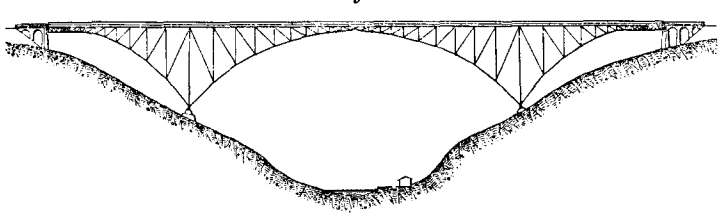
Discussion.

The President. The PRESIDENT observed that the Paper was rather different in scope and character from those which the members were accustomed to hear read and to discuss at the Institution; but the Council had had no hesitation in accepting it, both because it was an interesting Paper in itself, and because just at the time when it had been under consideration, a suggestion had been put forward by the Royal Institute of British Architects that an endeavour should be made to devise some mode by which the Institution could collaborate with that body in the designing of important bridges crossing rivers such as the Thames in London. The Council had not seen its way to offer any practical suggestions in that respect, but it had invited to the Institution that evening members of the Royal Institute of British Architects, and he hoped that some of them would take part in the discussion. He thought a good discussion on the Paper should ensue, and he was sure the members would agree with him that a hearty vote of thanks was due to the Author for his instructive and interesting communication, and for the great trouble he had taken in preparing so many diagrams.

The Author. The AUTHOR exhibited a number of photographic views of the various bridges. He also showed the elevation (*Fig. 48*) and a perspective view of the viaduct over the valley of the Viaur in

Fig. 48.



VIAUR VIADUCT.

the South of France, a structure chiefly interesting as being the largest three-hinged arch erected down to the present time, and the second largest steel arch in existence. The central span

measured 721 feet 9 inches, and the height of the rails above the lowest point of the valley was 380 feet. He directed attention to its æsthetic value as compared with the Niagara Falls and Clifton Arch. The chief difference in appearance occurred in the spandrel-bracing. In a Paper[1] read at a recent meeting of the Institution, Mr. Buck, the engineer of the latter bridge, had acknowledged a preference, on æsthetic grounds, for the large-span arch with diagonally braced spandrels, rather than for one of the Niagara type. He hoped that other valuable expressions of opinion might be elicited as to the relative merits of the two bridges. The Author.

Mr. W. Emerson, President of the Royal Institute of British Architects, remarked that it was a great privilege to have the opportunity of hearing so interesting a Paper, and he would like to tender his quota of thanks to the Author. He also thanked the President and Council of the Institution for their kind invitation to him to be present that evening. The Author had put before the meeting a large variety of designs of bridges which he did not propose to follow in detail; nor did he intend to trouble the members with any remarks as to how those bridges, which for the most part were of a purely utilitarian character, could be treated in a more æsthetic manner. He wished, however, to say a few words on the general question of the necessity for more æsthetic treatment of bridges in large metropolitan centres than was usually the custom at the present time. The Author had remarked that there were three fundamental points which tended to æsthetic effect; the first point was suitability to the exigencies of the case, the second, simplicity in design, and the third, proper treatment of material. The Author, however, had pointed those remarks by a sentence in his Paper in which he said, "Nowhere is this fundamental rule better exemplified than in Nature. A tree is undoubtedly one of the most beautiful of natural objects; yet even to the least trained mind it is apparent at a glance how stability is assured by the splaying out of the roots around its base, and a perfect balance is obtained by the shooting of the branches in every direction; whilst the decreasing girth of the rising trunk provides exactly the diminishing strength required for resisting the pressure of the wind and for carrying the weight safely." He thought the Author had hit off in that sentence the first element of æsthetic effect, but he had not carried his simile far enough; he had stopped just short of the mark. Not only in a tree, but in Mr. Emerson.

[1] Minutes of Proceedings Inst. C.E., vol. cxliv. p. 71.

Mr. Emerson. every work in Nature, whether tree, plant, or animal life, there was perfect construction, exactly suited to the requirements of the case. But that was the skeleton, and in many respects that skeleton appealed to a man's logical brain-power, and in a way might be beautiful. The bare skeleton of a man was so. In that way also works like Charing Cross Bridge, the Eiffel Tower, or the Forth Bridge appealed rather to the brain-power; but Nature went a step further. He took as an example the proverbial lily, which answered its purpose from the constructive point of view exactly the same as a tree; it had a firm foundation, and its stem and leaves were suited to resist the elements. But there was One who had said, "Even Solomon in all his glory was not arrayed like one of these;" and he took it that that raiment of the lily meant something entirely apart from and far beyond its structure. It referred to its æsthetic effect—its beauty. There were two distinct elements—the constructional and the æsthetic. It was true they grew up together, and were part and parcel of each other, but the one was entirely different from the other. He thought that principle should apply also to such public works as bridges, and it might equally apply to other public works in large metropolitan centres or the big cities of the world. He did not think æstheticism could be carried to any great extent into purely utilitarian works like bridges of enormous span in the country, but it seemed to him it was an important thing that in larger metropolitan centres the bridges should have both those elements in them; not merely the constructive element to appeal to the brain-power, but also the æsthetic element which, in the present age of high intellectual culture and educated taste, should appeal to the eye. Man, however, had no instinctive creative faculty, neither was he perfectly acquainted with every rule of constructive science, or every rule of art. It took an engineer the greater part of his life to become a master in his science, and it took an architect or an artist the whole of his life to learn something of art. It therefore seemed somewhat unreasonable to expect that any one man, whether an engineer or an architect, should be able in the present days of concentration of energy to carry out a work such as a very large bridge with perfect scientific skill and perfect æsthetic taste. That feeling was prevalent not only in this country but in most parts of the civilised world, certainly in America, France, Austria and England, and he fancied, from looking at the works of olden times, that it had been prevalent in ancient days also. At the present time a very good example was afforded by the Alexander III Bridge in Paris. It would seem

that if an engineer or an architect was not equal nowadays to dealing with both sides of the question there should be some collaboration between engineers and architects. There had been a good deal of discussion about the necessity of collaboration between architects and sculptors and painters, and he thought all would agree that there was absolute necessity for it. In the Alexander III. Bridge two engineers and two architects had been employed, and they had managed to work amicably; and he thought everyone would agree that the effect of that bridge was better than usual. In America it had been the custom for some time for architects and engineers to work amicably together in constructing buildings, both public and private; he understood the same steps had been taken in Vienna. With regard to ancient times, could it be supposed that the magnificent viaducts and aqueducts of Rome were built entirely by engineers? There must have been some artistic element in them as well as constructive ability. Again, supposing the bridge at Prague had been constructed purely on engineering lines, and had been devoid of its magnificent architectural approaches and adornments, he thought the loss to the world would have been inexpressible. In this country, however, there appeared to be certain difficulties in the way of collaboration between engineers and architects, and he could not help thinking that those difficulties were purely suppositious. From what he knew of engineers and architects, he would imagine they could, if they chose, come to some arrangement by which they could work very amicably together; but inasmuch as in Nature—in the lily, for example—the æsthetic effect grew up from the very commencement with the constructional design, so, in such a work as a bridge, it would be absolutely necessary for the architect to work with the engineer from the very inception of the work. It would be useless to cover a bridge with a veneering of architecture, or, after having designed a bridge, to simply clap on architectural ornament. The whole thing ought to be worked at from the commencement with considerable thought on the part of both engineer, architect and sculptor, and then carried out under their united supervision until it matured into a perfect work. He sincerely hoped that the day was not far off when, in towns like London, or large provincial towns, where the imperial character of the nation was at stake, municipalities and others, who had to initiate such works as bridges, would see the necessity for collaboration between engineer and architect; and he felt quite sure, that when such a stage was arrived

Mr. Emerson.

Mr. Emerson. at, England would not be far behind other countries in the æsthetic effect, not only of her bridges, but of her other public works.

Mr. Rennie. Mr. G. B. RENNIE agreed that the collaboration of architects with engineers was no doubt very important and, if it could be carried out, very desirable; but in a large engineering structure the architect would have to give way, in a great measure, to the engineer, because it would fall mainly upon the engineer to arrange the form of construction suitable for a particular site. Moreover, he thought it would be very difficult for an architect, in such structures as many of those referred to in the Paper, to improve the æsthetic effect to any large extent. No doubt collaboration in the case of the Alexander III. Bridge had produced a charming and beautiful effect; anyone who had seen the bridge would feel that. It should be remembered, however, that that bridge had been built for a particular purpose, viz., to connect the Fine Art buildings of the Exhibition with the rest of Paris. Therefore a thoroughly architectural design had been very suitable in this case. The bridge might be considered to be too ornamental for an ordinary engineering structure, but the whole structure was so pleasing that he thought it could be said that in such cases the architect might very well collaborate with the engineer. In London, as the President of the Royal Institute of British Architects had well said, it was very important to have a bridge with an architectural effect. The bridges which had been built by members of his family—Waterloo Bridge, Southwark Bridge, and London Bridge—had such an effect. Now it seemed that people were not satisfied even with the effect of those bridges as they were. In the case of London Bridge, some years ago it had been proposed to take away the present parapet and cornices, and to substitute corbels or iron cantilevers. That had been strongly objected to, and Messrs. Horace Jones and Charles Hutton Gregory had reported in 1875 that that system was utterly unsuited to the bridge. The proposal to add iron arches instead had come before Parliament in 1879, and had been very nearly passed, but through the influence of Lord Carnarvon it had been referred to a committee, and it had been absolutely condemned as unsuited to the bridge. The leading artists and architects of the time had given evidence against the general æsthetic effect of the iron additions, and so the Bill had been thrown out. At the present time it was reported that the old idea of corbels or iron cantilevers was being revived, but he hoped architects would try to prevent it from being carried out,

as it would certainly spoil the whole appearance of the bridge. He believed there was also some idea of widening Waterloo Bridge in the same way. He had not seen the design, but he thought that any alteration of the structure would absolutely spoil it. London Bridge had been built by his uncle, Sir John Rennie, who had strongly condemned any additions to its architectural features. With regard to structures of large span, such as were indicated in the Paper, he was inclined to agree with Mr. Emerson, that it was almost impossible to improve their general appearance. In the case of the Britannia Bridge, there was a grandness of design, a simplicity, and a situation which produced a very fine effect altogether; whereas Conway Bridge, a low squat bridge of similar construction, had a most damaging effect on its surroundings, and nobody could say there was any beauty in it. Mr. Rennie.

Mr. W. D. CARÖE wished, as an architect, to say a few words on the general subject. Mr. Emerson had said almost all that could be said on the question of the collaboration of architects and engineers in bridges of an architectural character. He thought the Author had been a little severe in dealing with early engineers in the opening words of his Paper, where he had expressed the opinion that they had not considered the æsthetic side of the question. His own feeling was rather the reverse. It was a great pleasure to him to be able to express amongst engineers the pleasure and satisfaction that some engineering structures had given him, and if he might mention a few he would put first the Menai Bridge, the effect of which was very much the same as that of one of the finest cathedrals. It was so elegant and so excellent in its proportions and details, and so admirably suited to its use and to its surroundings, that he felt he was standing before a work of genius. Again, with regard to its neighbour, the Britannia Bridge, he thought the Author was not quite fair; he praised it, but he praised its lack of architecture. It appeared to him that it had a very strong architectural flavour, and that it possessed one feature in a marked degree, which the Author had entirely ignored in his Paper, and that was the quality of architectural scholarship. It was precisely that quality of architectural scholarship, which took an architect his whole life to learn, that was missing in so many of the bridges which engineers produced. He did not think any blame attached to engineers on that ground, for, as Mr. Emerson had well said, the application of their Mr. Carõe.

Mr. Caröe. time and opportunities lay in another direction. The Britannia Bridge appeared to him to be altogether admirable in that respect. It was the work of a master, and he would much like to have seen it illustrated on the walls on a larger scale, because it was just such a construction that ought to be considered in detail in respect to the æsthetic treatment of bridges, and which had not been considered in the Paper. Again, there was the bridge at Budapest, of which all Englishmen ought to be proud, which had been the work of an Englishman in the year 1851. It afforded a very remarkable instance of progress. Mr. Adams had built a very similar bridge at Shoreham 3 years or 4 years previously, and then he had won the competition for the bridge at Budapest, and had produced one of the most remarkable works to be seen—a suspension bridge with admirably designed piers. The Forth Bridge filled Mr. Caröe with delight whenever he saw it, although he felt he was treading on rather delicate ground when he ventured in the presence of Sir Benjamin Baker to express the opinion that the land approaches were not quite equal to the large spans in character and design. The majority of the works of early masters might be studied with the greatest advantage in the matter of æsthetic construction of bridges. The main reasons why the four bridges he had mentioned gave him special pleasure, and were, in his opinion, worthy of great commendation, was that the engineering was excellent, the material being used to the best purpose; and that, so far as architecture went, the architecture was suitable, and even scholarly. As an instance of a different kind, he mentioned the Brooklyn Bridge at New York. That bridge had an excellent curve, and was in many ways, especially when seen in a mist, a fine structure, but its architectural qualities were irredeemable. There had been a foolish attempt to introduce a very shoddy form of Gothic architecture into the piers, which, to his mind, very much detracted from the whole conception. The Conway bridges had been referred to, and it had been stated that the chief interest of those bridges was their consonance and harmony with their castellated surroundings. It had always appeared to him rather remarkable that the engineers who had succeeded so admirably in the Menai Straits had failed so miserably at Conway; and the reason appeared to be that a sort of false sentiment was attached to the work, which, so far from being appropriate, was entirely out of harmony with the surroundings. Who in the world in these days would wish to protect a railway bridge or a suspension bridge from the inroads of an enemy by

putting up machicolations and arrow-slits? They were absurd, and, being absurd, they did not enter into the least harmony with Conway Castle, which was erected at a time when machicolations and arrow-slits had a proper and reasonable purpose. The whole subject was one of learning to use the materials correctly, with due reference to the occasion and the sentiments which surrounded it. With regard to the question of ornament as applied to bridges, he would be very sorry indeed to support in any way an idea which he was afraid was too often held, that architecture meant ornament. Architecture really meant nothing of the kind, and with regard to iron structures he thought it might be accepted as an axiom that when ornament walked in at the door Art flew out at the window. The Glasgow and Edinburgh examples appeared to him to be villainous. In the Paper a reference had been made to a successful masking of bridge structure with cast-iron plates or ornaments. He believed that the result of any attempt of that kind was certain to be failure. He had only to instance Westminster Bridge—which, he considered, might have been a pleasant and agreeable structure, but was quite spoiled by the architectural adornments which had been added to it. He could not help feeling that it was possible to arrange a workable scheme by which architects and engineers could work harmoniously together, with great benefit to the works produced. Architects could not pretend to produce engineering works, or to obtain the advantages from iron which an engineer could do, and did so often. Some of the skeleton bridges shown on the wall gave him the very greatest pleasure. There was no architecture connected with them, except that architectonic feeling which was obtained from all work rightly and scientifically constructed. In conclusion, he thanked the Council for inviting him to be present, and the Author for the charming manner in which he had placed so large a collection of bridge designs before the meeting.

Mr. Caröe.

Mr. F. E. Robertson thought it was scarcely right to introduce the Paper with a sort of apology for its being something out of the ordinary way, because it seemed to him that to do so was to lay engineers open to an accusation which was frequently brought against them—and he was afraid not without some reason, having regard to the diagrams on the wall—that they either displayed a great deal of indifference to æsthetic considerations in the structure, or, which was perhaps worse, tried to conceal an ugly carcase under meretricious adornments. The Author quoted, as an apparent paradox between what was pleasing to the eye and what was necessary to the structure, the cut-waters up and down stream

Mr. Robertson

Mr. Robertson. on the pier of a bridge; he was quite right in saying that they were pleasing to the eye, but he omitted to consider that they were also necessary to the structure. A clean run was just as necessary to a ship as a fine entrance, and if the Author would study the action of a cylindrical pier in a large river, he would see that a cut-water at both ends was certainly necessary to obviate scour. The Author also remarked, apparently as an excuse for the neglect of æsthetic treatment, that the obstacles to be overcome in the manipulation and erection of large bridges in situations of extreme difficulty often precluded the adoption of a more pleasing design. He hardly thought that was the case, because one could easily find two similar bridges, one of a pleasing outline and another of a design not so pleasing, and certainly the former was not the least economical. He might mention in particular the Viaur Viaduct. There had been a large model of it in the Paris Exhibition, and to judge from that the structure was a very elegant one and certainly economical. That the difficulties of erection precluded pleasing outlines could hardly be accepted as a ground for putting up an awkward-looking structure. A familiar instance was that of an ordinary girder-bridge. The large Indian girder-bridges, with parallel girders, as a rule looked like nothing so much as magnified coffins set out on trestles; but such of the bridges as had been built with parabolic girders were certainly far better looking than similar bridges built with parallel girders, and the parabolic girders were the more economical of the two. Mr. Caröe had remarked, with reference to the Conway Bridges, that they were inappropriate on account of the attempt to convey the impression that they were fortified. He was not sure that Mr. Caröe did not go a little too far when he repudiated the idea of fortification altogether in connection with bridges, because in India all the large-bridge-heads were fortified; it was invariably a matter of consultation with the Military Department. Of course it was not inconceivable that the same thing might be desirable in England, and he believed it was often done on the Continent. [Mr. Caröe asked whether Indian bridges were fortified in machicoulis and arrow-slits?] They were fortified for musketry, not for heavy guns. They were built according to the requirements of the Military Department with loopholes and machicoulis. He did not know whether it was proposed to pour boiling oil and melted lead down on the enemy, but the machicolations were demanded.

Mr. Ricardo Mr. H. Ricardo was cordially in sympathy with the principles laid down in the Paper. It had struck him, however, while the Paper was being read, that there was throughout a kind of dis-

trust of the position. Phrases had floated about such as, "This would mean good taste"—"This would succeed"—"This has generally been found pleasing"—"This might be done and this might not"—in fact, the shadow of Mrs. Grundy appeared to loom very large, with a fear of the "superior person" talking about "good taste." One element missing in the Paper was the emotional treatment of bridges, namely, the treatment of bridges from the point of view of sentiment and feeling. The word sentiment was open to many interpretations, but the Paper appeared to ignore even such an elementary sentiment as permanence. Sentiment contributed very largely to the beauty of things. Beauty was not extraneous, but inherent; it was a quality which came from a great knowledge of the materials, a wise distribution of them, and a certain fondness in the handling and fineness in the purpose. He might take as an instance a man standing by a ford and carrying people across pickaback. That man was doing a worthy service, but there was nothing inspiriting or particularly memorable in it. But if by chance a little child sprained its ankle and was carried over to the other side tenderly by the ferryman and handed over to people who would care for it, there had been imported into the action an element of pathos and humanity and of beauty. Again, taking a larger instance of the same thing, if it was anyone's business to, say, transport ten coach-loads of food from A to B, something was done which might be serviceable but was not memorable; but if, on the other hand, as constantly happened in India, for instance, immense viaducts were built for railroads to carry, in times of famine, quantities of food from a surplus store to where it was needed, a fine deed was done. Those were legitimate sentiments to import into the subject—sentiments based on the understanding of the function of the object. Beauty was talked of very glibly, but there was seldom any distinct statement to grasp. The canons of beauty were incessantly being enlarged. What was beautiful in the past remained beautiful, but its beauty was not that of the present time, under changed circumstances. He was old enough to remember connoisseurs of music complaining of Beethoven's later methods, and averring that if he had adhered to the pure simplicity and great beauty of Mozart his music would have been superior; but Beethoven had had something to say, and had said it, and now he had become a classic with his masterpieces of beauty. Then came Wagner, who also had much to say, and introduced a further element, which was instantly denounced as uncouth and barbarous; his dissonances were subjects of raillery, but

Mr. Ricardo.

Mr. Ricardo.

his work was now classic and his novelties were admitted as beauties. So in literature. Carlyle was a man with a gospel which he had to speak out, while the critics of the day declared that his style was ugly, vehement, turgid, and out of proportion; but he was now regarded as a master. So also in poetry. It used to be said that Browning was obscure, rugged, uncouth, but he had enlarged the conception of beauty. The same thing was being done by engineers. Engineers were enlarging what had been the canons of beauty. He regretted to see a certain admiration given to "architectural" book-learning, book-learning not merely as archæology, but as something which would enable a designer to apply to his bridge forms of beauty of past times. The "ornamentation" of the Great Western Road Bridge at Glasgow was an example. The haberdashery of architectural detail there had been stolen from work done at the time of the Wars of the Roses, and came from colleges and churches. It represented to anybody who really cared for such things, the masons' knowledge of his material, and his delight in dealing with it. The mason took his stone and used as little as he could, consistently with the purpose he had in view, and then, having enjoyed doing the work, he could hardly keep his hands off it, and elaborated it out of love for his work. But it was mason's work and mason's handicraft. The moulding applied to the steel rib might be referred to as an instance of utter misconception of the history of mouldings and their consequent beauty. Originally, when a mason wanted to put a rib across a space, he used a squared stone, and nobody could want anything better; but it was found that on the scaffolding, with clumsy men about, the stone was liable to get bruised and chipped, and so the next step was to chamfer the edge. That gave two edges liable to be damaged instead of one; but they were broader, and bore the hurt better. Very soon it was found that it was better to have a roll and a hollow, because the roll would take the injury and not show it. Hence, in bridge masonry, as a rule those two forms only would be found, the chamfer, and the roll and hollow. Therefore, the enrichment on the Glasgow Bridge was wrong, on the ground, first, that it was not made of stone, but iron; secondly, that it did not represent handicraft, but mechanism; and thirdly, that it did not represent any particular pleasure taken in the production of the thing, but a kind of feeling that Mrs. Grundy would desire such a structure. Again, this lack of reverence for the material diminished the life of the structure, because it made it more difficult to paint. The painter's brush could hardly get into all the crevices, but the

damp would. So that, from the point of view of Art, he thought it might be safely said that, Art being man's message to man, and beauty being the bloom that came to things honestly and sincerely worked, one must expect beauty to come from pride in the material at hand, and by the passion of the worker. That it would come from that did not always follow. There had been periods in the world's history, especially in England's history, when people at large sought for beauty, as shown still in the minor arts, where left untouched: the ordinary hand-plane of a carpenter was still a very pretty thing, as was the ordinary farm-wagon as it went across the field. But he thought the present time was not such a period. Often sentiments of space, grandeur, force, and so on, were found in a structure, but beauty was curiously absent. Every new lamp-post put in the streets of London was an added terror, and at the present moment the artistic mind was shuddering at the thought of what might be coming in the new postage-stamp. Beauty could never be obtained self-consciously; it could only come from the material and the pleasure of handling it. He thought the best thing to do was to keep to the firm ground the Author had started on, which he would like to have seen him tread a little more boldly. Mr. Ricardo.

Mr. R. Elliott Cooper remarked that, when he had first glanced at the Paper and the illustrations, he had really thought that the object of the diagrams was to illustrate how very far engineers had strayed from æsthetic beauty. He did not for a moment mean to say that the definition of æstheticism given in the Paper did not quite conform to what should be understood by that name, but it certainly seemed to him that, although no one could doubt the utility of the structures illustrated, it was difficult to see where their æsthetic beauty came in. A great many of them were designed in such a manner that their fine lines fulfilled the idea of the usefulness of the material used and of the structure as completed; but where engineers in England failed to a considerable extent in comparison with Continental practice was that, without in any way detracting from the structures themselves by any meretricious ornament, they very often failed to make the abutments and approaches to the bridges as effective as they might be. He could not see why, because a bridge was of large dimensions and of a certain form, it should be impossible to decorate it, or why the abutments and the general approaches to the structure should not in many cases be made more effective than they were. Anyone who had seen the great bridges of the Continent—such, for Mr. Cooper.

Mr. Cooper. instance, as the bridge over the Rhine at Cologne—must have been struck by the fact that the steelwork was not in the least degree decorated, but the approaches and the abutments were of a decorative character. With regard to the bridges illustrated in the Paper, as he had said, their usefulness was admitted. The Sukkur Bridge (Fig. 22, Plate 2) was practically a crane on one bank and a crane on the other, with a level girder between. No doubt it was a very remarkable work and served its purpose, but he did not see much æsthetic beauty about it. The Jubilee Bridge to his mind was still less an æsthetic structure; the centre girder, which practically served as abutments for the side girders, although exceedingly economical and perfectly scientific, could not possibly be called a beautiful object, nor could it be said that it did anything more than serve its purpose. He thought the various points brought forward by the Author had not had due recognition. For instance, the Author stated what he considered to be the reasons for the adoption of different designs, and why one was better than another. Reference was made in the Paper to two bridges of a very common form—bridges which engineers connected with railways had frequently to build—with three arches over a railway cutting. How it could be suggested that *Fig. 6* could be compared with *Fig. 7* for anything approaching prettiness of appearance he could not imagine, because it was manifestly wrong to have the side arches of a different curve from the centre one. It gave a most curiously hollow appearance to the centre arch, and he had never seen such a bridge built. Then with regard to tall piers, the Author considered that the one shown in Fig. 9, Plate 2, was very much more effective than the one with the straight battered face; that Mr. Cooper did not agree with. He thought the simple, battered face was far better than the curved face; and in a viaduct of that height it was much better to do away with the springers altogether, and to let the semi-circular arch come down to a tangent with the pier, rather than to build it in the way shown in the illustrations. Another point mentioned by the Author was the practice of carrying up cut-waters to the parapet. He thought that greatly detracted from the appearance of any bridge, especially a high one. If the parapet was broken up by pilasters corbelled out from underneath the string-course or cornice, the effect was far better than carrying up the pilaster between the springer and the cornice. That applied equally to Fig. 13 and Fig. 14. In both those cases, particularly Fig. 13, if the voussoirs had been continued until they met in the centre, without the interposition of the pilaster, the effect would have been much better. Those

were, of course, practical points which all engineers had more or less to deal with every day, and they were the views that appeared to him to govern even the ordinary works of construction shown in the diagrams. But turning to the larger works, it would be impossible to decorate the girders themselves. It might be possible, however, to add something to the approaches and the abutments, so as to give a more imposing appearance to the work as a whole. With regard to the question of the collaboration of an architect with an engineer, raised by the President of the Royal Institute of British Architects, Mr. Emerson and he had placed in the room a drawing of a bridge which they had designed together, simply as an instance of the fact that architects and engineers could work together without quarrelling as to which part the one or the other should take. A bridge of the suspension form lent itself more easily to decorative purposes than almost any other kind, and that was the reason why the suspension form had been adopted in that bridge, which had been designed for crossing the Tiber at the Piazza del Popolo. It had also to serve as a memorial to King Victor Emmanuel.

Mr. Cooper.

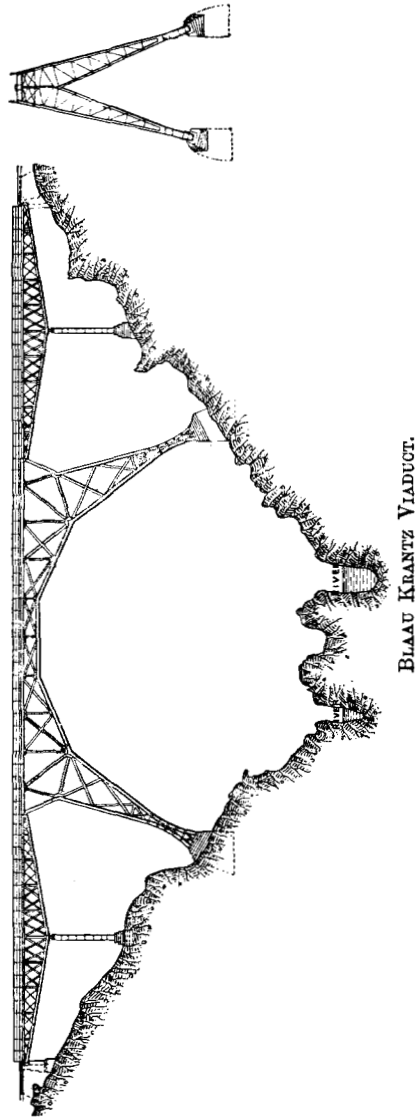


Fig. 40. Bladu Krantz Viaduct.

Mr. Cooper. The decorative portions did not detract from the general engineering effect, and the towers afforded the opportunity of showing in sculpture the various incidents in the life of the king. Mr. Emerson having been too modest to refer to the picture as showing an instance where an architect and an engineer had worked together, Mr. Cooper might perhaps be excused for referring to it. He had also put on the wall a diagram (*Fig. 49*), showing a bridge in which æsthetic beauty was lacking. It was a bridge he built about 20 years ago over the Blaau Krantz Ravine in South Africa. The idea of the bridge was simply that of two men leaning forward with their hands joined. The necessity for building such a bridge arose from the almost impossibility of erecting staging, as to get timber to the site would have cost nearly as much as getting the steelwork there. The bridge had to be built without scaffolding, except the poles which were used for the painting and the staging for riveting up the girders. In the sense that æstheticism simply meant using material in a form most economical and best adapted to its purpose, he might almost claim that that bridge was æsthetic, but he could not put it forward on the ground of its appearance. It was an instance of what could be done with an end in view, without any idea of beauty. It should be remembered, however, that bridges looked very different when viewed at their sites. The large number of different lines and angles made them look much better than they appeared in diagrams. Bridges, which were almost hideous when shown in elevation on paper, when actually viewed looked very fine. That was the case with the Blaau Krantz Viaduct. Seen from the valley below it was very graceful, although its appearance on the wall would not have suggested it.

Sir Alexander Binnie. Sir ALEXANDER BINNIE wished to add to the words of the President his personal thanks to the Author for having brought forward a subject which did not usually occupy the members of the Institution. The Paper was useful, because the Author drew attention to some of the fundamental points necessary in any structure designed with æsthetic effect. One of the first alluded to was that a structure should follow, as far as possible, the beautiful lines which Nature laid down for guidance. Looking back to the man whom he might call the father of the engineering profession—Smeaton—there was an instance of the adaptation of those lines of Nature in the construction of the Eddystone Lighthouse, a structure which had always claimed admiration for the elegance of its proportions. In bridge-building pure and simple there were the works of Rennie, Telford, and

Stephenson, which had been referred to with remarks of the strongest approbation. The bridges which Rennie had built across the Thames would ever remain monuments, not only of engineering, but of beauty. They had formed throughout the world models on which other bridges had been constructed. But he wished in that respect to draw attention to bridges constructed by Telford and by Stephenson. There was a general consensus of opinion that the Menai Bridge and the Britannia Bridge were objects not only of engineering skill, but of beauty and of grandeur. The same engineers had had to deal with a somewhat similar problem at Conway, and it had been remarked that their efforts had not been crowned with the success which had attended their labours at the Menai Straits. That pointed at once to a very important matter with regard to the construction of any bridge, when regarded from the æsthetic point of view, namely, that the site of the structure had a great deal to do with its appearance when finished. The bridges which crossed the Seine could not be compared with the bridges which crossed the Thames, without taking into account the fact that the one river flowed between comparatively steep banks, and the other for the most part was bounded on one side by high land and on the other by marsh-land. The difficulty introduced into the site of a bridge must of necessity govern the appearance of the structure when it was completed. Beyond the mere question and accident of site, the engineer often had to deal with other conflicting elements in the production of his design. He often appeared before Parliamentary Committees, where several opposing interests ultimately decided the width of his piers, the headway to be given to the bridge, and the gradients over it; so that, without his consent, and often against his advice, he found himself in the position of having to elaborate out of the main features of his structure something which would be most pleasing to the beholder. But, on the whole, he thought engineers had not altogether failed in their endeavours to carry out their work with the approbation of the public. The Author spoke of the construction of bridges of different materials, and said that attempts might be made to present in disguise one material for another, or possibly the resulting effect might be marred by the employment of too great a variety of materials. The use of one material to represent some other material was the subject to which he wished to draw attention. He would ask the members to look back at the history of classic architecture, to trace the source of the column, the source of the cornice, and the meaning of the triangular pediment at the top of

Sir Alexander Binnie.

Sir Alexander Binnie.

a classic design. Was that not in itself but the reproduction in stone of the pre-historic wooden building in which the ancestors of the Greeks lived? Turning to a more striking instance of a fact, patent to all who had travelled in the East, and forcibly brought to public attention by Fergusson in his work on ornamental art—namely, that the actual structures in stone at the present day, amongst the most beautiful the world had ever seen, were exactly copied from wooden models—he had himself seen within the same city a building in wood, and at no great distance from it a building in stone, which was almost a reproduction in every detail of the wooden building. It was absurd to say that the effects of one material must not be represented in another. To lay down a canon of art such as that was to destroy the possibility of art in any future structure. The present was a period of transition, not between a wooden and a stone epoch, but between a stone and an iron epoch. It must have taken a long time for the old architects to evolve those beautiful stone designs out of their wooden model. When it was said that the iron structures of to-day were not æsthetic, because engineers had not cultivated that taste which was necessary to appreciate the beauty of the designs, conclusions were being drawn too hastily. When the public became educated up to appreciation of the meaning of the structures; when they saw with what skill the various forces were balanced and counter-balanced, and how the molecular forces of expansion and contraction were provided for; then perhaps it would be time to say whether bridges were ugly, hideous, and not æsthetic. In the process of development the elements of beauty would gradually creep in, partly by concessions from the crude designs of the present day, and partly by that understanding of the labours of the builders which must spring ultimately from the true appreciation of means to end. But, after all, was it not a matter of personal opinion? What one man or woman considered beautiful, another man or woman did not. Nothing he had experienced brought so vividly before his mind the fact that art was a personal thing, a certain feeling that existed in the artist, as contemplation of the great works of painters and of sculptors. How would Michael Angelo have acted under the directions of a "committee of art"? He himself had attended committees of art, and the difficulty which he had always felt was to get such a committee to come to any concrete conclusion. The gentlemen composing the committee, for whom he had the greatest respect, had their own ideas, which differed from one another, and it was difficult

to focus them. Engineers were not so devoid of the artistic faculty as was supposed. They were met by difficulties of site and difficulties imposed by conflicting authorities; but he thought they could show a fair record in the works which had been constructed, and he looked forward with a considerable amount of hope to see in the future modern structures evolving into the most beautiful objects. He believed that designs would be produced as beautiful as were the stone copies which succeeded wooden structures. Sir Alexander Binnie.

Mr. R. M. PARKINSON remarked that according to the Author simplicity of design was an eminently pleasing quality. The question was, who was to be pleased? He did not think bridges should be designed to please the eye of the engineer or the highly-trained eye of the architect or artist. The beauty of the arches in the side aisles of St. Peter's at Rome was due to the very deeply-cut reliefs in the spandrels, and if those arches had been simpler he did not think the public would have appreciated them. The artist and the architect very much preferred the cathedral in Florence to that in Venice, but he thought the public generally would prefer the more highly wrought architecture of Venice. Therefore, something more than simplicity was required. The thing to be considered was, what were really the elements from which beauty could be obtained in a bridge? In an arched bridge the question arose as to the right curve to adopt. He thought the circle was generally considered to be the ugliest curve, although it was scientific. The circle practically agreed with the line of thrust. But he believed architects laid down the rule that a compound curve was necessary to beauty—not a curve changing suddenly from a sharp to an easy one, but something like the parabola. The only case in which there should be a sudden change was in the reverse curve. In the cut-water of a bridge the usual curve was a pointed arch, but he believed it would be much better in cut-waters to have a reverse curve, so as to show the angle of the pier. The Author stated that in an elliptical bridge the higher the rise the better, because it had a stronger appearance. He thought the public generally would appreciate Westminster Bridge more than Waterloo Bridge, as the sharper curve produced a more pleasing effect to the eye, although probably it was not so scientific. The Author also appeared to think that it was difficult to get due effect from iron and stone. He had always thought that the way to secure proper effect was to have considerable contrast. For instance, in an arched bridge a Mr. Parkinson.

Mr. Parkinson. pointed arch was better than an elliptical arch; and he thought the Skeldergate Bridge at York had a much finer appearance than Westminster Bridge. The contrast between the iron and the stone was also very pleasing in both. The Author did not refer to the question of painting, but a great deal of effect could be obtained from a coat of paint. In a bridge such as was illustrated in *Figs. 13* and *14*, the pilasters had been found fault with, and he thought they might with advantage be replaced by sinkings in the spandrel. It had been said that the bane of English architecture was the 4½-inch jambs; to get beauty it was necessary to have a deep jamb. In some viaducts he had seen, the parapet was very disappointing, because the cornice did not stand out enough. He had heard the objection raised against St. Peter's Cathedral that the proportions were so exquisite that the effect of its size was lost; but he thought in a bridge the cornice ought to look uniform with the rest of the work, and not be made small, in order to give an idea of height to the viaduct. Nothing had been said as to the widths and heights of pilasters, but the question of the proper proportions to use was a matter which sometimes troubled engineers. He believed that if anything was not square it should be decidedly oblong, not slightly wider than it was high. If pilasters were used slightly higher than they were wide, they had a very ugly appearance, but if the height was increased considerably the appearance was improved. With regard to the education of the engineer, he thought one of the most beautiful buildings was Giotto's Tower in Florence, which was the only work of the artist. He did not know how he could have arrived at such a climax without any previous experience.

Mr. East. Mr. ALFRED EAST remarked that, not being an engineer, he would not have spoken had not it been for some remarks that had fallen from Sir Alexander Binnie, which had given him information concerning the art he followed which he had not possessed before. Sir Alexander Binnie had remarked that art was a matter of opinion. He might say the tensile strength of iron was a matter of opinion; but it was not. He might also say, in reference to the æsthetic treatment of bridges, that it was a brave thing for any member of the Institution to bring forward such a Paper, and he took it that the Author saw the dire necessity for doing so before venturing to place the Paper before such an assembly; for he knew that engineers were, in the first place, of necessity utilitarians. The primary importance of a bridge was that it should serve its purpose. But if any decoration, ornament, grace

of line, or beauty of structure could be added to the bridge without destroying its useful purpose, surely that was worthy of consideration. Bridges were permanent structures: they were not like hoardings, to be taken away when their temporary purpose was served. Engineers were responsible to a certain extent for the cultivation of public taste, and when he looked at the designs on the wall he did not think that fact entered into their consideration. He noticed in them many opportunities for improvement. The spacings of the girders were optical irritations, and offended the eye terribly. He considered the sentiment of strength in the structure of a bridge was necessary, the feeling that it served its purpose, the feeling that it was strong, as well as the actual fact of its being so. When he was in the country painting a landscape, and he saw an ugly bridge, he thought out the problem of its situation. Perhaps he might come to an erroneous conclusion, but very frequently he thought that, with a little more consideration, the designer might have made the bridge a pleasing object in the landscape. He was ashamed of the bridges of his native country, as a rule. He had, however, seen splendid bridges and fine viaducts. Quite recently in Spain he had seen a magnificent aqueduct built by the Moors, a thing of grace and beauty: it was fine as a piece of architecture, and it served its purpose. He could not refrain from speaking on the Paper, because he considered that the rules of art were as necessary—and not a matter of opinion, as had been suggested—as those of science. Behind all great art, there was a dignity and simplicity, a quality which had to serve its purpose as much as the quality that made fine construction serve its purpose. Mr. East.

Mr. CHARLES HAWKSLEY, Vice-President, observed that a great many of what, he was afraid, must be called the ugly structures depicted in the diagrams, arose perhaps not only from the necessities of each case, but from want of a better training in architectural principles than engineers generally had. Again, he thought it might be due also to not devoting sufficient time and attention to study of the appearance as well as the utility of the works designed by engineers. Then there was the client, who generally had an idea, in which the engineer perhaps sometimes participated, that if a thing was only ugly it must be economical. He hoped the day would come when either by better knowledge and more study, or with the aid of their architectural friends, engineers would be able to improve such things. Sometimes, perhaps, there was another element, but, he thought, for the credit of the profession it should not have any great weight—namely, Mr. Hawksley.

Mr. Hawksley. that it was much cheaper in the drawing-office to design an ugly structure than it was to design one that looked well. When he had the opportunity he always endeavoured to impress the views he had enunciated on students, who were the rising generation of engineers.

Sir Frederick Bramwell.

Sir FREDERICK BRAMWELL, Bart., Past-President, wished to repeat an anecdote told him by the late Mr. Thomas Hawksley, Past-President, which was appropriate to what his son had just said with regard to considering clients in reference to ornament. Mr. Thomas Hawksley had told him that, once when he was making one of his many hundred waterworks for a corporation, the plans included an arch with a keystone which he had caused to be vermiculated. One of the Town Council, a tailor by trade, complained of the extra cost of the work, and Mr. Hawksley, in walking behind the tailor, saw that he had two buttons at the back of his coat. It appeared that those buttons were used originally for a horseman to button up the flaps of his coat when on horseback. The horseman disappeared and went by train, but the tailor still placed two buttons at the back of his coat. That gave a chance to Mr. Hawksley, and he said, "You complain of my extravagance in the vermiculation of that keystone: will you tell me how you can justify those two buttons at the back of your coat?" The tailor could not justify them, and, as always, Mr. Hawksley had the better of the argument.

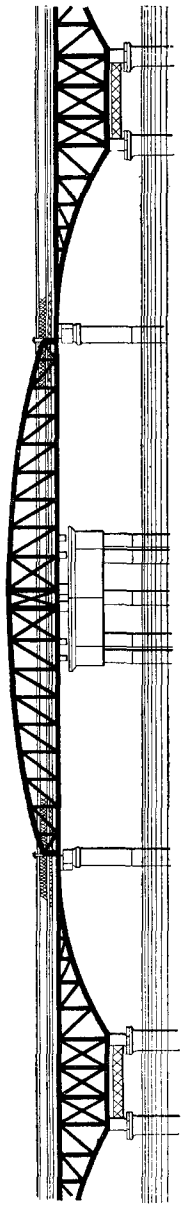


Fig. 50.

Mr. Goodwin.

Mr. G. A. GOODWIN referred to a diagram (*Fig. 50*) of a bridge he had designed some years ago, composed of a swing span with two cantilevers on one side and three on the other. His object in bringing it forward was to show one method of what he considered æsthetic treatment of a bridge with a swing span combined with fixed adjacent spans. It would be seen that the curve of the upper boom of the

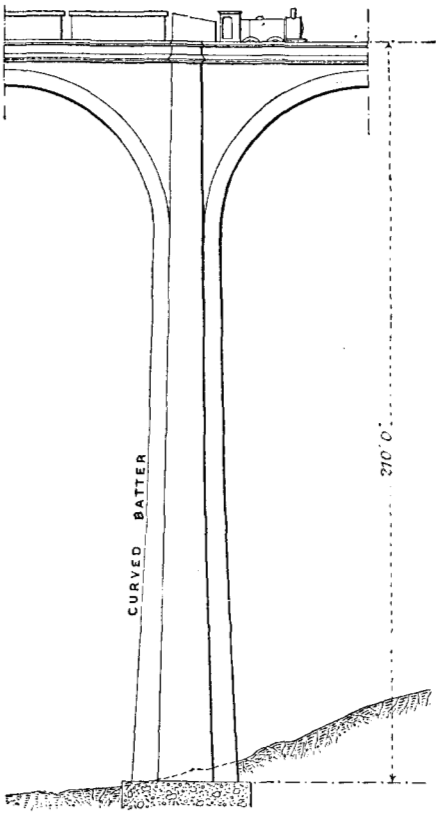
swing span conformed with the curves of the lower booms of the side spans, and gave a somewhat pleasing effect. At the same time the design was very economical; in fact it had been too economical in that particular case, as the metal of the centre portions of the spans had worked out so thin that he had had to increase the sections to allow for wastage. The highest part of the span was next to the shore, which allowed small boats to come alongside the wharf. In a larger bridge he thought the design could still be used by allowing the centre portion of the spans to be somewhat on the lines of Fig. 35, Plate 3. After what had been said in the discussion, he thought it was not always true that "a thing of beauty was a joy for ever;" and as men were frequently of different opinions, he had no doubt some members might consider that the particular detail of the bridge referred to had not a pleasing effect; but that only showed the impossibility of satisfying everybody. Bridges in public thoroughfares ought to be made as æsthetic as possible, but he did not think engineers would get much sympathy from railway companies in that matter, railway bridges in towns being usually covered with advertisements. He thought it was a disgraceful thing that in towns like Manchester and Glasgow, and in other large towns which were very great delinquents in that respect, such a thing should be allowed. Mr. Goodwin.

Sir GUILFORD MOLESWORTH confirmed Mr. Hawksley's remarks from his own experience. When a young man he had wanted to put some inexpensive æsthetic embellishment on the central arch of a viaduct, which he thought would be very appropriate. His chief engineer said to him: "My dear fellow, whenever you have to choose between an ugly thing and a beautiful thing, choose the ugly one, because the directors will like it best." Sir Guilford Molesworth.

Mr. R. J. G. READ remarked that the Paper dealt with a subject which was to a large extent a matter of opinion, and therefore it was not surprising that so many different views had been taken of the question. With regard to high viaducts, to his mind they were a very pleasing feature in a landscape, and could be made to carry out the æsthetic views of any architect. Mr. Elliott Cooper had referred to the high piers shown in Figs. 8–10, Plate 2, and had rather objected to Fig. 9, which the Author considered to be the best. For his part he was disposed to agree with the Author, and he had placed on the wall a diagram (*Fig. 51*) of one of the piers of the viaduct of the Grueize, in the South of France, which had been built on a railway passing over a deep gorge. The Mr. Read.

Mr. Read. viaduct was built of limestone, and from the description of it, he gathered that it was one of the most beautiful viaducts in France. The train went over it at a height approaching that of the top of the piers of the Britannia Bridge. The piers were slightly curved, the pilaster was carried up to the parapet, and the arch sprang from the curve of the pier. He thought it was a very graceful example of a viaduct of that kind. Foreigners, especially the French, had devoted a great deal more attention to, and had succeeded more admirably in giving a pleasing effect to their structures than English engineers. He had laid on the table a photograph of a viaduct he had seen some time ago in France, which illustrated the abutment-piers mentioned by the Author. They occurred at every third pier, and had a very pleasing effect. In stone the ancients had had a natural material which could be only used in compression. It was easy to build an arch or structure with stone in compression, because an enormous weight could be imposed on a stone arch without breaking it; but it was very difficult to go to the other extreme and to reduce the stonework to the least possible amount; and yet that was the difference between ancient structures and those of the highest class now built. Engineers now were supposed to know more about the lines of action of the forces in a structure of any particular form, and to place the material in the best position for resisting the

Fig. 51.



PIER OF THE GRUEIZE VIADUCT.

stresses which came upon it. He did not think the present engineering structures could be compared with those of olden times. As Sir Alexander Binnie had observed, the present was a period of transition, and perfection had not yet been attained. The subject which had been the main influence in shaping engineering work, namely, the great discoveries of science, had not yet been alluded to. In the seventeenth century, by the aid of the mathematicians, science made great strides; important discoveries were made in the treatment of mathematical problems; and problems were solved which had hitherto remained insoluble. It was interesting to note that in the solution of mathematical problems at the time of Descartes, Leibnitz, Newton, and others, in the seventeenth century, great importance was attached to a solution which was done in a graceful manner. Some men solved problems in a roundabout and cumbrous manner; but they were not reckoned equal to those who solved them in an elegant manner. Those men were the precursors of the modern engineer, who had benefited by their discoveries and inventions. The steel structures of the present day were the outcome of improved scientific knowledge and improved mechanical methods of manipulation of material. The material now available could be used in tension, and consequently demanded different treatment from the old material. He thought structures like large bridges and viaducts of the lattice-work type were the most advanced forms of bridge structure, and that in that form lay the right direction for progress and perfection in the future. With regard to the Alexander III. Bridge in Paris, it had been built principally with a view to artistic effect; but it was curious to note that although that particular work was thought to be the most recent of its kind, the features of the pilasters on the abutments very much resembled those of an old Roman bridge built at St. Chamas, in France, which had a triumphal arch at each end. With regard to the Viaur Viaduct, he had seen a model of it in Paris, and he thought it was one of the most advanced types of construction. It was not altogether an arch, but an arch with a weight at its back tending to lever it open; and as the piers were not fixed but hinged, if the back part were not properly proportioned and overbalanced the centre, the whole bridge would go over. The plans and calculations for that structure necessitated a very high degree of scientific as well as engineering knowledge.

Mr. Read.

Mr. HENRY DAVEY complimented the Author on having brought such an interesting Paper before the Institution, and thus re-

Mr. Davey.

Mr. Davey. lieved for a while the dulness of purely utilitarian ideas. He did not gather from the Paper that the Author laid down any laws to guide judgment as to what might be considered æsthetic and what the reverse. There were laws of artistic feeling—laws which were very difficult to define, but which were derived from a true appreciation of Nature, the source of all artistic feeling. Those laws existed in proportion and grace of outline, amongst various things. Proportion and grace of outline naturally had to be regarded in connection with magnitude and environment. It was obviously absurd to treat a structure of such magnitude as the Forth Bridge on lines which would be quite consistent in structures of more moderate dimensions. Again, with regard to environment, a model of the pyramids of Egypt, for instance, would look rather out of place in the grounds of the Crystal Palace. All those questions naturally set aside any attempt to formulate laws to apply in all circumstances. There was, however, a law implied in the argument of the Paper, one which he did not quite agree with and which he thought contained a fallacy, viz., the implied law that, to be æsthetic, a bridge should exhibit to the eye the distribution of stress within the structure; in other words, that nothing should be hidden. Following out that idea, the Author had condemned very strongly the outlines shown in Figs. 23 and 24, Plate 2; he might have condemned them because they were ugly structures in themselves, but he really did so because a centre girder between two cantilevers had been incorporated in the general lines of the structure, and that condemnation was due to a false sentiment. It seemed to Mr. Davey that if the bottom member of the cantilever was curved to coincide with the outline of the centre girder, that girder might be incorporated with the bridge without its usual obtrusiveness. How that might be carried into effect would readily suggest itself to any designer of bridges, and it appeared quite a simple matter to incorporate a centre girder so that it fell in with the general lines of the structure, and in that way to get a more artistic effect. The argument that nothing was to be hidden was entirely wrong. A tree was not less graceful because its roots were out of sight; a picture might be no less artistic because it was not realistic; and it did not require the eye of an anatomist to see the beauty of the human hand. Therefore, relying on the general principles of Art instilled into the mind by observing Nature, it would be seen that Nature did hide, and by so doing did not destroy the artistic effect. To carry the argument a little further, the Tower Bridge might be criticised for containing architectural work which did

not form part of the structure. That was false sentiment. He would go so far as to say that, even in a cantilever bridge where the supports of the cantilever, owing to the nature of the material, in structures of moderate dimensions—he was not speaking of huge structures where grace of outline and majesty of conception were the principal sentiments, but of such structures, for instance, as crossed the Thames, or of structures surrounded by buildings —it would not be at all out of the way to cover the supports of the cantilever. If a cantilever was designed with small details of trellis-work, it was obvious that any architectural treatment of the stonework it might be more ornate than it would be if the cantilever was more open work. There was an old v(

Mr. Davey.

> Straight is the line of duty,
> Curved is the line of beauty;
> Follow the first, and thou shalt see
> The second ever follow thee.

It was true that a curve was a line of beauty, but it did not follow that associations of curves would be always beautiful, and in dealing with reverse curves very careful treatment was required. The designer of the Borcea Viaduct (Fig. 26, Plate 2) had introduced reverse curves in as ugly a way as it was possible to do so. Reverse curves were constantly seen in the finest architectural work, especially in the Houses of Parliament. To be beautiful a curve must be a free-flowing curve, and the arch was almost the most beautiful thing in architecture. It was impossible to walk through a wood and observe the crossing and bending of the branches of the trees without discovering arches of all kinds, the elliptical arch, the semi-circular arch, the Gothic arch, and every form of free-flowing curve. It did not appear inconsistent to construct a bridge on a compound principle or on a simple principle appearing to be a compound principle—the appearance only being put in for artistic effect; *e.g.*, when an arch was put in for the lower or upper member, not because it was necessary for constructive work, but because it was desirable for æsthetic effect. In support of his argument he drew attention to the Britannia Bridge, in which it was difficult to say whether the girder was divided or continuous. In that instance there was concealment with artistic effect. In Fig. 40, Plate 3, there was no appearance whatever of hollowness in the supporting piers, but the Author said they were hollow and therefore the more to be appreciated. That was wrong. It was only necessary to look at a thing to see whether it was beautiful or

Mr. Davey. not. Poetry might be said to be "Thought, often thought before, but ne'er so well expressed:" the artistic feeling in construction had the subtlety of poetry—the difficulty was in the expression.

Mr. Blashill. Mr. T. BLASHILL remarked that by far the greater number of specimens of bridge construction placed before the meeting by the Author had to do with the use of iron, and such structures were essentially the work of engineers and not of architects. His view of the matter was that, in the construction of a bridge to which artistic qualities were to be given, he would depend largely, in fact almost entirely, upon the engineer for the outline. He could not think that some of the bridges illustrated, which appeared so ugly, had been designed in a manner that modern engineers would imitate. There was an absence of that grace of outline which usually characterized the best of modern iron constructions. It was only necessary to look at the Forth Bridge from below to admire its general outline and composition. He did not speak as an engineer, but knowing something of the manner in which it had been constructed, and appreciating very highly the skill of its constructors, he admired the appearance, the solidity, and the general character of the bridge, and its adaptability to its purpose. That was enough in a thing of that kind. There were bridges, however, which had to be built in places where the public expected beauty. He had been concerned in cases of that kind, and he had always desired to see first of all what the engineer wished, what it was that would best carry the load; and upon that he had endeavoured to work with him—not to introduce things which would interfere with the engineer's work, or overload it with ornament or architectural details, but as simply as possible to emphasize or give character in the smallest possible parts to the design. He considered that an engineer's work overloaded with architectural ornament was likely to be more or less open to criticism. Perhaps engineers thought less of the beautiful in design than they might do, and in that some engineers were wrong. They might well go to the same sources as the architect to get precedents, and to perfect themselves in the art of beautiful construction, and they would be very successful if they did so. Then the bridge might be the design of one person instead of two. With regard to the Britannia and Menai Bridges, he did not know that in respect of beauty the architect could improve them very much. In the question of the construction of a bridge, the engineer should be asked first of all to say precisely what he wanted, and Mr. Blashill would have great confidence that the engineer's outline would be graceful

and lend itself to the little architectural decoration that might be called for, or, artistically, would be permissible. Mr. Blashill.

Mr. W. E. RILEY thought it was very difficult, in co-ordinating two professions like engineering and architecture, to avoid being dogmatical. Each trenched upon its neighbour's domain, and it was necessary to consider with a good deal of sympathy where one left off and the other began. Engineers in the past had dealt with the problem of bridge-building in a very able way, but he ventured to think not enough emphasis had been given to the question as to where a stone structure should be designed and where the structure should be a purely metal one. He did not think there was an architect in London who would be ashamed to have been the builder of either London Bridge or Waterloo Bridge, and those bridges had been built entirely by engineers. He might touch first on what he conceived to be the proper characteristics of a stone bridge, and ask the members to look at it first from the water-side. There was the pier with a cut-water, the arch, the screen, the cornice, and the parapet, and those he thought should be dealt with in a very simple manner. The cut-water in very early bridges, as in the Bridge of Trajan, was carried practically to the top of the parapet. In the early bridges across the Arno there was the same treatment, and it would be found in the beautiful bridge at Bideford. That was a little detail mediæval architects probably employed to direct the masters of craft passing down the river into their proper channel, in order to make the opening between the piers. The beauty of London Bridge and Waterloo Bridge appeared to him to be the great strength which was evinced in the treatment of the arch, and the great simplicity with which the screen, the cornice, and the parapet had been made to harmonise one with the other. The proper and legitimate points for monumental architecture on a bridge were the approaches, not on the screen of the bridge at all. He thought that idea was exemplified in the Alexander III. Bridge, which he considered to have been the finest piece of construction at the Paris Exhibition. Saltash Bridge, looked at from the Saltash side, had a very imposing appearance. It had been criticised on account of the tallness of the piers; but the piers were sufficient, the construction was fine, and considering Brunel's precedents when he had designed the bridge, Mr. Riley thought he had made a fine engineering and architectural success. He could not quite understand why a metal bridge should be expected to do anything, æsthetically, but convey an impression of its fitness for its work. The mere size of a Mr. Riley.

Mr. Riley. bridge and the feeling of its security appeared to him to be quite sufficient. Anything in the way of ornament on a bridge like the Forth Bridge would be meretricious. The conception and successful carrying out of a fine engineering scheme appeared to him to be an ample reward to those who had been engaged upon it. With regard to the swing-bridge referred to by Mr. Goodwin (*Fig. 50*), it had been generally agreed that it was a pleasing structure, and, viewing it in the manner in which it was shown in the diagram, he concurred in that opinion; but he would ask the members for a moment to conceive that the swing portion of the bridge was open, when it would be seen that there was no necessity whatever for anything in the way of arch treatment in the wings on either side. He thought it would have been legitimate treatment to make those girders flat. The curved lower boom was unnecessary, and it seemed to him that when the bridge was open it would give an impression of weakness. The bridge across the East River at New York had been severely criticised, mainly because the piers were conceived in a somewhat shoddy Gothic style. It would have been a great deal better, he thought, to treat them in a simple, massive manner, without attempting too much "architectural" ornament; but he knew no modern engineering or architectural work which had given him such a thrill of pleasure as that bridge had given him the first time he had seen it. He thought that to endeavour to co-ordinate too closely the two professions of engineering and architecture was somewhat a mistake. In the Renaissance period engineers and painters had been practically the same people; Michael Angelo had done some fine engineering work as well as fine painting and sculpture. Frankly, he would never attempt to ornament a purely statical structure. Its size, and the feeling that it was fully justifying its position by doing the work it was called upon to do in bearing loads crossing a ravine or a river, was ample justification of its simplicity and lack of so-called ornament.

Prof. Pite. Professor B. PITE, as an architect, rose with great pleasure to take part in the discussion, feeling strongly that the design of bridges was a source of very considerable artistic emotional pleasure to the architect who ventured to practise it. The emotions that would follow in the construction of the bridge were another matter, and it was on that point that co-ordination between the two professions would be necessary for any peace of mind to either the one or the other. The title of the Paper evidently suggested an entirely different chain of ideas. The æsthetic treatment of bridges had appeared to suggest to Mr.

Davey a delightful reference to Nature, Nature which under no circumstances knew a straight line, a right angle, or a segment of a curve, without one or other of which all architectural accomplishment was impossible. He admitted a very strong sympathy for his fellow creatures who felt that the study of Nature was the basis of all Art; indeed he was sure it was. All were, as creatures of Nature, bound to study it, and their environment in it; but he humbly suggested that a very real appreciation of the laws of Nature lay at the bottom of all sound and effective architectural or engineering design, in directness, simplicity, and avoidance of affectation. There were a number of illustrations that could be drawn from the freaks of Nature, the freedom of Nature, the picturesqueness of Nature, the manner in which Nature set its own laws and principles at defiance, the way in which Nature decorated apart from construction—the stripes on the tiger's back being an excellent illustration of the latter; but he was afraid that in a discussion of that character it would not be possible, without a very long disquisition and possibly a great deal of difference of opinion, to derive any helpful considerations from reference to Nature herself, until a few fundamental definitions had been settled. It might be necessary to define what was æsthetic; it was certainly necessary to define what was artistic; and he would assure the members it was quite impossible that evening to define what was ugly. If it were agreed to banish those terms with any reference to Nature, he thought it might be possible to do a little useful work in the discussion. He might urge upon engineers that to a lay mind there was a beauty in a beautiful machine, as such, and he did not know why a different meaning should be attached to the word beauty apart from beauty of workmanship, of fitness, of power, and of directness of expression, beauties which were recognised now in the most unaffected locomotive, and which were beginning to be recognised in the most hideous ironclad, which expressed its fierceness, its strength, and its purpose in the very want of æsthetic quality in its lines. Why should it be necessary, when talking about a beautiful structure of metal, a structure of a mechanical nature to serve a mechanical purpose, to at once charge the mind with definitions of beauty, striving to ally it to Nature, to Hogarth's curved lines of form, and—as apparently some members of the engineering profession were anxious to do —to architectural forms which were themselves subjects of much discussion and conflict of opinion among architects? He would like earnestly and heartily, as a practical designer, to press

Prof. Pite.

Prof. Pite. home the fact that artistic simplicity would be achieved by dissociating from the mind all architectural phraseology, all architectural ornament, all architectural traditions, such fantasies as the curve and compound-curve lines of beauty, and by aiming in metal bridge building at exactly the same beauty of workmanship, beauty of economy of material, beauty of accomplishment that pleased the mind in any form of mechanical effort. In that way engineers would keep clear of the changing whims of artistic fashion; keep clear, in metal, of the traditions of an architectural art of stone; of the conditions of an architectural art in wood; and would work out in iron, with its different qualities and stresses, an æsthetic style based on the absolute scientific necessities of engineering practice, which would without doubt afford infinite satisfaction to generations to come. As an illustration he might draw the attention of the members to the recognised beauties of Gothic architecture such as was seen in Westminster Abbey. Those beauties had been achieved without any affected reference to Nature, or to imported forms of Art in detail, decoration, and ornament. Gothic architecture in its evolution and development was based upon the engineering necessities of vaulted construction applied to the plan of a church, transeptal, apsidal, or the compound apse, such as was found in Westminster Abbey. It might safely be called a sanctified form of engineering; it was engineering in stone, allying with itself and to itself in its progress highly developed craftmanship such as was found in stone-carving, wood-carving, glazing, and metal-work. Following the same principle in the new age, with the new materials, would lead assuredly to results equally successful. With regard to the unhappy mixture of architecture and engineering which frequently took place in bridge designs, he would like to point out as an architect who had to practise the mere outlines of mouldings, to study their nature and their effect, that there was a whole science and a whole art in moulding. There was also a whole science and art in the development and application of ornament. Ornament that was meaningless, that was achieved rapidly, ornament that was not the carefully expressed utterance of the delight the designer felt in the work of his own fingers, a delight which he succeeded in imparting by sympathy to others, was not ornament worth having. When it came to the application of recognised architectural forms such as architectural orders, cornices, rustications, treatment of voussoirs, he would have it remembered that behind each of those things there was a highly interesting and complicated history, and that the reckless

application of traditional forms to highly modern structures would be only productive before very long of possibly an acceptance of the skill with which the engineering difficulties of a particular case had been overcome, but with a contempt for the embryonic architecture which had applied unstudied detail to an engineering work. Such work, he was afraid, was inevitable. It was that result which made the subject of the co-operation of an architect with an engineer in bridge construction necessary. He ventured to urge that any attempt to assimilate architectural surroundings to bridge design was wholly mistaken. A successful artistic result came more by contrast than by affinity. The application, for instance, of a castellated form to a bridge pier or a bridge abutment was an anachronism which rankled the soul of an artist to its very core, and he earnestly begged engineers to consider that castellated architecture had feelings of its own. It had a past which ought to be respected, and traditions which ought not to be outraged for the sake of satisfying an untutored craving for ornament. The same thing underlay every detail. In stone-bridge architecture exactly the same laws would produce satisfactory æsthetic results as would produce it in iron-bridge architecture. The simple expression of the most useful, the most suitable, the most economical arch, and, if the pier was in the waterway of a stream, the most powerful and economical form of pier and abutment, and the simplest form of parapet, would bring success. He had taken the most recent design published of the new Vauxhall Bridge, and had accepted its engineering statements with pleasure. With the aid of a sheet of tracing-paper he had outlined every factor which represented an engineering truth. He had taken the simple outline of the parapet, the outline of the arch, showing no architectural detail, no cornice which affected proportion, no pier which indicated the designer's idea of traditional forms of architectural beauty, and no ornament which might be shown in a temporary and preliminary manner—the outline and the form of the bridge expressing solely its purpose, solely the object of stretching from shore to shore with elegance and power; and the bridge had in those factors, apart from architectural trimmings, every possible æsthetic element of success. It was when the architecture was added, when the science and art of moulding, the proper expression of cornice detail and balustrade, were attempted, that it was found, in a bridge of that scale, that the ordinarily accepted traditions derived originally from a Greek temple, copied by the Romans, and in the Victorian age found in every street, became out of place; and

Prof. Pite.

Prof. Pite. that there was no living traditional architectural form which could be applied without thought to the current necessities of building. The science, the art, the history of architecture, alike appealed for the most careful, complete, and æsthetic consideration of the artistic details of the bridge. Whether engineers, with the manifold claims on their skill, their science, and their time, felt themselves at liberty to enjoy and do honour to the whole art of architecture hidden in moulding, column, or parapet, was for engineers to say, and not for him; but he hoped the public in the future would justify their decision.

Sir Benjamin Baker.

Sir BENJAMIN BAKER, K.C.M.G., Past-President, apologised as an engineer for occuping a few minutes, because he considered the discussion to be an architect's discussion. He did not suppose engineers wished to hear the opinions of their professional brethren on the subject; they really wanted to hear what their other brethren, in a certain sense, the architects, had to say. He thought if there had been nothing else but the remarks of the President of the Royal Institute of British Architects and those of the learned professor who had just spoken, the reading of the paper would have been amply justified. He did not think a word had been said by either of those gentlemen which he did not cordially agree with, especially the absolutely sound common sense which had been so well put forward by Professor Pite, and which he hoped would sink deeply into the mind of every bridge-engineer present. Architects and engineers were agreed that the fundamental principle was fitness for the purpose, but by agreeing on that principle the difficulties were not overcome. That had been well illustrated in the discussion, and Mr. Blashill had reminded him of it by a reference to the Britannia Bridge. A Fellow of the Royal Institute of British Architects had expressed surprise that the Britannia Bridge had not been illustrated in greater detail as an example of what things should be, and that opinion had been endorsed by at least one engineer. He was afraid in that instance both architects and engineers had violated the fundamental principle laid down, viz., fitness. When he had first seen the Britannia Bridge many years ago, he had been unable to make out the piers. Knowing it to be a tubular girder bridge, he could not understand the object of extending the piers high up above the tube. Looking at it longitudinally, he could not see the use of the perforations in the line of the bridge through the piers; and he had come to the conclusion that it was a girder bridge with suspension-bridge piers, which was a very curious thing. He had ceased to admire the bridge from that time. But as both architects and engineers in

the discussion had selected that bridge as an illustration of what was to be aimed at, he had had the question looked up, and he had found the explanation in a report by Robert Stephenson, the engineer, to the directors of the Chester and Holyhead Railway in 1846. The explanation was to this effect: "Mr. Hodgkinson thinks suspension chains would be a necessary or useful auxiliary; Mr. Fairbairn says the tubes will stand alone: this will not make any difference to the masonry, because I am building the piers to admit of chains." He had heard a great deal of abuse of castellation and of mediæval contrivances for pouring down molten lead on the heads of enemies; but here he found architects and engineers holding up as a model a bridge designed for suspension chains which had never been erected! He only brought that forward as an illustration of the difficulty of applying the principle agreed upon, viz., that fitness was the fundamental condition of beauty. Then it was necessary to take instruction as to what was fitness. He had not the slightest doubt that the man who designed the windmill never had an idea beyond using the material he had at hand in the best way that his mechanical knowledge enabled him to do. Then, when he had done it in a straightforward way, all the leading painters of the day came and selected it to put in their landscapes as a picturesque object. But he was certain that if the builder of that windmill had come to him or to Mr. Davey, they would have puzzled their brains how to make a pretty windmill—and all the painters would have avoided it. There was nothing like honesty—going straight at the object in view. Then, in time, when people were sufficiently educated, if the work had been really done honestly, economically, and straightforwardly, with the materials of the district, the result need not be feared. It was not necessary to labour the question of the collaboration of architects and engineers. An engineer was really such a broad-minded man that any question of jealousy or false pride could not enter into the matter. Engineers consulted each other; on an electrical question they went to one man; on a question of locomotives to another; on a question of waterworks to another; and the idea of any jealousy or false pride in consulting architects was outside the question. As an instance he might mention the case of the great dam in Egypt. When the contract drawings had been prepared they had been handed over to the architectural department, and it could be easily imagined what had happened. When they had come back they had been saturated with Egyptian temples, and when he had seen the contract drawings lithographed, he had told

Sir Benjamin Baker.

Sir Benjamin Baker.

the contractors not to take any notice whatever of architectural detail, because the dam was not to be an imitation of a temple 4,000 years or 6,000 years old. Of course all that detail had been struck out. Then the tourists of all professions, artists, architects, and engineers, had been thoroughly dosed with Egyptian temples, and they all arrived at Assuan with ideas as to how the great dam ought to be finished. He had told the contractors to get their ideas and put up full-sized models on some of the completed parts of the dam, and make the suggestors ashamed of themselves. That had been done, and it had frightened Lord Cromer exceedingly. His Lordship had come down and seen about ten different sections of cornice along the finished part of the dam, and when he had met Sir Benjamin in Cairo, he had looked at him very seriously and had said: "I will find you any amount of money you like to make the dam safe and suitable, but I am not going to waste £150,000 or £200,000 putting up architectural details." He had told Lord Cromer there was no intention on his part of putting up anything of the kind; he had simply put up the models to see how they would look under actual conditions, in strong sunlight with very deep shadows. In the result, everybody had agreed that a suggestion which looked all right on paper for a limited length, when applied to the two sides of the dam, giving 2½ miles of cornice, was simply a thing to stamp the man who put it there as a madman. That was another instance of the fallacy of jumping to the conclusion that all the difficulties were solved in arriving at the principle that architects and engineers should collaborate. When very young he had thought he could do without architects; now he always consulted them. He might convince the architect, or the architect might convince him; but in any case the questions were argued out, and there was agreement in the end. It was impossible to say, "Here is an engineering drawing; pass it on to the architect to be altered and made architectural." When it came back to the engineer, he might say that it falsified the whole principle of the work, and did not meet his requirements. Ultimately, however, some agreement might be come to. In the collaboration of engineers and architects, there would have to be a constant see-saw of the plans backwards and forwards. As he had said, when very young—only twenty-two in fact—he had thought he could do without architects, and he had designed and carried out some very pretty work indeed. It had been so pretty that it had attracted the attention of Mr. Ruskin, who had mentioned it in one of his lectures. There had been columns and arches and scrolls in iron

work, and Mr. Ruskin had said that he had seen it, and that it made him wish he had been born a blind fish in a Kentucky cave. He thought afterwards that Mr. Ruskin had let him down very easily, because sometimes he could say nasty things! Sir Benjamin Baker.

Mr. MAX AM ENDE concurred in the views of Professor Pite. Æsthetic treatment was treatment which appealed to the senses, to the perception. If the designer of a bridge treated his problem carefully according to the dictates of fitness and economy, so that his work was clear to the perception of the beholder and produced in him a feeling of satisfied interest, he had treated his problem æsthetically. The design of a large bridge, especially, was a matter of much delicate and intricate thought, and if such thought was successfully conveyed to the perception of others, it might be said that no further æsthetic treatment was needed, inasmuch as what were conceived to be beautiful lines and pleasing proportions would naturally grow out of careful treatment. It was, however, desirable sometimes to bring to greater prominence those parts of a large bridge which would appear neglected when treated on strictly economical principles, and it was more æsthetic to do so by means of ornament than by a masterful elaboration of constructive detail. Such parts were, for example, the platform of the bridge, which appeared sometimes to be the least important part while it really was the most important, and the hinges of an arch, which always appeared insufficient in strength and stability. Mr. am Ende.

Mr. ST. GEORGE MOORE thought the Author had struck a false note, the only one in the whole of the Paper, in the title—"The Æsthetic Treatment of Bridge Structures." That appeared to him to imply that the bridge was to be designed first and ornamented afterwards, and that, as had been well said by other speakers, was not the true way to approach the subject. A bridge had to be æsthetically designed and not æsthetically treated after it had been designed. He had had occasion to pass the Alexander III. Bridge very frequently during its construction, and he confessed that the bridge had not been improved by the ornament. Its beauty lay really in curve and outline. Engineers ought to carefully avoid laying themselves open to Pope's criticism of the Artist and the Poet:— Mr. Moore.

> Poets heap virtues, Painters gems at will;
> And hide by ornament their want of skill.

Stone bridges had been under discussion for a great many years, and some wonderful and beautiful examples had been built. The

Mr. Moore. design of iron bridges, however, was practically a new science. He took exception to the remarks of several speakers with regard to the diagrams which the Author with great labour and perseverance had placed on the wall. Several speakers had referred to them without realising that they were engineering diagrams and not pictures of the bridges. It was absolutely impossible for the eye to see the actual structure in the diagrams. An engineer was accustomed to looking at a drawing of that sort, and it conveyed a meaning to his mind; but that an artist should look at it and complain of a want of regularity of spacing of the members rather surprised him. Mr. Read had struck the true key-note in saying that as the knowledge of the theory of ironwork construction and the knowledge of the nature of the material increased, bridges would naturally improve in appearance—that the truer the science the more closely would the rules of art be adhered to. Bridge construction and music were probably the two most mathematical sciences in existence. Any false mathematics in music produced a false note; any false mathematics in a bridge produced redundant and false members. He was sure that if engineers would apply themselves to the study of the works of recognised masters in the science of bridge construction they would improve their art.

Mr. Myers-Beswick. Mr. W. B. MYERS-BESWICK entirely agreed with Sir Benjamin Baker's remarks as to there being no difficulty in an engineer and an architect working together. It had been the practice of himself and his firm for some 30 or 40 years to work constantly with an architect without the slightest difficulty. In certain works an architect must more or less take the lead; for other works an engineer must be primarily responsible. In an ordinary bridge, in nine cases out of ten, the general mode of construction was decided by the circumstances of the case, and all the engineer could do, so far as the architecture was concerned, was to be guided in the exact line of a curve and in what might be described as ornament—chiefly applicable to the abutments or piers of a bridge. He considered that the designs shown in *Figs. 16* and *17* were very ugly, and he could not believe that either of them was necessary. Above the voussoirs of the arch there must be a road of some sort that would probably take at least the thickness of an ordinary stringcourse; there could not possibly be any difficulty in carrying the stringcourse above the voussoirs, and the parapet could be lowered or raised to any extent.

Mr. Inglis. Mr. J. C. INGLIS had been a little disappointed at the criticism of the æsthetic properties of the Britannia and Saltash Bridges, but after hearing the artist of the Forth Bridge on the principle he

had adopted—viz. fitness of a structure for its purpose, a principle which the writer of the Paper also enunciated, and one with which the meeting was generally in agreement—he had but little to say. The discussion had appeared at first, judging from the points which had been raised with regard to the Britannia Bridge, to be rather against the principles which the Author laid down. He had prepared four lantern-slides, including one of the Saltash Bridge as it appeared with its surroundings, and two of the Maidenhead Bridge, both those bridges being the work of Mr. Brunel; and if permission might be granted he would be pleased to exhibit them. Mr. Inglis.

The PRESIDENT remarked that such a proceeding was contrary to the practice observed in the course of the Institution debates; but having regard to the unusual character of the subject before the meeting, and to the fact that the discussion was now at an end, he would accede to Mr. Inglis's request. The President.

Mr. INGLIS then showed the views in question, and observed that in his opinion Mr. Brunel had fulfilled the conditions which Sir Benjamin Baker and other speakers had laid down, namely, he had followed engineering principles to their limit. He had done it himself, not deputing the work, and the results of his genius were personal results to a degree which was not often found in engineering works. A study of the surroundings of Saltash Bridge and of the Maidenhead Bridge, that was, of an iron bridge and of a stone bridge, rather traversed the statement in the opening of the Paper, that the æsthetic treatment of bridge structures had not received adequate attention in the past. Mr. Brunel's works showed that he had thoroughly understood the principles he was dealing with, and his carrying of them out point by point was as good an example of æsthetic treatment as any that could be met with in engineering. Saltash Bridge had been criticised on the ground that the centre pier was different from the others; but there was a thoroughly sound engineering reason for that departure from uniformity, and he was not aware that uniformity beyond necessity was one of those things that should be worshipped. The centre pier was founded at a depth of something like 90 feet or 100 feet below the water-level, so that it was necessary to lighten the upper part of the pier by making it in cast iron. He thought the chaste and modest treatment of the piers at the end of the tube was typical of the discussion that evening. With regard to the heaviness of the upper member of the girder tube, a false impression would be very likely conveyed by the Author's diagram, but the photograph on the Mr. Inglis.

Mr. Inglis. wall showed a logical engineering structure built 40 years ago, which he submitted to be a triumph of ingenuity. With regard to the Maidenhead Bridge, that was another example of a plain engineering design of a bridge with two spans of 128 feet each. Ornament was almost absent, but the exceeding beauty of the economy in effect was quite exceptional. There was a grand simplicity about the treatment of the arch, which was lamentably wanting in a structure so highly spoken of as the Alexander III. Bridge. In conclusion, he would exhibit a slide of a tunnel-mouth built by Mr. Brunel. It was rather a contrast to that engineer's usual structures, and he exhibited it rather as a curiosity, showing how a great engineer could depart from the true lines and really play with the æsthetics of architecture.

The President. The PRESIDENT thought the discussion had fully justified the Council in selecting the Paper for reading. He had been greatly pleased to see so many architectural friends present, and had been particularly delighted in listening to the able and eloquent speech of Professor Pite, the son of Mr. Alfred Pite, an old confrère of his in Brazil 40 years ago.

The Author. The AUTHOR, in reply, desired to acknowledge the vote of thanks accorded to him and to express the pleasure he had felt at the Paper and discussion having been the means of eliciting so many valuable expressions of opinion from members of both the engineering and architectural professions. Some speakers had complained of the fact that elevations of the bridges had been provided instead of perspective views. If it had been remotely possible to place perspective views of all the bridges on the wall he would have done it; but it would have been an utterly impossible task. That point had been already foreseen and mentioned in the Paper, and was the principal reason why lantern-slides of several of the more important bridges had been exhibited before the discussion. Some speakers also had appeared to think that all the bridges in the diagrams were put forward as examples of æsthetic design. He did not claim anything of the sort. Careful reference to the Paper would show that a few of the bridges, and a few only, had been emphasized as truly æsthetic structures, in his opinion. Those which he had attempted to emphasize in that manner were Figs. 3, 5, 21, 31, 33, which he specially admired, 37, 40 and 48. Most of the remarks made had almost necessarily tended to the expression of individual opinion on the points at issue rather than to actual criticism of the subject matter, and many of those remarks had been very conflicting. With reference to Mr. Elliott Cooper's remarks, the

The Author.

design shown in *Fig. 7* was distinctly mentioned in the Paper as being preferable to that of *Fig. 6*; incidentally he might mention that *Fig. 6* had been taken from an existing bridge. With regard to the bridge over the Blaau Krantz ravine, it had been stated that the chief reason for the adoption of that particular design had been the necessity for erecting it without scaffolding. In the absence of more detailed information, he ventured to think that an arched bridge of the same span might have been erected by overhang, under the same conditions, and would probably have had a much better appearance. An allusion by Mr. Caröe to the Conway Bridges had raised the question of the propriety of building bridges with defensive towers or abutments. He thought many instances might occur in which such a mode of procedure would be not only desirable but necessary, as, for example, bridges over rivers which constituted important political boundaries, or in positions of strategic value. It was a very usual proceeding to fortify the abutments of such bridges, and the Dufferin Bridge at Benares, and that over the Rhine at Coblenz, might be mentioned as examples. Exception had been taken to the remark as to one material being presented in forms more suitable for another. Certainly no one would wish to dispute the beauty of the distinctive features of classic design executed in stone, yet the special features referred to might with equal propriety be constructed in wood or in stone without violating the suitability of either material for the purpose, and this was probably an important reason why such forms of architecture did not appear incongruous. When, however, examples of bent wooden construction, and even such details as pins, notches and cotters were reproduced in stone, as was the case in many Eastern buildings, the effect might be striking, but it was scarcely pleasing. It was the inadvisability of thus going to extremes which had been implied in the Paper. The Author might be permitted to give a brief quotation from Fergusson[1] as bearing on the subject:—

"It is only in the infancy of stone architecture that men adhere to wooden forms, and, as soon as habit gives them familiarity with the new material, they abandon the incongruities of the style, and we lose all trace of the original form, which never reappears at an after age."

Mention of the effects producible by painting structures had been purposely omitted from the Paper. It was obvious, however,

[1] "History of Architecture," by James Fergusson, vol. i. p. 234.

The Author. that the particular colour applied to a metal structure might exert a considerable influence on its appearance, and not a few structures offended the eye in this respect. The viaduct with abutment-piers, of which Mr. Read had submitted an illustration, was certainly very pleasing, the principal reason being that the abutment-piers occurred at very frequent intervals. Their suitability in an exceptional case such as this had been admitted. Several speakers appeared to hold the opinion that very large iron structures could not possibly be regarded as æsthetic. He thought Sir Alexander Binnie had given a very lucid explanation why such opinions were entertained, in apprehending that the public did not yet sufficiently appreciate the meaning of those structures and the skill evidenced in their design. Much of the discussion had almost necessarily turned on the relation between the professions of engineering and architecture. In that connection it was satisfactory to notice that many modern works, especially in France and Germany, furnished examples in which most happy results had been achieved by co-operation between the architect and the engineer; and the members had had placed before them, in the design for the Victor Emmanuel memorial at Rome, an excellent example, such as would scarcely be looked for as the individual work of either an engineer or an architect. At the same time he ventured to think there was no adequate reason why the engineer should not make himself familiar enough with the essential principles of architecture to be able to successfully cope with any ordinary difficulty that might present itself. It seemed, however, distinctly desirable, where engineering proposals included a considerable amount of architectural design, that the assistance of an architect should be requisitioned. He was pleased to find so many members of the architectural profession agreed with him as to the excellent appearance of the masonry parts of many bridges which had been designed wholly by engineers. He thought also that the massive masonry piers and towers of many bridges, although devoid of architectural detail in the ordinary acceptance of the phrase, yet exhibited very successfully the application of the principles of what might be called engineering architecture. In instituting comparisons between British and Continental bridges, frequently to the detriment of the former, it should be remembered that opportunities for the erection of imposing bridge structures were much more numerous on the Continent than in England, and that in many instances such works were undertaken by the Government and carried through on a more lavish scale of expenditure than

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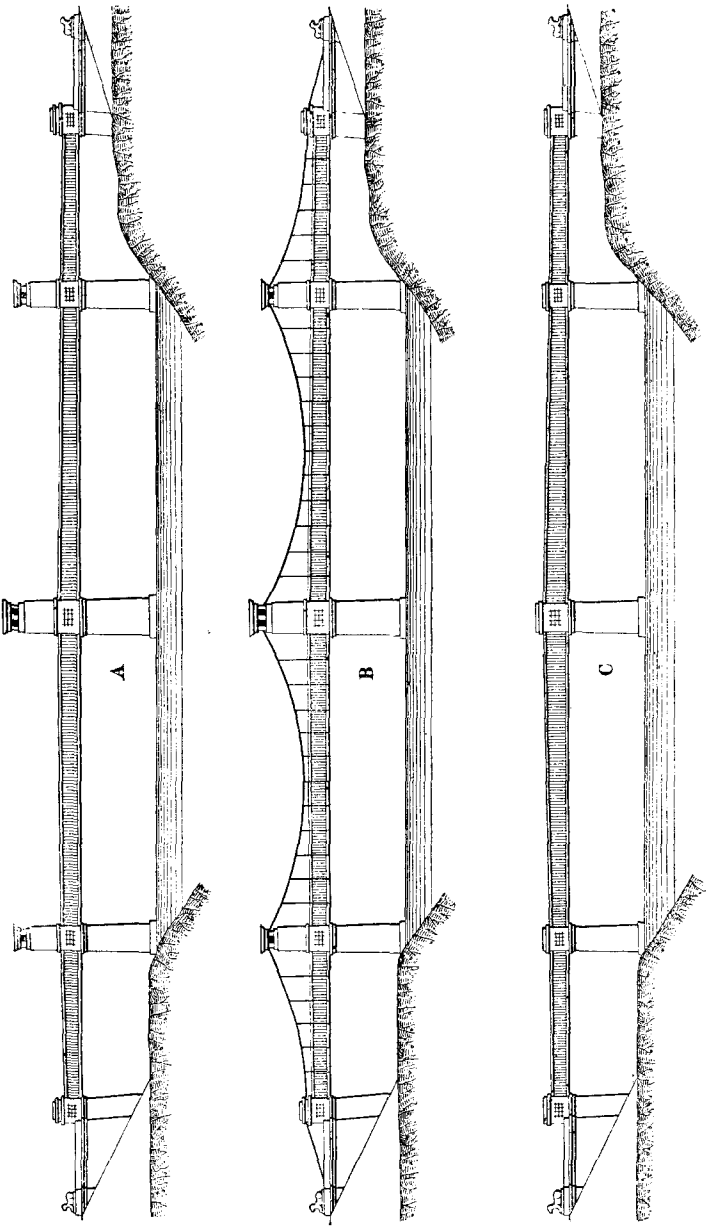

Figs. 52.

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