were also acting independently in conjunction with other chief designers—and then the problem is more or less back where it started. But there is a value in having a few allied technologists in an office who can deal with smaller jobs or jobs of a particular kind, because it provides a lesson in collaboration for the staff.

49. The practice of having the contractor prepare his own designs can work very well in such cases where the integration of the design with the method of construction is a major consideration, because that is undoubtedly the best way to achieve it. The Author is here thinking mainly of engineering structures such as marine structures and special industrial structures like chimneys, silos, etc. It can work extremely well, provided the contractors are good designers. To emphasize this it might be better to talk of the designer doing his own contracting. It might even work in housing when a firm has successfully developed its own system of building. But in such cases it would not do to let the firm be responsible for the architecture as well, unless there should happen to be a Nervi or Candela in charge. The principle that the client should have his own professional adviser to look after his interest should remain, and for all really important jobs it should apply to all engineering services as well.

50. To obtain the right design is the important thing, because that is the same as serving the client's true interest. That is exactly the duty of the two professions, a duty which, on the whole, engineers and architects strive to perform to the best of their ability, in spite of the fact that the financial reward happens to be almost inversely proportional to the effort put into the job—an oddity which it may be difficult to do anything about.

51. Now that practically every occupation is elevated to the status of a profession, designers may have to shed some of their conceit on that score, but the essence of their professional code is to create an atmosphere of professional integrity which is the client's best safeguard, and which should be preserved, whatever happens.

The Paper was received on 21 October, 1958.

Written discussion on these two Papers should be forwarded for receipt before 15 March, 1959, and will be published with the Papers and the oral discussion. Contributions should not exceed 1,200 words.

Discussion

Mr A. R. F. Anderson (Messrs Anderson, Forster & Wilcox) said that although architects and engineers might at present collaborate quite happily, they should be looking to the future, not to the past.

53. During the first half of the twentieth century, engineering services had become as much a part of a building as the basic architecture and the basic structure. To get them established early was almost more important than anything else; in particular, when planning buildings in central London, with planning controls (of which he approved in principle although not always in detailed administration), by-laws, and sanctions for all sorts of things, the engineering services had to be considered at the

very beginning. For example, heights of buildings within certain angles of light or heights of lift over-runs (a high-speed lift nowadays needed about 30 ft of travel from the last floor served) might immediately affect the whole envelope of the building.

54. More and more space was now required in the heart of a building to accommodate the air-conditioning and heating-and-ventilating services. For the former, vast duct sizes were required and the planning of these ducts in relation to the whole structure raised basic design problems. The derived depth of a beam might be impracticable because a duct had to go underneath it. With such problems as these the work of the structural engineer and the mechanical engineer assumed immense importance.

55. The architect must bring together, and collaborate with, all the different experts and consultants, although it might be that the engineer of the present or of the future might combine advice on all structural and mechanical problems.

Mr H. J. B. Harding (Consulting Engineer) said that the key to the two papers was in the last paragraph of each. The emphasis was on collaboration rather than rivalry and with this he concurred. He wanted to mention the subject of training, for he had had the interesting experience in his own family of observing at close quarters the education and subsequent development of a civil engineer training at the City and Guilds College, and of an architect training at the Architectural Association, and the development of many of their friends in both professions.

57. There were many different kinds of civil engineer and even more types of architect, for the fields covered by both professions were so wide. The architect had a harder part to play because he had to divide his personality into more contradictory fields ranging from artistic imagination to the interpretation of contracts and the supervision of work. In both cases there was the contrast in talents between the academic or artistic and the essentially practical or executant. The combination of high attainment in both fields was rare, but both were important. Consideration might be given as to whether, in both engineering and architectural colleges, instead of trying to reach a higher and higher theoretical standard for everyone, two separate streams could be formed after a certain standard had been reached. Thus in each profession, it would be possible to develop along the line of natural ability, whether predominantly practical or creative and theoretical.

58. A change which had taken place in Mr Harding's own generation was the way in which civil engineering contractors had taken on academically educated men and trained them on their staffs in a way which had been rarely done before the 1914–18 war. Now the staffs of leading contractors could bear comparison professionally with those of consultants or government bodies.

59. Building work was carried out in a quite different manner, and in recent years it seemed that the older type of building superintendent rising from apprenticeship, was being ousted by the quantity surveyor in actual charge of work. Mr Harding asked if architects could work for builders as civil engineers did for contractors, or was that professionally discouraged? Building work could provide a valuable field for the practically-minded architect.

60. In a discussion on practical training, it had been suggested that setting-out and some similar work could be done by sub-professional or technical assistants. There was a danger in this, for employers, especially in times of recession, were tempted to employ the cheapest labour available. If they were encouraged to use non-professional men for smaller work and detailing, a field of practical training would be greatly reduced for both engineers and architects.

61. In the past there had been rivalry, chiefly over disputes as to the distribution of credit, and the natural divergence in temperaments, but collaboration was now of an importance far exceeding such trivialities. More intercourse between the professions could have an educational effect on both of them, bringing a better appreciation of beauty to the engineer and of the realities of below-ground work to the architect.

62. Today, architects and engineers had as their principal clients, large corporate

bodies, both industrial and national, who surrounded themselves with bodyguards of accountants, lawyers, and quantity surveyors, so that it was most important that the two professions—engineers and architects—should stand together against attempts to belittle their position and whittle away their professional authority.

Mr S. E. T. Cusdin (Messrs Easton & Robertson) suggested that the Papers had been written about institutions and institutes, architects and engineers. His plea was for the individual, who was, of course, human and subject to all the frailties of likes and dislikes, and the occasional quite ungovernable hatred; it was on these terms that architects and engineers met in practice.

64. He had searched the R.I.B.A. code of practice to see what provisions were made for collaboration. He found it contained only one item. In the engineers' code of practice there was not even one item. It would seem, therefore, that there was a case for a simple statement by the two societies. He did not suggest that they should tie themselves to a recognized code of joint behaviour, but they could get together much more quickly if there was a statement which they both recognized was common in good behaviour as between themselves.

65. Respect for each other had been mentioned as a starting point for collaboration and he would like to combine with that the recognition of credits whenever architects and engineers associated together.

66. Contracts were also a thorn in the professional side. Engineers had one type of contract and architects had another. There was no guidance about it, whether applied to either power stations or other large buildings. There was no clear statement which both parties recognized.

67. His next point had a much wider context and it was one upon which any joint committee would find it difficult to agree. There ought to be a statement of recognized boundaries or spheres of influence; duties should be tied up a little closer as to where engineering began and finished. This would eliminate the need to exchange letters on joint appointments on a contract or project. It would be known almost automatically where one profession began and ended with the purely practical things both had to do. Such a statement would not commit the engineer to designing a cathedral or the architect a motorway. It would only be called upon when both recognized their limitations and wished to find a basis for mutual work.

Mr E. A. F. Johnston (Ministry of Finance, Northern Ireland) confined his comments entirely to buildings. His views, he said, were more in harmony with those of Mr Mathews, perhaps because for many years he had worked in very close co-operation with architects and had the highest possible regard for the profession.

69. The design and erection of buildings was a team operation between architects, civil, electrical, and mechanical engineers, quantity surveyors, and contractors. He believed there would be far more expeditious construction and greater economy in building if the contractor were appointed at the planning and design stage, so that he could have an opportunity of expressing his views on various points.

70. This team of professional men must have a leader and he accepted the architect as the natural leader. But he had some doubt as to whether the present-day training of the architect, particularly on the scientific side, really equipped him adequately, when perhaps more than half the cost of a modern building was accounted for by the engineering services.

71. He also felt that the architect did not concern himself sufficiently with the cost planning and control of these engineering consultants, and furthermore that he did not take sufficient interest in the site-execution side of the work.

72. So far, said Mr Johnston, his remarks appeared critical of architects. He could make just as many criticisms of young civil engineers, particularly at their post-graduate stage.

Mr Leslie Turner (Consulting Engineer) said that the days of the master-mind—the

"archineer" or the "engitect" had passed, except in the very occasional individual; and one must accept the architect-cum-engineer or the engineer-cum-architect combination. With understanding and reciprocity there was no reason why this method should not produce excellent results.

74. He understood from a recent lecture by an architect that an architect had no time during his training but for a most superficial study of engineering matters; likewise, engineers had little time for the assimilation of architectural precepts.

75. Having accepted that split personality, what was the soundest basis for collaboration? In addition to mutual sympathy, Mr Turner suggested that it was an agreement on definition of duties and responsibilities. In modern architecture, he could not say what these should be; it might take twice as long to design and alter details for the holes for services, etc., in a hospital than to design the structure itself, yet, each hole might reduce the cost of works at the expense of far more time in the drawing office. Again, modern work might take two to three times as long to design as to construct.

76. Mr Turner deprecated the use of the architect-engineer-contractor combination, where the client had virtually no control or lasting guarantee. The case of new techniques might raise an infrequent reason for employing an engineer-contractor combination, but the client should extract a firm guarantee for some years (if he could). There were so many variations and possibilities that each case should be investigated technically, economically, and legally before entering into a contract, because, in the ultimate analysis, it was professional ability that counted—not an insurance policy, even if such could be obtained.

77. As to who should be finally responsible for works, the decision was not difficult. An architect should be in charge of domestic and public buildings, office blocks, and the like, where final appearance was the ultimate test. An engineer should be in charge of essentially civil and structural constructions. The intermediate case of an industrial building could be tackled equally by the engineer or the architect best suited to the understanding of the processes involved in that building. Here the engineer usually had a great advantage and his services should be sought far more than they were today. The services engineer was generally even more specialized and was not trained to lead in buildings.

78. In all cases, both professions had to collaborate intimately, and whoever took precedence should ensure that the other had supervisory rights in his own sphere on the work and that direct contact with the contractor could be exercised, with, of course, due notification to all concerned.

79. On the whole, Mr Turner was content to let the present system of architect-engineer or engineer-architect continue and evolve as it would, provided each profession was granted its due reward and credit.

80. The only other system he would consider was the additional appointment of an independent business organizer to control the whole team, but he must act professionally and not be the contractor profiting from the job. This method might conduce to economy, but it was very doubtful if the art of architecture or the science of engineering would prevail.

81. Mr Turner was well aware that architecture reflected the conditions of the day and that modern architecture was at present largely hamstrung by mechanism and the lack of co-operation of the building trades unions. But means had to be found of interlacing curvilinear main and subsidiary aspects to relieve the boredom of the modern trabeated elevation when built in reinforced concrete. For such to be incorporated the structural engineer must be first in the field, and it would be a potent reason for either nominating an engineer or for the very earliest of collaboration between an architect and an engineer.

82. So Mr Turner's final conclusion was that a client should select his chief technical adviser from among those best fitted for the job.

Mr H. C. Husband (Consulting Engineer) said he believed the first joint meeting between the Institution and the Royal Institute of British Architects had taken place

on 12 March, 1901, when a Paper[2] on the aesthetic treatment of bridges was presented. Opening the discussion, the President (James Mansergh) had said[3] that the Paper had been accepted "just at the time when . . . a suggestion had been received from 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. . . . The Council had not seen its way to offer any practical suggestions in that respect, but it had invited to the Institution . . . members of the Royal Institute of British Architects and he hoped some of them would take part in the discussion."

84. Mr Husband drew particular attention to the words "practical suggestions". It was little use talking about the desirability of engineers and architects working together unless practical ways and means could be devised, not only for the benefit and satisfaction of the engineers and architects, but in order that their collaboration would produce better works and that the collaboration should be arranged for its efficiency and economy to be in the best interests of the client or promoter of the project. Sir Benjamin Baker had said[4]:

> "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."

Whether or not this was quite true in 1901 Mr Husband did not know, but if it was reasonably true today the difficulties must be largely financial.

85. Sir Benjamin had said further that in the collaboration of engineers and architects, "there would have to be a constant seesaw of the plans backwards and forwards." Mr Husband had little doubt that this distinguished Past President knew what he was talking about in 1901.

86. If a bridge was required, the client expected the engineer to design it, and if Sir Benjamin Baker's advice was to be followed, then the engineer should not be too proud to get an architect to help him. If it was a large building, most architects would be wise to arrange to collaborate with an engineer or engineers. But "the seesawing of plans backwards and forwards between engineers and architects" could be a great waster of time and money. Not only clients had appreciated this, but many large contractors had discovered that good and economical results could be achieved by employing on their staffs qualified architects and engineers working closely together under the same roof.

87. This was not an occasion to discuss the possible evils of "package service", but it had been Mr Husband's personal experience that most large modern structures, where there was a good deal of repetition in design in one form or another, could be efficiently handled by a well organized combination of engineers and architects, working in the same office, including the proper design of the structural and other engineering services.

88. He considered more encouragement should be given, both by the Institution and the Royal Institute, to real partnership, both in private practice and within public organizations, of architects and engineers to deal with the building problems of today. In this way, the problems of close technical collaboration, and the retention of respect, of client and contractor alike, could be achieved. The balancing of administrative, designing, and supervising staff as between the two disciplines would depend on the type of practice.

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[2] Joseph Husband, "The aesthetic treatment of bridge structures". Min. Proc. Instn civ. Engrs, vol. 145 (1900–1901), p. 139.

[3] *Ibid.*, p. 174.

[4] *Ibid.*, p. 207.

89. But whether the job were engineering with a little architecture, or architecture with a lot of engineering, or simply one or the other, in any event there would be an *organization* well designed to serve the client.

90. It was important for architects and engineers, in their own ultimate interests, to do the whole of the work which their clients expected them to do, and to do this in the most economical manner, and to charge accordingly. If they carried on with what Sir Benjamin Baker had referred to as "the seesawing of plans backwards and forwards between engineers and architects", they would be following an idea of 1901 in what, for better or worse, was a much more streamlined age.

91. In a few years, if engineers and architects did not get together as partners, then, as far as big building projects were concerned, these would soon be handled in their entirety by contractors employing their own technical staffs. Mr Husband thought also that the contractors would find ways and means of overcoming the main financial disadvantage of this arrangement—the cost of preparing unsuccessful designs.

Mr Greville Rhodes (Messrs Norman & Dawbarn, Architects and Consulting Engineers) said that collaboration between engineers and architects was part of a very much larger question—how much engineers and architects, working professionally, were prepared to see their activities and their influence in society gradually diminish over the years in favour of the "package service". The enormous potential the package service could bring to bear, in a sense, against engineers and architects working professionally should not be underestimated. The first reason was economic power, and this became more and more important as projects got larger and larger, and more capital was needed, and so on. Secondly, all the necessary skills for the design and erection of a complex building could be assembled under one roof on a scale which made smaller specialist units within that organization of an economic size.

93. He found no comfort in Mr Arup's statement that the design side of the "package service" was lop-sided. That would not always be so. With their skills all under one roof, with their practical experience on the contractual side, with their foreknowledge of what plant and equipment they could bring to bear on any project, the "package service" contractors could well become economically and architecturally highly competitive.

94. How were specialist consultants to combat this? It was no use solving the problem of today, in so much as it existed, because any remedial measures taken now could only be effective in a few years' time and by then the complexity of the problem would have increased. The most practical answer was for architect and engineer to combine in a similar way. The separation of the architect and the engineer into separate administrative units was false, and although Mr Rhodes agreed with previous speakers that they were different people and must remain so, he nevertheless felt there would be enormous advantages in working together under one roof and in this way becoming competitive with the "package service" in the future.

95. The merging of strong individual personalities would be difficult and could not be rapid but was essential for survival. Education on a different basis, stressing the overriding importance of collaboration and the obsolescence of the "personality cult" would go a long way to help.

96. In a combined firm of specialists, the individual sections would have to be large enough to be economic. This was sad for the smaller offices and many would regret their passing. Much of the pioneer work of the past had been done by them under the strong influence of an individual architect. But these were the pilot schemes of modern architecture and now that the scale of everything had increased, smaller schemes could hardly have the impact they once had.

97. If, as Mr Rhodes suggested, larger units were necessary to compete with the "package service", smaller architectural firms would have to combine to an economic size which would enable them to have their own specialists.

98. In conclusion, a closer collaboration and complete reorientation of both professions was necessary if they were to retain their present position of leadership.

99. Both of the Authors had spoken of the importance of the "master mind". Mr Rhodes accepted the fact that there must be a leader, and where the project was primarily a building, it seemed as though the architect was best suited to be the team captain, but, for two reasons, he did not accept the implication of the term "master mind" that the leader was the fountain-head of all creative design. First, because the influence of specialists should be felt at all stages of the design and even in the formation of the brief, for technicalities were no longer merely details to be fitted into the design —they were becoming fundamental. Secondly, an architectural firm, if it was to turn out good work, had to be receptive to the ideas of its staff. In the "master mind" concept, the ideas were going the other way. The "personality stamp" was not an essential ingredient of good architecture.

Mr L. Scott White (Partner, R. Travers Morgan & Partners, Consulting Engineers) agreed that the "committee method" of design was bewildering. Admittedly in a very big scheme subject to the control of a committee, such committee must make decisions. These decisions, however, should be restricted to preparing the brief and instructing the architect and/or engineer; to considering and approving sketch plans and later the proposed tender drawings and specifications and approving the placing of the contract; and receiving reports of progress.

101. Revisions to a scheme after the start of a contract should be most carefully avoided since they caused more delay and irritation than almost anything else.

102. There could be many satisfactory solutions to a building problem, but perfection in *all* aspects was almost impossible. Compromise was usually necessary and this was where the "master mind" had to sit in judgement to select the best solution.

103. Early co-operation between architect and engineer, even in the sketch plan stage, was essential. Schemes which called for unusual and expensive structural treatment might possibly be avoided; on the other hand, if an unusual or outstanding type of structure was the answer required (no matter what the cost) this was where early decision was of tremendous advantage.

104. In the United Kingdom, competitive bidding for building contracts was the normal procedure. For this purpose, designs and details were fully determined in advance, and specifications and quantities were prepared in detail. By this procedure, however, one important element was sometimes overlooked—the overall administrative capacity and plant resources of the contractor. In a relatively small contract this was of little consequence, since all tendering contractors should be adequately equipped or could hire the plant required to deal with the contract. On an outstandingly large contract, however, it might be advisable to select a contractor by a preliminary competitive tender, or even to select a contractor by agreement with the building owner. When a selection had been made, the contractor could then be consulted by the architect or engineer on practical problems. By this means economy, and certainly speed of completion, could be assured.

105. The execution of both structural and mechanical engineering services was sometimes carried through by one engineering consultant. Mr Scott White believed that this combined field was too wide to be covered by one organization. It was better to divide these responsibilities and to ensure that specialist minds concentrated separately on structural problems and mechanical services. The two services must, however, be interwoven and co-ordinated. This was a very important function of the co-ordinating architect or engineer.

106. The proposal in § 46 (which the Author himself considered heresy) that a prospective building owner should have a little peep at more than one "cat in the bag" was already provided for by calling for competitive schemes, which were submitted to and judged by an adjudicator who might, possibly, have been recommended to the developer by the Institute or the Institution. When the selection had been made, the developer should go forward with complete confidence, present his requirements fully and clearly to the architect or engineer commissioned to do the work and co-operate with him as harmoniously as possible during the planning and construction of the works.

107. Mr Arup's tilt in § 50 at the "financial reward" being inversely proportional to the effort put into the job might have been taken by some as a bait to promote discussion on the relative architect-engineer effort and reward. Mr Scott White, however, understood it as a complaint that when a thoroughly conscientious architect or engineer put his utmost effort into producing the required building as economically as possible, there was the anomaly that the more effort he put into the work to save his client's pocket, the less was his reward. This line of argument was somewhat specious, because his most acceptable reward was giving satisfaction to his client.

Mr R. Llewelyn Davies (Director of the Division for Architectural Studies of the Nuffield Foundation), who had been trained as an engineer but practised as an architect, referred to the broader aspects of the relation between the two professions, rather than the problem of individual collaboration. In thinking about these questions, it was important not to gloss over the very deep and essential differences between the two subjects of architecture and engineering. One could only see how they fitted together and how perhaps in the future they could help one another more effectively if they faced the very big gulf that really separated them.

109. Engineering was a precise discipline. It had an established theoretical basis. It was developing in common with most other precise disciplines down the path of specialization and research, with continuous accretions and additions to the body of knowledge, post-graduate training, and the whole machinery of the modern scientific subject.

110. Architecture, on the other hand, was not at all a precise subject, and it was a great mistake to talk as though it were. The factual basis of architecture did not exist in itself. The factual source of the architect's work and inspiration came from other subjects—from engineering, from the physical sciences, the sciences of materials, the social sciences (which told how people lived and used their buildings), and some of the physiological and psychological sciences.

111. Above all this, and apart from it altogether, was the skill or art of synthesizing the very many facets of building design into a whole. This was the nature of architecture, and it was brought out very clearly if the kinds of teaching were compared. He did not refer to the teaching at the Architectural Association as training, because if it was compared with the way students were taught in the School of Engineering it was not systematic training. In engineering, knowledge was imparted and the ability to use it in certain definite ways was tested by examination. The first thing he had been asked to design in the school of engineering was, in his very last year, a small bedplate for a sewing-machine. This was the only exercise in synthetic activity which came into his training. He went from there to the school at the Architectural Association and was immediately asked to design a swimming-pool. This was the essence of the difference between the two subjects.

112. What could engineers and architects do for one another? The answer was very obvious, and they had been aware of it for a long time. The engineering discipline, the attitude to work, the attitude to knowledge, were all things more of which were needed in the architectural profession. Far more important, they were looking to developing knowledge. Engineering was one of their main sources of inspiration. The creative thought in modern architecture in this century very frequently derived, deep down, from engineering thinking.

113. On the other hand, what could architects do for engineers? What could they give to engineers by closer collaboration or joint training? At first sight, very little: engineering was doing fine; it was a very good subject and was giving time to both specialization and research. But more broadly, perhaps, there were problems. Where were the future Rennies and Brunels? Did compulsory Greek and Latin really broaden the minds in schools of engineering? Might it not be better to think a little more about design, which, indeed, was the only way in which the bed-rock work of the engineer could flower and come to something great, whether he did it by himself in a bridge or with his architect colleagues in a building? It was the design process that really made

things come to life. This was what association with, and understanding of, architects could give to engineers.

Mr J. A. Neill (Consulting Engineer) believed that economic pressure had led to a slackening of moral fibre. It was all too easy—he did it himself—for the engineer to blame the architect and the architect to blame his clients when things went slightly astray. The fault lay in themselves. It was up to each one of them to be sure of what he did and more important still to be sure that those who instructed had given enough thought to their actions. This should increase confidence between the two professions and such confidence would bear fruit and propagate itself. Builders would have more confidence in them, and building costs should lessen as a result. Clients would have more confidence in them, and they would prosper. He was perhaps on dangerous ground in predicting that the confidence of district surveyors in them might increase but if it did they would lead quiet uneventful lives.

115. The point he was trying to make was that it was possible to reverse the vicious circle. If they tried to stiffen their moral fibre, freedom from economic pressure should follow.

Mr Bryan Westwood (Messrs Westwood, Sons and Partners) said that the engineer and the architect were not so much two different people as two different attitudes, both of them essential, to the building problem. There was very little danger that architects would try to be self-sufficient. They had done enough structural examinations in their course to realize their own limitations. But perhaps in England (particularly), which was a country with a literary tradition and a rather factual one, the engineering student and perhaps many engineers, too, did not realize to the full how much the colours and textures of materials could contribute to the final building, and transform it from a mere building into a work of art.

117. With regard to the point that the complexities of modern buildings could not be grasped by a single mind, he quoted Descartes who had said buildings where a single architect had planned and executed were generally more elegant and commodious than those which several had attempted to improve. If that was the case, the lesson was obvious. There had to be more than one person working, but the combination had to become more like one all the time, even when two people became three or four.

118. Finally, he would like to quote a question that had been put to him. Recently, after giving a lecture at a public school he had been asked by one of the boys: "How is building to remain exciting when engineers can easily solve any structural problem?" He had answered that building would remain exciting because it was going away now from being a mere rectilinear exercise into something far more organic. This was the final moral, he thought, of what he wanted to say. When that stage was reached, the engineer and the architect simply had to work together. They could not produce buildings both structurally sound and aesthetically attractive without both kinds of mind. It might be possible for one man, like Nervi, but both kinds of mind had to be there.

Mr J. R. Murland (Consulting Engineer) said that most of the difficulties were soluble from the old proverb which was applicable in this case to architects and engineers and above all to the client: "Don't pay a dog and bark!" It was really as easy as that.

120. His life was pleasanter when dealing with architects who did not know anything about engineering than when they did, though the end result was not necessarily better. The same was true of clients. His work was easier when he was serving a client who knew nothing and could be told. No doubt that the architects shared his feelings on that point.

121. Mr Cusdin had mentioned the extent to which the Institute and the Institution referred to each other in official documents? Mr Murland pointed out that the consulting engineer had no existence whatever in the R.I.B.A. form of contract. His legal position was technical adviser to the architect, and Mr Murland did not object to that

position personally. But the consulting engineer was not recognized and strictly, in law, if he wanted to give an instruction to change the size of a screw, he had to go through the architect, the main contractor, and down!

122. So far as building services were concerned, it was very hard to separate the electrical from the mechanical engineer. One was involving the other the whole time. The architect was entitled to ask that he should deal with one man. That one man might have in his office a proper specialist: he could not know it all. But so far as building services were concerned, the electrical and mechanical engineer must be visualized as one individual and not two separate ones. It was important not to multiply the people who had to be called in for consultation, if it could be avoided.

123. Mr Murland did not see why he, as a consulting engineer, should not agree to work for a contractor as part of a "package service" any less than for any one else who wished to employ his ability. But there was the implication—though he doubted if it really existed—that there was something not frightfully respectable about the "package service", an implication that consulting engineers and architects were stepping down from their professional pedestals. The cynical answer was very easy. There was a quotation that some might not have heard: "Let us take the broad long-term view! How does this affect us?" It was as easy as that: as soon as it ceased to be not respectable he did not think anyone would worry.

Mr John Powlesland (Consulting Engineer) said with regard to the "package service" that in other industries where there was a very complex design problem, such as the design of an aeroplane or a ship, the service offered was invariably of the package type. One organization controlled the whole of the design. Its success was the result of one man controlling the design team, it was usually very large and included not only designers but production and operation advisers. The leader probably did not understand all the details of the design, but he understood the whole thing in principle, and success depended on him. He was the manager or the "master mind".

125. The "master mind" would not arise out of anything other than the package service, because no one else would pay him the salary he deserved. The difficulties under discussion arose in the absence of this overall design manager, because everybody tended to over-rate the importance of his own individual contribution to the whole design.

126. The buildings on which the problem arose would usually be judged ultimately as architecture unless one fell down, in which case it would be judged as an engineering structure.

127. During the planning and construction stages, the client was very much interested in the cost, and one of the engineer's fields was surely to advise the architect on the cost, not only of his structural design but on his proposed method of construction. For that reason, during the design and construction stage the engineer might assume greater importance than he would warrant in the larger view. It should be part of the engineer's job to be a specialist on costs, and he should know much more than the techniques of structural design.

128. Some of the men who possessed this knowledge had also some architectural appreciation, and in his opinion the architect and the engineer should meet on equal terms at the beginning of the job. The only way this could be done practically was for them to combine in some permanent association between suitable characters who found each other stimulating to work with.

Mr W. W. Davidson (formerly an Engineering Inspector with the Ministry of Health, now retired) referred to Mr Mathew's suggestion that engineers did not collaborate with architects as they might. The Royal Fine Art Commission, in their fifteenth Report, 1957, referring to a very necessary major bridge over the River Ouse at St Neots, had "asked that an architect and possibly a consulting engineer be employed on its design."

130. He went on to criticize a number of structures for which, he believed, architects

had claimed credit. He wondered what real advantage had been gained by the employment of an architect on the Chiswick Fly-over. He spoke of present-day results of the employment of architects, which were mostly in the form of fenestrated packing cases; a suitable word for them would be "Architopia"—analogous to the word "Subtopia" invented by the R.I.B.A. for anything not attributable to an architect. He was sorry to read that one of the Colleges at Cambridge had adopted a packing-case-on-stilts design for a proposed extension.

The Chairman (Mr Basil Spence) interposed, in defence of the Royal Fine Art Commission, of which both Sir Allan Quartermaine, Past-President I.C.E. and himself were members, that the bridge at St Neots was the work of an engineer. The Commission had, in fact suggested that not only should the engineer perhaps have an architect to help him but another engineer.

Mr W. E. J. Budgen (L. G. Mouchel & Partners, Consulting Engineers) said that both Papers referred to the need for successful collaboration, but neither of them defined what this meant. In its lowest common denominator it would presumably mean that both architect and engineer made a profit on the job. At the other end of the scale perhaps it meant that they produced between them a successful work of architecture. And there one struck the first and fundamental difficulty. Could successful architecture be defined? If not, it must be very difficult to collaborate towards it.

133. It was Sir Henry Wootton who, many years ago, had described the essentials of good architecture as "commodity, firmness, and delight." It seemed difficult to improve on this definition. Commodity and firmness were capable of some quantitative assessment, although not strictly speaking until some time after the structure had been completed, and even then only by the relatively few who used or maintained the building.

134. The third quality, that of delight, seemed to an engineer to defeat definition and in the minds of his architectural colleagues it seemed to be almost as variable as women's fashions, so that one year structures must be arranged to give long continuous horizontal windows, and subsequently these must give way to continuous vertical strips of glass, and so on.

135. Frankly, he felt it was useless to ask for a sympathetic understanding of the architectural profession's problems from the engineering profession until there was some greater degree of unanimity as to what was good architecture. Apart from this difficulty, most of the other problems mentioned in the Papers were capable of solution. Difficulties of personal compatibility generally sorted themselves out fairly quickly.

136. It was, he felt, essential that the engineer should, from the start, have a clear brief from the architect. Was he mainly to advise on engineering economy (which might not necessarily be overall economy) or was he expected to suggest some daring and therefore usually expensive solution to a problem?

137. Sympathetic consideration must be a two-way traffic. The engineer must always pay tribute to the law of gravity, but nowadays the architect sometimes—particularly with his ideas of shallow beams and slender columns—urged the engineer to design structures which, while not unsafe, were still bad engineering.

138. As a further point, if the concept of "delight" was accepted as a necessary part of good architecture and if it was also accepted that this sprang from deliberate aesthetic choice and did not follow from functional design, then, as Burke had put it, the wedge-like snout of a swine, so well adapted to the offices of digging and rooting, would be extremely beautiful. If that conception was not accepted, then the architect must be the leader of the team and this aesthetic choice must be made by him.

139. Mr Budgen agreed with Mr Arup that the engineer should cultivate an interest in architecture, but there was at present nothing in his training which qualified him to make an aesthetic as against a practical choice. This position would probably worsen in the future when the dichotomy between art and science seemed to be widening, so that 14-year-old children were expected to specialize in one or the other. Under these

conditions, lack of sympathy between architect and engineer, artist and scientist, would increase and not decrease unless it could be fostered in later years.

Mr R. D. McMeekin (Partner, R. Travers, Morgan & Partners, Consulting Engineers) said that the two Papers and a critical examination of their theme were somewhat overdue. By that he did not imply that there was any sudden crisis in their affairs, but rather that the situation of architect-engineer collaboration could, like nearly everything else, probably be improved.

141. It might be argued that they were both the same sort of people inasmuch as they were—in the wide sense—both builders. But it was not as easy as that. They lived and practised in very complicated times; in times when it was very difficult for the architect, with all his artistic traditions and skills, to acquire all those technological and scientific abilities that today's conditions demanded. Just as difficult was it for the engineer, with his scientific background, to master the finer points of aesthetics and planning.

142. An architect solved many of his difficulties by looking at the drawing board and saying that what he saw there was either right or wrong. In aesthetics he had no proof. But the engineer got his answer by mathematics and if his answer was challenged, he produced his calculations and said, "That is my proof". That was, Mr McMeekin thought, the basic difference between them.

143. They were different people not because, in the wide sense, they were doing different things, but because they were doing the same sort of things in a different way. They argued from different points of view. But they were both still doing fundamentally what their fathers did. They were building. And he submitted that in their building they badly needed each other.

144. Speaking as an engineer, he thought that one of the failings of engineers was that they were tied a little too much to slide rules and mathematics. They should train themselves in aesthetics as well as in mathematics. This question was important enough to warrant a review of examination syllabuses. No one would deny that beauty in building was a very important matter, but engineering students were taken through years of training with hardly a mention of it, and they were never examined in the subject.

145. The training of architects also left much to be desired. They did already receive a good training in structural design, but he often felt that they could with advantage learn more about practical site problems. One learned on site how much easier it could be to draw something on the drawing board than it was to fix it. More young architects should learn that lesson; they rarely went into contractors' organizations as engineers often did. The R.I.B.A. might care to consider the pros and cons of the civil engineer's requirement of having to spend 12 months on site before qualification to corporate membership.

146. Could there not be a series of reciprocal lectures—architects to engineers and *vice versa*? He felt sure that all could learn something useful from senior men in the other profession.

147. Mr McMeekin deplored the idea of competition in design (§ 46). There was already a good deal of healthy competition; to take it to the stage where an architect or engineer was selected by his skill in preparing an outline design was, in his view, retrograde. But the real fallacy was surely that if there was a competition there must be a judge. And the judge must know at least as much as the competitors. In this case, the judge knew so much less than the competitors that he was later going to ask them for advice—a rather queer situation, to say the least. The client would have to appoint another engineer or architect to decide which was the best design, and if that architect or engineer were high enough in the client's esteem to judge the matter, then the client would presumably have gone to him in the first place and saved everyone time and money.

148. On the whole, thought Mr McMeekin, professional standards in Britain were

fortunately high and great care should be exercised before encouraging a state of affairs that would tend to bring out the spectacular rather than the best in design.

Mr C. W. N. McGowan (Head of Civil Engineering Department, Kuwait Oil Co.) said that no mention had been made of the past history of the problem, which was not new. Before the dates of incorporation by Royal Charter (the Institution in 1828, the Institute in 1834) there had been no distinction between an architect and a civil engineer. For example Wren had been as much civil engineer as architect. It was refreshing to find that the two distinct professions, after almost a century and a half, were considering getting together again.

150. The difficulty of divided responsibility had been overcome in France where architects and engineers worked together under a protocol signed by the two professional bodies. The agreement divided works into four categories, the architect controlling where the engineering work was subsidiary and *vice versa*.

The following contributions were submitted in writing.

Mr G. G. Baines (Partner, Grenfell Baines and Hargreaves, Architects, Preston) observed that the facts of complexity, specialization, and the consequent need for effective co-operation were accepted. However, to achieve the common will required for effective collaboration, all parties had first to agree on the objective, which was, surely, to produce the best possible "design". However, ends were easier to agree than means, and once co-operation to produce the best possible design had begun, its continuity depended on a common understanding of "design" which was so clear that it commanded respect at all times, especially when difficulties arose.

152. Those factors which inspired and made design in practically any field of creative endeavour were well-known. "Commodity, firmness, and delight" were terms current in the eighteenth century, but today commoner terms were "function" (or use), "construction" which (involved technique) and "economics", which in modern society was so important as to be a positive factor; finally "delight" had a meaning valid in all ages.

153. A design could be called successful when the requirements implied by those four factors in any particular problem at any time in any place had been given comprehensive consideration leading to a balance which represented a whole greater than the sum of the parts. Thus a philosophy for "design" could be expressed in the one word "balance". Balance represented the positive approach, compromise the negative. Obviously the character of the content of balance would vary with every problem as it occurred at different times in different places, but the common policy would be to seek and discover the possibilities of the limitations.

154. It had to be admitted that while the process of developing specialist knowledge in any one of the four factors mentioned could give power to deepen the content of design, it could also involve the danger of biased consideration of that particular factor or one closely related. In deciding the lines and priorities of co-operation, therefore, it was necessary to remember the purpose of design. It was for Man who needed space arranged for Use, secured by firm shelter, made comfortable by engineering techniques, and kept economic by cost control.

155. In this context, it would be seen that structure, roads, and engineering services were at the service of space; that planning was at the service of use; that economics could be a stimulus to discovering the possibilities of both; that beauty was a quality which should invest all thinking. Thus while design would derive inspiration from all four factors, the best design being the highest possible balance, it should not be forgotten that design was at the service of man, and it was those factors of design nearest to the human element in any given situation that mattered most.

156. The day when one man could know everything about everything had gone. This did not mean that quality of design could be advanced no further, but it did mean that future design developments would depend more and more on effective collaboration

between those possessing specialist knowledge of some factor or factors, together with a clear understanding of the nature and purpose of design.

Mr Maurice Nachshen (Partner, Maurice Nachshen and Partners, Consulting Engineers) referred to the growing activities of the contractor-designer. To survive independently practising architects, engineers, and quantity surveyors had to devise methods of co-operation in their work and to create suitable new forms of service contracts. Vigorous combined publicity was needed to convince potential clients that the employment of professional men, independent of contractors, was in their best interests. The contractor's "package or turkey deal" had an attraction for commercial clients who generally had little appreciation of aesthetics or of the great share of a large building that had to be designed by engineers. The importance of site supervision should be stressed. Contractor-design must lead to mass design to spread costs, as in the motor-car and aeroplane, but the latter were short-lived products, while buildings must last for generations. The deplorable result of mass design of buildings could be seen in the old working-class districts of industrial towns.

158. Appreciation of architecture should be taught to engineers, but substantial co-education of architects and engineers would produce, in maturity, specialized structural engineers rather than civil engineers with a wide experience in civil engineering, which was increasingly needed as difficult foundation and below-ground problems were created by taller and heavier buildings and the need to utilize poor sites.

159. Early and close collaboration between architect and engineer was very important in the early stages until the general form of the building was agreed by the client. Then it was best for the architect to have some time alone to elaborate and revise his scheme. That should avoid many of the later changes which sometimes obliged the engineer to scrap and re-do what had already been done—a common cause of irritation. The production of general arrangement drawings should then proceed in close collaboration. When they were completed and agreed, no further changes should be permitted.

Mr William Allen (Head, Architects' Division, Building Research Station, D.S.I.R.) remarked that two aspects of collaboration seemed to be of particular importance.

161. The first was how far should either profession go before inviting formal collaboration? Mr Mathews had suggested that it was not very far, for he thought it desirable to consult even at the level of a heating system for a house. That seemed to Mr Allen to be too far down the scale—using a sledgehammer to crack a nut. Consulting always involved meetings, correspondence, reports, and so on, which became disproportionate to small jobs, and which he thought should not be necessary. Both collaborators should surely be conversant not only with the general practices and functions of the other, but be able to carry out, reasonably competently, certain elementary stages of the others' work in their own offices.

162. Secondly, there was the question of appearance. It was one of the grouses of architects that in engineering structures it was often amateurishly dealt with, or sidestepped as a conscious objective. Sometimes one felt that British engineers were embarrassed by beauty, as if theirs was a rough masculine activity, to which a sign of softness would be a betrayal. Mr Allen suggested that no one, in common morality, had any right whatever to erect a structure in which he did not consciously strive for beauty and character. The few exceptions were not worth considering. Mr Arup had touched on that a number of times, and it would be fair to add that British architects had seemed to find beauty and character more highly valued and more competently handled by continental than by British engineers. This remark applied to all such items as lamp standards, railway engineering structures, dock and harbour structures, outdoor industrial plant, and the now familiar case of highway bridges. It could not be left to be dealt with just when the apparition of the Royal Fine Art Commission reared itself; it should be cultivated deliberately from student days forward. It was a vital element in successful collaboration with architects, and ought to be equally valued in an engineer's own practice. Much time in architectural education was consumed in

studying the chief principles of several fields of engineering; the counterpart to this should be this cultivation of design-sensitivity and appreciation in the engineering curriculum.

Professor Robert Gardner-Medwin (Roscoe Professor of Architecture, University of Liverpool) said that both Authors had suggested some degree of co-education. Excellent, but how was it to be done?

164. Mr Davies, while drawing a clear distinction between the nature of engineering and the nature of architecture, saw the necessity for a return to the creative approach of Brunel and Rennie in the training of the modern engineer.

165. In Professor Gardner-Medwin's experience, these two important propositions were clearly connected. In Liverpool University there had been founded a Department of Building Science with the idea of bridging some of the gaps in the education of engineers and architects—and of scientists, who were important members of the building team but who had hardly been mentioned. The attempt was being made at two levels: (*a*) through joint post-graduate research; and (*b*) through joint teaching of undergraduates by engineers, architects, and scientists.

166. At present, the greatest scope for effective "co-education" appeared to be at post-graduate level, where graduates and staff had every opportunity of working together on specific design problems and learning something about undergraduate-teaching techniques in the process.

167. At the undergraduate level it was easy to put students of architecture in contact with specialist engineers and scientists, not only in lectures but in practical design exercises. But it was far from easy to teach engineering and architecture students together. That was because of the very different nature of the engineers' course, which precluded design experience. In other words, the engineers were fully absorbed with mathematical theory and had no time for training in the imaginative problems of applied design. In the case of students specializing in structural engineering this seemed particularly unfortunate and perhaps explained why so many otherwise competent engineers meekly "solved the architect's design" instead of sharing the creative process with him.

168. If full partnership in design was to succeed, it must surely start with the students. At present that was impossible. Professor Gardner-Medwin suggested that the engineer's course was too short and that the greater part of an extra year should be devoted to the application of theory to design. Students of structural and mechanical engineering would then be able to undertake joint projects with students of architecture, to the great gain of both in experience and respect.

Mr J. S. Tritton (Consultant, Rendel, Palmer & Tritton, Consulting Engineers) remarked that there was already a Joint Committee appointed by the Association of Consulting Engineers and the Royal Institute of British Architects to consider the relations between members of those two professional bodies. Apparently the deliberations of that Committee had been somewhat protracted to date. In view of the further information afforded by the Papers and discussion he suggested that the Joint Committee should be asked to report progress within the next 3 months.

Mr W. B. Jepson (Projects Manager, John Laing & Son, Ltd) suggested that a design tender, possibly based on a standard form of inquiry and issued to a prescribed maximum number of teams, for any particular value or complexity of scheme, deserved serious thought. In the climate encouraged by such a system it would be easier to establish what would appear to be a vital re-organizational development—the formation of comprehensive design teams, such that:—

(*a*) They should take their name from that of their *active* leader.

(*b*) They should not be permitted to expand beyond the point that the leader had to delegate the responsibility to control his jobs, meet his clients, and co-ordinate the activities of the team.

(*c*) They should contribute to joint independently administered superannuation schemes, holiday funds, bursaries, and the like, in order that mobility was not restricted within the sphere of creative design, and that talent was encouraged, particularly before achieving partnership, to gravitate into a congenial orbit for its full development.

171. The "package deal" had been acknowledged and had also been criticized, yet in the field of mechanical engineering the engagement or retention of the services of a well-known successful designer to work exclusively with one manufacturer was not unknown. Design by teams and design tendering would together make possible improved service to the client, and would bring the contractor into the design team, and largely eliminate the advantages which the package deal undoubtedly had. Furthermore, by restricting identification to the name of the active leader, and controlling the size of teams, the bloated design service with its impersonal product, by whomsoever it is sponsored, would be eliminated.

Mr F. G. H. Murcutt (Architect) was uncertain whether the object of the discussion was to establish a *prima facie* case for a new joint approach to the problem of architect-engineer collaboration, or merely to expound view on a premise, mutually agreed beforehand, that the case had already been established. He had the impression that the discussion laid too much emphasis on the role of the structural engineer in relation to buildings, and none at all on the possible fusion of civil engineering and architecture on those projects of a singularly functional entity.

173. London's post-war architectural leadership had been roundly criticized by Mr Davidson, and Mr Neill had referred to lack of moral fibre. Both opinions were entirely backed up by the visual evidence of London's post-war buildings, and it seemed that, until architects had put their own house in order, there was a case for basic revision of the early stages of an engineer's education to allow a period of general joint training in the approach to constructional design, dealing entirely with function and good looks.

Mr R. J. Mainstone (Principal Scientific Officer, Building Research Station, D.S.I.R.) thought that there were two ways of approaching the subject. Either one could start from practical experience of collaboration and look for ways of bettering the relations that existed today between architects and engineers. Or one could attempt to define an ideal relation and then ask how it could more nearly be achieved. When, in § 5, he drew the distinction between architect and structural engineer, Mr Mathews was presumably thinking in terms of their present-day roles. It might well be true that in much current practice the architect created a structural problem and the engineer was merely asked to solve it. But, as Mr Arup had pointed out in § 24, this was far from the ideal and was a degradation of the engineer's true role. Mr Mainstone preferred to start from the ideal, likewise confining his remarks to the architect and the structural engineer.

175. For those jobs in which both new spatial and new structural solutions were sought, it was evident that these solutions would rarely be independent and therefore should, ideally, be pursued *pari-passu* from the start. The roles of architect and engineer would then differ only in that the architect would aim primarily at the first and the engineer at the second, their meeting point being a common interest in the forms which both defined the architect's spaces and embodied the engineer's structure.

176. In the past it had been much easier to achieve an ideal collaboration, often within a single mind, not only for the reasons that had been pointed out but also because the two roles had been essentially closer. New spatial solutions had been much more rarely sought, and there had been little, if any, distinction between the formal and the structural solution. The adequacy of the latter had been considered to arise directly out of the former and to a large extent had done so in any given context.[5]

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[5] R. J. Mainstone, "Structural theory and design. 1. Early proportional theories". Archit. & Build., Lond., vol. 34 (1959), p. 106.

177. Today, space, form, and structure had to be considered separately, and there was, in particular, a very real distinction now between the last two unless the consideration was confined to a single very limited type of construction. The distinction was enhanced by the very different natures of the criteria of structural adequacy on the one hand and spatial and formal adequacy on the other. The ultimate tests of an adequate structure were objective and unequivocal, and structural theory took note of this. However abstract and mathematical it might become it was always subject to and spurred on by the rigorous discipline that its predictions must conform to observable behaviour. The only known tests of a good spatial or formal design, however, were essentially subjective and must remain so as long as individuals remained free to order their own lives. Theories of formal and spatial design, therefore, were at best generalizations about fickle human behaviour and likes and dislikes, while many had remained purely speculative and valid largely to the extent that they were believed in. So, while the essential sequence of all design—the alternation of intuitive choice and analysis of that choice—had not changed, structural design had drawn apart in two ways. It was characterized both by a different and more abstract basic intuition and by a distinctive analytical process. It must, in the more fundamental sense, remain apart, though the gap could be narrowed considerably by a more scientific development of architectural theory.

178. If this analysis was correct and credence was given to Mr Mathews's premise that one condition of effective collaboration was that architect and engineer should be educated in such a way as to give each a sympathetic understanding and some knowledge of the other, then it was possible to be a little more precise about what this entailed.

179. The first requirement seemed to be that each should understand fully the nature of his own primary role and be as competent in it as possible, both in the intuitive side of design and in the analytical. If then he recognized the essential similarity of the design process in all fields and was shown how his own role and theoretical disciplines had grown out of common beginnings in the past, it would be a comparatively short step to at least an intellectual understanding of the role of the other and his rather different disciplines. Widening his knowledge in this way, by first teaching him more about the nature of his own job, certainly seemed preferable to the very questionable alternative of teaching the architect, as something largely unrelated to his own discipline, a few elementary calculation routines, and spoon-feeding the engineer with some equally elementary rules of architectural proportion and composition.

180. Beyond this it seemed important that the common interest in forms should be a true meeting point. For it to be so the architect's interest in forms *per se* must be complemented by an intuitive awareness of their structural potentialities; and conversely for the engineer. An intellectual recognition of the complementary intuition was not enough. The mind that was not naturally endowed with an aptitude for both must be taught, if that was possible, to function in a way to which it was not accustomed, and it was not easy to say how this could be done. Given some latent natural aptitude, though, it should not be too difficult. It should be possible to awaken it through those interests already present—for the engineer through solid geometry perhaps, as Mr Arup had suggested, through the geometry of structure, or even through the formal and aesthetic qualities of his own basic theories; and for the architect through the structure of natural forms and his intuitive awareness of the structural actions of his own body. Practical creative experience also should help. Apart from the freehand sketching suggested by Mr Arup, modelling and carving under the right guidance should develop the engineer's sense of form, while architects might experiment in building and testing simple small-scale structures.

181. The ultimate ideal would always be a return to the all-round designer who was both architect and engineer, and it might not always be as unattainable as it now appeared. The need for a mind able to think creatively and analytically in very different fields would remain, but the problem of knowledge might recede. At the moment the more one learned the more intractable it seemed to become. But the scientist's aim was always to find simpler more embracing patterns to comprehend his

growing fund of observations. As he turned his attention increasingly to the field of building one could perhaps look forward to the day when the sum of needful knowledge was more unified and the division between architects and engineers gave way to one between all-round designers and those engaged on basic research.

Mr R. J. M. Sutherland (Partner, A. J. & J. D. Harris, Consulting Engineers) remarked that both Authors had neglected the danger of mutual self-deception once co-operation between architect and engineer had become really successful. There was certainly no harm in an architect using novel structural forms for visual effect and there was equally no harm in an engineer designing by eye and then showing that his proposals were physically possible. The trouble started when either of them forgot which side of the partnership he was on.

183. In pure engineering cost and function alone had to be reconciled, the engineer balancing extra expense against greater physical efficiency. In architecture there was a third variable, the aesthetic one, which was by far the most difficult of the three to control. Ideally there should be no limits to what an architect was entitled to do visually, provided that he made his intentions clear to his client and explained their functional and economic effects.

184. To take a simple example of what may go wrong, an architect might wish to use an unusual profile of beam for essentially visual reasons but feel that it was not justifiable. He would probably approach his engineering colleague and try to persuade him to use this shape structurally, his motive being partly to save cost but also to satisfy his sense of structural purity. At first the engineer might think it easier to use a more conventional shape with the visual form added after, but if he was at all sympathetic he would feel it a challenge to make the most of the unusual shape. No-one could doubt the good intentions of either party, though the result was likely to be a fraud both more subtle and more reprehensible than the ageless ruse of hiding the structure; the client would pay more for what he thought was structural necessity; the architect would think he was being functional; and the engineer would persuade himself that he had arrived at a brilliant solution to a real problem; whereas the whole effect could have been achieved more cheaply by cladding a simple beam. New structural shapes were only justifiable as such if they led either to immediate or future economy.

185. It was just as easy for the engineer to start this train of deception, often by proposing shapes which he thought would be acceptable to his architect friends. Here lay the danger of architect and engineer working in the same organization; year after year each would pander to the prejudices of the other, without any stimulus from outside.

186. Mr Sutherland did not suggest that there should be less co-operation, but he firmly believed that the architect should recognize when he was using structural forms visually and that the engineer should tread very warily when he strayed into architecture. Also each should question his own and his colleague's motives very closely.

Miss Allison Downs felt that the ideal environment for collaboration was under one roof, and there was much to be said for the engineer and architect working anonymously behind the name of one firm. In that way the problem of who was to be the more equal of the two equal partners was resolved by the nature and characteristics of the building. The one-firm arrangement also solved simply the issues arising from forms of contract and gave the best opportunity for discussion.

188. Whilst the structural design was in the hands of one person, and visual design and planning in the hands of another, the real problem seemed to lie in the hard business of coming to terms with each other, so that the parties were both willing and able to negotiate a design policy. It seemed axiomatic that the more able and flexible the designers the smoother the path of negotiation. The power to communicate to each other was extremely important, and a joint early curriculum would facilitate this. Priority should, however, be given to producing graduates with a thorough understanding of their respective fields. Given a comprehensive background of his own subject,

the designer appeared to have the wisdom to meet the requirements of his confederate and to be less anxious to express himself in terms assigned to the other.

Mr R. F. Legget (Director of the Division of Building Research, National Research Council of Canada, Ottawa) thought it encouraging that the two Papers had so much in common. It was yet further evidence that when architects and engineers consulted together they could find so many mutual problems and so many common concerns that petty professional jealousies quickly disappeared. Looming large over all other common problems was the insidious encroachment of the "packaged deal" for the erection of buildings, with its glib arguments and superficial advantages, so appealing to the non-technical financial mind. If the two professions could not learn to work together, as the Papers suggested, each benefiting by the accumulative experiences and best practice of the other, they might find the financier-designer-contractor type of organization doing more and more building work.

190. Particularly encouraging was the fact that both Papers pointed to the advantages of some degree of common ground in the educational process for the two professions. In Canada, three of the four English-speaking schools of architecture were integral parts of university faculties of applied science and engineering; only recently had that desirable arrangement changed in the fourth case, after half a century of successful operation. Having had the privilege of teaching undergraduates in architecture and civil engineering in the same classes at one of the universities mentioned, Mr Legget could testify to the mutual benefit and understanding thus engendered in young professional minds.

191. Mr Arup had mentioned (§ 38) the preparation of "briefs". The descriptive booklet recently issued to entrants to an international competition for a large new proposed Canadian building had only the following to say about the mechanical equipment:

> "The building will be completely air conditioned for summer and winter. This will not be the concern of the competitor except that he will show approximate areas given up to mechanical equipment. Competitors are advised to get some technical advice on the area required for air conditioning equipment where summer and winter conditioning are involved. . . ."

It might be suggested that this vague statement was in keeping with the idea—so strange to engineers—of selecting an architect by means of an open competition and with this, Mr Legget agreed heartily. The attitude to modern building design, so clearly indicated by this statement, was the exact counterpart of the idea in the minds of some engineers that "architecture" was confined to the exterior decoration of a building. Both viewpoints were equally to be regretted. Modern buildings were such complex structures that architectural and engineering planning and design must proceed together, from the conception of the building, if a truly successful result was to be achieved.

192. Another stumbling block in the way of proper professional co-operation was the continuing practice of making awards to architecturally distinguished buildings on the basis of photographs and small-scale drawings, with no reference whatever to the actual performance of the building in question. Two such awards had been made in recent years in Canada to buildings which had given their owners considerable trouble in operation—trouble that had never been mentioned in the eulogies given for the aesthetic appearance of the buildings in question. Engineers found such practice hard to accept; so also did many architects.

193. The key to the problem under review had been well stated by Mr Arup when writing in § 14 that "the knowledge required to design a modern building or structure is far too extensive to be mastered by one mind". Both Authors had stressed the need for one leader of the design team, Mr Mathews' suggestion that "the successful collaboration represents an equality of compromise" being a singularly happy expression of the basis of the essential team work. Did not these several factors suggest that, with the steadily increasing complexity of modern buildings, the combined efforts of the

engineer and the architect were necessary for the most efficient prosecution of design? Mr Mathews seemed doubtful about the wisdom of the architect-engineer combination and yet it worked well, in a variety of forms, in Canada.

194. An unusual, but interesting example of what can be done by the full collaboration of architect and engineer from the very start of design had been provided by the now-famous reinforced concrete cantilever "arrow" at the recent Brussels International Fair. Mr Legget had heard the engineer member of the team, Professor Paduart, pay unqualified tribute to his architectural colleague. To follow the successive sketch designs for this unusual feature of the Fair, starting with conventional forms and finishing with the daring structure that had actually been built, was to see a vivid example of the potentiality of fully integrated architect-engineer co-operation.

195. In conclusion, Mr Legget repeated what he had said before[6]:

> "Finally I think that it is essential to the future well-being of the two professions that the two should learn to work together on comparable footings, the architect not "employing" an engineer as if he were a junior member of his own staff, the engineer not "employing" the architect as he would a draftsman. Admittedly, one man must be in control; in building work this will usually be the architect. But surely he can regard his engineering collaborator as a professional associate? You will say that this is difficult because of financial arrangements but I do not think that this is the case necessarily. As the ultimate objective, and the perfect solution, I envisage a return to the idea of the master builder—the existence of firms in which architects and engineers are joint partners, the architect knowing something about engineering, the engineer knowing something about architecture, but both co-operating, on an equal footing, in all their work."

He ventured to hope that the Authors would not disagree with this suggestion since it appeared to be in accord with the spirit of their respective Papers.

Mr Jefferiss Mathews in reply, said that there was little he could add (to what he had already said in the Paper) regarding the many interesting and valuable comments made in the discussion. Almost without exception the speakers had taken up, in one form or another, the theme which both Mr Arup and Mr Mathews had included in their Papers —close collaboration and mutual understanding of architects' and engineers' respective problems.

197. Where opinion differed on the form which collaboration should take, it indicated the lack of mutual understanding which undoubtedly existed to some extent and which the two professional bodies were striving to resolve. He doubted if it could be resolved by pious hopes expressed at joint meetings, or by any constructive action by those at present practising. Collaboration might or might not prove to be successful; personality played a major part when maturity had been reached. To achieve improvement in the long run it was necessary to start at the beginning; and the beginning was at the stage of students' technical education.

198. It was abundantly clear that this was the route to be followed and the possibilities of some form of technical co-education would have to be studied. It was a moot point whether this could best be done at under-graduate or post-graduate stage. Many would like to see it at both stages but it seemed probable that in the beginning the post-graduate stage would yield the most fruitful results, for at this stage there was less risk of running into the obvious difficulties of trying to train a man to be equally an architect and an engineer. That this combination had been possible in the past merely stressed, by comparison, the differences between the techniques with which the modern designer had to contend and those of his predecessors. Wren had been mentioned as both architect and engineer, and merely to consider the structural techniques and varieties of materials available to men 300 years ago and to compare them with those of

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[6] R. F. Legget, "The future of architect-engineer relations". J. R. archit. Inst. Can., vol. 22, (1945), p. 113.

today seemed to answer the advocates who said that the attempt should be made—whether by architect or engineer—to embody in a single person the skill of Wren. Mr Mathews believed that it was impossible, within an average human mind, to combine the extent and diversity of knowledge now necessary in architect and engineer in a single person. He strengthened this belief by looking at the difference in approach to a like problem which each must make; the creative approach without any yardstick of measurement required from the architect; and the resolving by precise mathematics of the stated problem required from the engineer. Each approach was so fundamentally different that each must appeal to a different kind of mind and temperament. And so Mr Mathews believed that the stage of the single master mind had been passed and it was now necessary to resolve by collaboration the nearest possible similar state in two or more minds working together.

199. He hoped that the two Papers and the discussion would make a fresh start in the closer collaboration between the two professions and from it, even if slowly, would emerge the closer relationship and understanding which was essential to replace the single master mind.

Mr Arup, in reply, said that it would hardly be helpful to try to reply in detail to each of the many contributions to the discussion, but it was difficult to resist the temptation of having the last word on a number of points raised.

201. Naturally there was general agreement about the necessity or desirability of early collaboration between architect and engineer. Only a thorough integration of architectural values and structural principles could produce the perfect solution. As Mr Llewelyn Davies had pointed out (§ 113) it was the design process which really made things come to life, and design must draw its inspiration from both fields. "This was what association with, and understanding of, architects could give to engineers" (§ 113). And this would enable the engineer to share the creative process with the architect, instead of merely "solving the architect's design" (§ 167).

202. In § 180, Mr Mainstone had observed that "the common interest in forms should be a true meeting point. For it to be so the architect's interest in forms *per se* must be complemented by an intuitive awareness of their structural potentialities; and conversely for the engineer". But it was important to guard against "a fraud both more subtle and more reprehensible than the ageless ruse of hiding the structure" (§ 184), namely that of confusing visual delight with structural necessity.

203. In many types of structure or building the so-called mechanical services played an increasingly important role, and must be considered at the design stage—in fact their design must proceed parallel with that of the structure. This suggested that the mechanical engineer should also be a member of the design team. This point had been made by several contributors, and did undoubtedly apply to all jobs where mechanical services in one form or another had an influence on the design.

204. A similar case could be made out for the contractor. The method of construction was of the greatest economic consequence and affected the design intimately. But to bring the contractor into the design team had a much more revolutionary effect on the whole organization of building. The necessity for this had to be faced in the case of unusual structures, highly mechanized site organization, or repetitive factory-produced buildings, but normally, as Mr Powlesland had put it in § 127: "It should be part of the engineer's job to be a specialist on costs, and he should know much more than the techniques of structural design."

205. Fundamentally, however, there was general agreement that for all important or complex jobs, the best result could only be achieved by the pooling of the knowledge of the architect, structural and mechanical engineers, and contractors at an early stage in the design.

206. The real question was therefore how to facilitate and improve this collaboration.

207. Various speakers had followed up Mr Mathews's suggestion in § 4 that the foundation for a successful collaboration should be laid already during the training of architects and engineers. Mr McMeekin had suggested (§ 144) that engineers should

be trained in aesthetics as well as mathematics; Mr Allen (§ 162) had referred to the "cultivation of design-sensitivity and appreciation in the engineering curriculum"; Professor Gardner-Medwin thought (§ 168) that "the greater part of an extra year should be devoted to the application of theory to design" and had suggested that "Students of structural and mechanical engineering would then be able to undertake joint projects with students of architecture, to the great gain of both in experience and respect".

208. Mr Murcutt (§ 173) also envisaged "a period of joint training", and Mr Legget, who had had experience of teaching under-graduates in architecture and civil engineering in the same classes in Canada. had testified (in § 190) to "the mutual benefit and understanding thus engendered".

209. Undoubtedly such joint training could be fruitful under the right leadership, but was it not true that the various curricula were already overloaded? The question was therefore one of priorities, and as Mr Mainstone had pointed out (§ 179), the *first* requirement was "that each should understand fully the nature of his own primary role and be as competent in it as possible, both in the intuitive side of design and in the analytical. . . . Teaching him more about the nature of his own job, certainly seemed preferable to the very questionable alternative of teaching the architect . . . a few elementary calculation routines, and spoon-feeding the engineer with some equally elementary rules of architectural proportion and composition".

210. Apart from freehand sketching, Mr Mainstone had suggested (§ 180) that modelling and carving under the right guidance should develop the engineer's sense of forms, while architects might experiment in building and testing simple small-scale structures.

211. Miss Downs had also stressed (§ 188) that "Priority should . . . be given to producing graduates with a thorough understanding of their respective fields. Given a comprehensive background of his own subject, the designer appeared to have the wisdom to meet the requirements of his confederate . . ."

212. While there were thus differences of opinion about methods, it was encouraging that there seemed to be general agreement about the necessity for giving the engineering student a more comprehensive background and a wider understanding of design and the function of structure, and the architectural student, by some means as yet to be perfected, an intuitive feeling for structure and a greater mastery of technically efficient detailing. It was to be hoped that this would bear fruit inside the respective schools.

213. Other speakers had turned their attention to the desirability of defining the boundaries between architecture and structure—or more possible, perhaps—between the work of the engineer and that of the architect.

214. Mr Cusdin had called (§ 64–67) for a simple statement by the two societies, covering "good behaviour", "recognition of credits", "contracts", and "recognized boundaries or spheres of influence". Mr Turner had also suggested (§ 75) that the soundest basis for collaboration was an "agreement on definition of duties and responsibilities". Mr Murland had complained (§ 121) that the consulting engineer was not properly recognized and had no existence whatsoever in the R.I.B.A. form of contract. There seemed definitely to be room for improvement here, but Mr Arup deplored the possibility of formulating a set of rules setting out in legal terms what an architect or engineer may or may not do. Architecture and engineering were intricately mixed up—they were in many cases almost the same thing—and to try to codify and define the boundaries *in abstracto* would only add to the confusion, just as it was to be feared that Mr Budgen would be disappointed when he demanded from the architectural profession a greater degree of unanimity as to what is good architecture (§ 135). But when architects and engineers were in fact collaborating on a particular job, it was just as well that the various professional and legal documents which were supposed to deal with the situation recognized this fact and allocated to each certain responsibilities and powers. In any case the partners must—as in all cases of collaboration—agree on what each was supposed to be doing, but it was doubtful if a *general* allocation of duties would apply to every type of job.

215. Mr Tritton had pointed out (§ 169) that there was already a Joint Committee

appointed by the Association of Consulting Engineers and the Royal Institute of British Architects to consider the relations between members of these two professional bodies. Perhaps that was the right forum for the discussion. If so, there was hope that some action might ensue.

216. A number of contributions had dealt with the actual organization of the work on the design. The increased efficiency resulting from architects and engineers working together in the same office, thus avoiding "the seesawing of plans backwards and forwards" had been stressed by several speakers. This advantage could be achieved by setting up joint design teams for specific jobs—and where this was possible it undoubtedly saved a lot of time and effort and was of great educational value to the participants. But the method could be applied only to large jobs, and moreover only to jobs on which work could proceed fairly steadily and not in fits and starts owing to oscillations and procrastinations often associated with the process of briefing and indeed with architectural creation.

217. Some speakers had therefore recommended that architects and engineers should combine in some permanent association (§§ 94 and 128). This was sometimes referred to as the "package service" and was seen by some as the only possible defence by the professions against a more comprehensive kind of "package service" sponsored by contractors, who undertook the whole design as well as the execution of the work. This method, for some reason referred to by Mr Nachshen (§ 157) as "package or turkey deal", was on the whole condemned, because it failed to protect the client against commercial exploitation.

218. Mr Jepson on the other hand suggested (§ 170) that "design tenders" by competing "package teams", bringing the contractor into the design team and ensuring competition in design, should be seriously considered. This idea of competition in design was anathema to Mr McMeekin (§ 147), because of the necessity of having a competent judge to adjudicate on the merits of the designs—and then the whole bother might be avoided by appointing this judge to do the design in the first place.

219. Other suggestions on organization were that the contractor might be selected at the design stage (§§ 69 and 104) or that an additional independent business organizer might be appointed to control the whole team (§ 80).

220. This whole question of the organization of the design team or the building team—to include the contractor—was a very vexed one, and it would be difficult to obtain unanimity of view. One reason was surely that there were so many different kinds of job, and what suited one job did not suit another. Then also the different personalities involved required different treatment. One could not ensure quality simply by organization—it depended on personal attributes. There was room for many kinds of people and many kinds of grouping, and that was probably a good thing.

221. It seemed, however, that the idea of a permanent association of architects and engineers was gaining ground. This was an interesting portent—but would it not be best to preserve the identity of a firm or group by retaining its character as either a predominantly architectural or engineering firm. It would not be an advantage if firms were completely self-contained—they should develop a speciality or personality and be able in this field to be of use to other firms. There should be collaboration outside as well as inside the office, to avoid stagnation.

222. One question which unfortunately had hardly been touched on in the discussion was that of the identity of the "client" and his relation with the design team. Would it not be profitable to discuss the many different methods by which a client obtained the services of a design team in the first place? The inquiry, commission, or order might come first to an architect, engineer, contractor, or some agent or go-between, it might be dealt with by government or municipal servants, by professional people, or by private enterprise—each following different rules of conduct and having different technical qualifications. No wonder some clients did not know where to begin and which pressures to resist.

223. The initial steps were vital in determining the nature of the final result, and the client was entitled to some enlightenment and guidance.