THE INSTITUTION OF CIVIL ENGINEERS.

WORKS CONSTRUCTION DIVISION.

Inaugural Meeting, Tuesday, 2 January, 1945.

LIEUT.-COL. C. M. NORRIE, D.S.O., B.Sc., M.Inst.C.E.,
Chairman of the Division, in the Chair.

It was announced that the following had been appointed by the Council of The Institution to serve on the Provisional Board of the Division: Lieut.-Col. C. M. Norrie (Chairman), Sir George Burt, Sir William Halcrow, and Mr. R. M. Wynne-Edwards.

The Chairman observed that the Division was starting with a membership of 600. Its object was to afford opportunities for the discussion of all matters connected with the execution of engineering construction on the site.

Report No. VI of the Post-War National Development Committee, on "The Organization of Civil Engineering Work" was submitted for discussion. A synopsis of the Report is given below.

POST-WAR NATIONAL DEVELOPMENT.

REPORT VI. "THE ORGANIZATION OF CIVIL ENGINEERING WORK".

In view of the interest shown in the subject by members and others in the series of Discussion Meetings on "Civil Engineers and the Building Industry" held at the Institution in the latter part of 1942 and early in 1943, a Sub-Committee was set up by the Post-War National Development Committee to consider and report upon the organization of engineering work.

Although a systematic study of procedure in various branches of industry has been made with considerable literature on organization as available, yet little has been written in regard to civil engineering; probably owing to the great diversity of conditions attending the proportion and location of the majority of projects and the variety of technical problems involved. Engineers, especially contractors, may hesitate to publish their accumulated experience, which is regarded as a value in addition to goodwill.

It is now realized, however, that a wider dissemination of the general feature of organization, together with the collective descriptions given in this Report, may lead to better collaboration between all branches and will undoubtedly assist young men during their practical training.

Although many recent legislative restrictions on the free exercise of action and individual control were intended to be only temporary measures, some may be retained for an extended period.

No information exists regarding the scope or nature of what may become permanent conditions applying to professional service, labour, employment, materials supply, and the prosecution of private enterprise generally.

No reference, therefore, has been made in the Report to the incidence of existing or the possible effect of extended legislative restrictions on the organization required for carrying out civil engineering work. Only the general features of that organization have been assailed, and it should be recognized that modifications may be necessary under future experience, when controls may play a different part in regulating constructional effort.

The Report is divided into two parts, the first dealing with civil engineering procedure up to the stage when actual construction is started, and the second with the details of works organization during the period of execution.

Part I.—Civil Engineering Procedure.

Under this heading the following items are dealt with :—

Promotion of Public Works; Qualifications of the Engineer; Preliminary Investigations; Competitive Engineering; Parliamentary or other Statutory Sanctions; Specialist Engineering Services; Policy for Execution; Constructional Risks; Invitation and Selection of Tenders; Factors in Economy; The Time Factor; Need for a Considered Programme; Administrative Functions of the Engineer; the Engineer's Responsibility for Valuation and Certificates; The Engineer's Responsibility in regard to Quantities; Organization of Engineering Services; Final Considerations.

Part II.—Works Organization.

The General Principles involved are outlined and the details of the organization are presented as follows :—

Duties of the Resident Engineer and Staff; The Contractor's Organization; Programmes and Progress; Use of the Programme and Progress Chart; The Use and Maintenance of Plant.

In Appendix I Specimen Programme and Progress Charts are illustrated and in Appendix II the training of Foremen and Inspectors is dealt with.

Discussion.

The Chairman, in introducing the Report, said that the Committee wished to have the views of the members of the Division upon it, which would be very carefully considered.

In his view, such a Report should be reviewed periodically, perhaps every five years. It would certainly require revision and possibly enlargement after the war, when the conditions under which the profession and

industry would have to work could be ascertained. No reference had been made in it to the organization needed while war restrictions remained, as the Committee felt that that would make the Report too largely of a temporary nature. Therefore he thought that in the discussion any exaggeration of the inefficiencies and time-delaying factors experienced at the present time should be avoided.

Those engaged in the industry should be thankful that they had not yet received in their work the attention of the organization expert. According to his experience in other branches of work, organization experts generally devoted their whole attention to giving out card indexes and wonderful forms to be filled up. If any proof was required of the resilience of the organization of the industry to meet new conditions, it could be found in the fact that the industry had been asked to make the "Mulberry" prefabricated ports.

It should always be remembered that organization was not a substitute for sound technical service and experience. It was useless to stress the merits of organized effort if the personnel employed in it were mere automata; they should be good engineers.

Sir William Halcrow observed that before the Council decided to form the Works Construction Division considerable discussion had occurred about the effect it might have upon Papers read before Ordinary Meetings and the meetings of other Divisions. Papers describing completed works which were presented at those meetings frequently included a description of the methods of construction and of the plant used, and some members felt that there might be insufficient scope for a Division dealing with those matters only. It had been decided, however, that in such Papers the references to plant and construction methods were usually to some extent incidental, or taken for granted, and did not provide sufficient matter for discussion, because the description and the design of the permanent works formed the main subject of the Papers.

One factor influencing the decision to form the Division was that the contractor's part in the organization of civil engineering works had grown in recent years to such importance that there was ample scope for Papers dealing solely with that aspect, and many members of The Institution would welcome an opportunity of discussing plant and construction methods divorced from the subjects dealt with in the ordinary Papers.

Another factor was that methods of construction were in many cases similar for works which were designed for entirely different purposes; for example, the same machinery might be used for the earthworks required for railways, roadways, docks, reservoirs, or aerodromes.

The interest shown by members in the other Divisions indicated that their value was appreciated, and he felt confident that the Works Construction Division would prove equally successful.

In recent years, in particular during the war, plant used for construction had undergone a profound change and great advances had been made.

There appeared to be little doubt that machinery would prove of ever-increasing importance in the construction of works, owing to the difficulties which had arisen with labour, the cost of which had steadily increased, although there had not been a corresponding improvement in output. Labour leaders appeared to have devoted their attention chiefly to increases in wages and to control of output, and political control during the war had made matters rather worse. If efficiency was to be achieved, so that Great Britain might compete successfully with other nations, engineers would be called upon to study even more closely the design and use of machinery and plant for public works.

When the Report was in draft form a very senior member of The Institution had said to him: "But we know all this; it is very elementary", to which he had replied that it had not been produced for the benefit of those who were approaching the end of their career, but rather for young men on the threshold of their life's work, to whom it should be of great assistance.

Section 5 dealt with "Parliamentary and other Statutory Sanctions." Many members knew that the Standing Orders of Parliament required Bills to be deposited on a certain date in the year and that the procedure in the two Houses usually took about eight months. It followed, therefore, that if a promoter missed the date he lost a year and it might take as long as twenty months to get a Bill through Parliament. The Post-War National Development Committee felt that some modification of the Standing Orders might be made to deal with the large numbers of Bills which were likely to come forward in the immediate post-war period and that the attention of the Parliamentary authorities should be drawn to the desirability of having Bills deposited at more frequent intervals. Consequently the Committee had drawn up Report No. V, on Private Bill Legislation for Public Works. That Report had been submitted to the appropriate Ministers some years ago and, although nothing had transpired so far, he had reason to believe that the matter was receiving attention and that action might yet be taken. He hoped that members would discuss the relative merits of private Bill procedure and procedure by an order of a Minister, who might call for an inquiry into a project.

In Section 15 the engineer's responsibility in regard to quantities was discussed. There was a tendency in some quarters to-day for engineers to pass on to qualified quantity surveyors duties which in the past had been those of the engineer. That was the practice of architects, whose work was of a very different character from that of the civil engineer. Moreover, the administrative problems encountered in running a civil engineering contract were totally different from those met with in building work, the engineer having at all times to look at the economic aspects involved in any modifications he considered it necessary to introduce.

The Council considered that it was the duty of an engineer to be qualified in, and responsible for, the preparation of bills of quantities; in fact,

The Institution's examinations included the subject of quantities, and in 1933 the Council had issued the Report of the Committee on Engineering Quantities.

Mr. A. M. Holbein said that, as a contractor, he was very happy to feel that The Institution, by the formation of the Works Construction Division, had shown its appreciation of the fact that the contractor was no longer merely a labour master, but that the responsibilities of a modern contractor included many which involved the exercise of engineering skill and he necessarily employed highly-trained and experienced engineers. He was responsible for the methods of construction of the temporary works of engineering contracts, and in that connexion he had to utilize his engineering knowledge, experience, and ingenuity. The Works Construction Division would provide opportunities for liaison between contractors' engineers, engineers on the staffs of consultants, and—perhaps even more important—engineers to public authorities. Such liaison was very important, and should be very useful in enabling those engineers to meet and exchange views upon the problems confronting them. It would also affect the relations between the resident engineer and the agent and between the assistant engineers on the resident engineer's staff and the assistant engineers and sub-agents on the contractor's staff; and he thought it would automatically flow down so that the foremen and inspectors would be infected by the same spirit.

By studying the section of the Report which set out the responsibilities and problems of both sides a contractor's engineer would realize that the consulting engineer and his staff had a very real problem and did an immense amount of work before the contractor appeared on the scene, and it might perhaps correct his rather natural thought that the resident engineer and his staff were employed entirely for the purpose of directing the contractor. Moreover, the setting out of the problems which faced the contractor might make the resident engineer's staff appreciate that the contractor was not a rogue attempting to rob the resident engineer. The Report emphasized the community of interest of the engineer and the contractor.

Its main virtue lay in the fact that it set out fully the tasks of both sides and suggested on the contractor's side a method of dealing with the problems from an organizational point of view. Clearly the intention was not to say: "This is the organization for the contractor." Therefore his remarks were rather intended to emphasize certain points in the Report than to criticize or present alternative suggestions.

It was very important that the standard of the inspector should be high. Everyone had met the inspector who suffered from a sense of injustice because the men he was watching were earning more than himself. Owing to the fact that from a financial point of view his job was not a very attractive one, an inspector was often a foreman whom the contractor had sacked as inefficient and who then took a lower paid job to watch the man who had

replaced him. That was an unhealthy and ridiculous position. The inspector should be of equal standing to the foreman, and should receive equal pay. If he did not know his job he would, largely in self-defence, just take the " book of words " and apply it absolutely, letter for letter. As a result, work might be held up and considerable irritation caused by his insistence on some unimportant detail. That point had been mentioned in the Report.

From time to time Mr. Holbein had found that considerable difficulty arose in regard to claims. A contractor sometimes said : " This is beyond what I contracted to do, and I shall claim on this." Many resident engineers or their assistants were very reluctant to agree to the facts. They seemed to feel that, if they agreed the day work sheets or the measurements as being records of fact, they were in some way committing themselves to approving the extra ; but that, of course, was not so. That point could be emphasized with great advantage, because clearly when the matter came to be settled at a higher level everyone's time would be saved if the facts were agreed. Lack of agreement was often a source of great waste of time and irritation.

Like Sir William Halcrow, he deprecated the practice of introducing quantity surveyors into civil engineering work. He had the highest regard for them, but he did not think that civil engineering was a suitable sphere for their activities, because so many matters that cropped up were day to day matters—conditions of the moment—and it was necessary to act quickly and without hesitation ; otherwise a disaster, large or small, might occur. Only the people who were dealing with the work from day to day could know it all and assess properly the valuation of conditions that had not been foreseen, and that was the job and the responsibility of the engineers, both on the consultant's side and on the contractor's side.

From the contractor's point of view, another aspect of the matter was also very important. If the contractor's section engineers were not responsible for their own quantities, a considerable incentive to efficient and keen working was lost. Those engineers would necessarily lose interest to some degree if a man from the office came along and measured up their certificate measurements, and so forth. They were responsible for the work in question, and they should have the job of measuring up as they went along, so that their interest was maintained.

Costing was also very important. The agent could not control his job efficiently unless he knew at once what the work was costing in all its important sections. The engineer who was responsible for measurement ought therefore to have a weekly measure to correspond with the weekly pay, and he should check up the measurements every month and make them equivalent to his certificate. One reason why costs could be so misleading was that the allocation on the pay-sheets was not complete. It was quite misleading and quite wrong simply to say : " All I want are the key items of work ; if I get the costs of concrete and muck shifting and so

forth I am all right." That might lead to allocating time to those items and to ignoring the rest of the pay sheets, and therefore unduly optimistic views of what the work was costing might be obtained. One might, for instance, ascertain the cost of the concrete while the concrete-mixer was turning, whereas the transport of the mixer, the bringing of materials to the site, and the preparation of the bottom to receive the concrete were all costs against the concrete. Therefore in costing it was necessary to make sure every week that every penny which had been spent in wages was allocated. That meant that the timekeepers had to know their job, and that was one of the great war-time difficulties. The timekeepers should be made to allocate every hour that they showed in their pay-book to be paid. If that were done, the costs would reflect everything that had been spent. In the days when sufficient staff could be obtained his firm used to have a weekly return showing all the main items as outlined by the agent, with the labour cost for the week, the labour cost to date, and the material allocated ; and the agent had that on each Monday for the pay-week ended on the previous Thursday night, so that he could immediately see any job that was beginning to run away. Only by that means could a tight hold be kept on the work.

That question of allocation of time and cost led to the parallel system of bonus or piece-work, which was used in order to reduce the costs. In that connexion again accurate measurement and quick results were important, so that the bonus could be squared up week by week and the man knew that it reflected what he had done ; it was no use having the bonus a fortnight or three weeks old. That dovetailed in with having efficient timekeepers and efficient engineers on the spot.

Readers of the Report might assume that everything in contracting could be cut and dried, but that was the last thing that could be applied to civil engineering. Neither the organization nor the programme should be too rigid, but flexibility should be the keynote of a contractor's organization. That did not mean that the programme should not be prepared in the fullest possible detail. The fact that the contractor had had to think in order to prepare the programme meant that he had focused all the problems, and that he had a grip of the job. But the contractor must be prepared very quickly to amend and adjust his programme or organization to meet the problems that might arise. For instance, some unexpected fine weather might occur in February, when it would be possible to do some of the more exposed work on a time-work job, whereas in the programme that work had been assigned to the presumably finer months of May and June, and it would be very foolish not to take advantage of that opportunity because the work was scheduled to be done later. It should be realized that the preparation of a programme did not mean that it had to be adhered to rigidly and could not be altered.

One of the fascinations of a contractor's engineer's job was that he had to be prepared to undertake all kinds of jobs differing in their technical

problems and in their organization. For instance, an engineer might be responsible for a £4,000 to £5,000 job and for an £8,000 or £10,000 job at the same time, and that called for another form of organization; but the main principles laid down in the Report still had to be adopted; in other words, the problems that were set out there had to be dealt with in the organization. Therefore everything in the plans should be kept broad and simple.

The Federation of Civil Engineering Contractors was alive to the need for the training of foremen and inspectors. It was in process of making arrangements with the Ministry of Labour for the training of foremen. It had in mind particularly the utilization of men from the Services who, by becoming non-commissioned officers, had shown that they had a power of command. It was hoped that the plan for the training of foremen would shortly be cut and dried and that the course would be run in conjunction with the Ministry of Labour.

Mr. T. A. Paton observed that it was a pity that the Report did not cover (it might be in an appendix) the organization necessary to deal with certain types of alterations occurring during the war. Changes in labour conditions had been accelerated by the war which otherwise would have taken place over a much longer period; for example, hot meals in the middle of the day; payment for wet time; improved housing conditions where accommodation in the vicinity of the job was unobtainable; holidays with pay; free travelling; and time allowance while travelling. He believed that such changes had come to stay, and it was essential that they should be taken into consideration in future work.

Firstly, the promoter and the engineer must think of the housing of labour in planning the work. Even when the work was near a town a serious shortage of accommodation might prevail, and that situation was likely to continue for many years after the war; but by co-operation with the local authorities it should be possible to design a temporary hutting scheme that would fit in later with future housing. In the case of jobs farther afield, much might be done to avoid the waste of erecting what amounted to a small village for the use of one particular construction job. The huts might be designed for ease of erection and dismantling, for future use as holiday camps, and so on. Any savings which could be made, particularly before letting the contract, would be well worth while.

With regard to wet time, he knew that it was difficult in civil engineering to provide any alternative work, but the matter should be considered both by the planner and by the constructor.

In Section 9 of the Report it was stated that it was desirable, at any rate in the case of important work, for the programme and methods of construction to be submitted by each tenderer. He felt that the word "essential" should be substituted for the word "desirable." One of the most difficult tasks facing an engineer was the selection of the most suitable firm to carry out a particular job. If the tenders from two or three firms

were very close it was only by examining the methods of construction proposed and considering the contractors' programmes prepared for the work, and possibly also by considering the contractors' key staff, that the final selection could be made for an important job.

He agreed with Sir William Halcrow that it was very important, and would be even more important in the future, to devote considerable time to methods of construction. There would be considerably more scope for the engineer, from the point of view of design, and for the contractor in devising and using up-to-date methods and plant. American engineers were rather ahead of British engineers in that respect, but, given equal opportunities, he was sure that British engineers could excel.

One typical example of construction methods was the use of shuttering for reinforced-concrete work. A great deal more might be done in the prefabrication of shutters off the site to simplify erection, dismantling, and re-use, restricting to the absolute minimum the use of carpenters' tools over the concrete work itself. The Chairman had referred to the "Mulberry" ports, and it was very interesting to observe the different methods adopted by the contractors in dealing with their shuttering. Mr. Paton was sure that those who went to the trouble of designing the shuttering really efficiently had benefited considerably both in time and in cost. Closely allied to that subject was the greater use of pre-cast concrete units in the work itself.

Research appeared to be mentioned in the Report only in the section dealing with the general principles of works organization. Mr. Paton considered that engineers should become more research-minded. The Americans had set them a very good example, and they might make use of the research which had been instituted and carried out in America. Firstly, they might make more use of the existing research facilities under the auspices of the Department of Scientific and Industrial Research, and, secondly, The Institution and the Federation of Civil Engineering Contractors might combine together to provide more financial and technical assistance to the central research body.

The careful preparation of programme and progress charts had been rightly stressed in the Report, and the importance of everyone concerned, including the staff and the foremen, being thoroughly familiar with those charts had also been emphasized. He would go even farther and suggest that the details of the targets and the actual progress should be posted up weekly for the information of the labour force. That would stimulate interest and bring about a spirit of healthy competition between gangs, whilst at the same time binding labour, management, and engineer's staff into a closer team. He saw no reason why concrete gangers should not be advised of the results of tests on concrete cubes.

He was sorry to see in Diagrams 1 and 2 of the Report that the resident engineer had to supervise the contractor's organization without any staff whatever. Possibly a little tree might be added as a separate diagram to

cover the duties of the resident engineer, which were almost identical with those called " civil engineering services."

Mr. R. U. Law observed the Report was too large a document in its scope and in its treatment of the subject to discuss at one meeting, and he hoped that opportunities to discuss the individual items in it would be provided at future meetings. An examination of the " Table of Contents " had impressed him with the tremendous field covered. There were fifty-one headings, and a separate Paper could have been written on each, but the Committee had managed to condense the matter and yet cover the subject in a very adequate manner. The Report would be a valuable reference book on procedure for everyone engaged on public works to have at his elbow. He believed that only a limited number of copies of the Report had been issued. If real benefit was to be obtained from it, every member and student of The Institution should have a copy, and he therefore proposed that it be issued to them. Moreover, it would be appropriate and in keeping with the good relations which were beginning to develop between The Institution and the Federation of Civil Engineering Contractors that each member of the Federation should be given a copy of the Report. The Federation was a very select body, having only 560 members, and he believed that the members of the Federation would appreciate that gesture. He considered that only in that way would the civil engineering profession and industry reap the benefit which it should obtain from the Report.

The Chairman said that unfortunately the paper shortage made it impracticable to adopt Mr. Law's suggestions at present, but they would be carried out as soon as possible.

Mr. A. J. Hill observed that on first seeing the Report he had thought that it would give a record to date of the practice in the industry and also perhaps make recommendations on matters worthy of attention in the future ; but he had noticed several major omissions which were worthy of consideration.

A section had been devoted to plant—which he agreed was a very important subject—but there was no section on labour. He felt that the management, direction, and welfare of labour should be first on the list of the industry. It was not sufficiently appreciated that the human aspect was of paramount importance. Man was the controlling factor in the output of a machine, and he was just as important in connexion with the machine as were its design, size, and quality. Engineers should give more consideration to labour ; that would enable them to be in a position to manage contract work, which at the moment, as a whole, they were not able to do. Only a minority of engineers were capable of doing that to-day —owing rather to their lack of training than to their not being fitted for the task.

Another omission from the Report was any reference to contracting finance and budgeting, which to a contractor was a very important matter.

The information on tendering in the Report was very scanty, yet that also was a very important feature of the contractor's work. It was when he was tendering that he should do his planning and his organization on paper—not when he had been awarded the contract.

In the Report a great deal of information on programming and progressing had been given, but, in his opinion, they followed on from planning, or, to use a better term, the plan of operations. The positioning of excavating machines, the setting up of concrete plant, the designing of shuttering, and so on, should be done early. The programme was allied to planning, but was not the controlling factor in planning.

Another matter which had been omitted from the Report, but which was well worthy of consideration and discussion, was production, which was a modern but a very important term. It included getting the best out of the programme that had been prepared, and also such things as time study of machines, time study of men, and the question of putting gangs into competition in order to get the best out of them. Those were all human aspects which were important and had to be dealt with.

He would have liked to see in the Report more definite references to certain subjects which were not quite accepted as being final in the industry. For instance, three types of contract or three methods of carrying out the work were mentioned, and he thought that the industry as an industry should make up its mind which was the best way of doing the work. He himself had no doubt in which way the major portion of the work should be organized and arranged.

The Appendix on the training of foremen and inspectors only scratched the surface of the problem of training in the industry. The industry should train its staff and its men, and unless something was done about that Great Britain would suffer in competition with other nations.

In Diagrams Nos. 3, 4, and 5 of the Report, dealing with staff organization, there was a cardinal fault in organization, in that two men were doing the same job. The agent and the assistant agent had the same duties. In Mr. Hill's opinion, either the assistant agent should be a personal assistant to the agent, and not in the direct line of the family tree, or he should cover a different field of responsibilities from that of the agent. From the diagrams it was not evident how the agent would exercise his power other than through one man.

He was not very much in favour of the form of progress chart given in the Report. The straight-line diagram was very useful for the major programme or the skeleton programme, which was prepared for all jobs, but it was not easy to follow and maintain in the course of a contract. Figures were not easily kept up to date in the method of progressing given in the Report. He had found great difficulty in appreciating at a glance what was meant by the form of chart given. He was an advocate of the two-dimensional programme, which showed not only the position but also the trend, which he thought was much more important.

He considered that the Report, although excellent as subject-matter for an initial discussion, was only a starting point. He would like to see it widened and much more attention given to the human aspect and to the creative side of the industry. It should not give the impression, to which Mr. Holbein had referred, that the industry was cut and dried.

Mr. J. C. Waddington considered that the Works Construction Division should not be permitted to become a forum for discussing the relations between resident engineers and contractors, or the various labour difficulties and legislative difficulties which arose in construction work to-day, but should be a meeting-ground for the presentation of ideas on construction methods. That field had been somewhat neglected in The Institution's proceedings. In many interesting Papers a brief statement that so many derrick cranes, so many locomotive cranes, and so many excavators had been used in the work described was all that was given about the actual construction. Construction methods were almost infinite in their variety. The chief matters which should come before the Division were the methods of solving problems of construction, how to deal with a certain type of ground, how a certain tunnel had been constructed and the methods used to overcome the difficulties that had been encountered, how a cofferdam had been put in under certain tidal conditions, and other methods of construction which had been devised by an engineer or a contractor in order to deal with a difficult situation.

The scope of the Report was extremely wide. It covered not only the engineering field but also the fields of the accountant, the welfare worker and, to some extent, the legal expert. Engineers were not entitled to probe into all those fields, but should confine themselves more or less to the engineering aspect.

With regard to the "invitation and selection of tenders" Mr. Waddington's view, as a contractor, was that in most cases insufficient time was allowed for the preparation of the tender. The amount of thought and investigation which had to be devoted to the preparation of a tender in the case of a difficult piece of engineering work was probably not always realized. Engineers who were responsible for sending out invitations to tender should, in the case of a difficult job, extend the customary two or three weeks to four or even six weeks, so that a proper investigation could be made of all the conditions attaching to the job.

In Great Britain, before the outbreak of war, 70–80 per cent. of tenders were invited publicly, but since the outbreak of war that system had completely gone by the board and invitations were issued by various Government Departments through devious means. In his opinion, after the war there should be a return to public invitations to tender. It was true, that in that case anybody would be able to tender; but a simple corrective would be for the authority that issued the invitations to adopt sufficient financial safeguards in the way of surety bonds and retention moneys, so

that firms which were inclined to rush in with inadequate financial resources would think twice before accepting the contract.

Mr. A. H. D. Markwick observed that the Report covered many aspects of the problem of works construction, but there was one very important matter it had not dealt with so thoroughly as he would have liked, namely, the control of materials, particularly on the site. The methods which had been described in the Report were those which were current in Great Britain up to the outbreak of the war; but since then, particularly under American conditions, a very big move had been made towards having on the site a materials engineer, subordinate to the resident engineer, whose duty it was to see that the materials conformed with the specification. To enable him to carry out his duties, the materials engineer had a small field laboratory in which he could test materials such as concrete, bituminous materials, and soils, and in that way the information as to whether or not the materials were what they were supposed to be was available immediately.

About 2 years ago Mr. Markwick had had an opportunity of visiting a large number of American contracts for the construction of airfields, and on twenty out of about thirty airfields which he visited there was a materials engineer who was controlling the work in the manner to which he had just referred. It was remarkable to see all those jobs one after another and to note continuously, day after day, that on the jobs where there was a materials engineer a very noticeable increase in the quality of the work resulted. It was also noticeable that it was the jobs which were without a materials engineer that were in general behind the schedule. In fact, the organization that could produce jobs to the schedule did not seem to have any difficulty in producing better quality work. Since that time British engineers had begun to make use of the system. The Road Research Laboratory had done a certain amount of work on the control of bituminous mixes, but in particular work had been done on the subject of concrete and considerable success had been achieved in cases where concrete of a very high quality, such as 4,000 lb. or 5,000 lb. per square inch, was required.

The experience in that connexion which had been gained in Great Britain was likely to be extended after the war, and he would like to see more reference made to it when the time came for considering the revision of the Report.

Mr. W. Hughes observed that he was in entire agreement with the view that the engineer should take out engineering quantities and be responsible for them. The quantity surveyor was not properly qualified to deal with engineering quantities. Very few engineers, however, received much training in that subject. He remembered that when the subject was first introduced into the Institution examinations many years ago much consternation was aroused among prospective candidates, who wanted to know what constituted quantities and where information could be obtained

about them. A class was started not far from The Institution building and many people attended it, but very little of any practical importance came forth. Mr. Hughes considered that it would be a very good thing if some method were available of training the young engineer in taking off engineering quantities. The subject was not a complicated mystery. Usually all that was required was plain common sense and ordinary mensuration, but the common sense should be used in picking out the salient features; some things needed to be emphasized, but over-complication should be avoided. In his view, the quantity surveyor's method tended to over-complication, frightened the contractor, and caused him to price a good deal higher than he would normally do. The young engineer should have an opportunity to see and learn how engineering quantities should be abstracted.

Mr. John Palmer observed that two questions should be considered in the preparation of the second edition of the Report. One concerned the employment of quantity surveyors, to which Mr. Hughes had referred. One difficulty was that, to the best of his knowledge, all the Government Departments, which were letting so many contracts to-day and would presumably let large numbers of contracts in the future, employed very highly skilled and well qualified quantity surveyors to get out their quantities, and engineers might almost be forced to adopt the same practice; otherwise there might be two quite different standards of civil engineering bills of quantities in circulation.

The second question was that of payment for wet time. At the moment most jobs were covered by the Essential Works Order. As soon as it began to rain men went to the canteen and sat down, and the contractor had every inducement to encourage them to do so, because they did not work so efficiently in the rain, whilst as soon as they went into the canteen they ceased to be on the contractor's pay-sheets and came on to the promoter's pay-sheets. Was that really desirable, or should the contractor accept the risk of wet time in his prices, as he did for accidents?

Mr. Palmer agreed that the sloping line diagram gave a great deal more information than any other form of progress diagram. It was a simple matter to superimpose it on the horizontal diagram. The base-line was time and one could put the vertical scales on and then draw the sloping line.

Mr. F. J. Harvey observed that the most important part of the organization of civil engineering work was that which came before the organization on the site could be attempted at all. Too much preliminary work could never be done before a contract was put out to tender, nor could too complete information be provided for the contractor tendering for the work in question. No contractor or engineer could form an efficient organization on the site if he lacked knowledge or information which should have been available before the contract was put out to tender.

During recent years contractors had been increasingly expected and encouraged to assume some of the functions which were properly exer-

cisable by the engineer, whilst many engineers had come to rely too much upon the practical experience of the contractor who was going to do the job for them. The engineer should be as much a practical man as the contractor whom he expected to carry out his ideas, and it was very important that the engineer's assistants who were employed on design should have frequent and ample opportunities of seeing works in progress. Many young men in consulting engineers' offices were chained to the draughtsman's board, with the inevitable result that they often put down, either in general or in detailed drawings, things which it was physically impossible to execute, and it was humiliating for a man who was expected to design work to be told that his design could not be carried out.

The question of organization was important because it sprang from knowing what one was doing. Anyone who had had to do, either on the engineering or on the contracting side, with the execution of contracts knew that the labourers and craftsmen on a job were very sensitive to whether the job was being done properly or not. They knew perhaps better than anybody else on the job whether the people running it were masters of it or not. Therefore he regarded organization as a really important matter, worthy of the utmost consideration by both sides.

Mr. Frederic Newhouse asked whether the resident engineer's staff was really necessary. Mr. Holbein had said—and Mr. Newhouse thought it would be generally agreed—that the men on the contractor's staff were the same kind of men, with the same sort of training and experience, as were the resident engineer's men. What were the latter doing except either carrying out duties which ought to be done by the contractor or acting as policemen in respect to the contractor's men ? The men who worked in offices should frequently go on to the works, but it was very difficult to justify the employment of a large duplicate staff by the resident engineer when the contractor was a decent honourable man with a good staff of his own. Why should two men be required to measure a chunk of concrete ? The measurement had to be checked, but why should not the contractor have one man measuring and another checking ?

Mr. R. M. Wynne-Edwards observed that some speakers in the discussion had said that the civil engineer was interested primarily in the technical aspect of his work. Mr. Wynne-Edwards did not believe that was true. It was becoming increasingly clear that civil engineers represented the head of a very large and important industry, and should therefore consider all the implications of running a large industry. Formerly there had been a tendency to divide those concerned with works construction into watertight compartments. The man who designed the structure, the man who built it, and the man who made the plant for building it were all in separate watertight compartments, and even to-day it was difficult for the designer of a structure to know what were the latest developments in plant or for the man who made the plant to have any idea of the changes in design. Somebody should take the lead in seeing that the industry, as

one industry, broadcast all the available information. If that was not done, the civil engineering industry would be left behind, because other countries would step in and do things, and in Great Britain other people would come along and say: "We cannot wait; something has got to be done now."

Probably everyone present had seen the exhibition of "Mulberry." He considered that "Mulberry" was one of the grandest feats of the British civil engineering profession. It was pure civil engineering from start to finish, and it was a success because all the brains and resources available had been pooled on it. The same kind of thing should be done in the post-war days, and The Institution—not necessarily the Works Construction Division—should find ways and means of doing it. The Division was a very young and small section of The Institution, but it was an important section, and should be a forum for the discussion of all kinds of constructional difficulties.

One duty of the Division should be to institute research, possibly with the formation of small Sub-Committees to undertake different pieces of research.

Whatever was done and whatever methods were adopted, it was very important that the Division should be alive and active. The Institution was a venerable body and had immense prestige, and its keeping was in the hands of its members. They could let it grow feeble and die or they could make it very much alive. Therefore he hoped that the members of the Works Construction Division would consider carefully the problems that faced them and would try to think out ways and means of co-ordinating all sides of the industry, including perhaps the labour side.

He hoped that the Provisional Board of the Division would receive suggestions from members on how best it could accomplish its aim, which was to take the lead in increasing the productivity, by mechanization and improved methods, of one of the most important industries in Great Britain or any other country.

Mr. W. E. Reed observed that he had no doubt that all the members of the Division were as keenly interested in The Institution as was Mr. Wynne-Edwards and would like to carry on its traditions honourably and nobly. In order to do so, the younger men should be prepared to accept much greater responsibility. In that way they could make a notable contribution to the welfare of The Institution, because the acceptance of responsibility arose for them almost every moment of the day and in almost every business or engineering transaction in which they were concerned. He believed all the members of the Division would agree upon the necessity for research, but where was the money to be obtained for that purpose? He suggested that The Institution itself might make a contribution to it and that the Federation of Civil Engineering Contractors might be approached to make a more notable contribution.

Sir Frank Gill observed that, without their being actually mentioned, the following points had been indicated in the Report:—

Firstly, "List your requirements at the beginning. Set out what it is

that you are trying to do and do not be hazy about it. Be as specific as you can." That was sometimes very difficult and the requirements could only be determined ultimately, but it was desirable to have the requirements at the beginning as specific as possible.

Secondly, " Make alternative plans for meeting your requirements." He believed that Dr. Oscar Faber had said that there was only one design that could have been produced for the Golden Gate Bridge, and Dr. Faber should know ; but Sir Frank was sure that that was not general. Members would recollect the objections that had been raised to the obstruction of the view of Lincoln cathedral by a proposed power-station. The Electricity Commissioners had visited Lincoln and held an inquiry lasting two or three days and then had produced an alternative plan, which was to reduce the height of the towers from 230 feet to 90 feet, and immediately the uproar had subsided.

Thirdly, " Analyse economically each of your alternative plans and then analyse them again from the intangible point of view—the point of view of social needs. Then from your alternative plans, each of which is capable of meeting your requirements in a technically sound manner, make your selection, giving the weight which you think is right to each of them." Most people did that in the case of their fire insurances ; they calculated how much they were willing to pay against an accident which they could not measure.

All the points he had mentioned led up to the promoter. Time after time in the Report, reading between the lines, members would find the advice to keep the promoter informed, not to let him come along with changes of mind because he had not understood, to teach him in time, and to induce him to work as part of the team.

With regard to " scheduling "—a less cumbersome expression than " programming and progressing "—it was much better to do a thing on time than to do it as quickly as possible. How could anyone catch a train at an intermediate station if the engine-driver came in as quickly as he could ? The right thing to do was not to come in early or late, but to come in on the programme date, and that undoubtedly was the key to getting work done.

Lord Kelvin had observed at a meeting of The Institution : " When you can measure a thing you know something about it." Electrical engineers often cited Kelvin's law and then went on to say that it was out of date. What did Kelvin do in order to derive that law ? He set out his requirements and he made alternative plans for meeting those requirements, every one of which was good technically : then he analysed those plans from the first cost point of view, analysed them again from the annual charges point of view, and finally made his selection. Kelvin's law was not a law which used to apply to electrical engineering and now did not ; it was a method for setting about any engineering job, no matter whether it was civil, electrical, mechanical, or chemical.

*** **Mr. E. G. Cove** observed that invitation by public advertisement was not a very desirable method of obtaining tenders. The system of preparing a list of suitable tenderers who were best fitted for the work contemplated was much better, as all the tenders would be based upon a skilled and contractual knowledge of all the conditions which might occur, and so avoid low-priced tendering from firms who did not possess that special knowledge, which entailed extra supervision by the Consulting Engineer in order to make sure that the Contractor was working entirely to the specification.

The time usually allowed for the preparation of tenders was inadequate, and should be increased considerably. A contractor had to make his site investigations, study all the relative documents, prepare his scheme of work, and on that information prepare his tender. Careful planning during that period was a very important factor and could be done only when ample time was allowed for tendering; therefore the allowable period of 2–3 weeks should be increased to 6–8 weeks.

Engineering Quantities were best prepared by the Engineer who had designed the work, as he was well aware in his own mind of what he required to be done, and also of the method in which it should be carried out; that was preferable to the employment of outside Quantity Surveyors, who would endeavour to measure and detail the work more in line with the building trades.

The section of the Report dealing with Works Organization gave a very lucid picture of the duties of the Resident Engineer and the Contractor, from which it could be readily understood that the Engineer and the Contractor formed a kind of partnership to carry out the work to the true intent of the contract for the employer, and that a harmonious atmosphere and liaison should be aimed at between both these organizations.

To-day the Contractor and his staff were highly technical, with a vast experience of the practical side of encountering and overcoming all forms of difficulties, and there could be no doubt that it would be of great assistance all round if the Consulting Engineer's staff had some experience with contractors, which would help them to appreciate that work should be so designed that it could be constructed.

Each firm had its own method of progress charts, which it might feel to be more suitable for its own requirements than those illustrated in the Report; but those illustrated were well worthy of consideration.

The suggestion in Appendix II for a form of training for foremen and inspectors was certainly very good and would assist considerably the Engineers' staffs on modern contracts, as they would readily appreciate the technical matters and the reasons why certain procedures were employed—procedures which in former days were ignored by the foremen, with dire results and worry to the Engineer.

Mr. Cove considered that training should also be given to certain tradesmen, including the concreting personnel, and that when they were

*** This and the following contribution were submitted in writing—SEC. INST. C.E.

qualified in that class of work some certificate should be awarded by the training establishment: and men so qualified should receive certain trade pay for such qualifications. The training of that personnel would result in a greater understanding of what the Engineer, the foreman, and others required to be carried out, and also in much better workmanship.

The contractors' national organization might sponsor such training at various recognized technical training centres, whilst The Institution might assist in preparing a suitable syllabus.

Mr. G. E. Scott observed that the preliminary estimate of cost need not ordinarily be accurate to within 15 or 20 per cent. of the actual cost. The acceptance of a tender for a considerable work was not usually within the competence of the Engineer-Adviser, though he would submit reasoned recommendations to the Promoter. The principle which would normally be adopted was that the lowest reliable tender should be accepted where competitive tenders had been called for. That principle was usually satisfactory to any auditor, including Government auditors, who might scrutinize the proceedings.

No mention had been made in the Report of the time-factor, and the penalties for exceeding the time fixed in a contract, possibly because of the complexity of the subject, though time was in many works of " the essence of the contract." In any subsequent edition of the Report the time question should be mentioned. Further, no mention had been made of the organization in which the responsible engineer also made payments for the work carried out, as was done in many Government Services, subject, of course, to competent audit. That side of the Engineer's responsibilities occupied a considerable proportion of his time.

Mention might be made, as a record of progress, of the " Register of Works ", which, by giving the expenditure to the end of each month, appropriately divided into sub-heads, afforded a reliable record of the progress of the work.

Mr. Scott agreed that the Quantity Surveyor should not be employed on Civil Engineering work. When an experiment was tried by employing a whole-time Quantity Surveyor on a series of considerable engineering works, it was found that one result was, by elaborating the accounting, to increase the cost of work.

It would rather seem that the Report had been drafted almost entirely to cover Civil Engineering works in Great Britain; but in view of the extensive operations of The Institution, future editions of the Report might be modified to cover works generally both overseas and at home.

The Chairman said he hoped that the members of the Division—the younger members especially—would follow Mr. Wynne Edwards's advice and send suggestions to the Provisional Board.

All the points that had been raised in the discussion would be carefully considered when the Report was revised, as he was sure it would have to be soon after the war.