatment must not be taken as indicative of usual eccentricities of American design, as it was probably an extreme case, but it served to illustrate the depths of engineering depravity possible, even in a city like Philadelphia. With the passing away

Mr. Crowell. of the meretricious and extraneous parasitic decorations had come a vast improvement in workmanship and dimensioning of all classes of metal bridges, so that even the plainer forms of structure had acquired a neatness and fitness that was akin to elegance. Taking all things into consideration, then, although the bridges of the past were, as a rule, far from beautiful, there would seem to be ground for the hope that as the engineer became convinced of the existence of popular appreciation of beautiful bridges he would find means to gratify it; for, to paraphrase Keats, "A bridge of beauty is a joy for ever."

Messrs. De Rudder and Van Bogaert.

Messrs. DE RUDDER and VAN BOGAERT, of Brussels, remarked that the principal, and perhaps the only reason why the older masonry bridges and modern works in metal were not æsthetic, was that they had been designed by engineers who had no notion of Art, and it must be admitted that it would be surprising if it were otherwise. The course of scientific studies needed for the engineering profession, already long and arduous, did not permit an engineer to study Art, and to become an artist as well as an engineer. It must not be forgotten that to excel in any art it was necessary for a man to devote the whole of his time to it. It was easier to acquire enough knowledge and taste to be able to judge the work of an artist; but even this capacity was by no means common, and it must be admitted that an engineer possessing, as the result of a study of Art, sufficient taste to judge an artistic work of construction, was not often met with. In fact, they considered that the artist-engineer was a myth, and the æsthetic engineer a *rara avis*; but they hoped that the future held in store many of the latter, and even one or two of the former. This did not prevent the rules indicated by the Author from being useful, and they would perhaps restrain engineers from erring very seriously; but no amount of observation of rules would produce a work of art. Turning to some of the points raised in the Paper, they did not consider that the design of masonry bridges had reached its highest point; they maintained that in the past 30 years great progress had been made in this form of construction and in its architectural treatment, and they cited as instances the bridges of Lavour, Antoinette, Castelet, Céret, and Gour-Noir in France, having openings varying between 40 metres and 60 metres; the almost similar viaducts of Jaremeze, Worochts, and Jamna in Austria; the concrete bridges in Wurtemburg with hinged arches; and lastly the Luxemburg viaduct, with a span exceeding 80 metres, in course of construction. Apparently engineers were returning somewhat to masonry bridges, which

had many advantages over those in metal. As the Author stated, their appearance was better, and this was due to the great simplicity of their lines. Moreover they scarcely afforded an opportunity for the engineer to go very far wrong. Large iron bridges and viaducts, with some exceptions, had the appearance of huge scaffoldings, the eye losing itself in the crowds of thin lines, which intermingled and crossed one another in every direction. It was impossible to judge such a structure from a small drawing of its elevation; the simple lines of the drawing became very complicated in perspective, and the anticipated effect was not realised. The metal bridges which were most satisfactory to the eye were arched bridges without spandrel-bracing, and unstiffened suspension bridges. These two types had very simple lines which, exclusive of the arch, ran in only two directions, viz., horizontal and vertical, like masonry bridges. Messrs. De Rudder and Van Bogaert.

Professor T. CLAXTON FIDLER observed that it had been the fashion with art-critics to assume that engineers were indifferent to the æsthetic treatment of their structures, but it was quite certain that every engineer would feel a deep instinctive interest in the subject which the Author had introduced, although he might shrink from laying down any set of principles that would pretend to rank as canons in art-criticism. It was indeed delightfully impossible to frame any rules for the æsthetic treatment of bridge structures. Architects had generally agreed that every kind of constructed ornamentation was bad, and yet the force of lingering association was constantly impelling them to reproduce some form of inappropriate ornament which they admired in bygone styles of architecture. The dentils and triglyphs, which seemed to have sprung from an extinct style of timber construction, were reproduced as "constructed ornament" upon the stonework of Greek temples, and if they re-appeared once more in cast iron upon the sides of a nineteenth-century bridge, the engineer might at least feel that he was sinning in very good company with the builders of the Parthenon. Amongst engineers, however, it would generally be felt that the greatest dignity in bridge architecture was that which was sometimes happily attained in a structure of unadorned simplicity, in which every line told by reason of its perfect fitness. The Eddystone Lighthouse might be confidently referred to as an engineering structure which expressed this feeling with the highest refinement. And with a similar simplicity of outline the builders of stone bridges, from the Romans downwards, had succeeded in producing structures Prof. Fidler.

Prof. Fidler. which were almost always picturesque, while some of them must rank as fine architectural designs. It could scarcely be said, perhaps, that the ironworker had maintained the same degree of success since the time when he had had to take over the functions of *Pontifex Maximus*, but he had had many difficulties to contend with. It had been impossible to preserve the broad simplicity of structural form—except in the single case of the chain suspension bridge—and in most cases the structure had become a complicated tangle of struts and ties, possessing no eloquence of structural meaning for the general observer. The fitness of each part for its work had not been sufficiently apparent to become an element of beauty, and indeed had been obvious only to the technical mind saturated with text-book formulas. Perhaps it was just this dominance of scientific ideals which had formed the main difficulty; for the æsthetic effect of any structure, good or bad, depended upon what it revealed as to the mind and intentions of the constructor, and if it revealed nothing but what might be suggested by a diagram in graphic statics it could hardly be beautiful. But the ironworker had very good reasons to urge in his defence. He had been so much occupied hitherto in the problem of building strongly and building economically that he had been unable to allow his mind to wander from these inexorable conditions. Under freer and more favourable auspices it was still possible that he might develop a worthy style of architecture in steel, and the structures of the present transitory age might then be described, amongst other antiquities, as examples of the "text-book" style of bridge architecture.

Mr. Fülscher. Mr. FÜLSCHER, of Berlin, considered that the Author's suggestions in regard to the architectonic treatment of bridge structures, whether of stone, or iron, or both combined, were well worthy of consideration. For many years past it had been, he might almost say, a rule in Germany that, in the preparation of designs for bridges of considerable size, especially where it was a question of suiting a structure to the character of the surrounding landscape or of existing buildings in the vicinity of the bridge, the engineer should unite with a capable architect, so that all questions relating to the treatment of details of construction fell to the share of the latter. In this way the designs of the bridges over the North Sea and Baltic Canal referred to in the Paper, and, so far as he was aware, also of all the newer bridges over the Rhine which were of notably handsome appearance, had been evolved; and as it was the exception for an engineer to be also a master in archi-

tecture the general adoption of this practice might be recommended. Mr. Fülscher.

Mr. A. GOUPIL, of Paris, congratulated the Author on the happy manner in which he had treated a delicate subject. As an example of a form of bridge construction suited to various spans and combining lightness of the girders with æsthetic treatment of outlines, he forwarded a short description of the viaduct carrying the Paris-Versailles line of the Western Railway of France over the Rue de Alésia, in Paris, constructed on a system which had been used by the company in special cases, and termed a *pont à béquilles*. The elevation of this viaduct was shown in *Fig. 55*. The girders were practically straight and were united to vertical pillars, the angle between them being rounded off according to the necessities of each case. With this system it was possible to give a very small depth to the floor, and consequently to reduce the number of cross-girders or even to omit them. In the example illustrated, which had a clear span of 20 metres, the depth of the girders at the middle was only 1·1 metre although the load was considerable, the sleepers being carried on ballast. Mr. Goupil.

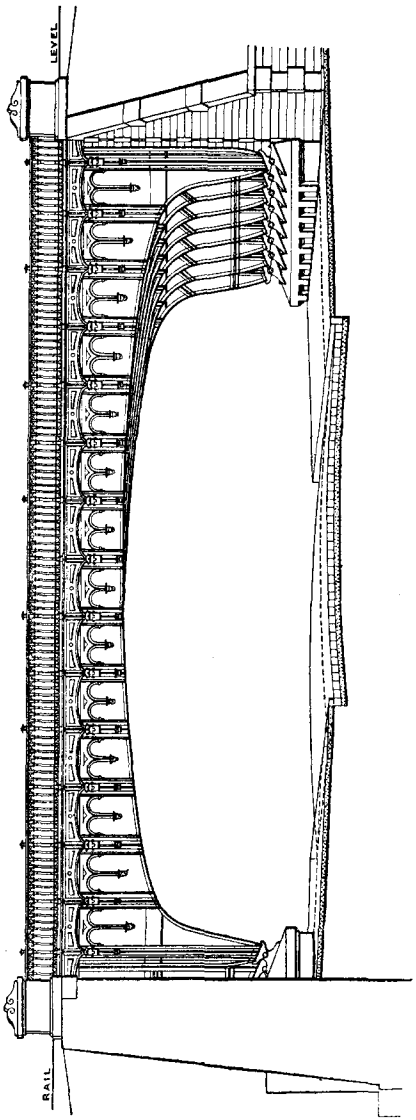


Fig. 55.

Mr. Gribble. Mr. T. G. GRIBBLE thought it was impossible to criticise the appearance of large bridges by means of skeleton diagrams. The irresistible sentiment of admiration which arose from the sight of a great achievement of human intelligence and skill was not evoked by a collection of geometrical figures. Criticism, without having seen a bridge and retaining in the mind's eye a vivid picture of it and its surroundings, was criticism not of the structure but of its skeleton. He could not at all endorse the criticism which disparaged the towers of the Brooklyn Bridge. Whether from the shore or from a steamer, the bridge had left upon his mind an indelible picture of all that was chaste and beautiful. The Sukkur Bridge had been the subject of a great deal of severe criticism on the part of the æsthetes. He could not pretend to offer any opinion, because, like many of its severest critics, he had only seen it when in course of erection at the Isle of Dogs. He could, however, quite understand an engineer feeling admiration for the actual structure if he were looking at the great span from a suitable point of view. Æsthetic criticism must be intelligent, and similar to a true appreciation of Nature. Imagine a naturalist and a hairdresser beholding for the first time a hippopotamus, the man of science delighted, the barber disgusted. Then, with intelligence, there must be also trustfulness in criticism. Where a great structure lacked symmetry in some particular point, it appealed by its own merits for confidence in its designer. It would be unworthy of the engineer to charge him with fancifulness, and therefore the intelligent mind at once began to seek out the cause, and while so engaged the eye forgot to be offended. Again, æsthetic criticism must be up to date. He quite agreed with Mr. Blyth's criticism of the Glasgow Corporation in their renewal of Telford's Bridge at the Broomielaw, described in his recent Paper.[1] If their veneration for the antique had gone no further than to preserve or widen the structure it would have been very commendable in hardheaded business men, but to "resurrect" an antique structure was, he thought, quite indefensible, not to say snobbish. Present-day bridges could not be looked at with the eye of a Michael Angelo nor even of a Telford; the present was the Iron Age, and had its canons of taste equally with the Byzantine or Gothic Ages; canons in which utility greatly transcended adornment, but which embraced symmetry, simplicity and appropriateness. But although bridge-building should be strenuously defended

[1] Minutes of Proceedings Inst. C.E., vol. cxliv. p. 6.

against unintelligent criticism, it might be frankly admitted that much of the unsymmetrical outline and ugliness in detail was avoidable. Comparing for instance the Viaur Viaduct with the Niagara Falls and Clifton Arch, the reason given by the engineer of the latter structure for the painful side spaces was that the view of the Falls might not be obstructed by the bridge. Surely the tourist would have forgiven him if he had put up a bridge of the Viaur type! Mr. Gribble.

Mr. W. R. HUTTON, having in mind the adage, *De gustibus non est disputandum*, thought it was unnecessary to comment in detail upon the Author's rules for æsthetic design of bridge structures. Some of them would condemn the most admired bridges of ancient and modern times, while many of the illustrations represented works which were not recognised as models of æsthetic design. In bridges of masonry the general arrangement, the proportions, and the method of construction were fundamental, and these were generally sufficient to produce a good effect. The arch should be detached from the spandrels by a marked projection or otherwise, the level of the roadway should be indicated by a string-course more or less moulded according to the conditions of the case, and a long line of parapet, unbroken by pedestals or supports, should be avoided. The straight truss, or ordinary cantilever, for railway or highway use was, as Mr. G. S. Morison had expressed it, a mere tool of transportation, and, as a rule, but little care was given to its æsthetic effects. The cantilever was popularly considered the most intractable form. But the possibilities of art were very great. An art-critic who wrote upon bridges had asked if a handsome cantilever bridge were possible. On being referred to the Pont Mirabeau in Paris, he had declared it to be the most beautiful bridge ever built. In metal arches the Author's test seemed to consist in dissimilarity to a masonry arch, and as, in the latter, the roadway could not readily be carried below the soffit of the arch, he selected the Grünenthal Bridge, which possessed that merit, as the typical æsthetic design. The similarity of the St. Louis Bridge to a stone arch was not easily perceived, although the Author recognized it. It was objected to this and to the Washington Bridge that the proportion of rise to span was such as was frequently observed in masonry structures, and the crowding of the spandrels with vertical supports emphasized the resemblance. The Washington Bridge also unfortunately required stiffeners on its broad web, and flanges to connect its segments, and these seemed to complete the deception. Happily these bridges stood upon their own merits and needed no defence. Yet one word might Mr. Hutton.

Mr Hutton. be written in explanation. The solid web of the Washington arch was characteristic of solidity and repose. If it had been a braced rib of open work like the Niagara Falls and Clifton arch, it would have been proper to show it as resting on the pin. With the solid web, it was essential to its character that it should be carried full width to the skewbacks. There was no deception, the pin being plainly indicated by the converging flanges of the rib and by the heavy framing of the pedestals. In his remarks on the magnificent Niagara Falls and Clifton arch (Fig. 32), the Author observed that in the actual bridge the rectangular panels were of course provided with diagonal braces. If the rectangular panels referred to were those of the spandrels in elevation, they were, of course, not provided with diagonal braces, which would be foreign to the character of the construction.

Prof. Johnson. Professor J. B. JOHNSON was very much gratified to find that the subject was beginning to receive the attention it deserved at the hands of engineers. No class of citizens merited such severe condemnation for outraging the artistic sense of the cultivated portion of the people as civil engineers in their designs for bridges. A bridge was usually placed in a conspicuous position, where, of necessity, it attracted observation and invited criticism; and the relative permanence of the structure also added to the necessity for careful designing. On the contrary, many of the ablest civil engineers, in America at least, had ignored and flouted all claims upon them for artistic effect, and had rather taken a savage delight in perpetrating monstrosities and thrusting them upon a long-suffering public. It was high time the members of the profession should protest against such indifference, for the protection of their own reputations and in the interests of a more wholesome public sentiment in such matters. As early as 1866, Professor R. Baumeister had begun writing vigorously upon this subject, but, as his works had not been translated into English, his writings had had little influence in English-speaking countries. When Professor Johnson, as joint author, had published a work on framed structures [1] in 1893, a chapter, prepared by Mr. David A. Molitor, had been devoted to this subject, and this had been said to be the first attempt in the English language to treat the subject of the æsthetic designing of civil engineering structures. Mr. Molitor had drawn largely from Baumeister and other German sources, but had added considerable original matter. Since the publication of this work a very noticeable improvement

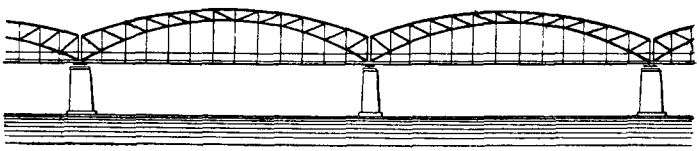
[1] "Modern Framed Structures." John Wiley and Sons, New York.

had been effected in America in the artistic design of bridges, and it was believed this could be largely traced to the chapter on that subject. It would require, however, long-continued agitation and considerable education in this field before engineers would attain to a satisfactory standard in æsthetic designing. He could in general heartily endorse the views of the Author as expressed in the Paper. Prof. Johnson.

Mr. G. KEMMANN, of Berlin, observed that the able manner in which the subject of the architectural treatment of bridges had been dealt with by the Author called for but few remarks. In Germany men of the highest rank in the profession as it had stood about two decades ago, like Gerber and Schwedler, had paid the greatest attention to the economical side of the art of bridge-building, but had hardly considered the question of beauty to be an all-important one. Gerber's bridge over the Main at Hassfurt, he believed, had never yet been surpassed in the matter of unsightliness. The principle of placing in an iron bridge only exactly the amount of material absolutely required by a special load-diagram ruling at the time of designing had been superseded. The consideration paid to future needs and the increase in wealth had gone far to strengthen the influence of those who were striving after the extended application of the rules of æsthetics to this class of engineering work; but the railways in Germany were now suffering to a certain extent from the consequences of a wrong policy, and were obliged to strengthen their structures to meet the increased axle-load of the engines. As to the metal arch, which above all lent itself to artistic treatment in bridge design, he might say that in Germany the construction of metal arch bridges had been developed on a large scale, and that that country surpassed all others in the number, variety and perfection of such structures; whereas the suspension bridge, though also exceedingly well suited for artistic treatment, had not come to the front at all. The Müngsten Bridge and its successors, and the Niagara Falls and Clifton Bridge, gave proof of the progress in the science of working out strains. They testified to the application of modern scientific rules, which opened up a wider field for artistic treatment. In this direction a trussed arch with a tie rod was much in favour in Germany. A charming example of such an arrangement was to be seen in Berlin (Brücke am Mühlendamm); large span bridges on the same principle were those over the Süder Elbe between Harburg and Wilhelmsburg and over the Mosel at Trarbach (*Fig. 56*). Mr. Lauter, of Frankfort-on-Main, deserved not a little praise for Mr. Kemmann.

Mr. Kemmann. having introduced a novel feature into the construction of street bridges with several openings crossing rivers. He gave the platform of the bridge a parabolic form, with a certain rise in the centre. Gaining thus in clear height above water-level, he at the same time gave a strong idea of the spanning of the shore-interval. This departure tended to further improvement in the design, as it afforded opportunity for gradually diminishing the width of the spans towards the ends of the bridge. Excellent specimens of this type were the Obermainbrücke at Frankfort-on-Main (built by Schmick after Lauter's ideas), the bridges at Offenbach, Hannöversch Münden, Mainz (over the Rhine, an extremely pleasing structure), &c. The same principle of variation in the width of the span was also well applicable where the abutments of the bridge were at different levels, such as at Basel, Switzerland. The Basel arched bridge was noted for the clever treatment of the difficulty of having an ascending platform. Here the width of span gradually increased from the lower end to the upper end.

Fig. 56.



Bridge Over the River Mosel at Trarbach.

Mr. Lincham. Mr. W. J. Lineham remarked that the importance of the subject of the Paper could scarcely be overrated, and if the Author's initiative would only be followed by other competent Papers dealing with bridges in their æsthetic sense, a great change might result in bridge design. It seemed unlikely that engineers would have to do with the masonry arched bridge in the future, so that any remarks upon it could only relate to the further beautifying of existing structures. Long horizontal lines should be broken by "refuges" supported on pillars more or less heavy. The lighter pillar in *Fig. 14* was well shaped, and would be strong enough for the purpose; but it appeared rather paltry in connection with the proportions of the bridge, and he would certainly prefer the ornamentation of Blackfriars Bridge, to which the Author had not referred. Mediæval architects had been very fond of excrescences on bridges, from refuges up to chapels, *e.g.*, the chantrey chapel on Wakefield Bridge. He fully agreed with the Author's condemnation of niches without statues, as in Fig. 2, Plate 2; niches had

Mr. Lineham.

been much used by the Romans, but the figures had never been absent. The Alexander III. Bridge was the latest and perhaps the most brilliant example of the small-span structure. The ornamentation was perfect and in thoroughly good taste, and it seemed doubtful whether the bridge could be improved in any particular. As regarded utility the bridge left very little head-room for the passing of boats, except near the centre, and even as a matter of beauty, a more elliptical form of arch would have served better. With the rise at his disposal, however, the engineer could scarcely have done otherwise. The one feeling that interfered with the perfect satisfaction of an educated observer was a fear that the rise was too small, and that a somewhat heavy load would assuredly cause collapse. This feeling became strengthened on walking across the bridge itself and observing the large amount of vibration. A bridge of recent construction between Passy and Auteuil had always appeared to Mr. Lineham to be admirable. The river was here very wide, and there were two piers in the water, but the spans were large and of low rise, as in the example previously mentioned. The curves were much finer, in his opinion, than the arc of the Alexander III. Bridge, and the extreme simplicity of the structure, unornamented except by colossal bronze sitting figures at the piers, was very charming. In dealing with large steel bridges many serious difficulties arose, which in most cases were insuperable; and the Author might have considerably aided the discussion of the subject had he treated these bridges by means of perspective views. It appeared to Mr. Lineham impossible to obtain a real idea of the effect of one of these large structures on the mind of the observer, except by means of photographs taken from the usual points of view. Even then the idea of grandeur due to size was not obtained, but it might be noticed how beautifully the lines of a stream were cut by the curves of the metal arches, as in the Berne Bridge; the high-level bridge at Newcastle might even be admired as seen from the quay, broken by the lines of the shipping. Suitability to surroundings was the most important point of all in the æsthetic treatment of bridges, and all premiated designs should be set in a model of the landscape, tastefully finished by good artists, so that views might be obtained from all likely points of vantage. He was aware that Mr. Eiffel had had landscapes painted on the flat behind his bridge-models, but he doubted if all the foregoing suggestions were ever carried out. Taken from their surroundings, he feared certain bridges, such as the Sukkur, the Poughkeepsie, the Borcea, and Saltash, could not be made beautiful by any treatment whatever; and some had no

Mr. Lineham. beauty even in their native landscape. The Forth Bridge appeared to him to have a distinct beauty of its own, and this was most probably due to the high economy of the structure. He had always thought that if a structure represented the utmost economy of material it must be essentially beautiful in line; for thus Nature would have built it, and then no one could have helped admiring it. The only difficulty in the way of the engineer-architect was that Nature was not in the habit of building bridges, and so he must needs deduce his lines from a consideration of what Nature would have done had she had a bridge to build. In this connection it was interesting to note *Fig. 43*, showing that the removal of a redundant member had the effect of improving the appearance. A bridge spanning a ravine might be so constructed as to appear to grow out of the landscape itself, and thus great harmony of line was obtained. Nothing illustrated his meaning so well as the simple but beautiful Garabit Viaduct (Fig. 35, Plate 3), where the supporting piers looked like two great pine trees, and the arch itself like branches of trees which had fallen forward till they met each other. Whether extra ornament might be applied to certain bridges would, he feared, always be a matter for debate. Yet, following Nature, whose forms were always perfect, there was a natural objection to abrupt endings, whether of base, capital, or springing. Cast-iron ornament was easily applied, but without great care it was apt to be patchy in appearance: and, on the other hand, it was often said that rolled bars and plates were unsuitable for decoration. For his own part, he thought an era of ornament in the latter material was opening up, of the future development of which engineers had but mere ideas; for, given a sufficient scale, the most charming growths could be imitated in section-bars. There was a staircase in the new "Grand Palais" at Paris which was so ornamented, and anyone who had seen it would admit the charm of these products of the section-rolls when directed by the eye of the artist. The Author deserved thanks for opening up this important subject.

Mr. Macdonald. Mr. CHARLES MACDONALD, of New York, remarked that the Author struck the key-note of æsthetic construction in his reference to the works of Nature as the true guide. A study of natural law led to the inevitable conclusion that the lines of least resistance were followed in every change which occurred in existing conditions, whether it were the growth of a tree, the flow of a river, or the slow but certain modification of mountain forms. Not a single particle of matter changed its position except upon such lines, with the result that each new combination was effected with a minimum expenditure of energy, and with the most

expressive, and therefore impressive, effects. To apply this rule to bridge construction, it was only necessary to determine the most scientifically economical combination of material to effect the desired result, and an outline would be found which, to the artistic eye, carried conviction that the beautiful had been combined with the good and the true. It was not enough to say that a bridge was a good bridge, in that it was strong enough to carry the required load. Any engineer who was familiar with the laws of statics could calculate the stresses and proportion the material for a given diagram in which the number of panels and relation of height to span was taken arbitrarily; and the result would be that the structure so proportioned would be as strong as might be desired for the required purpose. But, if the diagram so chosen did not present a pleasing appearance, it would be found that more material had been expended in meeting the requirements than would have been the case had a more scientific arrangement been adopted. A striking instance of this was to be observed in the change which had taken place in the design of simple fixed trusses, with a span of, say, 500 feet. The earlier practice had been parallel top and bottom chords with a proportion of span to height in the neighbourhood of 10 to 1; whereas now the accepted practice was to curve either one chord or the other, according to circumstance, thereby obtaining the same strength with less material. In this connection experience of the Hawkesbury Bridge might be referred to, as this was one of the structures mentioned in the Paper. The original design for this bridge had involved trusses with parallel chords and inclined end posts; before construction had actually commenced it had been found that by raising the top chord for the three centre panels (*Fig. 42*) a saving in material was effected; and before the bridge had been completed, further investigation had proved conclusively that an arched top chord, as in *Fig. 41*, would have resulted in a further saving, with a very evident improvement in appearance. It had been asserted that the cantilever type did not lend itself readily to artistic construction. Whilst it was true that most of the existing examples were open to this criticism, the cantilever must not be condemned for that reason alone. There were many situations in which a properly constructed cantilever would prove to be the most economical solution of the problem, and it therefore remained with the engineer to combine economy and beauty in his design. The relative lengths of projecting brackets and suspended span must first be determined on economic lines; after which the determination of the proper proportions of each became a simple problem. To begin with the suspended span;

Mr. Macdonald.

Mr. Macdonald. if the length warranted, the upper chord should be curved as in the case of a through bridge, for reasons already referred to in the case of simple fixed spans, inasmuch as the conditions were exactly similar. With the projecting bracket, whilst the economic proportion of height to length was a matter easily determined by calculation, there was no necessity for transmitting stresses by straight lines to the top of the tower and thence back to the anchorage, when a graceful curve would effect the same purpose; neither should the intermediate loads between the tower and the outer end of the bracket be counterbalanced entirely through the anchorage, when a more economical balance could be effected through corresponding intermediates in the anchor span. It should be obvious that the engineer must not attempt to apply the cantilever principle where other forms of construction would be more appropriate. It would be a breach of privilege, so to speak, to spend thus a client's money merely for the purpose of gratifying personal ambition. At least one notable example of this misapplied energy was mentioned in the Paper. Probably it never would be referred to as an artistic success. Stiffened suspension bridges for long spans were rapidly coming into notice where the limit of economy of the cantilever was exceeded. The proper proportions of steel towers and the suspension curvature were comparatively simple of determination; but the arrangement of the necessary stiffening-trusses was more complicated. The bridges across the East River, New York, had stiffening-trusses with parallel chords, but for railway traffic it would be difficult and expensive to secure the necessary rigidity by following these lines.

Mr. Morton. Mr. D. H. MORTON observed that Papers of the class to which that under discussion belonged seldom came before the Institution, but it might be worthy of consideration whether Papers and discussions of an abstract and academical character might with advantage appear more frequently in the "Proceedings," which were chiefly occupied by records of work accomplished. The Author was to be congratulated upon his courage in bringing forward a subject which, as he had indicated, had been much neglected by engineers, and which, when discussed at all, generally proved to be highly controversial. The practical suitability of a bridge or other similar structure to fulfil the functions for which it had been called into existence, were capable of proof, more or less definitive, by calculation, by test-loading, and by daily experience. When the æsthetic side of the subject was approached, the case was much altered. The discussion passed from the solid and utilitarian into the ethereal realm of taste, of the fine arts, in fact; and without some appreciation of fine art, and some systematised knowledge of

Mr. Morton.

the art of architecture, the engineer could hardly avoid producing structures which were frankly ugly. As the Author pointed out, this architectural knowledge was not to be used as a means of adding extraneous ornament in improper places, or of working up badly-copied architectural details on unsuitable materials. True decoration was never incongruous; enrichments on engineering works might readily be overdone, and in many cases they might very properly be dispensed with. Strength, dignity and simplicity were the characteristics of engineering works successfully treated; the leading essential or utilitarian features of the design were seized upon and accentuated, and a pleasing effect was produced by skilful and orderly arrangement, good grouping and proportions. All were acquainted with engineers who did not feel that they had any responsibility regarding the æsthetic side of their work; they were like men without the saving grace of humour, they did not know how much they missed in going through the world. But apart from such cases of arrested development, it was to be hoped that the majority of engineers aspired not only to meet the requirements of the Board of Trade, County Council, or Highways Committee, but to earn the approval of their brethren and of the community at large, by creating something which was capable of delighting the eye and the mind. Such aspirations could only be realised by men who had added the study of architecture to sound constructive experience, or who had been fortunate enough to secure the collaboration of an architect who was sufficiently broad-minded to enter heartily into the spirit of the general design, and to avoid the temptation to use the engineer's work merely as a scaffold on which to exhibit samples of his own affectations. Collaboration, however, was difficult. As the Author indicated, a few of the noblest engineering structures were a law unto themselves, because of their magnitude and because of the obvious difficulties which had had to be overcome in their construction; but such cases were few. Much of the engineer's work lay in urban districts, requiring treatment in harmony with architectural surroundings, or the blending of iron and steel ribs or girders with masonry piers or abutments. An engineer could not touch masonry above the surface of land or water without entering the domain of architecture, and if he would dabble in mouldings and classic orders, without having given some attention to the broad principles of the art, he would certainly produce results calculated to make accomplished architects gnash their teeth. The Author deserved the thanks of the Institution for having prepared a Paper which showed so clearly

Mr. Morton. that, in order to secure successful design, a knowledge of the fine arts must be included amongst the qualifications of the engineer.

Mr. Statham. Mr. H. HEATHCOTE STATHAM having had the honour recently of reading a Paper [1] before the Royal Institute of British Architects on "The Æsthetic Treatment of Engineering Structures," was naturally much interested in the subject. With the opinions expressed in the Author's able and thoughtful Paper he was generally in entire agreement; there were only two points on which he would raise a question. In regard to the pedestals (or, rather, pylons) which flanked the entry to the Alexander III. Bridge at Paris being too high in proportion to the line of the arch, they should not be regarded as part of the bridge design. They were monumental erections intended to give dignity to the bridge approaches (just as the Romans, in the bridge at St. Chamas, had erected an arch at each end with the same object); and, in connection with the Exhibition buildings, they had also the object of carrying on the architectural vista of the avenue from the art-palaces down to the Invalides, so as not to leave a gap where the river crossed. Secondly, he did not agree with the suggestion that piers built in a running river should be of the same design on the up-stream and the down-stream face. Some degree of projection on the down-stream side might be desirable to lessen scour; but inasmuch as character in a structure arose from its fitness to the practical conditions, it seemed absurd to design a pier in a running river, where the water-pressure was all in one direction, in the same way as a pier in a tidal river, where the water-pressure was in both directions alternately. Symmetry of structure was out of place where the forces exerted on opposite sides of the structure were entirely different. To take an example on a large scale, he would point to the character given to the Victoria Bridge over the St. Lawrence by the immense cut-water buttresses on the up-stream side; to repeat those on the down-stream side, merely for "symmetry," would mean waste of material and loss of character. What was true on a large scale was true on a small scale. The modern engineer who imitated stone structure in iron had been defended on the ground that the Greeks had imitated wooden structure in stone; but no one who had studied Greek architecture, or the history of architectural development generally, could regard such an idea as otherwise than palpably absurd. The Doric column was an entirely masonic form; its *origines* were to be traced in the sixteen-sided stone columns of Beni-Hassan and

[1] Journal of Proceedings R. I. B. A., vol. vi., 3rd Series, p. 385.

Deir-el-Bahari; and the farther back the matter was traced, as far as examples of the Doric column existed, the thicker and more massive were the columns. The entablature of the Doric order (and of that alone) showed indeed clear traces of its wooden origin, but in a form entirely "mason-ified," so to speak; it was not an imitation of wooden structure, but only a reminiscence of it, translated into stone. All architecture, for the matter of that, went back ultimately to the hut or the wigwam, if the connecting links were forthcoming. In regard to the general question, engineering structures might be classed under two heads: pure structure, and decorated structure. Pure structure, unreservedly displayed, could never be in bad taste; such structure was its own justification. Therefore he had no sympathy with architects who called the Forth Bridge, for instance, ugly; it was not beautiful in one sense of the word, certainly, it was not a decorative design, but it was a grand and stupendous structure, and as such ought to be interesting and attractive to everyone with any feeling for or knowledge of structure. Similarly with London Bridge, a grand structure of granite with scarcely any attempt at ornament, which was perfectly satisfactory to the eye. No doubt architects and artists would rightly prefer stone to steel where it could be used; its surfaces were broader, it was more monumental both in fact and in appearance, and it was harmonised with nature by weathering, and did not require painting. But the plainest and most uncompromising steel structure was preferable to a stone or granite one bedizened with bad and ill-designed ornament. No doubt occasions would arise when it was suitable and desirable that a bridge should be treated in a decorative manner; but this was not to be achieved either by giving it an archæological treatment, or by plastering on to it architectural details which had no reference to the structure. The Tower Bridge afforded a sad example of both mistakes. It had been supposed that because it was near a mediæval building, therefore it must be mediæval to match. There could not be a more absurd idea. The Tower of London (so far as the original work remained) represented the manner in which the men of that day had naturally built a fortress; the best way then known. To follow their example, the bridge should have been frankly designed and constructed in the best way now known. Instead of that, the real construction was masked by a gew-gaw architectural skin of modern-mediæval design, and suspension chains were made to appear to hang upon sham masonry towers which they would in fact rake down at once if the construction were what it appeared to the eye to be. The same mistake, in a less flagrant form, had

Mr. Statham.

Mr. Statham. been made in the case of Conway tubular bridge. On this head he might support his opinion by that of the late Mr. Gilbert Hamerton, a critic of not only English but European fame. Speaking of the Menai tubular bridge, Mr. Hamerton had said:—

> "The whole bridge is admirable as a work of art, though the art is very simple and severe. The long line of tube (which looks like a great beam) is fortunately broken by the piers of marble which are finished above the beam as towers, and the majesty that naturally belongs to a work of colossal size and weight is enhanced by the prudent use of some architectural adornment. The tubular bridge over the River Conway near the castle is less fortunate, because the neighbourhood of a great mediæval building led the architect of the bridge to adopt a castellated style for the entrances to the tubes—a style which might be more or less in harmony with the fortress, but would scarcely in any other situation have been chosen to accompany a bridge which was nothing but two parallel beams."

Apart from what might be called the "archæological craze," it was essential that any decorative treatment of a bridge should be such as arose out of and assisted to express the construction. This was not to be done by taking architectural details (so-called) out of books and clapping them on as a kind of addition. It was this kind of process which had spoiled many recent engineering works. It was the common British fallacy about questions of art, that all such things were matters of opinion. Beyond a certain point, no doubt, artists would differ in opinion as to what they liked best. But up to the point where it was still a question of good or bad taste, of right or wrong, artists, as a matter of fact, differed very little in opinion, if it were a matter of opinion; but it was not. The difference between "good" and "bad" in design was a matter not of opinion but of perception; perception which was only acquired by study of the subject. One of the first things, for instance, which a young architectural student was made to do, was to study and draw the classic orders carefully; not necessarily with a view to imitating them, but because they represented the severest study in the proportion of details to a whole which architecture had to give; the column and entablature forming (to borrow a term from construction) the "element" of the design, in which every detail was designed, and every moulding profiled, with reference to the whole. The mere study of the profiles of Greek mouldings, with their exquisitely refined curves, was in itself a kind of liberal education. If engineers went through any such training, they would perceive some things which they did not perceive now. They would not, for instance, imagine that they were giving "power" to a pier by capping it with a single moulding of 3 feet girth—a process which had only the double effect of

rendering it coarse in appearance, and at the same time reducing the scale. They would not introduce clumsy and ill-profiled mouldings, or travesties of classic ornament magnified to a Brobdingnagian size. They would not disfigure a bridge-pier by such tawdry ornament as was to be seen on the piers of Blackfriars Bridge, a first-rate engineering work entirely ruined and vulgarised by its so-called ornament. It was not particularly good taste for architects to come to engineers and say, "You cannot do without us," and he did not wish to take that position. It might be pointed out, however, to engineers who might think themselves affronted (as some evidently did) by any proposal to associate an architect with them in the design of a bridge, that they had only to cross the Channel to find themselves in a country where that was considered a natural and necessary course with all important bridges built with public funds, and where the public authorities would be severely criticised if they did not take that course. In the case of the Alexander III. Bridge, the very lamp-standards had been put into the hands of one of the first of the younger sculptors of the day, who had shown a special talent in decorative modelling. In England they would have been designed in the engineer's office, or perhaps made from a foundry pattern. But what architects might say to engineers, without any imputation of bad taste, was this: "If you wish to treat your structures decoratively and to add to them that kind of expression which architectural detail can give, make the study of architectural design and detail a part of your professional education, so that you may learn how to handle it, and acquire a perception of its use and meaning." If engineers replied (as they perhaps would) that they had neither time nor inclination for such study, then architects would ask them (and surely it was a reasonable request), in that case, to at least be good enough to let it alone, and to give plain unadorned structure, which, at all events, must be interesting, and could not be in bad taste.

Mr. Statham.

Mr. J. STÜBBEN, of Cologne, agreed with the Author's view that a bridge must owe its æsthetic character to its appearance as a whole, that was, to the arrangement and outline of its essential constructional elements, and not to subsequently-applied meaningless ornamentation. The Bonn, Grünenthal, Garabit, Müngsten, Alexander III., and Niagara Falls and Clifton Bridges fulfilled this condition. The æsthetic impression which they gave was satisfactory. Moreover, suitable decorative treatment of the members was not excluded, as the Bonn and Alexander III. Bridges showed. Figs 27, 28, 29, and 30, Plate 2, also showed, in his

Mr. Stübben.

Mr. Stübben. opinion, designs calculated to produce a pleasing general impression. On the other hand, none of the bridges of the cantilever type shown in Figs 19–26 was of satisfactory æsthetic appearance.

Mr. Thorpe. Mr. W. H. THORPE thought the Author's criticism of abutment-piers in long masonry viaducts, as justifying their existence only in the event of failure, open to question, and that they served a purpose other than that of only limiting the amount of damage, if any occurred; for, the greater number of spans being heavily loaded, the remainder might suffer by the aggregate spread of the loaded spans concentrated as an effort to close the rest, accompanied by a considerable movement of the pier-tops nearest to which the extraneous load ended. The abutment-pier checked this tendency, and it was not unreasonable to think that an appreciation of some such effect in the mind of the observer rendered the adoption of such piers quite consonant also with æsthetic principles. As to the use of double cut-waters in bridge-piers, the plea for symmetry need not be the only reason for their existence. With a square face to the down-stream end of a pier, flow of water through the bridge-openings would be less free than with piers pointed at both ends, due no doubt to the eddying and reverse currents incidental to a square-ended obstruction. Perhaps the most successful productions of the engineer, considered from the point of view dealt with by the Author, were those larger works in which, the material being iron or steel, the outline and principal internal lines, whilst fully satisfying structural requirements, conveyed also to the mind of the ordinary observer a sense of fitness. In such structures, supplementary ornament was commonly and rightly absent. With smaller metal bridges it was customary to challenge admiration by the use of forms usually associated with stone-work. It might be argued that, as many details in architecture had admittedly arisen from a reproduction in stone of forms originally borrowed from Nature, or earlier timber constructions, it should be equally allowable to produce these in, say, cast-iron; but he submitted that though a stone structure in its simplest possible form, free from all artistic embellishment, and pleasing only in its proportions, might be legitimately improved by the tapering of columns, the enriching of bases and capitals, and the use of mouldings, since there was in this no violation of the original idea, yet in metallic bridges ornamentation could not with the same propriety be adopted if it took the form of facia-mouldings, elaborately pieced together, united by internal flanges and bolts, and applied to the main structure by similar expedients; or, in the case of an arched bridge, of ornamental spandrels to the

outer ribs, having no relation to the spandrel structure of the inner ribs. Such detail, not being a rational development of the real structure, failed to satisfy a critical taste, and became an extreme application of the principle, otherwise to be heartily accepted, that "Beauty is its own excuse for being." Mr. Thorpe.

The AUTHOR, in reply to the Correspondence, observed that it was perhaps not quite correct to characterise the land arches of the Menai Bridge as wholly redundant. The tying down of the landward chains to the masonry would tend to stiffen the bridge materially by reducing the horizontal movement of the chains at the saddles; the land chains would also thereby derive a certain amount of lateral rigidity, whilst it was apparent to the observer that the land arches must have been a considerable aid in erection. These, however, were only secondary reasons for their existence, and probably no modern suspension bridge would be found to perpetuate them. After all, it was principally these land arches in combination with the landscape which gave to the bridge its distinctive and unusual character. It was a remarkable coincidence that both the Menai and Britannia bridges should possess prominent features which were in a great measure redundant, and yet that those very features were mainly instrumental in imparting to the bridges one of their greatest charms. A few remarks might be made with regard to the increasing employment of the Monier and allied systems of construction. Mr. Clarke had advocated some such method of construction as a satisfactory means of screening an internal skeleton of ironwork by an outer covering of concrete. The Author thought that from an æsthetic point of view the objection might be raised that such arches would generally appear to possess an abnormally small thickness as compared with the masonry structures they were made to resemble, whilst there was nothing to indicate the presence of the reinforcing material within. It might be wise also, before adopting this construction on an extensive scale, to enquire carefully into the actual durability of comparatively small sections of iron and steel when embedded in concrete. With reference to the æsthetic aspect of American bridge-design, he was glad to find competent critics in Canada and the United States express the conviction that material improvement was at present taking place. Speaking generally, American designs in the past had fallen lamentably behind those of their European contemporaries, and it was distinctly satisfactory to read the forcible remarks made by some of the American engineers. He could scarcely agree with Mr. Goupil as to the pleasing appearance of The Author.

The Author. *Fig. 55.* This bridge appeared from the illustration to possess several of the faults of the Philadelphian example so ably described by Mr. Crowell. In selecting examples with which to illustrate the Paper, it had, of course, been impossible to include more than a very limited number, and he had since regretted having omitted to cite the suspension bridge at Budapest as an example in which the design of the piers had been eminently successfully treated, comparing very favourably indeed with those of the Brooklyn and Clifton bridges. The ornamental festoons on the Alexander III. Bridge, as remarked by Mr. Clarke, might well have been omitted without compromising the design, in which case the purely structural portion would have strongly resembled the Pont Mirabeau—a pleasing example in which just the required amount of structural ornament appeared to have been applied, although the latter bridge was not nearly so favoured by environment as the former. He much regretted that he had not seen Mr. Statham's Paper, and he would certainly take an early opportunity of reading it. With regard to the very pronounced buttresses on the up-stream faces of the piers of the Victoria Bridge over the St. Lawrence, he had always been under the impression they were intended principally to act as ice-breakers rather than as cut-waters only, and that this accounted for their unusual size. In conclusion, he desired to thank the correspondents for their valuable remarks on the subject, and also for having drawn attention to many foreign bridges which, although perhaps not so familiar to the majority of English engineers, yet possessed many of the most desirable attributes of æsthetic design.

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19 March, 1901.

JAMES MANSERGH, President,
in the Chair.

The Discussion upon the Paper on "The Æsthetic Treatment of Bridge Structures" occupied the evening.

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26 March, 1901.

JAMES MANSERGH, President,
in the Chair.

The Discussion upon the Paper on "The Æsthetic Treatment of Bridge Structures" was continued and concluded.