and friendly collaboration in connexion with the warehouse described herein; to the Technical Director of the mill-owners, for his kindness in permitting description of a few of the buildings which the Author has had the honour of designing for his Company; and to the Author's assistant, Mr. K. G. H. Montgomery-Smith, M. Inst. C.E., who collaborated in the design of all the buildings described.

The Author also acknowledges, with gratitude, the help and collaboration received from the Technical Department of the mill-owners, which was responsible for the layout and design of all the machinery in the buildings, and from Messrs. Peter Lind & Co., Ltd., Mr. Henry Wilcocks, Messrs. Richard Costain, Ltd., and Messrs. J. L. Kier & Co., Ltd., Contractors for the various buildings described.

The Paper is accompanied by twelve sheets of drawings and by three photographs, from which Plates 1, 2, 3, 4, and 5, the half-tone plates, and the Figure in the text have been prepared.

Discussion.

The Author, in introducing the Papers, observed that there was no connexion at all between them; no suggestion was made that the principles propounded in the first Paper had been successfully applied in any of the structures described in the second Paper.

A few hoary fallacies were mentioned in the former, many of which were due to " wishful thinking", such as the easily-disproved heresy that if a structure was really scientifically designed it must be beautiful. That was mere nonsense. Such a structure might, indeed, happen to be beautiful, but it might equally well be ugly. He did not doubt that Charing Cross bridge had been scientifically designed; but, even if it could be shown that every member had the same factor of safety to the fourth significant figure—and the right factor of safety—it would not alter the fact that, so far as he knew, no one admired it as a thing of beauty.

It was easy to be destructive of aesthetic theories. He had read many books which were completely convincing when they shattered to atoms the aesthetic theories of the past, and equally unconvincing when they attempted to become constructive. Hence it had needed considerable courage on his part to attempt to write a constructive Paper; but an examination of structures judged beautiful by common consent indicated certain qualities which they had in common, such as harmony, compliance with certain rules of composition, character, and interest.

Harmony might be internal, that was to say, harmony of the component parts of the structure among themselves, or it might be external, that was to say, harmony of the structure with its surroundings. Character covered certain properties which some structures appeared to have in common with

human beings. For example, some structures were excessively heavy—Teutonic in design—whereas others were graceful. Some stood up with self-assertion, as much as to say, "Look at me; I am here, and you cannot help looking at me; I am a very important building," whilst others were of a retiring character and, even when they were beautiful, did not force people to look at them. Interest was very important in a building, because the quality of charm could not be imparted until interest had been aroused. It might be aroused by many things, for example, by the expression of function—the function of the building being expressed in its design—or by expression of the construction, that was, how the building worked and how the forces acted. In the old cathedrals that expression was provided by flying buttresses, which indicated how the various forces were acting; and that undoubtedly gave an interest to the buildings which they would not otherwise possess. Rhythm, texture, colour, and silhouette all entered into the interest offered by a building. He had attempted to show that a structure would be aesthetically pleasing in proportion as it satisfied the requirements of harmony, composition, character, and interest, and he had made some attempt to discuss those requirements in the most condensed language of which he was capable. The second Paper was a plain and straightforward description of some plain and straightforward buildings.

The President thought that it would be agreed that the second Paper was a very interesting description of some engineering structures. The rapidity with which the work proceeded must really have formed practically a record. The subject of the aesthetics of engineering, however, was probably one with which nobody else in Great Britain could have dealt so ably as the Author.

Professor C. E. Inglis expressed unqualified commendation of the Paper on "Aesthetics," which he considered would come to be regarded as a classic in the annals of The Institution. It should be read not once, but again and again by all engineers who were zealous not only for their own personal advancement but also for the raising of the status of the civil engineering profession as a whole.

As the Author had pointed out, up to about 120 years ago the architect and the engineer were indistinguishable. The cleavage came when wrought iron, with its comparatively high tensile properties, became available in sufficient quantity and reliable quality as a building material, and then bridge building in particular became a science in which art was relegated for the time being to a position of minor importance. That was quite understandable; new vistas were opening up and miracles of construction were being performed—miracles which were quite beyond the reach of artistic criticism. But in that neglect of the aesthetics of their works of construction engineers went on far too long, and it probably reached its worst stage in the late seventies and the early eighties of the last century.

Professor Inglis exhibited some lantern slides to illustrate his views. He observed that it was rather difficult to make a suspension bridge unsightly, but in the design of a Forth bridge which was actually under construction in 1879, and was subsequently abandoned, that unenviable distinction was certainly achieved.

Although the early eighties of the last century was artistically a bad period in structural engineering, there were great engineers in those days, including Sir Benjamin Baker, whose Forth bridge was certainly pleasing owing to its size and the excellent proportion of its parts.

In contradistinction to a suspension bridge, a cantilever bridge was difficult to treat æsthetically; it was full of discontinuities, and meaningless discontinuities jarred the artistic senses. But the discontinuities in a cantilever bridge where the cantilevers ended and the suspended span began were not meaningless, and the correct way to make a cantilever bridge look pleasing was to emphasize those discontinuities until they were quite obvious. Too often the reverse process was adopted and engineers, thinking that they were improving the appearance of the structure, camouflaged those discontinuities to such an extent that it became impossible to detect where the cantilevers ended and the suspended span began.

An example of that was provided by the Queensborough bridge over the East River at New York, where the discontinuities were slurred over to such an extent that the stresses became highly indeterminate, and, behaving unsatisfactorily under a test load, its carrying capacity had subsequently to be reduced. Going to the other extreme, he thought that in the case of the Sukkur cantilever bridge, in India, the lamp of truth shone with too lurid a flame, and that in the stark nakedness of its anatomy the bridge presented an almost immodest appearance.

Professor Inglis exhibited a slide of a cantilever of the first ill-fated Quebec bridge, taken the day before it collapsed. To his mind the structure presented a perilously frail appearance and the exaggerated curvature given to the bottom chord served only to emphasize that feeling of fragility. In comparison, the second, and successful, Quebec bridge inspired complete confidence. It suggested great strength combined with simplicity, and the straightness of the bottom chord left no doubt in the mind as to where the cantilevers ended and the suspended span began.

A bridge which had played a leading part in shaping the evolution of the long-span metal arch was the Hell Gate bridge, over the East River, New York, which was completed in 1917. Its design was settled only after many years of investigation in which a great number of alternative constructions were carefully reviewed. In the final survey it was considered that none of those preliminary designs possessed the dignity looked for in a bridge which was to occupy such a prominent position in the city, and attention was then directed to the superior artistic merits of a metal arch bridge. Eventually the choice lay between a crescent-shaped and a

spandrel-braced arch. Finally opinion favoured the latter, reversed curves being introduced into the top chord to improve the general outline. It was considered more pleasing in appearance than the crescent-shaped arch and the deep vertical posts at the abutments were helpful in erecting the span by the cantilever method. He considered that the majesty of the structure amply justified the years of preliminary investigation which resulted in its evolution; and, in so much as imitation was the sincerest form of flattery, the Hell Gate arch bridge had received abundant admiration, since it had been the prototype of many metal arch bridges built subsequently, the great Sidney Harbour bridge being an example.

Probably in the early days of suspension-bridge evolution engineers did not give serious thought to the artistic merits of their designs. When, for instance, the Brooklyn suspension bridge, with its span of 1,600 feet, was completed, in 1883, it was regarded as one of the engineering marvels of the world. It was little short of a miracle; probably nobody at the time attempted to assess its artistic merits, and its beauty, which was undeniable, was automatically achieved. In fact, it was difficult to make suspension bridges unsightly, though he knew of one or two cases where that difficulty had been overcome. For instance, he considered that the Williamsburg bridge over the East River, New York, completed in 1904, came into this category owing to its stiffening truss, which was so deep and massive that the supporting cables appeared to be an unnecessary adjunct. In 1926 a suspension bridge of 1,750 feet was built over the Delaware river at Philadelphia, which he regarded as a masterpiece from the aesthetic point of view. It was not cluttered up with unnecessary architectural embellishments, and it was by the sheer unadorned beauty of its anatomy that it achieved such a high standard of aesthetic perfection. The graceful cable-towers were flexible in the fore-and-aft direction to accommodate changes in the lengths of the cable, whilst they possessed great rigidity in the direction transverse to the bridge.

The mighty George Washington bridge, with its span of 3,500 feet achieved much of its impressive effect by the majestic splendour of its cable-towers, which were 600 feet high and, owing to the downward pull of the cables, supported a load of 112,000 tons. The original intention had been to conceal the steelwork under a veneer of masonry, but the engineers fought against that concealment and won. To suggest that that stupendous load was carried on anything other than a steel structure would have involved the perpetration of an outrageous structural lie.

As the Author had pointed out, when in the fighting-line of engineering progress there were no alternatives. That was exemplified in the wonderful Golden Gate bridge, with its span of 4,200 feet. That bridge could only be a cable suspension bridge, and along that line of advance it might be claimed that engineering construction was leading and not following aesthetic considerations. It was only in dealing with bridges of shorter span, where many alternatives were available, that engineers had to

cultivate a sense of what was or was not beautiful. That, in many cases, should be the deciding factor, and engineers must grasp the fact that most members of the public had—or thought they had—artistic perceptions. When an engineer went before a town council with plans, the members of that council in general could not, and did not want to, discuss technicalities, but most of them were interested in the aesthetic aspect of the proposed structure.

If the engineer could not deal intelligently and sympathetically with that side of the problem, they would turn to somebody who could, and the engineer would consequently have to accept a position of minor importance.

The value of the Paper was enhanced considerably by the fact that the Author had given definite reasons why some structures induced greater mental satisfaction than others. For instance, he had explained why a bridge should preferably have an odd number of spans. Professor Inglis was of opinion that the same principle applied to girder bridges, and that a girder with an odd number of panels was superior in appearance to one with an even number of panels.

The Author was entirely justified in accusing engineering colleges of having neglected instruction in this all-important aesthetic side of engineering. Certainly, looking back to his student days, Professor Inglis recognized that whereas he was taught how to design bridges which structurally and economically were correct, it was never even suggested that consideration should be given to the question of how the bridge was aesthetically suited to any given site. In the University to which he had the honour to belong the importance of this consideration had at last been recognized, and in consequence the Author had been invited to give a course of lectures on aesthetics in engineering, which had been enthusiastically received. The Institution also was taking a lively interest in that particular branch of knowledge, and was promoting and subsidizing a scheme for providing instruction in that fascinating and all-important development in engineering education.

Mr. Conrad Gribble observed that he was particularly interested in the second Paper because he had had something to do with one of the structures described. It had met with great success and had received general appreciation from those who had to use it, and also from those who looked at it. Incidentally, it had an advertising value, since it was prominent and attractive, especially when floodlit, and it drew attention to the company for which it had been constructed and, he thought, did honour to that company.

The difficulty was to know how to design bridges so that they would be pleasing to look at; engineers suffered from a lack of education in that respect, and Mr. Gribble considered that, if anything had been brought out in the discussion, it was that a young engineer ought to be trained to design bridges and structures of all kinds so that they would form pleasing and

happy monuments instead of very distressing ones. He had heard many harsh criticisms of Charing Cross bridge from time to time, and he supposed that they would continue so long as that bridge existed; but he did not think that the Author's assertion that no one had ever said a word in its favour was quite correct, because he remembered very well a photograph of Charing Cross bridge taken by an architect in the misty evening light of London, at the time of the great controversy about the proposed new bridge; that photograph appeared in the press, and the architect who had taken it expressed the view that the bridge was really rather an artistic structure!

Mr. P. J. H. Unna considered that engineers should be careful not to regard aesthetics too much from the technical point of view, or they might be called "highbrow." The ordinary public could not be expected to appreciate the technicalities and niceties of engineering design, and considered a thing beautiful when they thought they understood how it worked. They regarded an arch or suspension bridge as beautiful, but were completely floored by a rolled steel joist. One of the reasons why Charing Cross bridge was so universally condemned was that people did not understand how it stood up.

The discussion had rather centred on the appearance of bridges, but there was also the view from the bridge. It was as important to provide a good view for passengers as for persons on the banks. The worst culprit was the railway bridge at Putney, where the top boom was on a level with the eye, so that nothing could be seen. Further, it might be justifiable to perpetrate what Professor Inglis had called a "structural lie", and apparently Waterloo bridge would do that. It would have girders disguised as arches, and that would be correct. The public would not understand the girders, but they would the arches.

The question of aesthetics should not be entirely confined to buildings and bridges, for roads were even more important. A road that was badly designed in detail could destroy whole stretches of the countryside, and could do far more harm than a badly designed bridge or building which might be seen only a few streets away. There was much room for improvement when making or widening roads in Great Britain.

Mr. T. Peirson Frank observed that the first Paper was of particular interest, as the Author had broken new ground, and it should certainly be studied carefully by students and the younger engineers. He agreed with the Author in many respects, but there were one or two points to which he would like to refer.

With regard to the question of economy, he assumed that it was necessary to look forward to some economy at the conclusion of hostilities. Many structures erected during the period from 1919 to 1929 were affected seriously by the wave of economy which developed then and continued even into the early thirties. That had affected many engineers. In the housing schemes which were undertaken a limit was imposed upon the

sizes of rooms. Mr. Frank considered that they were too small; but economy had to be effected.

On p. 148 the Author had observed: "It will be noticed that all the better bridges across the Thames, including the new Waterloo bridge, have five spans." A new bridge which had recently been completed had only three arches, but Mr. Frank submitted that that bridge did not deserve the castigation that it apparently received from the Author. The Royal Fine Arts Commission had stated that they very readily endorsed the scheme; and that the bridge was appreciated outside England was demonstrated by a letter received from an engineer in Hungary, who was about to build a bridge over the Danube and who stated that he liked the design and asked for some particulars of its construction.

With regard to character, Mr. Frank believed that all buildings in London were affected by the Building Regulations. In the provinces control was effected by the building by-laws, which exercised a marked influence upon the design of structures.

He did not agree with the Author's statement on p. 162 that: "the 'Rocket' was a wonderful machine, designed to achieve speed; but its lines were hardly such as to suggest speed." He was sure that when the "Rocket" was constructed people thought that it suggested high speed.

Again, the Author compared the Golden Gate bridge with the Forth bridge, rather to the disadvantage of the latter; but Mr. Frank considered that in order to judge those structures correctly one should bear in mind the knowledge that the designers had at the time of their construction. The very latest works of the present time might be condemned after 100 or 150 years, if the knowledge available at the time of their construction was not taken into consideration.

The Author had suggested the merging of the two professions of engineering and architecture into one. They could easily be merged, and that was being done in many districts. The borough engineer or the city engineer was frequently the borough architect or the city architect, and his staff were partly interchangeable. Mr. Frank considered that adoption of the Author's suggestions would do much to improve the aesthetic appearance of structures which members of The Institution might have the honour of designing.

With regard to the second Paper, Mr. Frank would like to know whether the Author had noted the effect of any high-explosive bombs in the near vicinity of any reinforced-concrete columns similar to those illustrated on Plate 1.

Colonel C. L. Howard Humphreys observed that he had been told on the best possible authority that there was another supporter of Charing Cross bridge, namely, Mr. George Bernard Shaw, who had said: "It is the only bridge in London worth looking at!"

Colonel Humphreys had had his mind cleared to some extent by his very superficial study of the Paper on aesthetics, and he was grateful to

the Author for setting out the essential requirements of an engineering structure. That, after all, was the text of the sermon. He considered that engineers should look for harmony in all that they did, and that their buildings must harmonize with the surroundings of those buildings. He had always felt that London largely lacked the atmosphere that could be found in many continental cities, and that a certain disharmony existed. There were many fine buildings, but they did not produce the effect that one experienced in a city like Genoa, where all the buildings in large areas harmonized with each other, or were in a very similar style.

There was one other harmony that should be achieved. The extreme view of the engineer was exemplified by the student's comment cited in the Paper, that " engineers might well leave the consideration of cathedrals and things of that kind to architects " ; whilst the extreme view of the architect was, perhaps, exemplified by the definition of an architect which Colonel Humphreys had found in a dictionary, namely, " Any contriver, for example, the Creator." He considered that a middle course should be steered between those two schemes. He had always deprecated the tendency for an unseemly wrangle to take place when aesthetics were discussed. The two branches of what might be called the construction industry ought to be led nearer together, and he was quite sure that, if that were borne in mind and people who tried to wrangle were silenced, the public interest would be served.

Mr. W. A. Willox disagreed with the Author on one point : he thought that if the purpose of a structure was properly served as the result of its design, the structure would be beautiful, provided always that the beholder agreed that its purpose was a good one. It depended very largely upon the view of the purpose for which the particular structure had been designed, and upon the efficiency with which that structure had been built ; and that efficiency depended upon the state of knowledge at the time. The purpose of the Forth bridge, for example, was amply fulfilled, and, in the state of knowledge prevailing at the time of its erection, it was probably built with the utmost efficiency. Such a structure would not be built at the present time, because of the development of knowledge ; yet the Forth bridge was a beautiful structure in the eyes of most people, simply because it accorded with the prevailing canons and fulfilled its purpose as perfectly as it was possible to do at that time. With that basis he thought that it was possible to judge what might be regarded as a beautiful design and what was likely not to be so regarded. The great point was that, with the knowledge available, the utmost efficiency in achieving the purpose of the structure should be striven for, and, if that efficiency were allowed to suffer for any extraneous cause, the result would suffer correspondingly in its appearance. For example, an engineer might be instructed to build a bridge for a specific purpose, with the stipulation that he must be parsimonious ; and if he allowed that stipulation to interfere with what he knew to be the proper purpose for which he was striving,

the result would inevitably suffer. On the other hand, an engineer or an architect might strive deliberately to make a structure beautiful, and then, when the work was finished and he had handed it over, somebody who was not an engineer, but who had the object of parsimony in mind, might come along and affix hideous placards to the structure, so that all the engineer's efforts to achieve beauty were rendered vain. An advertiser might yet stick posters on Charing Cross bridge and then, Mr. Willox thought, the opinion that it was hideous would be unanimous. Charing Cross bridge had never offended him personally. He thought that it was probably quite good at the time when it was designed, although it would not be built to-day, because it was not an economical design.

He would like to utter one word of warning, especially to younger people. Although the Author's Paper on aesthetics was a most valuable one, it should not influence anyone to strive unduly after beauty. Instead, he would suggest that the engineer should refuse to be deflected by one hair's breadth from the object of achieving results with the maximum of real efficiency.

*** **Mr. D. T. Lloyd Jones,** of Halifax, considered that the two Papers, short essays in precept and practice in applied sciences and arts, challenged more serious thought than would at first sight be suggested by their unassuming titles and the manner of their presentation. In the present stirring times of new order in the radical direction of human effort they pointed either to the need for new philosophy, or to the revival of fundamentally founded and inescapable philosophy.

In the first creation man was created in God's own image, and was imbued with creative faculties to continue by evolution the development of his earthly paradise, according to the Divine plan.

Cycles in world history revealed a recurring sad story. Conscious of his powers, man bred arrogance and contempt for ideas other than his self-satisfying own, and sought every so often to create a world of his own conception, a Tower of Babel. And when men became individualists, they did not speak in the same tongue. Such disunity of thought brought in its train confusion and chaos, and the brave new world of man's own making crashed about his ears. The present world upheaval was one of those cycles on the threshold of a new world, and engineers were privileged to bring in a new order. Were they worthy of and equal to their task ?

The scope of the Papers had been limited to structural engineering, in which connexion no happier term could be found than " order," the title accepted by architects through the ages for that masterly arrangement of components which, in the perfection of the art of ancient Greece, raised the character of building from the simple service of man's needs to the highest peaks of applied and symbolic art, for our edification and delight.

The point at which mutual understanding and helpful co-operation

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*** This contribution, and also the following, were submitted in writing.

between engineers and architects might be reached had been discussed very fully by Mr. Lloyd Jones before the Institution of Structural Engineers in a Paper entitled " The Sixth Order, the Architecture of Concrete [1]."

In comparison with the architect, the structural engineer was a newcomer, and he approached the subject from a different angle. The new term " Engineer-Architect " would appear to define fairly well the position of the master builder in the great traditional classic periods, and was equally acceptable as describing the field of action of his modern counterpart, whether represented by one person or by two or more in collaboration, each limiting his responsibility to specific portions of the work. Collaboration obviously had its pitfalls in the present days of specialization, unless the respective parties had so complete an understanding of each other's functions as to be able to undertake individually the entire " work "; and it was doubtful whether every age produced even one Michael Angelo. The term " work " had been chosen advisedly, because it represented the fundamental difference of opinion between the engineer and the architect. To the engineer work meant performance according to some scale of power or measure, something functional, done to meet a need which in itself was sufficient and proclaimed its purpose openly, whereas the architect visualized work as an abstract thing, a form of expression making its appeal almost wholly to the aesthetic senses, and in extreme cases so exclusively as to prostitute his art. The argument as to whether building was a science or an art had done much disservice to both great professions by ranging their exponents in several camps, in which two schools of thought predominated, namely, the " functionalists " and the " traditionalists." Generally adherents to the former group were to be found amongst the engineers, whilst the champions of the latter embraced most architects.

In his reply to the discussion on " The Sixth Order," Mr. Lloyd Jones had observed that " on the one hand there were the functionalists who asserted that that which is plainly constructive and quite obviously performs the functions intended for it, is sufficient in itself, is necessarily beautiful because of its fitness, and has no need of adornment, that is the mechanical mind in architecture. Opposing, there was the traditional camp, in whose Pharisaical view all that is new offends the established canons of the aesthetic, is in short an outrage to good taste, and whose exponents should be denounced, and if needs be, crucified in the name of art."

Nothing was so abhorrent to any thinking engineer as frustrated or wasted effort. In the coming days of reconstruction every social institution would require to embrace a new order if the sum total of human effort were to attain the maximum results. The Author's timely plea

[1] "The Structural Engineer," vol. 10, p. 496 (Dec. 1932); discussion, *ibid.*, vol. 11, p. 386 (Sept. 1933).

that the collateral education and training of engineering and architectural students should be undertaken was long overdue, and if instituted without delay might well be the means of reconciling sister professions, to their mutual advantage. Who could say that, with intimate understanding and a unified front, the glory of traditional Greek architecture might not even be surpassed ? Even to doubt that was a betrayal of ages of human advancement and culture.

The underlying principles of design for both function and aesthetic appeal were clear to follow and simple of enunciation, and were in fact the same. Design might be defined as the shaping of a conception. Structurally any design which in its outward form clearly showed the method of assembly of its component parts, and their functional motive, could be accepted as satisfying, and could therefore be accounted good. The vanity of the artist in man, however, sought to idealize his own work by further adornment and by the refinement of visual characteristics which were, by some vague quality, pleasing to him ; and in the aesthetic design he might bring to his aid a further help in the power of symbolism. All that could be conceded as perfectly legitimate so long as it did not depart materially from the first functional conception. When the aesthetic design introduced a new theme, it became insincere and condemned the first functional design as something which had failed to satisfy because of its unworthiness and should therefore be concealed, from shame. The point to be pressed was that the functional was a principal criterion of all good art. Yet, strangely, practically all writers on the subject of aesthetics subscribed to the heresy contained in Mill's definition of art as " an end in itself or the means to that end." In other words, art knew no law but that of self-satisfaction. True art was something more than the pictorial, and its dependence upon, and correlation to, such scientific aspects as function could be easily demonstrated. A piece of sculpture exquisitely conceived, skilfully executed, yet grouped without regard to balance or poise, could never become recognized as a work of art. Many well-known examples were to be found up and down the world. At all events, it was true that those examples of architecture wherein the aesthetic appeal was so great as to place them in the ranks of works of art, were satisfactory because a certain fitness of purpose had been achieved ; they had remained functionally true. Were that more generally appreciated, the teachings of Ruskin, great artist as he was, would have been better received. Throughout building history, inspiring peaks of excellence had been reached by the application of the following two axiomatic principles :—

(1) That constructional necessity lies at the root of all design, for no composition can be entirely happy which is insincere from the constructional point of view.

The characteristic styles of building grouped in the generic title of

" Architecture ", were not " created " in the minds of dreamers, but represented endless toil and experiment in the intelligent and rational use of material. And so " characteristic " were they that they could be readily distinguished as " wood architecture", " stone architecture", " brick architecture ", " concrete architecture ", and so forth.

(2) It is in the intimate understanding of the nature of the material handled more than in anything else that true architecture has its being.

That was not to say that all buildings in a given principal material would look at all alike. Other influences, such as climate, racial characteristics, commercial, recreational, and religious pursuits played their part in the requirements of building plan, so that a church, a public building, or a factory would never appear to be anything but what it was, no matter of what material it might be constructed. If any building or structure did not openly proclaim its purposeful existence, it must be of intrinsically bad design.

For the tall chimneys of the Battersea power-station, and for the new Waterloo bridge, reinforced concrete was employed as the principal and characteristic material; yet they presented no danger of confusion, and both could be regarded as eminently successful aesthetically, because they were clothed with material traditional to their respective structural type and their visual design followed the forms which those materials liked best.

From every point of view art would benefit from a better understanding of the physical characteristics of the materials employed. That understanding should partake of the nature of a human friendliness, which recognized the toil and stress we asked of our servants, sympathetically felt the strains they suffered, and cringed under the discomfort and even torture to which they were subjected if forced to carry their burdens in an awkward and uncomfortable way. The " feel " of a material in that way was an unerring instinct in design, of far more value than was generally supposed. It might be that we were products of a highly scientific age, who worshipped the false gods of utility and economy, and sacrificed our better selves upon their altars of analysis and mathematical proof in an attempt to justify the rightness of our conceptions. How could the genius of a Michael Angelo or a Grinling Gibbons be explained without believing that they imbued their materials with human attributes, and imparted to those materials a soul with which they could commune. The Author's suggestion that the family of science and art should be re-united had much to commend it. Intensive specialization had arisen from the complex nature of present-day problems, and no one could doubt that the unwieldly number of civil engineering Institutions caring for the interests of several sections of the same profession was not conducive to effective collaboration. Mr. Lloyd Jones wished to put forward a sug-

gestion which he had often made before, that the parent Institution should welcome back home all kindred institutions, accepting their members as its own, and designating each group, including its own, by the particular branch of civil engineering which they were qualified to practise. In the period of reconstruction which lay ahead such a fusion would be of inestimable value in unifying national effort towards another epoch-making renaissance.

Dr. David Anderson observed that the Author had touched upon the question of the texture of the surface of structures. Dr. Anderson could not but think that engineers as a whole had failed to produce a satisfactory finish to their concrete structures. Some finishes were deplorable from the start, but even others which were more pleasing to begin with, suffered very badly from weather, and at the end of, say, 5 to 10 years were very disappointing from the aesthetic point of view. He would like to suggest that The Institution should appoint a Committee to discuss and investigate the whole question of the finish of concrete structures. One or more architects should be invited to join the Committee, as their collaboration should be distinctly helpful.

It might be thought that the middle of a war was hardly the time at which to call such a Committee together; but there would inevitably be a large program of construction as soon as the war ended, and preparations should be made in the best possible way.

The Author, in reply, expressed his gratitude to those who had added so much to the value and interest of his Papers by their interesting contributions to the discussion.

Professor Inglis's contribution was so outstanding that it almost constituted a Paper of its own. His excellent selection of slides had illustrated many examples of beautiful and ugly bridges, and he had shown, in particular, that many of the ugly bridges were doing their work quite efficiently, thus giving support to one of the points in the Paper, that beauty and scientific efficiency, whilst they might indeed go hand in hand, were, in fact, under no compulsion to do so, and that whilst an engineer who was untrained and uncaring in the aesthetic might indeed by chance produce a beautiful thing, the chance was sufficiently remote to be one upon which it would be unwise to gamble.

It would be almost churlish, when the Author was so conscious of the debt of gratitude which he owed to Professor Inglis, to disagree with anything he had said, but if there was one thing which the Author wished to disclaim it was the underlying theme referred to at the beginning of Professor Inglis's contribution.

No doubt excellent reasons existed why engineers should "pull up their socks"; but the desire to do so should be actuated by an intrinsic love of perfection rather than by a fear of what might happen to them if they failed to do their work well.

In the Author's view, it was the desire for perfection in the structures of

the future which should be their concern rather than a question as to what might happen to the members of one profession or another if they took or failed to take a certain line of conduct; and he was quite sure that Professor Inglis really agreed with that view of the matter.

Engineers and architects were, in fact, facing the same problem, and mutual help was undoubtedly the keynote to the solution of the problems of the future. Each had so much to give the other that no kind of rivalry should receive any support; and if that friendly collaboration were carried to its logical conclusion a point would eventually be reached at which the two terms, "engineer" and "architect", would become indistinguishable and the theme in the words used by Professor Inglis would no longer have much meaning; but the general call to engineers not to neglect that important aspect of their subject was one which was entirely independent and should be independently expressed. Apart from that small point, the Author found himself in complete agreement with everything Professor Inglis had said.

In thanking Mr. Gribble for his contribution, the Author wished also to express his gratitude for the active assistance which he had received from Mr. Gribble at the time when the Southern Railway warehouse was in process of design and construction.

He was pleased to learn that he was wrong in stating that no one had ever said a word in favour of Charing Cross railway bridge as a thing of beauty. Apparently one person had now been found who had said a word in its favour, having observed it in the misty evening light of London. It would be interesting to know whether his appreciation would have been even greater had he observed it during a really dense fog.

Doubtless the structure was quite efficient from the scientific point of view; but with the exception of the individual whom Mr. Gribble's industry had brought to light, its beauty did not appear to be the quality which had attracted most people in their admiration of it.

Mr. Unna had expressed the view that Charing Cross bridge was so universally condemned because people did not understand how it stood up; but the Author did not think that that was the reason. He doubted whether the public took the strength of an arch for granted more than the strength of a girder, and indeed the proportions at Charing Cross bridge were in no sense bold or calculated to throw any doubt upon its ability to carry its loads.

The Author thought merely that the lines were not beautiful in the way that those of an arch or a catenary were beautiful, and that the eye was disturbed by the mass of details in all the bracing and counter-bracing which detracted from a general conception of the main lines of the structure, just as certain locomotives of continental design, which seemed to have all their works on the outside, were less pleasing in appearance than some of the later British locomotives.

In reply to Mr. Peirson Frank's question, reinforced-concrete columns

had stood up extremely well to very heavy high explosive bombs, and indeed no damage at all had been suffered except to glass.

With regard to Mr. Frank's suggestion that the first Paper should be studied by students and the younger engineers, the Author wondered whether they had more to learn by a consideration of that subject than had some of the older members of the profession. It had been brought to the notice of the Author by one of the former class that when engineering structures which failed to be beautiful had been designed by engineers, it was never the students and the younger engineers who were guilty, since they had not so far had the opportunity of perpetrating anything, and must therefore be free from blame.

The Author disclaimed any intention of suggesting that the next generation of engineers was less well equipped in those matters than the present one, but he hoped that in a short time they might be much better equipped, in which case perhaps the time which he had devoted to his Paper might not have been expended entirely without benefit.

The observation of Colonel Howard Humphreys that Mr. George Bernard Shaw considered Charing Cross bridge to be the only bridge in London worth looking at, afforded probably the most convincing proof that anyone could ask for that ordinary people did not acclaim it as such, and provided one of those few occasions when it was justifiable to say that the exception proved the rule.

In reply to Mr. Willox, the Author would observe that one advantage of discussions upon Papers presented to The Institution was that members could disagree with one another in a friendly way, and he was going to avail himself of that by disagreeing with Mr. Willox.

He did not think that anything disparaging had been stated in the Paper about the Forth bridge, which was a masterpiece for the period when it was built. In those days a bridge with a span of 1,760 feet was a very wonderful thing: engineering workshops had not the tools or the facilities which existed to-day for machining large members, so that many of the large compression members had to be built on the site by boiler-makers. The Forth bridge was a magnificent achievement, but there was no question then of aesthetic choice, because the way in which it was built was the only way in which people at that time knew how to build a bridge of such a large span; and when only one design was possible there could be no choice. That was no reason why some years afterwards people should not be entitled to consider the merits, from an aesthetic point of view, of that structure in comparison with others; and, if they felt to-day that, from a purely aesthetic point of view, the Forth bridge was less satisfactory than certain other bridges, for example, the Golden Gate bridge, the Author considered that they were entitled to say so without any disrespect to the Forth bridge.

Mr. Willox had urged that students should not be deflected one iota from the efficiency of their engineering. No suggestion had been made in

the Paper that they should be so deflected. When engineers were not dealing with a design where they were striving on the border-line of what was possible for a man to achieve, they would find that they had a number of alternatives before them. If they were considering a bridge, a number of different ways might be available for the solution of a particular problem—for example, by an arch, by a girder, or by a suspension bridge —and from the engineering and the scientific point of view all of those alternatives might be exactly equal in efficiency. Then somebody had to settle which design was to be selected, and thus the question of aesthetic choice arose. That aesthetic choice should be made by someone who had studied the problem and had discovered, by examining the things of the past which had been universally pronounced beautiful, the underlying principles upon which the beautiful depended. When those principles had been discovered much less difficulty would be experienced in deciding which of many designs was the most beautiful; and that was a matter which would have to come within the scope of the engineer if engineers were going to merit and be accorded the responsibility for making the ultimate decision.

Dr. Faber wished to express his appreciation of the observations of Mr. Lloyd Jones, which formed a notable contribution to the discussion of the subject of aesthetics.