P. M. Carew-Smyth, A.R.C.A., Art Inspector, Victorian Education Department; J. Sarvaass, B.A., M.C.E., Head of Engineering Department, Working Men’s College; and F. W. Green, Head of Engineering Department, Swinburne Technical College, Melbourne.

A hearty vote of thanks to Mr. Clark for his very interesting paper, moved by the President, was carried by acclamation.

At 10.25 p.m. the meeting closed.

PAPER.

THE TRAINING OF AN ENGINEER.

By DONALD CLARK.*

The training of the engineer is a theme on which there will always be wide differences of opinion. Many different successful engineers acquired their preliminary training in so many different ways that it is not possible to outline any course of study and work which will be universally applicable. Further, since engineering is largely progressive applied science, it will be necessary to provide in the future for so many branches and sub-branches of the subject that any comprehensive scheme of training must only be foundational and never complete. It is correct to state that the training of the engineer goes on right through his life of active practice; he is always learning, and his knowledge is tested by a critical world.

It is therefore necessary to state only some of the points which demand attention up to the time he is launched forth on to the world equipped to make a start on his professional career. The main aims of any form of preliminary training should be:

1. To fit him to be of service to his employer.

2. To give him such a knowledge of basic principles underlying his purely engineering subjects as to

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reduce to a minimum the danger of making mistakes.

3. To encourage and develop a spirit of confidence, resourcefulness, and initiative.

4. To enable him to deal with practical problems, including their relationship to financial matters such as commonly occur in engineering, as well as purely academic matters.

There are many necessary subordinate matters involved in these qualifications. They pre-suppose an exact knowledge of English, mathematics, and science. One of the first qualifications for the future engineer is aptitude for this class of work. It is too often assumed that, because a boy is smart at mathematics or shows talent in some other way, he can be sent to a University or to the workshop or some other institution, and there go through a course of study or training which will transform him into a competent engineer. Many parents have sent their sons to the University for professions only to find that the desire on the part of the boy was mistaken for power and ability.

In engineering, perhaps more so than in any other profession, a natural aptitude for some one of the branches of work, especially mechanical engineering, is one of the main qualifications so often overlooked or under-estimated.

Those who have carefully watched boys will agree that family characteristics become apparent at a comparatively early age. Although children, even in one family, show marked differences, they generally possess common physical and mental attributes. It is not uncommon to find several children in one family possessing special aptitude for branches of mechanical work, while in other families this is noticeably absent.

Some thirty years ago, a heated controversy was carried on in the columns of the "Engineer" on the training necessary for engineers. It was argued on the one hand that a liberal University education was essential, and on the other hand that the practical training of the office and workshop was preferable. The engineer trained by the latter method, it was held, was able to dispense with a lot of the theory taught
by the University professor, and was kept on the straight and narrow path by the possession of "mechanical instinct." After the elapse of more than a quarter of a century, the conflicting schools have converged to paths not widely different; but there is much truth in the old contention that an inherited aptitude, or what may be termed "mechanical instinct," is of the greatest value to the youth who is to become an engineer; the boy who does not possess it may possess intellectual ability and may be formally trained, but is not likely to ultimately become a highly efficient engineer.

From an educational and national point of view, if we are to make the best use of our human material (the success of any nation depends on the services rendered by its people), it would be well if the whole of our youths could be sorted out, and each given the fullest opportunity to develop his latent talent; it would also be well if we possessed more definite information as to the positions which our youth must in future occupy. Too much has been left to chance, and our methods of muddling through have not given us the best results.

Our present University system is based on a process of selection of those who have reached a certain intellectual standard, as tested by examination, and a rejection of those who have not. The sifting operations are carried out year by year until a few remain who are entitled to start on a professional course of education. The student takes up law, medicine, science, arts, or engineering courses because he may have won a scholarship entitling him to enter on one of these courses, because he may have had some preference himself, but very often because the matter may have been decided for him by his parents. He may possess an aptitude for the particular branch of work he has entered upon, or he may not. It is largely a matter of chance. The schoolmaster very seldom inquires as to what has become of the rejects from this system. If he did, he might be astonished to find that so many who were rejected on account of their lack of ability to satisfy his standard, have become the chief cornerstones of many of our industries. They possessed qualifications of more importance than mere bookwork or academic knowledge.
It will therefore be necessary to consider the training of the future engineer, not only from the University standpoint, but also from that of the workshop, with the elementary education which a boy should receive from the age of 12 years. At that age he should possess a sound, if elementary, knowledge of the three R's, and should have learnt to use his hands for elementary constructive and drawing work.

From this stage onwards, it becomes necessary to allow for his fuller mental development, and at the same time to limit the number of subjects on his programme. We are at once confronted with the fact that, from the one secondary school, boys will undergo a preliminary training for all professions or for the completion of their education, and, naturally, the simplest method from the school point of view would be to adopt a common curriculum for the whole lot of them. The matter becomes more complicated by the University insisting on the passing of certain subjects by the candidate who wishes to enter on certain professions, and still more complicated by the multitude of ways by which a pupil may matriculate.

Dealing first with some of the matters which affect the boy who may ultimately go through the University course in Engineering:—Up to the present, the candidate who matriculated and entered engineering classes at the University is required to pass the Junior and Senior Public examinations. The former includes seventeen subjects, and a candidate who passed at one examination in six of them, including the compulsories, was entitled to a pass. The compulsory subjects for the Engineering student were English, Arithmetic, Geography, and French or German. After passing Junior Public, he may obtain a pass in Senior Public by passing in the subjects of two of the eight groups specified, but he must pass in the compulsory subjects, Algebra, Geometry, Trigonometry, and Elementary Mechanics.

Time need not be taken up in critically dealing with these examinations. They commended themselves to neither the teacher nor the pupil, and were condemned. They will, next year, be replaced by another set of standards, one of which is called the intermediate certificate, which is supposed to correspond with Junior Public, and the final one, the leaving certificate, which is supposed to correspond with Senior Public.
One main reason for the introduction of the new scheme was due to the complaint of schoolmasters that it was not possible to organise their schools, seeing that a pupil might matriculate in about a million different ways, and that it was not possible to follow out a satisfactory course of general education, owing to University entrance requirements.

At the preliminary meetings held by those interested, the advantages of having a common educational course which would satisfy everybody was recognised, but the efforts of the Schools’ Board, which was appointed to deal with this matter, show nearly as many weaknesses as the Junior and Senior Public Examinations which will be replaced. Since these certificates will affect every future engineering student at the University, the course of work outlined may be briefly indicated. Assuming a lad has reached a satisfactory standard of elementary education at the age of 12 years, he then enters on a four years’ course of work for his intermediate certificate. The subjects of examination for this certificate do not differ materially from those of the Junior Public. Eighteen subjects are still set down. Candidates will be given a pass if they pass in six subjects, including English, one other language, or History and Civics, and one branch of mathematics. Candidates from certain approved schools need only pass in English and two other subjects, provided they produce the headmaster’s certificate that they have pursued all the subjects of an approved course of study for a period of not less than three years, or in special cases, two years, and have made satisfactory progress in them.

The school leaving certificate may be gained by pupils who have obtained their intermediate certificate, and who have passed in English and three other subjects. The concession given to certain schools, as in the case of the intermediate certificate, limits the examination test to English and one other subject.

The courses outlined for secondary schools include:

1. The Classical course.
2. Modern Languages course.
3. Combined Languages course.
4. Mathematical and Science course.
5. Commercial course.
A study of these courses, which have been drawn up with much care, indicates that the only one which concerns the future engineering student is the Mathematical and Science course. Incidentally, they show how the effort to produce a common educational course has failed.

<table>
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<tr>
<th>Science Courses</th>
<th>16-18 (B)</th>
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<tr>
<td>10-12</td>
<td>12-14</td>
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<tr>
<td>English</td>
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<td>Latin</td>
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<td>French</td>
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<td>German</td>
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<td>History</td>
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<td>Geography</td>
<td>3</td>
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<tr>
<td>Mathematics</td>
<td>5</td>
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<tr>
<td>Science</td>
<td>2</td>
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<tr>
<td>Drawing and Manual Training</td>
<td>5</td>
</tr>
<tr>
<td>Physical Training</td>
<td>2</td>
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<tr>
<td>Singing</td>
<td>1</td>
</tr>
<tr>
<td>Allotment unspecified</td>
<td>2</td>
</tr>
<tr>
<td>(A) Religious Knowledge</td>
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</tbody>
</table>

Periods per week ... 35 35 35

NOTES:

(A) In registered schools where religious knowledge is given, the unspecified allotment will be available for that subject.

(B) The course 16-18 includes English, the special group, and one other subject in addition to physical training.

(C) Latin and German are alternative subjects, or this time may be given to Drawing and Manual training. These are the courses indicated by "D" on the table exhibited during the reading of the paper.

Although it is stated that the courses outlined are not mandatory, but suggestive only, it is easily seen that if we are going to have a multiplicity of courses, the schools will be in much the same position as before. In this and in other educational matters, it is time that the engineer should have more to say in the preliminary training of the engineer.
The most serious objection which can be urged against this scheme does not concern the youth who completes his education in the secondary school, but it does concern the future engineer. As Herbert Spencer pointed out over half a century ago, the preliminary or school training of our youth should not occupy too large a portion of life's allotted span, yet here a youth is asked to spend six years at secondary school work, four years at University work, and then be turned out into the world to commence to gain the experience and knowledge which will enable him to make his way in the world.

It probably will be said that the smart youth need not spend six years on secondary school work alone, but the main effort of the Schools' Board seems to have been to produce uniformity in the working of the schools; and any teacher knows that if courses of work sufficient for one year are outlined, it is not possible to compress them into six months, nor is it possible to allow the class to move forward except at the pace of either the medium or the slow boy. The result from this point of view is likely to be the same as in the State School, where a common curriculum must be followed, where only a portion of the pupils can keep up to the work prescribed; the remainder will be a year or two years behind.

The amount of time devoted to manual training and drawing (two periods per week from 12 to 14 years of age) is so meagre that these subjects might as well be omitted from the programme. No drawing and no manual training are considered necessary for the last four years of the course.

It may unhesitatingly be stated that boys who spend about half their time studying languages and history and for the rest of their time mathematics and science until they are 18 years of age, will never, in engineering subjects, be able to compete with boys of similar attainments who have done their drawing and manual work, and who have gained more practical information than can be given in a secondary school.

Further, if boys are kept at pure academic studies until they have reached the age of 18 years, it will be found that they will evince a decided distaste for the everyday work of the practical engineer. Experience in other schools has shown
that if a boy does not enter the mechanical engineering workshop before the age of 16, he shows a positive distaste for the drudgery of the workshop.

Criticism of these courses may be premature, but it is evident that the Board has not been able to find a course in general education, which will suit the needs of every youth, even up to the age of 16 years, and it is further evident that the courses drawn up consider the needs of the schools concerned rather than the pupils. No one will belittle the value of any form of mental training which develops and strengthens character and intellect, but we must not shut our eyes to the fact that the training for the future engineer must be largely vocational, and if the mental discipline can be given by means of subjects which form a natural part of that training, these subjects should not be displaced by others which do not. The field of knowledge is too wide, and life too short, to attempt to teach everything to the immature youth.

The most rational method of dealing with the subject would be to have a special school devoted entirely to the preliminary training of the future engineer. Such a school would not be hampered by the compromises which must be made in a secondary school of a general type which caters for the needs of various other classes. It is realised that there are many difficulties in the way. The aptitude or suitability of a lad for the work, the traditional standing and influence of our public and secondary schools, the scattered communities in the State, all present special problems or difficulties.

The curriculum of such a school should include:—

<table>
<thead>
<tr>
<th></th>
<th>Age 12-14</th>
<th>14-16</th>
<th>16</th>
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</thead>
<tbody>
<tr>
<td>English</td>
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<tr>
<td>Arithmetic</td>
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<td>Algebra</td>
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<td>Geometry</td>
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<td>Trigonometry</td>
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</tr>
<tr>
<td>Science</td>
<td>4</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>History</td>
<td>2</td>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>Geography</td>
<td>2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Drawing</td>
<td>4</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Manual Training</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
Physical Training ............ 2 2 2
Business Methods and Correspondence — — 2
Foreign Languages ............ 5 2 —

This scheme is suggestive only and is mainly put down on account of the subjects included. Parents pay little attention to what their children learn at school, and the engineers have apparently handed over the preliminary training of the future engineer to the schoolmaster, therefore, some opinion should be definitely expressed on the subject.

The next step in the training of the engineer may be given by the University. Students who have matriculated and passed in the compulsory entrance subject and reached the age of 16 years may enter on their University courses. There are now four distinct engineering courses at the University of Melbourne—Civil, Mining, Mechanical, and Electrical. The subjects of the first year's course are common and include:

- Pure Mathematics—Part I.
- Mixed Mathematics—Part I.
- Natural Philosophy—Part I.
- Chemistry—Part I.
- Geometrical and Mechanical Drawing.
- Graphics.

Students must also do five consecutive weeks' workshop practice.

During the second year, the following subjects are common to all courses:

- Pure Mathematics—Part II.
- Natural Philosophy—Part II. (Engineering Course).
- Surveying—Part I.
- Mechanical Engineering—Part I.
- Engineering Design and Drawing—Part I.
- Strength and elasticity of materials (Taken in 3rd year of mining and electrical students).
- Chemistry—Part II. (Engineering Course) is taken by mining and electrical students only.

Practical work is also taken for five weeks under a practical engineer.

During the third year, the common subjects are:

- Mechanical Engineering—Part II.
- Hydraulics and Hydraulic Engineering—Part I.
Mixed Mathematics—Part II. (except for mining students).

**Civil Engineering:**
- Civil Engineering—Part I.
- Surveying—Part II.
- Geology—Part I. (Engineering course).

**Mining Engineering:**
- Metallurgy—Part I.
- Surveying—Part II.
- Geology—Part I.

**Electrical Engineering:**
- Electrical Engineering—Part I.
- Engineering Design and Drawing—Part II.

**Mechanical Engineering:**
- Electrical Engineering—Part I.
- Engineering Design and Drawing—Part II.

Practical work includes 5 weeks' surveying or engineering.

The fourth year for each group includes:

**Civil Engineering:**
- Electrical Engineering—Part I.
- Hydraulic Engineering—Part II.
- Civil Engineering—Part II.
- Architecture.
- Civil Engineering Design and Drawing, or Architectural Drawing.

**Mining Engineering:**
- Electrical Engineering—Part I.
- Mining Engineering.
- Metallurgy—Part II.
- Geology—Part II.; and Mining Geology.

**Electrical Engineering:**
- Mechanical Engineering—Part III. (A).
- Electrical Engineering—Part II. (A and B).
- Electrical Engineering Design and Drawing.

**Mechanical Engineering:**
- Mechanical Engineering—Part III. (A and B).
- Electrical Engineering—Part II. (A).
- Machine Design and Drawing.
- Metallography.
It will be seen that these courses include many subjects in common, and that differentiation takes place mainly after the second year. It may be interesting to mention that the courses of training are widely different from those in force 25 and more years ago. The University authorities at that time held that the engineer should complete his three years' Arts course before he entered upon the formal study of engineering subjects provided he passed in Lower, Upper, and Advanced Mathematics, Natural Philosophy—Parts I., II., and III., Surveying and Levelling—Part I., and a few other subjects. The result was that the engineers who went through in those times took up the study of English Language and Literature, Inductive Logic, Political Economy, Jurisprudence, History and other subjects. All these were very interesting to the men who went through them, but I am afraid that they were studied at the expense of subjects of more vital importance to the engineer. Tribute must be paid to the father of the Engineering School—Professor Kernot—who bore the whole burden of engineering teaching on his shoulders.

As time goes on, the tendency of University teaching is to become more and more technical, and to deal with matters which fit the young graduate for his post. His training, however, is far from complete; he should not make mistakes in scientific principles nor in carrying out simple engineering work entrusted to him; but one very important section of his training has been neglected. He knows very little about the laws regulating employment, contracts, agreements, and his knowledge of framing specifications and of estimating costs is largely academic. In fact, while his knowledge of mathematics, forces, geological faults and lodes, elastic limits, and other lecture and laboratory dicta, may be quite sound, he has a great deal to learn with regard to general organisation of labour and the commercial problems which are inseparable from engineering work. It may be urged that he can gain this information outside, but the same can be said with regard to a great deal of what is taught in the University.

There is a place in the community for the University trained engineer, and every opportunity should be afforded to those qualified intellectually, and otherwise suitable for attendance at the excellent courses now provided at the Uni-
versity. Any attempt, however, to restrict the courses of training to the University would be a mistake. Statistics will often point out the successes due to University training. This is in part true. The continuous system of selection, if it is of any value, should place certain men in a class by themselves. These men, other things being equal, should have come to the front in whatever branch of industry or commerce they occupied. It is also often stated that these men, on account of their special training, will become our industrial leaders. This is not necessarily so, for many other qualities beside those of intellectual and technical ability are needed.

There is no doubt that the Civil engineer receives as full and as adequate a training as it is possible to crowd into a four years' University course, but I am not sure whether the same can be said of the Mechanical engineer. At present, I am not certain what position he is to ultimately hold, but I do not consider that, in the University course, the student can gain an adequate knowledge of workshop materials and processes. If two years were spent in a workshop and if facilities were given for acquiring practical knowledge in the various departments before the student went to the University, he would understand and appreciate his work very much better. As an alternative, six months' workshop practice and six months' University work spread over a five years' course would make a better mechanical engineer of him.

Apart from the University, there are large classes of men who have risen and will continue to rise from the ranks. These men have become qualified for their posts on account of their innate ability, their experience and their sound judgment in dealing with men and materials. Many of them have not had the fullest opportunity for acquiring theoretical knowledge, but others have attended evening schools and put their knowledge gained to the fullest use. It must be confessed that in the past our educational scheme largely neglected this class. The smart boy was encouraged by scholarships to go for a University course and become a doctor, a lawyer, or a teacher, and occasionally an engineer. The greatest care was taken to lay down progressive courses of study and to assist him throughout and even to protect him afterwards from unlicensed competition, but the boy who entered the workshop-
had to light his own way. A few technical schools were open to him in the evening, but he was often asked to do work for which his elementary education did not prepare him. Steps have been taken during the last few years to give a suitable training in Junior Technical Schools to the lads who must ultimately form the great majority of our skilled craftsmen and industrial leaders.

In former times, a number of engineers were trained by the employers they were articled or indentured to. The articled pupil received a training corresponding to his own ability, and that of his employer, while the apprentice was given the fullest opportunity under agreement for learning his craft or trade. The modern apprentice is in a different position. Many lads never receive an adequate training in the workshop, and are often kept for years at subordinate work, or he becomes expert at some simple repetition work and never advances further. Of workshop tuition there is none, and unless he attends some technical school and gains the necessary information there he is likely to finish his apprenticeship with little knowledge of his branch of work.

The junior technical schools admit boys who have completed their first stage of work in the elementary schools. This stage is reached by most boys at about 13 years of age and, in the case of the smarter boys, at 12. They enter a special school under special teachers, and continue their elementary education in English, geography, civics, and arithmetic, but also take up a simple course of work in algebra, mensuration, and science. This occupies half their time. Drawing and modelling take up one quarter, and manual work including wood and sheet-metal work one quarter. Even at this early age, boys give indications of any special latent talent they possess. The teachers are able to select those who are fitted for various classes of work, and encourage them in that work. During the second year, the ordinary educational subjects are continued, but boys take up the practical work for which they are best adapted; some take up woodwork, others metal work, others elementary scientific handicraft work, and some design. At the end of their second year, a few pass into the higher technical schools for day courses of work; others take up workshop practice until they find suitable
avenues of employment; but the majority go out to work in the industry they are most adapted for. They secure employment owing to the co-operation of employers and the assistance rendered by the teachers whose duty it is to look after their interests.

In the near future, the courses of work in these schools will be extended, and boys will gain preliminary experience of workshop practice before they enter the workshop at all. Possibly later on, trade workshops will grow out of these, where lads will be given a practical training under expert workmen, and will also receive the necessary theoretical instruction. The growth and development of these schools will ultimately exert a pronounced influence on our industries. It can be safely assumed that many of them will prove themselves fitted for the most advanced instruction to be given in our technical schools, and that several of them will ultimately annually enter for courses of University training. It is noteworthy that, in the space of only three or four years, the students occupying the foremost places in several of our technical schools were boys who received their preliminary training in the Junior Technical School.

Up to the present, these schools have been untrammelled by University or secondary school requirements. They are designed primarily for the training of the artisan, the craftsman, and the skilled mechanic, and also for the lads who have the ability and means to take up day courses of work in the higher technical schools. It is my opinion that the training given in the junior technical schools, followed by a day course in a higher technical school, supplemented with workshop practice and evening technical instruction, will give us the most useful type of mechanical engineer.

DISCUSSION.

The President said they were indebted to Mr. Clark for a very carefully thought out and lucid paper upon a most important subject, the education of the Engineer. Mr. Clark had given them the benefit of his considerable experience in the important work of educating and training young men intending to follow one or other of the branches of the engineer-
ing profession, and his ideas would doubtless receive the
earnest consideration of the members of the Institute, and he
hoped to hear the views of a few of the visitors who were pre-
sent to-night, and who were engaged in the work of educating
youths in the engineering and other professions. He might
take it that, notwithstanding Mr. Clark's reference to the
objects of junior technical schools—which were now mainly,
if not entirely, for the training of youths for crafts and trades
—the paper was primarily dealing with the training of the
engineer in the highest sense of the term, namely, the profes-
sional man. It was a subject to which not much attention had
been given in this country, but it was one which ought to
receive every consideration, particularly bearing in mind the
need for a higher national efficiency, not only in this country,
but in all parts of the British Empire.

When he started, engineering technical schools had only
just come into being, and the steps generally taken by those
who desired to join the profession mainly consisted in becom-
ing apprenticed to some well-known engineering firm. That
system had been tried, and found to be a failure, for, though
the youth gained a certain amount of practical knowledge,
his time was otherwise not utilised to the best advantage.
The apprentices themselves wasted much of their time. There
was no one deputed to look after and train them, and to get
the best out of them. A change, however, had come over the
engineering industries in Great Britain, in regard to the educa-
tion of youths, and now they found excellent systems in vogue,
whereby youths were trained at engineering works under
special instructors, their workshop practice being sandwiched
in with theoretical training at the University and Technical
Colleges. That seemed to him a sound course to follow. The
youth did not take to workshop practice kindly after the age
of 17 or 18, so it was necessary for him to take up practical
work as soon as possible after leaving school. He would like
to hear the views of those who were experts in the matter of
education as to whether, in the future, they should not have
colleges instituted solely for the training of engineers, at
which boys would commence a special course at an early age,
say 13 years. He knew it would be said that at that age
many boys had not made up their minds as to their profession
in life. He would point out, however, that in the naval service boys started at 13 to study engineering in specially appointed institutions attached to that service. He thought there should be schools set aside for the training of engineers, where no time would be lost in studying subjects which would be of no use whatever to them in their future career, and where the whole course of study would have as its object the production of a highly-trained engineer.

Mr. W. N. Kernot* thought they were indebted to Mr. Clark for the paper he had placed before them. He believed, of all the educational people in Melbourne, Mr. Clark had superior opportunities of seeing how all the courses were working.

From that point of view, he (the speaker) had also had a good deal to do with engineering education, as a consequence of his long, past connection with the Working Men's College—practically from the beginning—in charge of the engineering work, until he assumed the duties at the University. He had thus had an opportunity of looking at both sides of the subject.

The great point raised in Mr. Clark's paper, he thought, was the contrast between the courses for the engineer, which involved an elaborate preparation and preliminary examination, and one in which the student was free to enter the course without any test whatever. The technical schools at present would allow anyone in who would pay the fees; but the University provided a special course of preparation and examination before he would be accepted.

Thus there arose a tremendous difference in the standard of lads that came into the school. From the technical schools they turned out very good students. They occupied responsible positions and were doing good work. Men who had trained under him at the Working Men's College now occupied high positions. At the University they turned out men who also occupied similar positions. Ultimately the question was, which was the better course of training? Mr. Clark had spoken very largely from the point of view of the mechanical engineer, and contrasted the possibility of the mechanical en-

* Lecturer on Engineering Design and Drawing, Melbourne University.
gineer trained under the University course with the man from the technical school. At the technical school the mechanical man would get a great deal of workshop practice. He would be in the shop for possibly 30 per cent. or more of his time, with coat off and "blueys" on, doing his work. At the University the workshop work that the mechanical man would get would be five weeks in his first long vacation. But five weeks was rather short. It was not long enough to get into the swing of the shop. Although the University men were well received, five weeks gave them a very poor smattering of workshop experience. Then, further experience was more or less a matter of chance. They had to have a certain definite experience, and that experience would be accepted in office work or drawing work. The mechanical course was a new one, and had only been in existence for a few years. Most of the men who had completed the course had done very well. His own opinion was that, for the mechanical engineer, shop practice was most important, and mere academic work was not sufficient.

As to the students coming in without examination, the trouble was that a great many boys would come in who were not prepared to work up to a high standard, and they would pull down the average of the class. On the other hand, the University examinations certainly were very rigorous. He thought a great advantage the University course could claim was that to a large extent it put the student on his mettle. There were those who believed the student coming to the class should be fully prepared for any work put before him up to the standard. Thus they had the University student trying to fill as many of the conditions as possible, and it made him more of a man.

In respect to an examination at entering—the question as to what the subjects should be was a big one. To start with, they were restricted enormously by one thing—the requirements of the Institution of Civil Engineers of London. There was a great desire that students of the Melbourne University should become students of that Institution, and to do that it was essential that they should be students of certain subjects stipulated by that body. There had been correspondence going on for years to try and arrive at a compromise, and re-
DISCUSSION—TRAINING OF AN ENGINEER.

cently it had been arranged that students passing in certain definite subjects could be admitted without further examination, to the Institute, which was a great concession. On the other hand, they could see the effect in the list of subjects before the meeting. Those subjects with “C” before them were alternatives. That was the effect. There were quite a number of subjects they must get through. Geography was one of them. In mathematics there were certain definite subjects in which students must pass before the Institution would recognise them. This procedure was a question of policy.

The subject of mathematics during the manual and science training on the list (p. 25) was cut down very much. For example, in the case of drawing and manual training from 10 to 12, 2 hours; 12 to 14, 2 hours. One of the most essential things for a student was to be able to draw. He meant mechanical drawing. Of course he must be able to do freehand as well. A great many students whom they received had not touched drawing; and for some reasons they were glad, because it gave them a free hand to train them from the beginning; but if drawing was to be left out in the last three years of the course, he thought it would be a lamentable position. A lad would make his name if he was able to do a little drawing, and do it neatly.

There were certain subjects left out of the list that had been exhibited he would like to put in, but it seemed a difficult thing to arrange, according to the opinion of the ordinary teacher or lecturer.

The commercial side was very important, but many engineers knew nothing else but technical engineering and designing. The University man was not supposed to be turned out as a commercial man, though he must be able to do such things as keep accounts, look after pay sheets, and do other things incidental to the management of men. This was a difficulty not only in connection with the University. He would like to see them included in the curriculum. A commercial course would teach a man method.

Another thing was drawing up specifications, and the legal aspect. At the University, as soon as the engineer-
ing representative suggested dealing with the legal aspect, the law faculty would come along and say they would do it for them. But they rather talked above the heads of students, to whom the legal points were only incidental. As for formal logic for the engineer—it was supposed to teach him to reason clearly. But anyone looking for that result from that source would not get what he wanted. He thought in all these classes the course was too stereotyped in an endeavour to conform to the Institution of Civil Engineers' requirements. But at the present time departures were being instituted by the University. With the architectural students they had a special mathematical course taught by engineers. As to how far it would be a success remained to be seen.

In connection with graphics mentioned by Mr. Clark, he might say the usual thing was to try and get the student to start off solving simple problems graphically, long before he had been taught any of the pure advanced mathematics relating to it. The procedure involved the methods of integration and differentiation in engineering long before the student had mastered the formal modes. It was astonishing how well the students took to the work. The University was putting more of graphic solution into the course.

He thought Mr. Clark had raised a question of very great interest, and if the engineers would only come forward and help the teachers in this matter by offering their opinions and discussing the matter, they might possibly improve things a great deal. Of course every engineer who employed students from the technical colleges or University hoped to get the best. They wanted to try and work the student separately as far as possible, for it was a great difficulty to bring out the lad's latent talent.

Mr. F. W. Green* said he had listened with interest to Mr. Clark's paper, but before making any remarks upon the paper, he would like to say he felt rather ashamed of himself, being an engineer, that he had not been within the Institution's rooms before. He wished to plead lack of time as the sole reason, and hoped he might be able to attend more frequently in the future.

* Head of Engineering Department, Swinburne Technical College, Hawthorn.
The subject of the paper was an extensive and debatable one; and, judging by the amount of discussion taking place upon it in various parts of the Empire, one the importance of which was becoming more and more recognised.

The President had referred to what he termed the failure of the apprenticeship system. To say that the apprenticeship system was a failure was surely a grave statement to make, and from his own experience of an apprenticeship of close upon six years, he was not prepared to admit so much as that. Doubtless some of that time could have been more profitably employed if better means had been available for training the apprentices in the works.

Mr. Clark and Mr. Kernot had spoken of the training of engineers at the University in Melbourne. One thing that had struck him in connection with that training was that the courses were not nearly so closely allied to practice as they should be. He had noticed that particularly. His idea of an engineering apprenticeship or training was, say, at the least, three years in a works and three years at college, making six years in all. Part of his own training had been at the Armstrong College, in England, where the course was much more closely in touch with practical work than at the Melbourne University. The requirement here of experience in an engineering works for two or three periods of five weeks at a time was of very little, if any, use; he felt convinced of that. He wished to mention a system in vogue at the Armstrong College, Newcastle-on-Tyne. A course of 5½ years was there outlined as follows:

| College, 1 session, September to July | 4 years |
| Works, July to second following September | 1½ years |
| College, 2 sessions, Sept. to second following | 2 years |
| Works, July to second following Jan. | 1½ years |

**Total 5½ years**

He thought that much preferable to the arrangement here.

In regard to the training that was now being given in the technical colleges in Victoria, of which he had some considerable experience, he felt sure that if some of the members of
the Institute would visit the Swinburne College and see the progress made by some of the senior students, they would be much impressed. The students had made much better progress than the speaker had anticipated. In fact, some engineering employers had been much impressed with some of the work done by even the Junior Technical School students.

Another point needing attention was that some of the students from the technical colleges might wish to go on to the University, and they might not previously have passed the junior and senior public examinations. Unless the University authorities relaxed the rules there, students would be debarred from the University courses. He again thanked Mr. Clark for his paper.

Mr. Carew-Smyth* said he felt somewhat like a fish out of water amid a body of Engineers, but he was interested in the subject of Mr. Clark's paper, and as he had got along fairly amicably with that gentleman for some years, he felt that he was not going to fall out with him now. Mr. Kernot, as he rose to speak, had said to him, "Speak about Drawing." He had come with the deliberate intention of speaking about Drawing, and there was a fine text for forcible remarks in the time allowance given to "Drawing and Manual Training" in the table commented upon by Mr. Clark. This purported to set out from the scholastic point of view a preparatory course for youths intending to be engineers, but it appeared to be laid down by men whose ideas regarding education were those of monastic days.

He noticed that a capital "D" in front of certain liberally treated subjects was said to indicate "alternative"; it had quite another meaning in his vocabulary. He saw that the time allowance for Drawing after the age of 14 years was represented by a dash. He would leave them to select the term which that dash stood for with him. It was difficult to be serious when one contemplated this time table. What was in the minds of those who formed it? He was reminded of the story told of Robert Browning, how, one day, somebody asked the poet what was the meaning of a particular passage in one of his poems, and Browning replied, "Well, when I wrote that

* Art Inspector, Victorian State Education Department.
God and I knew what it meant, but, now, only God knows." He thought that the authors, if asked for the meaning of this time table, might well give a similar reply. He certainly could not explain it.

He had been an examiner in drawing for many years, and he knew what was possible of accomplishment by young people. He considered the time allowance for drawing absurd—it should have four or five hours per week instead of one or two. He noted the time allotted to Latin, and thought that, so far as the training of the embryo engineer was concerned, this time would be much better spent if devoted to drawing or to work of a practical kind, such as that suggested by Mr. Green. He could not think that the course before them was an adequate preparation for the engineering student.

Regarding the training of the engineer, one side appeared to be neglected. Why was it that the engineer had no artistic training whatever provided in his course? He had to deal with structures which might or might not be extremely ugly. Why was no attempt made to cultivate his taste? He knew that there were engineers who would concede a certain something to art by here and there trying to cover up constructions with so-called decoration. He had seen some lamentable attempts of that nature. And yet what possibilities there were if the engineer were trained in art. For example, take the modern ferro-concrete building. It was essentially an engineering structure. Architecture had often not a great deal to do with it, and was frequently confined to the architecture which the Boston man said was to be added to his house after it was built. Yet the engineer-architect in planning such a building had to consider the final effect of the structure, and base his plans accordingly. When effect was thus considered as against mere utility they had art. Like considerations should, he contended, govern all engineering structures, and point to the necessity for artistic training in the engineer. He had often said that the connection which existed between art and science in a structure was very similar to that which existed between the skeleton in the human body and its clothing in flesh and blood. The skeleton was the structural, say the engineering, portion which gave strength and rigidity to the whole, and the muscular clothing was the artistic portion which made the rest
agreeable to look at. But the pleasing and artistic proportion of the skeleton governed the effect of the whole figure.

He had insisted that boys in the Junior Technical Schools, who intended to become engineers, should have some instruction in decorative design, and more particularly should study the effect of agreeable proportions in surrounding objects. They were asked such questions as "Why were windows rectangular instead of square?" They were shown the effect of square windows upon a building, instead of windows of the usual shape, and thus there was impressed upon the boys' minds the value of proportions in producing a pleasing or an objectionable appearance. He thought that he had spoken long enough, but the point he particularly desired to make was the necessity for some modicum of artistic training in the course laid down for engineers.

Mr. S. N. Rodda,* said it was a privilege and pleasure to have listened to the paper by Mr. Clark, and to the subsequent speakers. The Working Men's College, in which he was more particularly interested, was the training ground for a great number of engineers; but the trouble of training engineers was not so great with them as the trouble of finding material to train. He found the ambitious parent came along with the willing son, and drafted him into the Engineering Department, whereas he should have been placed, for instance, at wool classing, or blacksmithing, or something like that, and at the end of the year they found a big wastage. As far as the preliminary work was concerned, if the student was 16 years old, and had reached Junior Public standard or equivalent, he was good enough material for them to work on. Twenty per cent. turned out very good men, i.e., the survival of the fittest.

One point which had been touched upon was the lack of commercial training, whether in connection with a technical school or the University. This was brought home to him every day. He found almost every specification put in by a young man was bad. He would miss points from start to finish, and very often would lose a good job simply through inability to write what he wanted to say. He knew what he wanted to put in a job, but had no knowledge of getting out the cost.

* Principal of the Working Men's College.
As far as the up-to-dateness of the training was concerned, they tried to do all they could at the College, and were bringing in this year what was a very good thing, giving effect to a suggestion of Mr. Clark's, that they should create a series of faculties, or advisory boards, for the different departments, and the Council would call upon the Institute to appoint two or more members to act on the engineering advisory board; and, with their assistance, they hoped to keep the Engineering Department still more up-to-date, or a little ahead.

Mr. J. Sarvaass* thanked the Institute for the invitation to attend. Unfortunately he had not received it until he reached the lecture room of the Working Men's College that evening. Consequently he had not actually heard Mr. Clark's paper read. He felt, therefore, that, in speaking to the subject, he would probably wander off the track, and he did not want to inflict upon them a dissertation of his own on the subject. He thought it was a matter of serious necessity that they should organise the engineering training better. They wanted better co-ordination between the University and the technical schools. They wanted the highest talent they could get in specialists in modern instruction. And they required to have an arrangement with the University to bring about co-operation with the schools for receiving the boys who were technical students.

About 70 per cent. of those who were trained engineers—municipal, water supply, surveyors, mining surveyors—had been trained outside the University. The other 30 per cent. had gone through the University. He had deduced these figures from official returns which he had had occasion to analyse some time ago. The reason was simply that the University had never been in touch with the other engineering bodies. Many students left the secondary schools, and proceeded to the University, understanding that they would be qualified to enter, upon securing their degrees, upon all private practice. But they found they were blocked—and he thought properly blocked—because they had had no practical experience, and in many cases the law required that they must have had practical experience before undertaking public works. When he himself left the University, he discovered

* Head of Engineering Department, Working Men's College, Melbourne.
this. He entered an establishment to acquire experience, and at the end of his term found it to his advantage to assume the duties of an engineering lecturer at Bendigo. But he found that, to undertake any work in connection with civil engineering and mining surveying, he would require a mining surveyor’s certificate; and he could not get the mining surveyor’s certificate until he passed the lands surveyor’s examination; and they would not give him that certificate until he had practical experience. Therefore he obtained the mining surveyor’s certificate. It took him about six years, subsequent to his University training, before he could fit himself for the work of his life.

It constituted a long procedure, and either the University was at fault or the Engineering Boards were at fault. He was inclined to think the University authorities had been at fault, so far, in that they should recognise—and they did not recognise—men who had gone through the municipal work, and were quite competent to proceed to the University for degrees.

He thought many young fellows went into offices and got their training practically, and then attended a technical school and obtained their theoretical training; then, at the end of about four years, they present themselves for the municipal examination, and if they passed were in a position to obtain employment. But what was to prevent the University accepting those men to graduate at the University, without requiring them to pass the entry examination? In that way they would be qualified, and the University degree would reach the highest standard of recognition, as the highest hall-mark a man could possess in engineering, a consummation which they all desired to see accomplished.

The University course had only this value, as far as the privileges it conferred were concerned, that it somewhat reduced the amount of practical experience a man had to put in with a practical engineer, and it also exempted him from certain subjects in the legally established municipal and other examination. But in after life the great breadth and comprehensiveness of the University training, must tell as far as its influence on the individual was concerned. The University was deficient at the present time in the opportunity for a man
to get practical experience. How it was to be remedied he did not know. It was for engineers and the University authorities to collaborate and decide.

Mr. J. N. Reeson said he had listened with great pleasure to the paper, and also to the remarks of the different visitors. Most of them, he thought, were the teachers of engineers. Perhaps it would not be out of place for one who had the good fortune to employ young engineers to say a word or two on the subject. The question of training, as had been mentioned, was one they could discuss at very great length. Speaking as one trained in England, and a comparatively new arrival here, he would not like those members present who were Australian trained, to gather from what the President had said that the training of engineers in England always followed on his own unfortunate experience. He might say, the President must, judged from after developments, have made very good use of his time when he was outside the works.

It seemed here, from what he had heard of the remarks of the previous speakers, that the question of works training had been somewhat lost sight of, and most of the remarks had been in the direction of either technical school or University training. In England they had endeavoured, for some considerable time, to combine the two; and he thought, perhaps, the most valuable remarks, from his point of view, had fallen from Mr. Green. Elaborating that point of view, i.e., the course of study at the Armstrong College, the same course was followed by the Central Technical College of South Kensington, where they had a very good preliminary training for engineers, after which the budding engineer was drafted to the works or office, where he completed his training. There he was able to obtain workshop practical experience, which seemed to be unfortunately lacking at the Melbourne University. It was quite true that a man entering the University, assuming that he commenced at 18 or 19, was at the time he completed his course (and he ventured to say few of the students here completed their course in four years), absolutely unfitted for workshop experience. It was, after that age, against the grain. The student knew a great deal too much then to take off his coat and learn something from the
fellow who wielded the hammer. And so they got men here who were most excellently trained in all theoretical subjects. They could solve problems that would leave him cold, and also out in the cold, but would pass by a most elementary mechanical device which was out of order, and not notice that it was out of order. This was a state of things that was lamentable. What they wanted to do was to combine the theoretical and the practical. And it was difficult to say which should come first; they might almost say that the lad, on leaving school, was at the best time for doing practical training. But by the time he had finished his practical training he had forgotten all he knew about science subjects, and it would be quite impossible for him to pass even the earlier examinations at the University. From what he had seen, those earlier examinations were often the stiffest, and rather than encouraging the young engineer, they seemed to discourage him. The fence was so stiff that he had the greatest difficulty in getting over it, if he got over it at all.

Mr. Sarvaass had hit the nail on the head when he said, what was the use of the University degree? He was beginning to think they all wondered what use it was. Mr. Sarvaass had told his experience, and it probably was not unique. At any rate, one did wonder what became of the graduates in engineering that were turned out by the University. He knew of many who had never practised, and were never likely to practice. That was a very serious matter, and one that ought to be thrashed out. They ought to come to some conclusion on the subject. He did not think the way was through technical schools entirely, nor through the workshop entirely. Some combination of them was essential; and then the problem was to devise some means by which they could combine the technical training with the theoretical.

Mr. W. N. Kernot said several things had been stated, and as he was there to some extent as the University representative, he would ask to be permitted to comment upon certain of them. First, he would ask Mr. Green whether his remark as to lack of practical training at the University, referred to all the engineering courses at the University, or only to the Mechanical Engineering course?
Mr. Green said he had not been thinking of any particular grade when he made the remark.

Mr. Kernot said in that case he could not agree with the remark. Out here there was not the possibility of working in the shops that there was in England. The position was entirely different. If they were to discuss the question of training the mechanical engineer at the University it would open up a good discussion. There was a tremendous amount of practical work done that Mr. Green was not aware of. The student had very little time off during the whole year.

In answer to Mr. Sarvaass, in training up a student in a special phase of engineering, it was not reasonable to assume that the student thereby acquired privileges in other phases of engineering. Out here there was very little private practice. The Government did nearly all the work.

As to the question of the usefulness of the degree, nobody was going to say the degree was good if the man had passed the examination, and he could not back up that certificate by his work. Ever since he had been at the University there had not been the least difficulty in getting positions for students. If they could turn out twice as many, he believed they could place them all, and in equally good positions.

In connection with the student being able to get through the examination, it was easy for the student to get through the Government examination, having obtained the University degree. They allowed him to get through with very modified work. If a man went out as a mechanical engineer and then wanted to change to something else, of course he must do the work necessary for that purpose. It would be nice if they could turn out the men so that they could do everything, but it would be rough on the community. It was unreasonable to expect that the men should be turned out in that way. A man required very little practice for the surveyor's certificate now. There were great concessions made to the graduates.

There was a form of art in connection with engineering, and he would like to bring some example of it under Mr. Carew Smyth's notice, viz., the design of machinery, the proper proportions, etc. Take the frame of a machine. Men gave tremendous attention to the proper shape of the casting. They
would look at a piece of machinery and say at once, "That was designed by an amateur," or "That designer knew what he was about to get that good shape." In connection with the design of machinery in correct form, and the design of parts, there was a great deal of work done for which perhaps engineers were not getting the credit they should get.

The President said he had expected to hear some remarks on the apparent overlapping of the functions of the technical schools and the University. When there was money spent mostly by the Government on educational work, they should get the highest efficiency. Both those Institutions had workshops on which large moneys had been expended. It seemed inefficient to have two institutions, both with the same object in view, having spent large sums on separate workshops. It was a matter that should have careful consideration. He would ask Mr. Clark to reply before declaring the discussion closed.

Mr. JAS. ALEX. SMITH said if the President desired a formal motion for the continuance of the discussion, he would be happy to move it. After the paper was printed in the usual course, he was sure that members would desire to pursue the discussion further.

The President asked if it would be possible for Mr. Clark to attend at the next meeting?

Mr. CLARK said he would prefer that the subject have the fullest discussion. In the interim he would offer a few remarks upon points which had been raised that evening.

He could not say what his engagement would be at that time. He would like to have a fairly full discussion on the matter, as it was a question of vital importance. One liked to be guided by the expert opinion of the engineer rather than by schoolmasters. He thought they should be able to get practical results. No doubt the schoolmasters would like to have the approval of the engineers. Perhaps that approval might be given in a formal way without asking what is meant by approving.

As far as the discussion, so far, was concerned, there were not many points to mention.
As to the overlapping, he did not see how that could be avoided, with the University stipulating certain qualifications. That meant that a great many would be excluded, though they had been catering for perhaps the highest intellectual attainment. They might get a man with strong mechanical ability and yet he might not have that academic knowledge which seemed to be required by the University. So that in any case, since those men came to the workshops they must keep the technical schools open. The technical schools catered for those who tried to get their workshop experience in with the work done at the college. He did not think enough mechanical engineers had gone through the college to enable it to be judged what would become of them. He quite agreed with Mr. Kernot. He saw no reason why the University should not be brought into contact with men in actual practice, so that the student might get actual practice in some way.

There were a good many other matters that might be discussed, and probably if the paper had been perused some of the points would not have been raised. He advocated a system of giving about half the time to the workshop and half to the University. He was dealing rather with the local problem. The conditions were not the same as they were in England.

The President thought it was advisable to postpone the discussion until the paper had been circulated. No doubt there would be further discussion. He would like to take the opportunity of presenting to Mr. Clark the formal vote of thanks for his very interesting paper.

The vote was carried by acclamation.

The President said there had been circulated a list of papers that were likely to be read during the session. He hoped members had taken note of the very interesting subjects. They had a great amount of material, some of which was now ready. At next meeting they would probably have at least two papers by Prof. Hy. Payne on "The Influence Line" and "Non-Axial Distribution of Stress," and possibly a third by Mr. Jas. Alex. Smith on "A New Method of Determining the Density of Flue Gases."

At 10:25 p.m. the meeting closed.
the American Society of Civil Engineers, the Photographic Society of Victoria, etc.

Mr. Mais died on February 25th, 1916.

DISCUSSION.

THE TRAINING OF AN ENGINEER.

(Paper by Donald Clark.)

Mr. T. D. Anderson* sent a written contribution to the discussion as follows:—He had just received his copy for the “Proceedings” for May, and he was very sorry he had been unable to be present when the paper was read, or to hear the discussion thereon. He had to apologise for his absence from the present meeting also. The technical training of engineers was a subject on which there was a great diversity of opinion, and one on which engineers, and engineers alone, should be the advisors. Mr. Clark had truly said that the engineer had been satisfied to leave the preliminary training of engineers in the hands of the schoolmaster. It was pleasing to see that the Institute as a body was now going to take an active interest in this matter. Mr. Clark was to be congratulated on the manner in which he had brought the matter before the Institute.

There was one aspect which Mr. Clark had not touched, and that was the case of the boy at present in the workshop. He had dwelt on the University student at length, and touched on the junior technical student and his future, but in the technical schools at the present time the difficulty was with the boys who were actually engaged in the workshop. The average boy left school at 14 or 15 years of age; he entered a shop as an apprentice under the usual conditions; he had little to encourage him during his hours of work, and, very often, too little to look forward to in the future. In most cases the parents of these boys could not afford to give them a technical training, buy books, pay travelling expenses, and keep them during the early years of their apprenticeship.

*Head of the Engineering Department, Castlemaine Technical School.
When the boy became able to go to evening school, he had contracted other engagements; or upon entering the school he found that he had forgotten nearly all he had ever learned at the primary schools, and could not follow the work in the technical school; the result was that he became discouraged, and drifted away. This was a source of wastage in our technical schools.

The present system of apprenticeship was altogether wrong, and the attempt was made to make many boys engineers (?) who were totally unfitted for that career, and should have been at something else. An employer wanted an apprentice, and in many cases he got a boy he knew nothing whatever about; the boy had to get work, and stepped into the first opening, whether he was suited for it or not; the result was—good farmers had been made into bad mechanics.

Now, the obvious and only remedy lay in the establishing of technical schools, junior and senior. In the junior school the sifting process would be done, and boys would be drafted into spheres for which they were most adapted. For instance, if an employer required an apprentice fitter, a student would be sent to him who had the three essentials for the making of a skilled artisan, viz., inclination and ability, character, and education. There was a right place for every boy, no matter what his capacity was; if he had not the mental capacity, he should be trained physically, and not be allowed to drift. This applied not only to engineering, but to all other trades.

In conclusion, he should like to see this matter taken up earnestly by the Institute, and would like to suggest that steps be taken to call a conference of the various Institutes concerned, together with the University, Education Department, and Technical Teachers' Association, so that a firm foundation might be speedily laid, from which an efficient superstructure might be raised.

The President said there was one point he thought had not been touched upon, and that was the fact that Great Britain was behind most other nations in regard to its system of weights and measures. They had heard a great deal in the past about the necessity for introducing the decimal system of weights and measures, but true to her conservative prin-
ciples, she had hitherto refused to adopt it, except in certain cases. In the last few years engineering works had in their drawings and blueprints abandoned the method of measurement by feet and inches, and had used feet and decimal parts. Perhaps that was the forerunner of a proper decimal system. The educational establishments should endeavour as far as possible, to introduce the metric system in all their measures, to make their students used to that system; give up measuring temperature in terms of Fahrenheit; and give up the binary systems. All those measurements were doomed, and the sooner the British Empire recognised that and placed the matter on a proper basis the better for the prosperity of the country. The technical classes at the University could do a great deal in teaching students to take their measurements by the metric system.

Mr. J. T. Noble Anderson said, during the first twelve years of his professional life he had spent fully half his energies in training and practising young engineers in their profession. A couple of hundred engineers had passed through his hands, some of whom were holding high positions in Australia and the Empire. Consequently, he claimed to speak with some experience. He had also discussed the subject with such men as the late Lord Kelvin, George Fitzgerald, and the late Professor Kernot, one of the Institute Past Presidents.

One thing that had struck him in the discussion was that they had been rather vague in what had been said. They had to a great extent mixed the training of an engineer with the training of a mechanic. They ought to aim at training something very much higher than a mechanic. He noticed several had spoken of the necessity of acquiring the practical work of the profession before the lad was 16 years of age, because afterwards he had a great impatience for it. That certainly would apply to the mechanic. In mechanical schools in Great Britain at present they found it necessary that the children should enter the workshop as early as 12 years of age, so that they would not find the mechanical labour of the work irksome. But so far as the man who wanted to rise to the ranks of the engineer was concerned, he thought it made little difference to him whether he acquired his practical
training before or after his education, because his whole mind was bound up with his profession, and the practical work that he did meant no more labour to him than the act of walking meant to a tourist walking through beautiful country. He was an engineer first, and his natural tastes and desires were drawing him in that direction. Undoubtedly it was very important that he should be under the best teachers as early as possible. What he learned to do with his hands was something he taught himself rather than something he was taught. The mere manipulation and tricks of trade could be learned at almost any time. But the taste for the profession must grow with him.

It had been said that if a student did his manual work before he was 16 he would thereafter not find the work distasteful. That had not been his experience at all. He had met a great number of Whitworth scholars (who from the conditions of that scholarship must have been early initiated into the workshop), and he could not recall a single one of them who bothered himself to do any manual work if he could avoid it. He had attacked that part of the subject first, to show that in the minds of the speakers there was largely not the education of the engineer, but the education of the mechanic. The two things were distinct and apart.

Some 12 or 13 years ago he had written a presidential address for this Institute on "The Standing of the Engineer," in which he made the point that the engineer's standing depended upon his value to the community. Since he left off teaching, it had come home to him more than anything else that they must not raise rigid bars against the entering of juniors into the profession.

In connection with that, when he left the University and went into practice, the first thing the late L. L. Macassey said to him was, "Engineering is not a science; it is an art." He drew this distinction: science was a thing they could know all about; and art was a thing they must know how to do intuitively. They acquired the practice of it, as a musician acquired the practice of a violin. A man must be expert in both the science and art of engineering, to be any good as a professional man. There was all the difference between knowing the theory of the profession and knowing how to do-
it—the latter was as important as ever. Of all the teachers of engineering he had met, the most successful—the one whose students had been men of note—was Professor Maurice Fitzgerald. He taught the science of the profession in the lecture-room, and he loved to give his pupils the stiffest nuts he could to stimulate them to greater efforts. He had worked through the workshops of Easton & Anderson at Perth, after his own University course was closed; and he always made his engineering students take some good piece of work by a good engineer, and follow it out, and discuss every detail of it. Each student during his course had to thoroughly master some good piece of work. Whatever it was, he would get into touch with the engineer carrying it out, and get the full details, and make his students discuss it, just as if they were in the chief engineer's own office engaged on that actual work. They should encourage the students to take a comprehensive view of the theory of the subject, and then follow on with the practice of it. To be a thoroughly successful engineer they must know something about every branch of engineering, and everything about some one branch of it, make themselves masters of some one thing, and get as wide a knowledge of the profession as possible. He would deprecate speaking of the engineering school as "the shop."

He knew that several members of Institutes had been circularised by the Carnegie Institute to give their opinions on engineering education. They divided under eight heads the different qualities they would give prominence to. Each of those eight qualities—such as administration, business ability, tact, knowledge of the world, etc.—was to be given its relative value. Something of that sort was wanted, but going into the present desultory discussion one was oppressed with the thought that they were a very long way from having got to the bottom of the subject.

He would like to say something, too, of the possibility of turning out engineers in directions that, so far, Australia had done very little towards. He thought it was quite feasible that they should turn out men capable of taking their places in the highest electrical or mechanical sections, without having been educated in Britain. If they had their teachers in sufficiently
close touch with such men as Dr. Merz, so that they could get from those men at first hand their working drawings, they would take their students a great deal further on than they did at present. As things were, after a student had spent a good while here he went abroad, and it took him some time to get into the stride there—and much valuable time at the most critical period in his career was wasted before he got his feet securely on the ladder.

Mr. JAS. ALEX. SMITH said he wished to add his meed of appreciation to the words already uttered in regard to Mr. Clark's paper. The communication certainly impressed the reader as sane, sound, and wholesome in tone. That was to be expected from its writer, since he had had not only academic, but commercial and professional training in engineering, and was now the administrative head of the technical education branch of the State Education Department of Victoria.

On many points—on most points—he was in accord with the views of the writer. In fact, many of the views came to him as a reminiscence or echo of the past, since Mr. Clark had independently, and upon other grounds, arrived at the same conclusion which he (the speaker) had had the honour to submit to the Institute in presidential addresses* years ago. He had not changed the views he had then propounded. Time had strengthened them. He could not better express his present opinion than by adding to the current contribution to the discussion quotations from his previous papers.

The author placed as his first essential, the premise that the training was intended—

"1. To fit him to be of service to his employers."

He did not think he could endorse the apparent spirit of that premise. Certainly an engineer must give value for money. Certainly he must give effective service. But he was not a servant. He should not be considered merely as a subordinate to others. He thought there had been a tendency to so consider him in the discussion; but he thought that was not the

interpretation placed upon the term “engineer” by that Institute. His own definition had been, in referring to engineering guidance, thus:

"An urgent need will emphatically be men—well trained, fully trained men—not merely material in replenishment of generation to generation loss. That suffices when population and requirements are in equilibrium, when advance is slow. The need is for men trained, fostered, destined to open up new fields, to build a Commonwealth from its foundations, to be the brains, light and leaders of a population unknowable in older countries.

"Of men for the relatively lower grades there always will be a sufficiency. Of the best human material for all grades there is no dearth. But the work of administration, the higher functions of the engineer, upon which the progress of a State intimately depends, can only evolve as it is essential that they should evolve when the material has been made in all things equal to the contemporary material abroad.

"Upon training and the opportunity for training all depends. In the haste of attention to lesser matters of immediate interest much is undergrasped, forgotten. It is inexplicably difficult to secure continued recognition by administrations of the elementary fact that the engineering issues are now of such magnitude—growing magnitude—that in a working lifetime a variation of even one—it may be many—per cent. from the world-set standard of competitive engineering efficiency spells a saving or loss of millions sterling. We know that the loss is real and avoidable, the gain possible; that one per cent. does not begin to express the effect of the personal equation; but how slowly and expensively others are learning the lesson."

That, he thought, was the type, that the ideal, the great Universities should have in mind. If engineers did not always see eye to eye with those administering those seats of learning, if they criticised, it was because they wished the Universities well, wished to see their graduates recognised as men of the highest standing, and wished to assist them in their efforts to fulfil their function on the highest plane.

And this Institute could assist. It had a power, corporate and individual, that many of its own members did not fully recognise. Years ago the then Professor of Engineering, the late Professor Kernot, was called upon to train engineers in a school deficient in every requirement of modern practice. His school was starved in every essential. The Professor, from his own pocket, had himself contributed to somewhat better the conditions. If ever man was called upon to make bricks without straw, that man was Professor Kernot. He (the speaker) had brought the matter forward in a presidential address. Then he had waited upon the then State Premier
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and upon the Treasurer, and, after a surprisingly cordial interview, had received an intimation that funds to the extent of £30,000 would be forthcoming if the hands of the Cabinet were strengthened by the Engineering Profession and the University.

But, in the interim, Prof. Kernot had passed away, and was denied that opportunity he had so long awaited, and had so well deserved. But the work went on. The University consulted the Institute, and they advised thus:—

Melbourne,
22nd June, 1909.

"Dear Sir,—

"In order that the assistance which the Committee of the University Council desires me to render shall be, not only cordial, but representative of engineering opinion, the Council and leading members of this Institute have been consulted, and the subjoined precis has been drafted. It embodies the views on the present situation of the Victorian leaders of the professional sections of:

Civil, Mechanical, Electrical, Consulting, Manufacturing, Municipal and Shire, Railway, Hydraulic, Naval Chemical, and other branches of Engineering; also Engineers engaged in technical education.

The following precis is submitted with a full sense of responsibility, and of the fact that any action taken now will markedly control the future of the Engineering profession in Victoria, and its efficiency in relation to public and private interests for at least a generation to come."

"B. (i) It is eminently advisable to remodel and greatly extend the sphere of usefulness of the Engineering School. 
(2) This course is obligatory if the Mechanical and Electrical degrees are to connote serious tuition in those branches, and if the diplomas are to have an intrinsic and commercial value.
"C. (i) If Mechanical and Electrical Engineering are to be taught the equipment must be greatly extended."

"G. (i) The training given should be strictly correlated to the actual duties to be subsequently performed. 
(2) In view of the extremely limited time available to the student, non-essentials should be minimised to the lowest point compatible with a liberal education. 
(3) Matters which are essential, such as mathematics and some of the physical sciences, should not receive disproportionate attention. They should be imparted with a due recognition of their true perspective in actual work.

"Now, or later, the experience of the members of this Institute is freely and fully at the service of the University, but my present authority to unreservedly advise is subject to the preceding views, with which I fully concur.

Yours very truly,
(Sgd.) JAS. ALEX. SMITH,
President, V.I.E.

"T. S. Hall, Esq., D.Sc., etc., 
Acting Registrar, The University."
A new Professor was appointed. Deputations from the Profession and the University waited upon the Minister for Education, and Prof. Payne was placed in possession of funds which enabled him to establish an Engineering School, of which Victoria need not be ashamed.

He did not think that this or similar discussions were unprofitable or vague as Mr. Anderson had seemed to imply. They influenced the right men. In the past they had borne most excellent fruit.

Passing from that phase to Mr. J. T. N. Anderson's question as to whether engineering was an art or a science, he would submit that it was both, and more, and would again quote himself in support:

"What, then, is engineering? A trade? A profession? An art? A science? A philosophy—statecraft? Something of each, and now—as always—one of the most potent executives of progress, the catalytic activity which materialises abstract thought into concrete accomplishment. To excel in the connection of the components of engineering, to connect each with each, and all with the economy of the State, the engineer must be more than engineer."

Those were the points they must bear in mind in training the youth to be, not simply superior mechanics, but engineers; for engineering in the full sense was far higher and deeper than a mere memorisation of theory and data, or a mastery of technique.

Another matter that had arisen in the discussion was Mr. Kernot's statement that the University engineering curriculum was largely controlled and limited by the requirements propounded by the Institution of Civil Engineers of London as an essential condition to its receiving the University men as student members. He accepted that statement as substantially true. He had the highest respect—as what engineer had not?—for the Institution of Civil Engineers of London, and the greatest cordiality towards the University. He held, however, that the function of the University was not to train men to fit them for membership of any body of specialists, however influential, but to train them for the pioneer development of a Commonwealth in which the conditions were essentially different from those in Britain. Further, in Britain there were in addition to the Institution of Civil Engineers, the Institute of Mechanical Engineers, the Institute of Electrical Engineers,
and other bodies, all on the same level, the members of which differed not one whit in breadth of training, ability, or status. There should be no question, then, of ignoring any one of the three great co-equal branches of the engineering profession.

Here, University effort had been concentrated upon the "civil" side, and one might state, as a generalisation, that all the very able mechanical and electrical engineers—he, of course, referred to professional engineers—who had risen to fill the highest positions, had been trained outside the University walls.

It had been a misfortune that the University had not earlier undertaken the effective training of those classes of professional men. This omission, and the popular feeling that none other than civil engineers so trained could be professional engineers, which had been allowed to grow, had denied many young men suitable careers, and had gravely tended to retard the development of national primary production and the establishment of industries:

As the time for proceeding to the next business had almost arrived, and as others might desire to speak, he could not read the further quotations from previous papers he desired to lay before members.

The quotations referred to are as follows:

From "The Engineer in Australia: The Pioneer of a Continent" (1909)—

"The immature youth cannot grasp the concept that there are phases wholly beyond his ken; he is in the hands of his teachers. With each increase in maturity new outlooks are revealed, new meanings found hidden in that which was obscure. He finds that his profession is not a cold abstraction, but is a living ever-strengthening strand in the scheme of human progress. He learns that to master engineering he must have studied human nature. He finds that the qualities and training which foundation eminence in the engineer are of the same order as those which are essential in all the other higher walks of life. Too often, also, comes the knowledge that what he has learnt has no direct reference to his career, that essentials are wanting, and that he has much to unlearn.

"Much special administrative attention and privilege have been given to some professions—little to engineering. How relatively little is realisable when it is recollected that Australia has no national physical or engineering laboratories, no public means for pursuing research.

"Were those who, with all good intent, secure the continuance of these methods, to look out upon the world with
seeing eyes, they would recognise that the obliteration of individuality, of originality, by the stamp of a common mould is fatal. That engineering is not 'static,' not formula, not a fixed finished science, but that it is everywhere advancing by intelligent weighing and compromise—as regards methods, material—between diverse advantages, conflicting interests, conflicting policies. To be of real advantage the preliminary education work must realise this; must be in complete consonance with the wants of the times and the predictable needs of the future.

"There is much that cannot be replaced, and must be copied, in the older methods of individual training under intrinsically competent men in office or works. Then tuition and the immediate fixing by application of tuition under conditions of responsibility—but always subject to watchful, critical check—progress simultaneously, and a profession is learnt as a native tongue is learnt.

"Britain—and later America—has been the object-lesson of the world in inculcating the eminence that developments based upon engineering can bestow.

"The classic Universities, the public schools of England, have not appreciably directly assisted—it is not implied that they should not assist. Magnificently equipped and staffed technical colleges have been established, and are recognised as indispensable aids, but not, as there is a tendency here to regard them, as all-sufficing.

"Searching below the surface of things, it will be found that there is a determination in Britain to use all educational means as aids to engineering supremacy, but an equally forceful determination not to permit an abstract academic training to become the sole avenue of approach, not to jeopardise in one jot the supremacy that has been built upon the axiom that engineers can be trained only in the school of responsible work, and that by their work they are known.

"Throughout history the natural, unforced guiding of youth each in his sphere, each in his full degree, by competent men, and in contact with the conditions to be perpetuated, has been the basis of stability of dominating cults and professions.

"The layman, however eminent in his own sphere, cannot adequately comprehend these and other requirements of engineering education; Engineers alone can fully know them. Upon them they should speak direct, not through intermediaries between whom and themselves sufficing channels of thought communication do not exist.

"We are not wise in accepting any decision upon the issue of education except upon the broadest representative lines laid down by the broadest minds. We have not been wise in tolerating policies which tend to retain the profession on a plane of importance and influence lower than its merits require and progress demands.

"Neglect has permitted at this late stage this dilemma: If essential branches of engineering are to be operative in
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effecting development here, and if the men are to pioneer the work, the special skill must come from abroad, or local men must be sent abroad for training.”

From “A Plea for Breadth in Engineering Thought and Plan” (1911)—

"Unaided, technical training of average men can but assure their competence to deal with average conditions in an average way. The basis of the training implies that some inherently capable of higher flight will be retarded, that repetition takes precedence of originality; that a reasonable average capacity in the many, rather than the fostering of individualism in the few, is the end desired.

"Necessarily all educative processes contain, as well as an element of advance, an element of retardation, unavoidable, justifiable by the public policy, which requires that the world’s work must go on, although the bulk of that work is soulless routine.

"There must be a training for the ranks, an ideal of plodding. Perhaps it is unavoidable that some machine-made, machine-like characteristics may result.

"It is also, sometimes, overlooked that centres of education are centres for the distribution of learning rather than, in engineering, sources of learning, and that the real work of the world is originated outside the doors of the school, in the cruder, but no less crucial, domain of office and shop. Academic knowledge, without a complete knowledge of economic wants and applications, may be as ineffective—perhaps may be more ineffective—than a ‘practical’ knowledge of effects without a recognition of causation.

"So far the generic term engineer has been used. Properly applied, it covers engineering in all its professional phases, but there is a discernible local tendency to restrict its significance. Because of that narrowness of view the State has suffered heavy loss.

"Mechanical engineering is a materialisation of the highest physical science, it is at the root of manufactures. Had this been grasped, had mechanical engineers been earlier accorded full facilities to attain the highest training, then a class of professional men would have been constituted who could have found their career, their life’s work, only in the development of all that goes to the manufacture of a nation’s products. They must have become the apostles of industrial development.

"Had it been recognised that the material side of warfare—naval and military—is but a complex problem in mechanical engineering; that the victories to come will be as much victories by engineering as by courage and strategy; that the battles of the future are being lost and won, now, in foundry and workshop; that a single idea evolved in engineering laboratory or works may revolutionise—as it has revolutionised—the relation of great powers; then the place of the mechanical engineer in Australian defence, and the effective preparation for defence, would have been better appreciated.
"Had mechanical engineers not been ignored, there would have been unity of railway gauge throughout Australia. Because he has been ignored it was possible to say, 'we cannot manufacture locomotives, we cannot build ships, we cannot produce steel in Australia.'"

Mr. J. BORRIE said there was one paragraph in Mr. Clark's paper that had struck him. Possibly it was presumption to criticise it, but was the civil engineer receiving as full and adequate a training as it was possible to crowd into the four years' course? The reason why he mentioned it was that the course had been brought specially home to him through his son having recently passed through it, and it had occurred to him, in watching his son's training, that the work he had been getting was not the best for practical purposes. He thought it was too theoretic. Taking part of the work during last year, his son had spent a great deal of time in designing a turbine by theory. He knew the drawing was good, and the calculations were good; but of what practical use was it to write up 90 pages of calculations and comments on a turbine? How many young fellows were going to design a turbine in practical life? That time would have been more profitably spent in other directions. If he had had to design and lay down a hydro-electric works it would have been much better. The architectural work his son had to do was mostly house-planning—how to make an economical house. If the whole theory had been laid down, including the building, and after he had performed his work on it, criticism had been passed on it, and it had been handed back to him, it would have been much better for him.

There was another class of engineer for whose training he did not think enough provision was made—the industrial engineer; the engineer whose work dealt with our manufacturing industries. He did not think the industrial engineer had been recognised in the past as he ought to have been. His training should be given the same weight. First of all, he must be a mechanical engineer, well versed in the use of steam and ventilation, electricity, refrigeration, building design, including reinforced concrete, and the general layout of factories. He needed a good commercial knowledge, not only of correspondence, but he also must have experience in buying. He must understand the facts about insurance on
the work he was to lay out, and, above all, have an intimate knowledge of the industry in which his work was being done. There was no provision made for training a man like that. He had problems to meet that were very difficult to deal with, and if the industries of the future were going to progress as they should, there ought to be something done to help the manufacturer. No class of men had set themselves out to take a grip of the industries and become fully proficient in all that was required to help on those industries.

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**PAPER.**

**THE INFLUENCE LINE.**

By Professor H. Payne.

When the designer has to consider problems connected with travelling loads, he can approach the subject by various methods. In every case he desires to obtain data upon which he may base his calculations as to sizes for the particular work under consideration.

It is now generally conceded that a carefully drawn or graphical solution possesses quite sufficient accuracy for design. If a proper choice of scales be made and reasonable care in draughtsmanship be exercised, the draughting error need never reach 2 per cent., even after several successive graphical operations; any error is not greater than the same order of magnitude as exists in the variation of the physical properties of constructional material obtained in commerce.

To obtain a graphical solution the designer must perforce set out the problem on the drawing board to acquire such data as will enable him to take into account the varying effect of the moving load system in producing stress and strain.

The influence line is a graphical method for studying variations of stress and strain arising from the action of a moving load system.

**DEFINITIONS.**

A curve drawn to exhibit the effect or influence produced by a single moving load, during its passage over...
The President said they had listened to an interesting paper on a subject on which Mr. Anderson was recognised as an expert. He would ask members to show their appreciation of the paper by passing a vote of thanks to Mr. Anderson. The vote was carried by acclamation.

The paper was partially discussed, and the further continuation of the discussion postponed until the next meeting.

At 10.20 p.m. the meeting closed.

DISCUSSIONS.

THE TRAINING OF AN ENGINEER.
(Paper by DONALD CLARK.)

The President said that the discussion had already run through two meetings, and it was hoped that at to-night's meeting they would be able to complete the matter, as there were other papers to be read, and they wished to avoid congestion. He had to apologise for the absence of Prof. H. Payne, through indisposition. He had intended to take part in the discussion, and had sent a written contribution, which would be considered in consonance with Rule 64.

Mr. A. E. Hughes said he had listened with great interest to Mr. Clark's paper, and he thought, if some of the author's suggestions were accepted, it would be greatly to the benefit of those who instruct engineers, and also to the advantage of the students themselves.

It seemed to him that the problem they had to face was this: That if Australia was to occupy its proper position, it must develop into a manufacturing community, preferably manufacturing those lines the raw materials of which were at their doors. Therefore the necessity devolved upon them to train—to educate—the industrial engineer rather than the higher theoretical man. In reading through the paper, it struck him that it was presented to them more from the schoolmaster's aspect—that the practical portion of the engineer's training was rather lost sight of. Mr. Clark had made one suggestion that was very good—that at 12 years of age lads should be drafted from the ordinary primary school to the junior tech-
nical. The result would be that, if the lads continued at the school from 12 to 16 years of age, they would then have a fair idea as to what future career would best suit them. Then at 16 years of age, he thought it would be better for the lad to be apprenticed at an ordinary works, making it compulsory for him to attend a senior technical school. It was quite possible, as an addition to the necessarily restricted training that he would get in a large commercial factory, to sandwich in a certain amount of commercial and theoretical training, and when his apprenticeship was completed he would then be a useful engineer.

On the other hand, take the lad trained in a University. The course generally averaged five years, and during that time the practical work rarely amounted to more than six months, distributed over the five years in periods of four or five weeks. Thus when his course was finished he had largely forgotten the practical work he had learned in the earlier periods. Experience had proved, without doubt, that if a lad did not enter the workshop until 21 years of age, he was very much out of touch with the work. He objected to the "rough and tumble" life of the workshop. His mind was less plastic, and he did not enter into that sympathetic relationship with the workmen as he would have done at the earlier age. He had developed ideas of his own as to the character of the workmen; and he found that the ideas he had gained rather led him to think that the workman was not competent to teach him essential portions of the profession.

Then he had had a very expensive training. The lad who went to the University was the lad whose parents were in a position to spend the money. He had finished his course, and naturally expected to get remuneration in keeping with the amount spent upon his education. He went out into life, and found, when he looked for positions, that he was deficient in the practical portion of the training. He had a very fair theoretical knowledge, but scarcely any practical workshop experience; and he lacked one of the first essentials an engineer should have, and one that could only be gained in the workshop, and that was knowledge of the handling of men as well as the handling of materials. It had been proved in many cases that an average of two to three years' practical
workshop experience was necessary to fit him for an engineer's position. On the other hand, the lad who had been apprenticed from 16 to 21 years of age in the workshop had had a thorough practical training; he had become a good mechanic; he had worked with the older workmen, and understood the views and individual idiosyncrasies of the workmen. The lad in the University had not had those advantages, and hence when he came to deal with men and labour he found himself handicapped, because he lacked the essential experience that was necessary to so deal with them that he would get the best out of them. He was deficient in the very training that was one of the paramount essentials of his profession.

If they would bear with him for a few minutes he would give them a brief description of the manner in which one of the largest commercial undertakings in Australia dealt with the problem—he spoke of the Colonial Sugar Refining Co. The general manager had made enquiries in different parts of the world, with the result that they had devised a scheme for the training, not only of their engineers, but also chemists, with a view to staffing the different branches of their factories. They took boys of 16 years of age, with an education equal to the standard of the present Junior Public Service examination, or better, if possible. These lads were taken in the different branches, and given three months' trial. If they proved satisfactory, their indentures were made out, and a systematic course of training was undertaken. Not only did they get an ordinary workshop training in the factory, but they had the advantage of handling steam plant, the handling of men, the economic combustion of coal, etc. And it was made compulsory that those lads should attend at each of the branches one night a week for technical education. An endeavour was also made to get them to undertake night studies. Once every year an examination was held at each branch. The papers were opened on the examination morning, in the presence of the students, and the examination held in the same manner as an ordinary university examination. The papers were sent to headquarters, classified, and the leading boys were given prizes. The papers were progressively harder, and at the end of their apprenticeship the boys turned out remarkably good men.
He could say that the scheme had been very successful. There were 62 engineering apprentices alone, and of the ex-apprentices, eight occupied chief engineers' positions; eleven were second engineers, or assistants, to chief engineers; and there were numerous juniors, all serving the company at various branches. If any of them should leave the service, every endeavour was made to keep in touch with them, and generally at some future date they drifted back again into good positions. At the present moment, two of the ex-apprentices trained at the Yarraville works, were in France serving with the Royal Engineers, both having received commissions.

MR. M. E. KERNOT said so much had already been said on this all-important subject that he felt it was something like temerity on his part to add to it. If he let himself go he did not know when he would finish. The subject had been brought home to him in so many ways. But if they would have patience to hear a few remarks from the point of view which he had in his daily work [as Chief Engineer for Construction, Victorian Railways], he might, perhaps, be able to put a few new ideas forward, which might help to bring the discussion to a profitable conclusion.

There was no doubt the subject was one of the most important the Institute had discussed. He thought they all recognised the merit of Mr. Clark's paper; he had given them a good start, and good matter to go on. He might say that he had had such a mixed training himself that he could view the matter in an impartial way. He had a partial training in a university; some in technical schools; and more in the school of hard experience. He thought the young fellows of the present day had more advantages than he had; though they generally said that there were advantages in the past that they did not get now. However—let that be as it might be.

There was one point he would like to bring under notice—that of the starting out of the young man who wished to become an engineer. If they could only devise some scheme for sorting out candidates, and giving them the course that
was suitable for them, they would save many failures. He found many who were not intelligent enough to take up the more learned course, but who would do very well if put into an office to commence their training in that way. Few men who had started in that way had failed, if they only had some strength of character and a fair amount of application. But he had seen many make a failure through attempting to become engineers in their own way. A man who was not quick mentally should not waste his time in studying the higher mathematics. He might make a very good man in a lower position. Then there was another class, rather more intelligent, that should go straight to work, and add what training they could get in technical classes and night schools. Then there was the third class, the brilliant and quick ones; they were the men who should go to the University. It was only this class that he found, in his experience, did justice to a university education. They had had men come to them who had plodded through three, four, or five years at the University, and had got through their examination somehow; and when they came to him they had to start right at the bottom. He would like to give a man all the education he could take in; but to have it plastered on him was not good enough. A Bachelor of Civil Engineering came to him; he was not getting on very well in the office, and they sent him out into the yard to count fish plates. And he could not do that. They had to get a "rough and tumble" man to do it. That man turned out a good man in the end, but they had to train him for it. But the man who was plodding all the year, hoping to get through his examinations at the end, was not the man for a highly scientific course.

It had struck him that they should look at the training of the Engineer in this way. What did they want him to do? The duties of the engineer generally were first to originate work. The man should be trained with some idea of doing that. He should be able to design the work. He should be able to estimate its cost and how long it would take to carry it out; and further, he should be competent to carry out the work on his own design, and to carry it out at his estimate of cost and in the time that he had estimated, for that was what he had had to do, and most engineers came up against it.
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Design was what was mostly taught in the technical schools and in the University. But even that was only taught partially. A man would come to him who could design a steel truss; but if they told him they wanted to build a road, a railway, or a water channel from one point to another, he would not know how to begin to design it. He did not get that training.

When it came to estimating—a most important part of the work—he thought there were as many mistakes made in that as there were in designing; and yet they taught very little of it in their schools and colleges.

Then to make a design a man must understand how to estimate its cost. The teaching of the subjects involved in originating work, designing it, estimating its cost and carrying it out, was a big undertaking. To cram it into three or four years was beyond most of them. All the subjects in the University course were good; but a man could have too much of it. They should not let them crowd out other things. It was all very well to teach a man geology, chemistry, and the higher mathematics; but if he acquired these and could not do the ordinary duties of an engineer he could not succeed. As to carrying out work, he had no knowledge of handling men, and no idea of how to go about it. And yet that was the duty he had to face. He might say he would get a contractor to do it; but that was not always possible, and he had found himself in the position of having to be his own contractor.

To provide for training in extra subjects, they were at once faced with the difficulty of time. They must not cram too much into the course. The American colleges and Universities were beginning to train men in the direction he had indicated. Their courses were being altered; and he thought ours must be altered if it was to be up-to-date. When they had got the more important subjects, then let the men take on the other subjects; but they must make the engineer a man of resource and initiative.

The University training should be a broad training. It was evident they could not cram a lot more subjects into the course; but they ought to broaden the training. They should be less exacting in some parts of the present training and bring in other subjects which were needed in the daily practice.
of the profession; and if the student liked, let him stay a few years more and take up special subjects. The higher the class of man they had to train, the broader should be his training. The weaker man should go into the workshop. He had known men who, if they did not know how to do a thing they would always find out—they wanted to teach the men to help themselves more. If they gave the men a general training that would influence their lives broadly, and then sent them out from the University or college to study further in directions which they found most useful, they would get better men and have fewer failures. The pity of it was that they had so many comparative failures. They trained men in one portion of the profession, and did not train them in other portions.

The engineer must be a business man. He must also in carrying out his work be adaptable. His difficulty in training men on business lines was that they took such a narrow view. If they were taught the principles of business they would be more useful. Give a man the broad principles and he would come down to the details later. That was what he would aim at in training engineers.

Mr. J. T. Noble Anderson moved that the discussion be postponed to give Prof. Payne an opportunity of contributing to it.

The President said before discussing the motion, he would point out that, under the by-law "no discussion shall extend beyond two such meetings unless by special resolution." The matter was in members' hands. He would also point out that it was hardly fair to ask Mr. Clark to attend again in order to reply to the discussion.

Mr. D. Clark said he was not prepared to reply at that stage. A good many things had been said; and he was not present when the previous discussion took place, and had only received the copy of the "Proceedings" that afternoon.

Mr. J. T. Noble Anderson moved: "That the standing orders be suspended to permit the discussion being continued at next meeting."

Mr. A. E. Hughes seconded. Carried.
Mr. JAS. ALEX. SMITH said he would suggest for Mr. Anderson's consideration that all branches of engineering be included.

Mr. ANDERSON said that was his purpose.

The discussions on "The Influence Line" (by Professor H. PAYNE), and "A Method of Determining the Density of Flue Gases" (by Mr. JAS. ALEX. SMITH) were postponed until next meeting.

Mr. C. CATANI read a paper on "Earth Excavators and their use in Victoria," illustrating the contribution by lantern views and explanatory interpolations.

The PRESIDENT said Mr. Catani had charmed them by his interesting description of an important piece of work he had in hand, and of the dredger he was using to accomplish it. He moved a hearty vote of thanks to Mr. Catani for his contribution.

The vote was carried by acclamation.

At 10 p.m. the meeting closed.

DISCUSSION.

THE TRAINING OF AN ENGINEER.

By DONALD CLARK.

Prof. H. PAYNE said Mr. Clark, in his paper, gave much of interest, and he was glad to know that he commenced with the statement that there would always be wide differences of opinion in the matter of training engineers; for, in fact, in the matter of engineering education, that stood out very prominently—that the greatest differences occurred: the greatest differences in method and curriculum existed. He would be a bold man who asserted that the *summum bonum* of engineering training was confined to any one school.
Criticism was always welcome, provided it was not destructive, but constructive. In fact, its presence was a healthy sign, and was a means of gauging the attainment of the technically trained man.

To obtain a competent engineering education meant something more than training, academic or workshop. It meant an inherent capacity in the individual to be an engineer. No one could produce a leading engineer without the capacity for the profession, any more than one could produce a scholar from a man without brains. It was true that certain requirements might be specified as likely to eliminate the wrong type of candidate. It was a sort of sieve. All sieves aided more or less in securing a right result. In the absence of sieves, many candidates would continue to plod on; and it was doubtful policy that the door should be so wide open as to admit every candidate into the profession. Every College or University trained men to obtain a certificate or degree which purported that he had passed through a certain minimum sieve. That was shown by his holding a certificate or degree. In that connection there was no question that, once a man had obtained from a competent authority a certificate or degree, recognition should be granted to the work done, by all other examining boards. It was just as well to state that there were a number of examining boards that imagined that other people were quite unable to examine but themselves. But it did not matter what the competent authority was, providing the examination was carried out well, it should be recognised.

There were four guiding aims which should be studied in the training of the highly qualified engineer. They were to give him a good secondary general education; to found him in the underlying fundamental scientific principles upon which engineering was based; to encourage in him the spirit of inquiry and initiative; and fit him to be of some direct engineering service as soon as it was consistent with his course of training.

A new system was referred to by Mr. Clark. It was to come into operation next year. The new system was, in the training of an engineer, to give a school more latitude in the course of study, and, for the first time in Victoria, due recog-
nition was about to be given to the work done in the school. The results of that new system would be watched with keen interest. It would come into operation at the end of next year for the first time, and it was hoped that that recognition would ultimately lead to the recognition of the certificate from the head master of a recognised school, as a means of matriculation to the University without further examination.

The school courses as outlined by Mr. Clark, and by the Schools' Board, were the first that had been drawn up. In every case they were suggested courses, and would no doubt form the actual basis of school courses. On the other hand, full provision was made in those courses to permit divergence of choice of subjects, and the number of hours to each subject.

Coming now to the suggestion of Mr. Clark to have special schools for engineers, it might be said in favour of such a school that they had the Naval College at Jarvis Bay for the training of naval men, and it gave promise of good results. On somewhat different foundations, the State had the Senior and Junior Technical Schools, each fulfilling its special function. The question of moving from those schools to the University was at present under consideration, and he hoped that the way of entry to that Institution would be rendered easier than at present.

With regard to the systems of training at the Armstrong College, Newcastle, and Central Technical College, South Kensington, which were mentioned in the course of discussion, attention might be drawn to the fact that those two were dealing with quite different systems of training. The Armstrong College employed what was known as the sandwich system; whilst the University of Melbourne employed the same system as the South Kensington system, with one addition, that the Melbourne University demanded from a candidate for the degree that, before he was granted the degree he should show 12 months' satisfactory experience to the Faculty of Engineering, in the branch of study that he had undertaken at the University. That was an additional qualification that was not required by the Central Technical Institution, South Kensington.

Certain remarks were made as to specific work by a particular student, following his course of study at the University,
as regarded the examination. In that respect his point of view was that every lecturer must be allowed freedom of choice over the examinations which he set in conjunction with his work, for he chose the examinations primarily from the standpoint as to training in thought and method.

The President, in consequence of a point of order raised by Mr. H. E. Grove, under By-law No. 1, par. 21, said the discussion must be confined strictly to matters arising out of the author's paper.

Prof. Payne said he bowed to the President's ruling. He then concluded his contribution to the paper.

The President called on Mr. Donald Clark to reply to the discussion.

Mr. Donald Clark said it was gratifying to him to find that his paper had evoked such an informative discussion. He had learned a good many things from it, and gained a good many things from members which had modified his opinions to a certain extent, and strengthened them in other directions.

His contention was that a prolonged secondary school course, which was almost purely academic, followed by a course at the University, without a sufficient amount of practical training, was not likely to give the best results. The aim of the secondary school, which was designed to train the boys from 12 to 18 or 19 years of age, was to give what was called a good secondary education to the class of boys who generally attended secondary schools. The course of work up to the age of 18 was set forth by the Schools' Board, and, although it was stated it was not mandatory, it would be found that, unless some action was taken, it would be almost impossible for any schools to depart from it. He knew of certain cases where they had had dual courses running. The organisation of a school would not allow dual courses to be effectively carried out, and since the number of prospective engineers would be small, they naturally would have to fall in with the majority of boys on what was called the general system of education. He knew the difficulty the
Schools' Board had had. There had to be a lot of compromise in order to suit the whole of the schoolmasters. But he thought they would confess that their aim was to draw up courses which they could carry out in the simplest and most effective manner.

In drawing up that course, the schoolmasters had not been able to see much beyond the boundaries of their own institutions. Therefore he thought that the general course was not likely to be as successful as some of them anticipated. The Board of Education in England had adopted a freer, broader, and wiser system of education, in sending boys who were capable of filling certain definite occupations to types of schools in which they were better prepared than if they attended the usual secondary school.

Arthur C. Benzon, C.V.O., LL.D., in an article in a recent number of the "Nineteenth Century," said: "The philosophic schoolmaster has exercised himself in trying to discover a curriculum which would be good for all alike, and named it a sound general education. It has not been sound, and it has been general only in the sense that it has aimed at nothing in particular. The same class has reigned in commercial schools, in proprietary and private schools and in elementary schools. It has been one vast and helpless compromise, an attempt to satisfy every claim. . . . To leave school, as I did, in blank ignorance of all the manufactures and commerce of my native land, seems to me a wanton sacrifice of knowledge which would have been easily and cheerfully acquired in the course of a few lessons. When I think of the innumerable hours devoted in my own school life to the slow production of stilted Latin verse, to the repetition of Latin poetry, of which I hardly retain a single line, and to dreary construing, with a trickle of scholarly exposition, of a small fragment of some wholly unaccountable classical author, I think with horror of the amount of inquisitiveness, imagination, and interest that streamed to waste." This expresses the views of one of the most eminent Cambridge schoolmasters, and the trend of the discussion here supports his contention.

Mr. J. T. N. Anderson's remarks might be somewhat differently interpreted. He stated that he thought it made little
difference to the man who wanted to rise to the ranks of the engineer whether he acquired practical training before or after his education. He ventured to say, however, that no flights of fancy would overcome the difficulties the young engineer of 25 years of age had to face. He must begin as a novice, and have lean years before he overcame the difficulties connected with the simplest practical work.

He had recently discussed this matter with two engineers who had completed courses at the University, and who now occupied prominent positions. Both these men had passed their courses at the age of 19 years, but even at that early age, they found many difficulties in stepping from a University into practical work, and both were emphatic on the necessity for a better introduction from any school to actual practice and to everyday problems. Yet it must be remembered that in future lads will only be commencing their University courses, under the proposed arrangements, at an age when these men were in practice. He took it that the President, Mr. Carew Smyth, Mr. Reeson, Mr. J. T. N. Anderson, Mr. Smith, Mr. Hughes, and Mr. Kernot were not favourably impressed with the preliminary training proposed by the Schools' Board.

The next point in the discussion was on the University courses generally, but these were only introduced for the purpose of completeness of the paper. Such courses should indicate the highest form of engineering training carried out in the State. His sympathies were with the University, and he would like to see every brilliant student have a chance of going through the University. He could not agree with Mr. Reeson. He did not know many engineers who had gone through the University who were not practising their profession. He knew many who would take engineering graduates from the University now if they could get them. He was in communication with the Universities of Melbourne, Sydney, Adelaide, and Perth to get men who had gone through the University courses. They could start straight away in some of their schools at salaries of £300 to £400 per annum. Of course, it was not wholly engineering work. The training they got for that type of work was better than they could get from almost any other institution.
At the same time, he was in accord with those who drew attention to some of the defects of the University system. One was that a great many obstacles were put in the way of the student who desired to go through the University course in engineering. He found that in Adelaide they had a much more liberal system of dealing with the students. The student had to get his matriculation, but he could get it in an easier way than in Melbourne. If he passed in certain subjects, he need not pass in those subjects again. Although they grouped the work for higher courses in years, as was done at the Melbourne University, it was not essential that they should be passed in that order. The student might take up natural philosophy and go through that; then chemistry and applied mechanics; and in that way he could do just as good work as passing the whole of those subjects at one time. In fact, he had no confidence in loading the student up with a number of subjects dissimilar in character, and asking him to pass the whole lot in one year. The Royal School of Mines had adopted a somewhat similar plan, in which the student went through one subject at a time, and he did it thoroughly; and he thought that would give, educationally, just as good results as the method at the Melbourne University.

As to the difficulties Mr. Saarvass spoke about, he had to pass several examinations in order to obtain the licensed surveyor's certificate, the land surveyor's, and the municipal engineer's. He must say that since Professor Payne had been at the University he had done away with a great deal of the difficulty, and lessened the outside subjects of examination that the young engineer previously had to pass, and as time went on the difficulties would be greatly reduced.

He was pleased Mr. Hughes agreed as to the necessity of commercial training. He need not do more than refer to it. He was pleased to see that the training of the industrial or chemical engineer had also cropped up. In that case it was necessary to start at an earlier age. It was of no use leaving the boy at school until 17 or 18 years of age at classical subjects, which were no doubt valuable as a form of mental training, but which took the place of subjects which were just as valuable, and which were of a great deal more service to the future engineer.
Although his paper dealt mainly with the University, in a few remarks at the last he mentioned the work they were doing in the junior technical and the technical schools. He was pleased to see that the comments on this work were generally favourable. As to overlapping, there were a great many students who wanted to go through some course of engineering, perhaps not of the same wide character as that of the University, but of a more specialised kind. They could go through the technical school, get their diploma, and a great many of them came out very well. He did not think it interfered with the University attendances at all, because he would like to see every brilliant student in a technical school have his chance of completing his course at the University. If technical schools were not in existence a large number of students would never have a chance to go through an engineering course.

Mr. Anderson had also referred to the training of the engineer and the training of workmen. Mr. Anderson was under the impression that the paper dealt with the training of a mechanic. Whilst the mechanic received his training at the technical schools he was not the type of man referred to in the paper. The engineering technical school student received a more practical training than that given at the University. When he finished his course at the age of 19 or 20 years he generally tried to get into actual work as soon as possible. The sandwiching system was likely to give the student a better insight into his work than any theoretical course was likely to do.

Mr. M. E. Kernot had referred to the different types of student suited for the University and the technical school. Professor Payne had also referred to the sieve. He did not object to the sieving process at all, if sieving was done by engineers; but if the sieving was to be done by the schoolmaster, then the results were not likely to be wholly satisfactory. It was necessary for the engineer to consider the question in full, and see whether some modifications of the syllabus at present drawn up could not be brought about. On the other hand, the technical schools of the past had had to take every candidate that came, and that accounted for the statement made by Mr. W. Kernot. In many cases the
boys were just as unfitted for the technical schools as for the secondary schools. He would give one instance where the opposite was the case. A mother came to him, and said her boy wanted to attend the School of Mines in the evenings. He suggested that the boy should go through the day course. She said his father was against it. He persuaded her to give the boy a trial. That boy came, and at the end of the second term was at the head of his class; and at the end of the year was far and away ahead of any of the other students there. He had a more brilliant course than almost any other student he had had, and afterwards did very well, securing an excellent position, which he had held ever since, and was likely to hold until he left it himself. The boy’s father told him afterwards that the school he was attending had a schoolmaster who was a classical man, and that schoolmaster informed him that the boy had no brains; all he was fitted for was to drive a cart. It showed that if the sieving was to be applied by men of a non-engineering type, some of the best engineering material might be rejected.

He only wanted to say one thing more, and that was in reply to Mr. Smith, as to the status of the engineer. He had meant “by a sufficient training for the young student to fit him for the service of his employer,” that the graduate should have some practical knowledge to start with. So many young men who had got their first appointment were so ignorant of simple practical operations that it was humiliating to them to find that they were of so little service. He quite agreed with Mr. Smith that the engineer should occupy the highest position in a progressive community. It was not what the engineer learned in the technical school or university, but what he did afterwards, which would show whether or not his training had been on the right lines.

He thanked members for the patience they had shown.

The President declared the discussion closed.