

adequate attention were in future paid to this aspect of engineering education, which, in the Author's opinion, constitutes at least half of a competent engineer's qualification.

In conclusion, the Author would ask the older and experienced engineers to examine their own careers and to decide how much education or instruction they have actually received in the subjects outlined in this Paper. All of them will recall education and instruction in the technical aspects of engineering, but the Author ventures the opinion with a considerable degree of assurance that few have received instruction in the subjects mentioned by him. He asserts with equal assurance that an analysis of the work of the senior engineer will show that much of his time is spent on organization and the economic aspect of engineering. If these opinions are correct, they form a strong justification for directing attention to the necessity of including it in the curriculum of young students.

The Paper is accompanied by one diagram, from which the Figure in the text has been prepared.

Discussion.

Brigadier D. Harrison, D.S.O., who introduced the Paper in the absence of the Author, said that he was sure the members would sympathize with him in the task that he had undertaken. He felt extremely diffident in addressing them, because he had not the honour of being a member of The Institution. His excuse for speaking was that he had been consulted by the Author during the preparation of the Paper, and their views on the subject with which it dealt were exactly the same. Also, he was Commandant of the School of Military Engineering, at which there was a Construction School which dealt mainly with the building side of civil engineering. Bridging was also taught, that being a serious problem in the war, and possibly it would be the major problem when the British Army returned to the Continent. His own experience over many years had covered a fairly wide field of construction and maintenance of roads, bridges, water-supply, lighting, and buildings.

The Paper was not meant to be a tilt at any section of the engineering profession, but it was intended to show a very serious gap in the education of young engineers. Great trouble was taken, both in the universities and outside them, to train engineers in the technical aspect of their profession. The qualifications for membership of The Institution were mainly technical qualifications, although there was a provision that before membership could be gained a candidate must have a certain amount of practical experience. It was not until practical experience had been obtained that engineers learned—and learned by their own mistakes—the value of

organization and the importance of economics in relation to engineering. He remembered very well that, after a long and, to him, rather tiring education, lasting for five and a half years and including a period under Professor Inglis at Cambridge, he had gone abroad, thinking that he knew all there was to know on the subject of engineering (he still thought that as a technician he could hold his own up to a point), and it had been a great disappointment to him when, on the first job that he had to tackle—a very simple one of making about 50 miles of road—his chief engineer had come out after about a fortnight and told him that the organization of the job was beneath contempt. That was, in fact, the case; he knew nothing about organizing a job, and had not realized the necessity for balancing labour, materials, transport, tools, and equipment. From that time onwards the importance of getting that balance right before the job began had been borne in upon him more and more, over some 28 years, and he was quite certain that much time and money would be saved if the young engineer placed in charge of a job for the first time had his feet firmly on the ground and knew how to set about the job to the best advantage. In that connexion he would remind the members of something which engineers were perhaps a little apt to forget, namely, that it was the completion date, and not the commencing date, that was of importance to the community whom they served.

The plea made in the Paper was merely that some education in the organization of work should be included in the curriculum of the young engineer, and that he should be introduced to the economic importance of his task. The Author did not consider that every engineer should be an expert accountant (that was not the function of the engineer); but he should have a knowledge of the elementary finance of engineering, he should be able to extract from the accounts which were prepared for him by a specialist the information which he required to enable him to control the work of which he was in charge, and he should be able to anticipate additional cost, since his duty to his client, whether an individual or a public body, was to carry out the work as nearly as possible within the estimate of cost which he had furnished. Engineers had seen again and again (he was quite certain that no experienced engineer present would dissent) cases in which work, after being started, had, at some time or other during its progress, virtually come to a standstill because of some unforeseen difficulty, due, perhaps to inefficient planning on the part of the engineer. Should engineers who were experienced and skilled in their profession allow unforeseen happenings to hold up the progress of work? Even admitting that such events were sometimes beyond their control, he thought it would be agreed that on occasions tools, equipment, materials, the right tradesmen, or transport were missing at the crucial moment, owing to lack of foresight, and that the progress of the work was consequently retarded unduly, with the result that the cost was increased. Planning to ensure that the essentials for any job were there at the right

time and in the right quantity was what was called organization of work. A good deal of stress was laid on that in the military world. Some might think that too much stress was laid on it by military engineers, but in war hours, and sometimes even minutes, of delay might mean disaster, and consequently in the Army that "split-second" organization was given considerable prominence in the training of the young engineer. It might be to the benefit of the civil community if civil engineers practised the same organization rigidly and always. He did not suggest that experienced engineers in civil life did not do so. He knew quite well that their organization was a pattern for military engineers, and it was only with the greatest difficulty that military engineers attained anything approaching the perfect organization which undoubtedly did obtain in most big engineering jobs in civil life; but in the small job, handled by the young engineer, he was quite sure that experienced engineers would agree that they themselves had seen many cases of lack of organization.

He had to deal with a large number of young members of The Institution. Some came to him as military officers, or on the way to becoming military officers, and others in a civilian capacity. They had to be taught the "red tape" which was so beloved by the Army; there were reasons for that; it was not quite as bad as it sounded, and he found it quite easy to impart. It had been found, however, that the standard of knowledge of the elements of organization on the part of most young engineers coming into the Army was surprisingly low. He had seen them abroad and at home, and he had seen a very great many during the present war, and he made that statement very definitely and very firmly. Their standard of technical knowledge was very high, possibly much higher than was required for military work, but their knowledge of organization was poor.

The Paper was a plea, and should not be taken as anything more than a plea, that, in the framing of the qualifications for membership of The Institution, and even in the consideration of the curriculum for the education of an engineer, the two very important subjects of the organization of work and the economics of work should not be disregarded. It was interesting to notice that, whereas technical qualifications had been a *sine qua non* ever since The Institution had been founded, there had been little or no mention of a qualification in organization or a qualification in economics. That was the gist of the Paper, perhaps not given by him so well or so fully as the Author would have liked, but he craved indulgence for his own shortcomings in that respect.

Mr. A. S. Quartermaine said he was sure that all present would feel that an admirable exposition had been given by Brigadier Harrison of the intentions of the Author in writing the Paper. It had been made so clear that the Author's desire had been to achieve the introduction of something which was considered, from the point of view of the Royal Engineers, to be lacking in the educational arrangements for young

engineers, that he felt some difficulty in putting forward views which were in any way opposed to the accomplishment, on the lines suggested by the Author and Brigadier Harrison, of the practical training in question.

Two specific points in the Paper occurred to him to form a basis for opening the discussion. Firstly, the Author had stated that in his experience civil engineers were more highly technically trained and less capable of organizing than were Royal Engineers. The work which the Army did so successfully (perhaps more successfully in the present war, if that was possible, than in previous wars) was composed of set tasks which, whilst not being identical, were largely similar tasks. Military engineers had to produce roads, bridges, and so forth, by some rapid means, not exactly in a standardized form, but in a form which the Corps of Royal Engineers had been taught to use for the specific purpose in view. On the other hand, the civil engineer had before him, almost every day of his life, problems which might be, and often were, entirely different from those with which he had dealt before; in other words, he was faced with constantly changing conditions in respect of the work that he was asked to do. His work was by no means standardized and the design was not done for him; it had to be worked out for each job. The very fact that he had to be an expert in design rendered it difficult for him to be so well trained in organizing and executing work as was the Royal Engineer, whose life, apart from ordinary military duties, was spent in carrying out the more or less standardized type of work which the Army required him to do. In consequence of the fact that the civil engineer had to spend so much of his time on design that he had not the fullest opportunities for training himself in the organization and execution of work, the execution of civil engineering works of any magnitude was usually undertaken by contractors, except when the engineers employed direct labour. Mr. Quartermaine had had opportunities of using both systems, and most contractors had told him that they could do the work that he did by direct labour much more cheaply than he could do it. That was a matter of opinion, but it was their view and there was a very good reason for it. The contractor made a speciality of the organization and the execution of work, and he spent his life in doing the very work which Brigadier Harrison had said was an essential part of the training of the young engineer. If among the engineers who came to Brigadier Harrison there were young engineers who had fortunately been in charge of small works, they would probably possess the organizing ability which he wished all engineers to have. The contractor, in order to be successful in organizing and executing works, must give up that specialization in design which was part of the engineer's work. Engineers in civil life were, therefore, divided largely into two camps; in one camp were those who were expert at designing and had a fair knowledge of the execution of work, whilst in the other camp were those who were experts in contracting and had only a fair knowledge of designing. Thus the difference

between the Royal Engineer, as trained, and the civil engineer, was that the former was very good at organizing and executing and very fair at designing, whilst the latter was in one of two camps, of designers or contractors, each able to do a certain amount of the other's work.

That led Mr. Quartermaine to the Author's statement that he had been faced with the difficulty of deciding the difference between a resident engineer and a contractor's agent. The two camps were looked after by those two representatives. The resident engineer was in charge of the work for the engineer, and was responsible for seeing that the work was carried out in accordance with the requirements of the engineer, that the materials were satisfactory, that the workmanship was according to specification, and that the setting out was correct. Besides any alterations that were necessary as the work progressed, he dealt with any question of design and certified the accounts. He should be a fair-minded man, who could understand the contractor's difficulties, but he should be sharp enough to prevent unsatisfactory work being carried out. The contractor's agent was not the designer, but he exercised managerial functions and he should know how to organize and execute works. That was his life's study. Many contractors' agents were members of The Institution and could speak at length on the subject of organizing works. The contractor's agent had to be a specialist in many things of which it was not necessary for the engineer to acquire a knowledge. He had to understand the handling of labour and the national agreements in respect to labour, and be able to deal with the welfare of labour; he had to purchase materials at the commercial rate, to make arrangements for plant and maintain it, and to fix transport rates. Generally speaking, he had to see that the work was executed in a commercially successful manner, sufficiently satisfactorily to meet the resident engineer's requirements.

In the work of the Royal Engineer, the question of cost was not of the same importance as in civil life. The officer in the Royal Engineers was concerned principally with the execution of work, and to a smaller extent with design. Mr. Quartermaine had served in the Corps of Royal Engineers in the last war, and had obtained valuable experience which would be of great interest and use to him, principally on the practical side, for the rest of his life. On the design side, the standardized designs were certainly of value in connexion with temporary works, and so on, in civil life, but he had not expected to learn very much about designing when he was in the Corps.

The need for estimating was much more important in civil life than in Army life, and the Author had rightly stressed its importance. The student in his early days had the elements of that subject instilled into him. If he had not the idea of economy in his mind, when he designed a structure he would make it stronger than it need be and so waste money. As soon as he had completed his design, he was taught to take out his

quantities and price the work as best he could with the limited knowledge that he possessed at that stage. As he went on through life he acquired increasing knowledge of how to price quantities for various works. The Author had expressed the view that the detailed analysis of rates was the work of the quantity surveyor and not part of the duty of the engineer. Mr. Quartermaine gathered it was not suggested that a quantity surveyor, using that term in its ordinary sense, would be expected to deal with the pricing of major operations in engineering work, such as the erection of a bridge, the driving of a tunnel, or the sinking of a cofferdam. It was essentially the knowledge of pricing gained over years of experience which enabled an engineer to give the cost of such matters; but he could not be expected to price so efficiently as a contractor who had possibly done similar work on many occasions and knew the plant he had available, his overheads, and the many other things which pertained particularly to his organization. The need for learning to cost work at an early stage was obvious, but it was not capable of accomplishment in the case of engineering structures, except after years of experience, and engineers never ceased learning what the cost of works should be.

The Author's statement, on p. 121, *ante*, that "There is an undoubted tendency to reduce estimates of cost of large public works in order to obtain acceptance of the proposal" had shocked and surprised Mr. Quartermaine, and he could not believe that it was founded on anything like correct information. His own view, after putting forward schemes and estimates for a good many years, was that, no matter what the scheme was, or who the client was, when the client received the estimate he very often wanted it to be reduced. The engineer said that it could not be reduced, and the client then desired to reduce the size of the scheme, or to alter the design with a view to achieving something less expensive. The engineer could do that quite legitimately, and then the estimate would be lower. But what actually happened when a scheme was approved was that the client usually found a number of things that he wished to have put in which he had not thought of before; for instance, a road which was intended to be 30 feet wide became 40 feet wide, or a goods line was turned into a passenger line. If a scheme was amended in such a way as that, the final cost would be higher—and the fault would be attributed to the engineer. That was by no means correct. The fault lay with the client who had not known what he wanted in the early stages.

Unsatisfactory estimating and unforeseen happenings could not always be avoided. With the best possible investigation, it was not always practicable to have full information with regard to foundations, underground watercourses, and so forth.

Finally, Mr. Quartermaine wished to tender his heartiest congratulations to the Author and to express his appreciation of the manner in which the subject of the Paper had been presented.

Lieutenant-Colonel C. M. Norrie, D.S.O., said that he wished to refer to one factor which he thought the Author, and perhaps Brigadier Harrison also, had forgotten, namely, that the military engineer was a specially selected man. He was selected for Woolwich and he was chosen from Woolwich because of his fitness and ability to belong to a corps which was rightly considered the brains of the Army. Further, he was in a disciplined organization, and he continued under intensive routine tuition for many years longer than his opposite number in civil life. It would be very surprising if such men were not capable of making the best use of all the opportunities offered to them for both theoretical education and practical training, and, if the Author had found the Royal Engineer less qualified in theoretical attainment, that was doubtless because the higher standard of attainment was not necessary. Obviously such men, being picked men, ought to be able to equal the civil engineer, if equality was required. That had been brought out very clearly by Mr. Quartermaine in his remarks about the two branches fulfilling their own special functions.

The Author considered that the military engineer was a better organizer than the civil engineer. Colonel Norrie agreed so far as purely military work was concerned, because that was a specialized job and all the training of the military engineer was aimed at making him a good field organizer within the military machine. It had to be remembered that within that military machine were many kindred services ready to help the engineer and to relieve him of responsibilities and duties which the civil engineer, as a rule, had to undertake in the case of civil works. The military executions, as had been pointed out, were generally of previously designed uniform structures, adapted for rapid erection, but the civil engineer had to meet a wide diversity of demands, many of which required the solution of new problems in design and entirely new methods of execution. The fact was that civil engineering work was not organized on the same basis as military work, and therefore a comparison between personnel did not seem to be profitable.

An example of the combination of the two branches of engineering—the designing and administrative side and the executive side—was provided by India, where, in the Public Works Department, the two functions of designing and execution were combined to a much greater degree than they were in Great Britain, where specialization in one branch or the other had become almost a necessity.

Without casting doubt on Brigadier Harrison's remarks, he thought that civil engineers would like to know a little more of the conditions under which the comparisons were made, and of the personnel involved in the Author's conclusion on p. 117, *ante*, regarding the relative merits of "civilian engineers" and Royal Engineers. The Institution should not be blamed for inadequacies in civilian engineers; the shortcomings should be pinned down to inadequacies in qualified or chartered civil

engineers if they were to have any effect on the provisions which The Institution could make for the future.

As a contractor, he entirely agreed with the Author's remarks about the scarcity of men with good organizing ability. It was very difficult indeed to find such men. He could not agree, however, that a mere extension of tuition by giving students exercises to do would achieve the desired object. Success in acquiring organizing experience depended on patient observation of work in progress with all its purely material and human aspects, on learning how to remedy accidents and how to prevent them and the many other things which tended to upset the best laid plans, but, most of all, on a lengthy and direct contact with one's fellow men, superior and inferior in rank, in the ups and downs which made everyday business life. That could not be learned from textbooks or correspondence classes, and, in fact, it was not desirable to teach young men that they could treat paper programmes as substitutes for real hard practical experience.

Important factors in all tests of practical training were the age of the candidate and the opportunities he had had during training. Further, it should be realized that not all engineers were required to have specialized organizing ability. In civilian life the available opportunities for training were not uniform, and men were not all shaped to one mould. When the Author judged that The Institution's standards of attainment as published were inadequate, he did not perhaps realize the impracticability of defining and imposing anything in the nature of a standard "pass out" test as from an academy. The main objective of any assessment of practical experience in young men from 25 to 30 should be less to test a candidate's acquirements (they could not be very high at the average age of examinations) than to assess his aptitude to take advantage of the varied opportunities that lay ahead. Differences of opinion might exist as to how that aptitude should be gauged, but Colonel Norrie thought it was generally accepted that the best man to judge a candidate's practical qualifications was the Corporate Member under whom he was serving, or had served, while gaining his experience. Apart from all examination tests, the ultimate condition for election to corporate membership was a sponsorship by those who had personal knowledge of the candidates ability. Great importance was attached to that sponsorship and Corporate Members were jealous of the privilege that would be assailed through irresponsible support of unworthy candidates. Colonel Norrie thought that the Author's assumption that the practical side was treated as of little importance, was far from correct. If such an impression were held outside The Institution—Colonel Norrie had not found that it was—only good could come from a discussion of the subject and gratitude was due to the Author for having introduced it.

Mr. K. T. Lomas observed that he did not think it was fair to say that The Institution, in its examinations, took the practical side for

granted. Section C of the Associate Membership examination covered in a great measure and, in fact, as far as possible, the practical side of engineering. The engineer continued learning all his life. He went from job to job, each one being different, and his education never ceased. If there was a fault in The Institution's examinations, and in the training of the civil engineer, it was in the direction of too much economy in design. The civil engineer nowadays was not taught anything of the architectural aspect, with the result that he was criticized as being a man who could design a perfectly adequate structure, but whose design was nearly always submitted to an architect for the face to be added. The young engineer should be trained in the broad principles of architecture and have his eye trained to perspective and proportion. That, however, was a very contentious subject.

Mr. Lomas did not think that the Author's suggestion that the first duty of the engineer was to produce an appreciation of the situation on any job would be of much use in the case of civil engineering jobs of any size. It would not be so useful as setting out a time diagram. The engineer knew the time allotted for completion of the work, and his first task on a contract job was to set out a time-diagram. The engineer or the contractor subdivided the allotted time to cover the various stages through which the contract had to pass, and the actual time plotted against each phase would tell him whether he was keeping up to date with the work. A similar diagram of costs, the details of which could easily be taken from the bills of quantities, would keep him informed, all the way through the contract, of the position in regard to expense. An "appreciation of the situation" could not be used very largely in civil work, although one was often prepared on railways where occupation of the line was required and where the programme had to be worked out to the last minute.

As the Author had stated, the really good organizer was born, not made, and no training in the engineer's younger years could help very much in that connexion; the work of organization could be learned only from experience on jobs. Mr. Lomas, when he first went to China, had been severely criticized by his engineer for his organization on a job, but he had very soon learned from experience. He did not think he could ever have learned how to organize from papers or from the curriculum for the Institution examinations.

Dr. Oscar Faber said he would like to add his meed of thanks and praise to the Author for his excellent Paper, but he would suggest that it dealt particularly with military problems rather than with those which faced the civil engineer in his somewhat different tasks. The latter had to deal with the whole conception of a job from the design stage, and design, as had already been said, had to take into account functional problems, cost, aesthetics (it was hoped), and many other factors. When the design was finished, the client had to be satisfied that it fulfilled his

particular requirements. That obviously involved ability to estimate the cost, because not many clients would express themselves as satisfied with a design without having fairly accurate information as to the probable cost. Not until all those bridges had been crossed could the question of erection, and the organization necessary for erection, be considered. In a sense the work of the military engineer was almost confined to erection. As a rule his work had already been pre-fabricated; it came to him in ready-made pieces, and his task was to organize on the site the best method of assembling them in the shortest possible time and in conformity with all the conditions. Thus the qualities required in a military engineer were different from those needed by a civil engineer, who was concerned not only with the problem of erection, but also with the whole conception of the job, design, estimating, satisfying his client that what was offered was what he wanted, and so forth.

Dr. Faber agreed that some knowledge of estimating the cost of work was an essential part of the equipment of a civil engineer. Without that a civil engineer could not even be a good designer, because surely the essence of a good designer was to be able to make several designs to satisfy a problem and decide, among other things, what their relative cost would be; and obviously he could not determine their relative cost unless he could estimate the cost of each of them. Therefore a civil engineer should be able to estimate the cost of work; but most young engineers were not given much training in that direction by their colleges. The question of how the knowledge was to be acquired by the civil engineer was a very difficult one. Ought some attempt to be made to give the knowledge to students at college, or should they rely entirely on what they picked up afterwards? Several speakers had mentioned that it was the kind of thing which could not be learned at college. He himself took an intermediate view on the matter. A college was a place where all the machinery was designed to one end, namely, to impart as much knowledge and information as possible in a given time, with the least trouble to the student, so that concentrated knowledge could be acquired in a very short time. The knowledge gained in practice afterwards was usually acquired much more laboriously, and very often much more slowly. Undoubtedly much could not be taught at college, but some training in organization and in estimating the cost of works could be given, with the advantage that when the young engineer went on to a job he would at least know that those problems existed, that they were important, and that he must keep his eyes open for them, so as to learn a great deal more about them. If he acquired such an elementary knowledge at college, he would acquire the rest much more quickly in his after life.

When it was suggested that a new subject should be added to the curriculum, the problem at once arose (and he was sure that Professor Inglis would be sympathetic about that) whether some other subject

should be omitted, and, if so, which subject, or whether the college course should be extended. His own solution of the problem was that much of the work now done in the first year could be omitted. In most technical colleges—and certainly in the one which Dr. Faber had attended—much of the first year's course could be omitted without any detriment to the student. He had been fortunate enough to miss it, but he had had the advantage of seeing what some of the students in the first year were doing, and he had found that many were drawing full-size details of Flemish bond and English bond in brickwork, and painting them pink. He had never regretted having missed the first year's course, and he was quite sure that, now that the schools were turning out students with an ever-rising standard of knowledge of the basic subjects such as chemistry, physics, and mathematics than formerly, the technical colleges and the universities would have no difficulty in accepting students with a higher degree of knowledge, and demanding it by their examinations; much more attention could then be devoted, in the third year, to the subjects dealt with in the Paper, such as organization and estimating, and the many other subjects which the young engineer now had to learn after he left college and before he became of very much use in his profession.

Dr. Faber thanked the Author for his valuable service in presenting his Paper.

Mr. R. M. Wynne-Edwards said that while listening to the discussion he had felt that there had been too much looking into the Paper and too little looking at it as a whole. The important point was that it put a perfectly straight question, namely, should a civil engineer be trained in organization or should he pick up his knowledge of that subject later in life?

During the past three years his work had brought him into contact with a large number and a considerable variety of jobs, and he had formed the impression that in the industry of which civil engineers formed perhaps the most important part there was a great lack of knowledge of organization and management. He cited two examples.

Firstly, although the present was a machine age, when people thought in terms of machinery on every side, he had continually found a lack of awareness of the real function of plant. Engineers and contractors regarded plant as a useful adjunct to have on a job, and not as the whole core around which the job should be planned, with the corollary that constant maintenance was necessary if the economy of the plant was to be preserved.

Secondly, he had observed that most people thought of progressing as a method of following the progress of the job; but it was not that at all. Progressing meant planning the job in detail, fitting section to section, to make the whole, and then carrying it out according to plan.

He agreed with the Author that it was of tremendous importance to civil engineers as a profession to consider very seriously the question of

management. It was hoped that in the post-war world conditions would exist which had not obtained before the war. Civil engineers were part of what might be called a casual industry, and he thought that had been the cause of a great deal of sloppy thinking. If, in the post-war world, there was going to be no unemployment, if there was going to be a guaranteed week, and if there was going to be planned economy, civil engineers would have to be prepared to continue working under more or less the same conditions as existed at present; they would not be able to order materials overnight to make up for a slip in their calculations, and they would not be able to pick men up on the street corner and discharge them when they liked.

As he had already said, civil engineers were the most important part of a very great industry, and he believed it was their duty not only to consider the consulting engineers and the resident engineers, but also to consider the contractors' engineers. Contractors, after all, employed engineers, and he supposed that perhaps one-third of the members of the profession were contractors' engineers. The profession would rely upon those engineers for the planned economy of their whole industry, and they would be the people responsible for carrying out the work. If the industry as an industry was to take its place in the planned economy of the post-war world, the rebuilding of Britain would depend upon the man-power available, and, instead of just knowing the cost of a job, it would be necessary to know how long it would take and the man-power that would be needed. All those things necessitated a general knowledge of management. The urgency of war contracts and the simplicity of the engineering work on them had led to an improvement on the management end, but that was not enough. Civil engineers had to look to the future, and to the young men who would take their place, and he believed that The Institution ought to examine the best ways of training young men to be organizers and managers.

The method described by the Author for the training of the Royal Engineer would not apply to civil life, but various things could be done. For instance, it had frequently been the practice for engineering students to spend their summer holidays on some work or other, and he believed that, if civil engineers could bring the contractors into conference to consider together the kind of curriculum which should be established for engineering students, summer work could easily be planned in which, instead of learning setting out, the students could learn something about the running of a job. The matter should be regarded as urgent and important, and The Institution should form a Discussion Group at once, to consider the ways and means of setting about the work.

Mr. A. T. Best said that the Paper did not suffer from lack of emphasis: the Author had the courage of his convictions. His opinions were expressed "unhesitatingly", as he said; but they were not "undoubted", as he also claimed. Taking for example "the opinion that the

execution and economic side of engineering had not received a tithe of the attention accorded to the purely technical side", an opinion which the Author said "could not be successfully challenged", Mr. Best would challenge it, if by a "tithe" was meant one-tenth. But the more moderate statement on the next page that "insufficient attention is paid to the economics of engineering" might be accepted as sober fact and the Paper was well worthy of attention on that account. But there were points that called for comment, and he would mention three.

Firstly, the title was too comprehensive. The Paper only treated of "Engineering Work" in the very limited sense of construction on a moderate scale and by direct administration. He said "construction" because not a word was said about mechanical or electrical engineering, mining, research, or manufacture. He said "on a moderate scale and by direct administration" because the Paper did not seem to have in view large public works executed by contract. That limitation of vision seemed to colour the whole outlook because, under the head of "Organization of Work", the Author spoke of the engineer as being "faced with the duty of construction" and proceeded to outline direct administration; but, when a scheme was approved for execution, surely the first question to arise was whether the work should be done by contract—and, if so, by what type of contract—or by direct administration.

Secondly, there was a puzzling passage where the Author said he had been "faced with the problem of deciding on the difference between a Resident Engineer and a Contractor's Engineering Agent." In public works, at any rate, the terms "resident engineer" and "contractor's agent" were as clear and distinct in their meaning as the terms, defined in most contracts, of "engineer" and "contractor." The Author seemed to be asking as a conundrum what was the difference between two things as different as a square and a circle.

Mr. Best recalled an experience of his with the most competent resident engineer he had ever known. Thirty years ago he had been drafted on to that resident engineer's staff and on the first day he and another man were taken for a walk round the job by the resident engineer, who had said something like this to them: "Now, you fellows on the engineers' side will be thrown into close contact continually with the contractors' men, in setting out and in measurement and so on. They are out to do a good job, the same as you are. Give them credit for it. Be as friendly as you like; the more good fellowship there is the better. But all the time never forget that they are on one side and you are on the other." Was not that the essential difference between the resident engineer and the contractors' agent? Both might be fully qualified engineers, and of equal standing in the profession; but one was on one side and the other on the other.

Lastly, the Author had mentioned twice in the Paper, as if he approved of it, the saying that an engineer was a man who could do for one pound

what anybody could do for two. With that catch-phrase Mr. Best entirely disagreed. It was a half-truth, as might be demonstrated by the fact that the opposite was equally a half-truth, namely, that the engineer was a man who could do, properly, for two pounds what any fool could do, badly, for one.

Mr. H. J. B. Harding said that the Paper was particularly challenging as it confronted the members with a fundamental problem. Did they as a profession show any desire to improve the present methods of training? Did they as a profession form a united body?

In the Army, service conditions prevailed and Royal Engineer officers formed part of a regular ladder of promotion. In the civil engineering profession, many of the members, some from choice, but the majority from hard necessity, came under the heading of "casual labour." That fact at once brought up the difficulty of training young men. Continuity of work was difficult to achieve in the fitful way in which work arose, and, if there was no intention of continuity of employment, an employer might train up a possible rival, which he was not anxious to do.

Most people would agree that civil engineering and medicine were the two professions most beneficial to man. The medical profession was, generally speaking, a united body, the members standing together as a whole against all comers. In his Paper the Author had thrown at engineers a bomb of a delayed action type. Although he did not say so, he had forced them to realize that, unlike the medical profession, they were not a united whole.

In The Institution there was a vertical plane, with the consulting and resident engineers on the right and the contractors' engineers on the left. There was also a horizontal plane cutting clearly through those two vertical columns, with the employers above and the employed below it. Those dividing planes had to be recognized before any of the steps described in the Paper to improve training could be taken.

With regard to the cleavage between engineer and contractor, the engineer frequently designed a finished work without much indication of how it was to be put into position, and then called for schemes from competing contractors for carrying out the work.

The contractor was held responsible under the contract for anything and everything that could happen, and so he was bound to be the pivot around which the organizing of the work must revolve, and would remain the most fruitful source for the study of organization and a good training ground for future resident engineers.

The custom of contracting for work made the provision of a resident engineer necessary, and so a form of dual control grew up which could have the effect of thoroughly disorganizing a contract.

The ideal which should be aimed at was that the engineer should design with the carrying out of the work in mind, and for difficult work some form of contract or remuneration might well be devised whereby

several contractors could be consulted before the work was tendered for. The resident engineer and the contractor's agent should appreciate each other's position and be sufficiently large-minded not to try to obtain the sole credit for the carrying out of the work. By that means harmonious relations could be achieved. Programmes and methods should be discussed between them, and the resident engineer should actively assist the contractor to keep to his programme and should not rely on sarcastic criticism. Mr. Harding could not agree with Mr. Best's statement that the contractor's agent and the resident engineer were poles apart. He thought a better analogy was that of the Royal Air Force and the Army, where it was found better to have mutual co-operation than service rivalry.

For the efficient and peaceful carrying out of contracts, it should be remembered that it was as dishonest to prevent the contractor obtaining his just deserts, either by obstruction or by falling back on a quibble in the specification, as it was for the contractor to obtain payment for work not carried out.

The fact that a profit motive was still officially considered the necessary spur to efficiency should not make it a matter of scandal for the contractor to make a profit. So long as the profit motive was insisted upon, a highly organized firm of the modern type, involving technical and financial experts, was a national asset, but it could not continue to exist unless it paid its way.

If engineers wished to unite the conflicting elements of the profession to which they were all proud to belong, they would first have to realize that contractors' engineers were as jealous of their professional reputation as any other class, and that they were of no different personal integrity. In order to achieve professional unity, more trust should be shown in the contractor of repute, and steps should be taken to see that newcomers kept to the standards of the old-established firms. If the fear of the contractor still prevailed, he could be obliged, under the contract, to employ a certain number of Corporate Members of The Institution. It should then be possible to establish a standard of conduct, and to maintain it in the same way as the medical profession maintained its standard of conduct.

* * Mr. George Ford observed that from the contractors' point of view, an examination in the subjects proposed by the Author would be a valuable step forward in the training of qualified engineers and would eliminate the possibility of engineers, highly qualified technically, being placed in charge of the organization and execution of large engineering works without previous experience in that branch of the profession.

Mr. Ford doubted whether, if The Institution should decide to include a test of practical training in the qualifications for Associate Membership, a written examination would provide sufficient indication of a candidate's

* * This communication was submitted in writing.—SEC. INSR. C.E.

works experience. Instead, he suggested that that should be the subject of an oral examination which could be short and of a general nature, but from which it could be determined whether or not the engineer had had the requisite practical experience.

Brigadier Harrison, in reply, said he had found the discussion very enjoyable, and was glad to find that the Author had brought forward a fairly controversial subject. He wished to thank particularly Mr. Wynne-Edwards and Mr. Harding for lifting the subject into what he considered was its proper perspective.

He had no intention of defending any individual sentences in the Paper, nor would he argue about its title; he was inclined to agree with Mr. Best that the title was perhaps not as descriptive as it might have been.

In his opinion, a time diagram and a costing diagram were exactly the same thing as the "appreciation of the situation" to which the Author had referred.

A few misconceptions had become evident which, in fairness to himself and the distinguished Corps to which he belonged, he would like to remove.

There seemed to be a general idea that the Royal Engineer officer was concerned with similar tasks, or standard tasks, and that he had not very much to do with the cost of the work that he carried out. He had been concerned in peace time with almost every phase of engineering, including water-supply, power-stations, refrigerator plant, including dry ice plant, and considerable road work and construction work, including the building of a central gaol for five hundred prisoners. In peace time money for the Army was not plentiful; every penny had to be considered before any job was embarked upon, and the Royal Engineers had to watch expenditure carefully, persuade the ruling powers to approve it, and fight long and hard battles in order to obtain the minimum accommodation and the minimum engineering services of every kind for the well-being of the small Army maintained by the nation in peace time, and to lay the foundation for the expansion necessary in war time. In doing that they had not to satisfy the individual clients to whom Dr. Oscar Faber had referred, but they had to satisfy the country's somewhat harshly criticized bureaucracy. Even in war time the Royal Engineers did not embark upon construction regardless of cost, but they tried very hard to give the taxpayer good value for his money. Consequently from the beginning of their service they were closely connected with estimating and with the economic side of engineering.

Again, it had been said in the course of the discussion that military engineers worked with disciplined labour. That was sometimes the case in active service operations in the field, but it was the exception in other circumstances, and it never happened in peace time. In the case of civil labour, the maximum number of men he could recall was 21,000, most

of whom were black. All the direct labour employed by the Royal Engineers in England in peace time was civilian ; it was subject to exactly the same rules as the labour with which engineers had to deal in civil life, and the same difficulties were experienced.

He thought that the Author's purpose in writing the Paper would have been served if he had stimulated a certain amount of active thought, and he would like, on the Author's behalf, to thank the various speakers for the thought they had given to the Paper and for the obvious care they had taken in commenting upon it, which had been very gratifying.

The President proposed a vote of thanks to Brigadier Harrison, which was accorded by acclamation.

If any reply to the discussion is made by the Author, it will be published in the June Journal.—SEC. INST. C.E.

OBITUARY.

ROLLO APPELYARD, O.B.E., J.P., was born in London on 1 January, 1867, and died there on 1 March, 1943. He was educated at Dulwich College and privately, and commenced his scientific training at the City and Guilds College. Later he was appointed a demonstrator in Physics and Telegraphy at Cooper's Hill. In 1888 he gained the medal for electricity and magnetism of the Science and Art Department. In 1892 he joined the submarine cable department of the India Rubber and Gutta Percha Company, and after assisting in duplexing the cables between Pernambuco and Santos, Brazil, he was put in charge of a research laboratory. During his 22 years with the Company he made many improvements in dielectrics and carried out extensive researches on various physical problems ; one of his inventions was the conductometer for the measurement of electrical conductivity.

In 1914 he was called by Admiral Lord Fisher to the Admiralty, with a commission as Commander R.N.V.R., to organize submarine defences. He designed booms for the Clyde, the Tyne, Portsmouth, and elsewhere, and also worked on urgent aeronautical problems for the Grand Fleet. In February 1917 he was lent to the Air Service to advise on aeronautical instruments, and in September of that year was appointed to the War Staff for the Convoy Section, where he prepared several confidential statements on convoy defence. He also designed improved methods of