The question of Engineering education is, and for some time past has been, a very live one. Quite recently the Institution of Civil Engineers of London has held what may be called a complex plebiscite, and has elicited and tabulated replies from a great number of engineers upon no less than 13 important points. This constitutes a very valuable contribution to the debate, and shows the trend of opinion amongst a considerable number of persons who are in a favourable position to judge of the actual results of the educational methods at present in vogue. Further, the engineering press for many years past has both in its correspondence columns and its leading articles given vent from time to time to various and often vigorous expressions of opinion, usually, but not always, representing the old and empirical school of practitioners whose favourite motto is "that an ounce of practice is worth a ton of theory."

Having been the pioneer engineering student of the Universities of Australia, if not the Southern Hemisphere, and also the pioneer engineering professor, and having now had nearly 40 years' experience in training engineers, many of whom have since risen to high positions, it appeared that the question of Engineering Education would be an appropriate one for my latest Presidential address.

The conflict that has so long raged about Engineering Education is, I think, largely due to two causes. First, that there is great difference of opinion as to what an engineer is, and what should be required of him; and second, what are the possibilities and limitations of the so-called education that usually intervenes between the lad's ordinary school work and his filling a position where he earns a living and performs work of a practically useful kind. To prevent confusion, let us first consider what an engineer is, what are his duties, and what his desirable qualifications.

The engineering profession is an exceedingly complex and varied one, much more so than, for example, that of medicine. The physician or surgeon is usually a solitary individual. His hat covers his establishment. He needs, of course, theoretical knowledge and practical skill of doubtless an exceedingly high order to successfully deal with diseases and injuries of the human frame, but that is all. He has no large staff of subordinates, no intricate business transactions, no disputes involving thousands of pounds, no delicate negotiations requiring the utmost tact and diplomacy.
He is free from all this, which often imposes on the engineer a burden compared with which the actual designing of his work is but a trifle. The medical man is supreme in his own sphere. No outsider interferes with him; but the engineer has to satisfy Cabinet Ministers, Boards of Directors, Railway Commissioners, and administrative or business men of all kinds, who often present that combination of ignorance and power that is so peculiarly difficult to deal with. He has frequently to handle millions of money, and is exposed to temptations and pressures of the severest kind. He also is subject to endless newspaper criticism, often of the most violent and ill-considered sort. The ordinary press writer never discusses the ingredients of a prescription or the most approved system of applying splints to a broken leg, but he continually sits in judgment upon engineering points, of which he knows no more than he does of the former. All this renders the position of the engineer burdensome in the highest degree, and the qualifications needed most difficult to obtain in well-proportioned combination.

Of course this is not true of all engineers. There are some whose positions are analogous to those of their medical brethren, and their work, and needed qualifications correspondingly simple, but with very many it is far otherwise. To illustrate this part of the question, and show how various are the requirements to which persons roughly classed under the general heading of engineer are subject, let us indicate alphabetically a number of typical cases, as below:

(A) represents what may be called the pioneer engineer. He is a man practically unknown in old and fully-civilised countries. His existence is undreamt of by the highly elaborated experts of Great Britain and Germany, but in a new country like Australia he is a person of enormous, though often unrecognised, importance. He precedes settlement, prepares its way, and guides it in desirable directions. He locates and lays out townships, selects lines of road, chooses harbours, bridge sites, reservoirs, cemeteries, and other necessities of civilised life. He makes roads, fords, ferries, bridges, and has to do it all at a minimum of expense. In performing his work he should have an eye to the present, and also to the future, securing immediate accessibility of property at small cost, but often in confessedly a somewhat imperfect manner, and at the same time arranging so that it should be possible when population comes, and revenue accumulates, to carry out works of first-class efficiency. This pioneering work rarely occurs in an old country like England. There the roads were fixed, the land alienated ages ago; vested interests have grown up in all directions. The engineer lives, moves, and has his being amidst the accumulated errors of centuries, and all he can do is to tone down, to mitigate the very worst features. Witness, for example, the enormously costly, but still far from perfect, reconstruction of streets in London during the past forty years. But in a new country, there is carte blanche, a clean sheet, and a wise and far-
seeing pioneer engineer will secure enormous ultimate advantages, while a short-sighted one will let slip that which, once lost, can be recovered again only at enormous and often prohibitive cost. Unfortunately, examples of such fatal errors are only too common.

Now what about the qualifications of this very important man? Well, first, he should be a man that can see; and, second, he should be a man that can think. He should have what is called an eye for country, should be a good bushman, inured to hardships, able to use intelligently the simple instruments—notably the compass, clinometer, aneroid and box sextant. He need not use the theodolite—that is the surveyor’s instrument, and may come on the scene later. He may, perhaps, use a small level, but for most of his work the clinometer will do better. He should have some general knowledge of geology and botany; some simple medical, ambulance or first-aid knowledge, for use when at a distance from medical assistance; a little applied mechanics, including calculations of beams, simple frames and in some countries such as New Zealand, suspension bridges, but he need not know differential calculus or the design of turbines or dynamos. Active, physically strong, good tempered, keenly observant of natural conditions, intelligent in adapting and utilising what nature supplies, he will be far more useful than any mere bookworm full of academic knowledge that he has got up for examination purposes, without properly understanding or being able to intelligently apply it.

After the pioneer engineer has done his work the surveyor may come with his theodolite and his logarithm book, and carefully define boundaries, but not before.

(B) is what may be called the administrative engineer—the head let us say of a great Government department, such as the Railways, Public Works or Water Supply in a country of the scale of one of the leading Australian States, or say the city surveyor of Melbourne. He is the head of a large and complex organization, comprising experts in various specialities, who in their limited spheres know, it may be, immensely more than he does himself. He is like the general of an army, who has under him experts in cavalry, infantry, artillery, engineering and hygiene, each of whom is a high authority in his particular branch, but all of whom he controls and co-ordinates. What qualifications should this man possess? Why, strength of character, knowledge of human nature, tact, firmness, probity. He has to rule, may be, hundreds of subordinates, to handle thousands or millions of pounds, to steer steadily amidst the clash of interests and hold the reins firmly despite every pressure. His work is often of a judicial sort, and so should his qualifications be. Of such an one it has been said that he should be a diplomatist, a disciplinarian and a detective, and if to these he can add scientific knowledge well and good, but much in that line should not be expected.

(C) is the commercial constructing engineer—the man who runs a foundry, smithy, boiler, girder or ship building yard, or in another sphere acts as engineering manager to the contractor for
some large public work, such as a railway, breakwater or reservoir. He is not required to do much original designing as a rule, though often he has the opportunity of showing his skill in devising cheap and effective scaffolding, staging, temporary pumping plant etc., but his chief care and anxiety is with the financial and administrative side of his work. To estimate soundly so as neither to lose the job by sending in too high a tender, nor to make a loss in carrying it out by sending in a needlessly low one, and thus to incur financial disaster, needs care, knowledge and skill of a kind not taught in the schools and but little appreciated by the mere academic man. Further, to control large bodies of skilled and unskilled workmen, with their prejudices against each other and against their employers, their trade societies and professional agitators, so as to obtain the maximum amount of work from them, and avoid labour troubles, is a task that may well occupy the most strenuous attention of the ablest man. I often wonder how such men survive their cares, and thank heaven that my lot is cast in comparatively smooth and straightforward paths.

(D) is what may be called the managing expert. He is the responsible head of a gas works, electric supply station, pumping station for sewerage or water supply purposes—or possibly like my esteemed predecessor in this chair, the head of an establishment where sugar, stearine, chemicals, textile fabrics, etc., are produced or complex metallurgical operations are performed. His position is in some ways simpler than that of (C), but nevertheless is by no means without its anxieties—variations in quality and cost of raw materials—fluctuations in the market where the finished product is sold—changes in the public taste—labour troubles and many other disturbing causes combine to render his position anything but a bed of roses. Still he has this advantage, that he is interested in one product, and usually one only, and so can specialize and thus relieve his mind of the burden of covering too wide a field of knowledge.

(E) is the scientific referee, the expert witness of the law courts, the engineering consultant, who is called in to deal with cases of special difficulty or novelty. He has no large organisation of subordinates, no complex commercial transactions. He need be in no sense a business man, need have no skill in managing any more than the judge, barrister or physician. To this class I belong myself—I sit on the bench and give decisions after hearing and weighing evidence. Sometimes I sit alone as sole arbiter; sometimes as colleague or assessor to a judge. I conduct enquiries, alone or in conjunction with others who may be engineers, or not, give expert evidence in court, report on the value of inventions, investigate the causes of accidents, hold examinations of candidates for technical positions—but business I avoid. Close and unremitting attention to petty details and the endless cares of management are inimical to the proper performance of my real work. Like a barrister—and barristers are usually credited with being bad men of business—I concentrate my at-
tention for the time on one question only, and neglect, or forget, everything else until the question is finally settled.

(F) is the inventor. He is a most peculiar and nondescript individual, often by training not an engineer at all. Like the poet he is born, not made, though indeed this may be said to some extent of highly successful men in every line. James Watt was a half trained mathematical instrument maker, whom ill health prevented properly completing his indentures. George Stephenson an uneducated labourer who taught himself to read at an age when most lads have left school far behind. The inventors of the power loom and reaping machine were clergymen, the originator of modern spinning appliances a hairdresser, and so on, favouring the conclusion that it is the born genius unconfined by the narrow grooves of the customary course of training that conceives the great original ideas, makes the entirely new departure. But all are not such giants—and even the great inventor usually needs much nursing and assistance from the ordinary practitioner and engineering man of business before he can make his invention a practical and financial success.

This list of the different species of the genus engineer is by no means exhaustive. Many other varieties might doubtless be named and classified, but it will suffice to show how varied are the duties and how diverse the qualifications of that vast profession to which we have the honour to belong.

And now as to education. What does it mean? What does it involve? What part of a man’s life will it occupy? What methods have been adopted, and with what results? What reforms are needed? To these questions I answer that education is the development of the man, and the fitting him for his work—that it is a lifelong process, that just as the musician or painter studies and practises incessantly, so must the engineer. To relax the process is to fall behind his competitors, to be distanced in the race. If, however, we limit our enquiry to the question of how long will it take to prepare the young engineer for a position of what may be called primary responsibility, that is to do important engineering work on his own initiative, I reply on an average about 20 years. In other words, assuming the ordinary school education which he enjoys in common with lads intended for other vocations to terminate at from 15 to 17 years of age, he ought to be fit for a controlling and responsible position at the age of from 35 to 40 years—previous to this he may do valuable work, as a subordinate under a more experienced head. Of course this is not a hard and fast rule. We have had great conquerors and a Premier of England well under 30, and so we may have brilliant outbursts of engineering talent at an early age, but such occurrences are very exceptional, and my own experience which has been fairly large is that a man of 35 is in average cases quite young enough to begin to carry the load of full responsibility. Of this 20 years the first five will be occupied by what is ordinarily spoken of as engineering education. During the other fifteen the man must, if he is
to be a success in these days of competition and intellectual activity, diligently educate himself. During the first five years he is expected to earn little or nothing, afterwards he should be able to support himself, and by the time 15 out of the 20 years have passed, a wife and family in addition.

The question that we really have to discuss is how to occupy the pupil’s first five years with the object not of his earning money, but rather of laying a good foundation on which he may afterwards build. Five years speedily pass, and if partly or wholly wasted mean leeway that it is very difficult to recover. How, then, shall he spend this precious five years involving about 1,500 days, or 10,000 hours when Sundays and holidays have been deducted. Three leading systems have been in vogue, though in many cases combinations in various proportions of two or even the whole three have been employed.

First, the time-honoured apprenticeship system employed for ages in most trades, and only recently extinct in the medical profession. The pupil is bound by a legal contract to his master, pays a greater or less sum as a premium, serves a term of years, and finishes by receiving a certificate of faithful service and diligent learning. Sometimes he becomes an inmate of his master’s house—practically a member of the family and in the end marries the daughter of his master and succeeds him in the business. Now all this was most delightful, and in olden times before things moved at the furious pace they do now, and when master and pupil were conscientious and kindly persons, the system worked to mutual satisfaction, but with the changed conditions of modern life and the rise of large and complex organisations instead of the little group of master and two or three pupils, the apprenticeship system has broken down. It is dead in the medical profession, dying in most of the trades, and loud calls are rising far and wide for a substitute. The difficulty is that the master is too busy to take an individual interest in the pupil, that he lacks the time, skill, and appliances to teach him effectively. Hence he makes a convenience, a drudge of him, giving him only low routine class work, and fails to fulfil his contract to fully teach him the business. I have more than once been consulted in litigations where the parent of the pupil attempted to recover by appeal to the court, damages against the master, while complaints loud and deep have reached my ears in many other cases.

The second system of educating and qualifying engineers is what may be called the Government system. In Australia the Government is actively interested in engineering work, in a way unknown in England. Railways, which are in private hands in England and America, are here made and worked by the State, while roads, bridges and waterworks, even if made by local authorities are largely aided by Government subvention and inspected by Government experts.

Further, a system of surveying and describing boundaries by angles and lines instead of by time honoured land marks certified
to by the oldest inhabitant, as in England, renders the State responsible for the accurate definition of private property. Hence the Government insists on enquiring into the qualifications of engineers and surveyors by means of very stringent practical examinations, with one of which I have been connected for more than 30 years. Before coming up to the examinations a certain practical training or experience is demanded, but not necessarily any college or university course.

The Government system was started fully forty years ago by the establishment of a land surveyors’ examination, which was in due course followed by municipal, mining and water supply examinations, on similar lines, and these examinations have become correlated so that if a man proceeds in the proper order, the passing of the first examination excuses him from certain portions of the second and so on. At the present time a large number of engineers hold the certificates granted at one or more of these examinations, and are thereby legally qualified and permitted to practice certain branches of engineering from which those not having passed are excluded, no matter how highly qualified at universities or elsewhere.

Lastly, we have the University or College System. This has come into existence in most parts of the civilized world during the last half century, and during the last twenty-five years has received extraordinary development in both Europe and America, where elaborately equipped colleges have sprung up in all directions, partly at public expense, but in many cases, especially in America, through the generosity of wealthy benefactors. An illustration of this is to be seen as near as Sydney, where the late Sir Peter Nicol Russell donated £100,000 to the University Engineering School. Sir Peter was an old mechanical engineer, who had long conducted a lucrative manufacturing business in Sydney, and who might naturally have been expected to have little sympathy with the academic and theoretical side of engineering, nevertheless he presented this magnificent sum to the University and a palatial house for the engineering department is now being built with it.

A rather unique and noteworthy benefaction was made some forty years ago in England by the late Sir Joseph Whitworth. He did not give his money directly to any educational establishment, regarding the teaching there as too exclusively theoretical, in which I think he had much justification. Instead he founded the well known Whitworth Scholarships, which were granted after a double examination, first in engineering science, and second in mechanical handicraft. Many able and prominent men now write Whitworth Scholar after their names, and it is noteworthy that the Professor of Engineering at Sydney is one of them. The essential characteristics of the University system of education are:

(1) A matriculation or entrance examination to test whether the student is sufficiently advanced to understand the University lectures.
(2) Formal instruction by carefully selected teachers, followed by examinations.

(3) Instruction and examination in the sciences bearing upon engineering, preceding the instruction in actual engineering subjects.

(4) A degree or diploma given at the close of a three or four year course of the above kind. In some, and I think the best institutions, this degree is withheld until the student has had at least twelve months of bona fide practical work at some recognised branch of his profession.

These degrees, it will be noted, are not legal qualifications to practice, as the Government certificates are, and hence complaints arise, the University graduate alleging that it is unfair that he should be excluded from lucrative work when less completely educated men are admitted, and compares his position with that of his well protected legal or medical brother somewhat bitterly. Thus it will be seen that there are two conflicting systems of training and qualifying engineers in this country, one, the simpler and cheaper, enforced by Act of Parliament, the other by far the more elaborate and costly, having no legal sanction whatever, although carried on largely at Government expense.

We do not find such an anomalous state of things in either the medical or legal profession. There, there is one clearly defined course which if a man takes he becomes legally qualified, and is protected from the competition of those who have not passed through the mill. But in engineering he who at great expenditure of time, labour and money has qualified at the State endowed University, finds that he is outside the pale, while others who have entirely escaped compliance with many of the most stringent conditions imposed, not by our University only, but by sister institutions all over the civilised world, are inside and in undisturbed possession of lucrative practice. Such a state of things would certainly seem to demand explanation if not justification. Of course one does not expect a Government to be consistent, but still one would think it would not go so far as to tempt a man to spend valuable years in acquiring a certain training and then reject him in favour of those whose training is of an essentially different sort. This conflict of policy between the University Engineering School and the Government departments has been marked and unmistakeable from the very first. Indeed the strongest opposition to the original establishment of the school came from the gentleman occupying the very highest Government engineering position in the colony. As time went on, however, great changes ensued, and the department that he presided over has now become the most favourable of all to the University man. The department which still continues most opposed is that of the Lands and Survey, and the strongest attack on the University work at the recent Royal Commission came from that quarter. Had the Commission followed the matter up and enquired into the history and rights of that contest, good might have been done, but this they failed to do. I would there-
fore endeavour with all possible fairness and without favour to either side to give the history of the trouble.

Some forty years ago but little population existed in the country parts of this State. Large pastoral holdings filled the country with sheep and cattle, not men and women. The cry of "Unlock the lands" arose, and Governments were faced with urgent demands to settle the people in country parts. The Lands Department became the most important of all the Government offices, and for years the Minister of Lands was Premier.

Land surveyors were in great demand, and earned large fees, and many very unsuitable and unreliable persons were pushing themselves forward. The danger of large systems of surveys getting into hopeless tangles was imminent. A severely practical examination, not of any significance from an educational point, but mainly a test of speed and accuracy in ordinary field work was instituted, and many surveyors passed it and thus gained access to lucrative practice. Years passed, the bulk of good and accessible land became alienated, the Lands Office declined in importance, the land surveyor found his work and fees diminishing, his prospects and social importance waning. Naturally and rightly he tried to protect himself, used all his influence to keep up the standard of examination and so minimise competition. At the same time he endeavoured in every way to add work of an engineering nature which was rising in demand to his declining survey business. The University man he looked upon as a dangerous competitor to be kept out if possible—and it is a fact that years ago, an apparently moderate and reasonable concession by the Board of examiners to men holding high University degrees evoked a most emphatic protest from surveyors all over the country. It is only fair to say that some of the leaders of the profession on this occasion showed great magnanimity and breadth of view, but the rank and file were most unmistakably against them and against the University. The Lands Office naturally is influenced by and reflects the opinions of the land surveyors, and so continues most unsympathetic to the University as many instances could be quoted to show, did time permit.

Some years after the establishment of the Land Surveying examinations, Local Government was introduced into Victoria. The country was parcelled out into boroughs and shires, each with its president, councillors and surveyor, who really was a road, bridge, and street engineer. As the revenues of these bodies were small, Government subsidies were required, and to secure the proper disbursement of these some guarantee of competency on the part of the municipal surveyor was needed. To secure this another examination, the Shire engineers' or Municipal surveyors' examination was instituted. The originally appointed examiners were engineers, not at all in touch with University ideas, but of the old empirical school that is now fast becoming extinct, and they instituted an examination of a narrowly practical sort and of extreme severity, so that often men of considerable experience would come
up time after time without success. An agitation took place, and a concession was made exempting men of a certain number of years' experience from examination. In course of time the personnel of the Board changed, more liberal ideas came in, and the municipal surveyors' examination now grants large and valuable concessions both to the man of undoubted experience and also to the man of good University standing. Other examinations have since made their appearance, controlling other branches of engineering work, but the policy does not differ seriously from that of the Municipal Board, and so, excepting in the case of the Lands the grievance of the University man is decidedly ameliorated, though by no means entirely removed.

Now what are we to say to this trouble? On which side is the fault, or are there faults on both sides? What reforms are conceivable, and how are they to be brought about?

Well, in regard to the Government system I would say the fault is in relying on an examination alone. The examination is the fetish of the ignorant educationalist, the easy but defective and often fallacious test. When the examination is depended upon and subordinated to the teaching, it is tolerable, and in judicious hands moderately reliable. When the teaching is subordinated to and controlled by the examination it is bad, and destructive to true education. It is practically impossible to arrange an examination that an ignorant man may not be crammed through by a clever coach who knows all the ways of the examination and idiosyncrasies of the examiners, or that a really good man who lacks the time to go into a special course of training for it may not fail to pass. One of our ablest University engineers went up to the Land Surveyors' examination, and failed. He explained it fully in evidence before the University Royal Commission as being simply a question of time. Being engaged on other work he was unable to go into training and so acquire the mechanical facility needed.

The bulk of our municipal examination consists of about a dozen specifications of road and street construction and three bridges, usually of a very ordinary character, and this continues with little variation for many examinations. Candidates go to coaches who supply them with precedents which they memorise, often I fear without properly understanding. If a change takes place in the examination, candidates will often answer the old questions they have got up by rote, and make no attempt at the new, and when they do succeed they often don't know why. Said a candidate to me not long since "I went up and gave what I thought a good bridge and you plucked me and at the next examination I gave what I thought much worse and you passed me. I can't understand it at all." The defects of the system may be analysed as follows:—

1. There is no certainty that the candidate has had a proper general education. He may be, very often is a State school boy from some obscure country district. His early years are spent with few books, amongst rough men and far from the educative in-
fluences of great towns and seats of learning. After a few years upon bush roads he aspires to the examination, and by the aid of a clever and experienced coach gets crammed through, without really understanding first principles or reasons for what he is doing.

(2) There is no provision for a decent knowledge of the sciences underlying engineering. Men may, many I believe do pass the examination with very little mathematics, no geology, chemistry or physics whatever. Now this is surely wrong. Their certificate qualifies them to take charge of the most important towns in the State, where municipal electric light and tramways may exist, where sanitary questions of complex kinds may press. Surely so important an official should have some knowledge of electricity, hygiene and bacteriology—as well as road making and small bridges. But how are these subjects to be provided for? The examination is at present as heavy a burden as examinee and examiner can endure.

(3) Even in the subjects in which he is examined it is doubtful whether the candidate really understands what he is doing or is only making guesses in the hope that he may hit the fancy of the examiner, or repeating by rote what he is far from properly understanding. Well, you say, "Mr. Examiner why don't you improve matters?" I reply, "I don't see how." It has given me long and anxious thought but so far without result. All I can say is that we want education rather than examination. Proper courses of study under reliable experts, proper experiments, illustrations and laboratory work. Granted that, I care little whether you have an examination or not. But that means that the men must come to the University or some well equipped technical school, and how to effect that I see not. The candidates I deeply sympathise with, and could I help them would be glad to do so, but how can it be done, and till it is done I fear our municipal service will be but little esteemed, and that the disgracefully low rate of remuneration prevalent in so many places will continue. But if what I have called the Government man is so imperfectly prepared to deal with the multitudinous new developments of this rapidly advancing age, what about his competitor, the University or College man? Is he the one perfect engineer? By no means. His faults, though in a somewhat differing direction are glaring enough. He comes as a student from schools conducted by people who are in most cases altogether out of touch with practical engineering, and saturated with the idea that the chief end of man is to pass endless theoretical examinations. In fact, and I hope I shall not give offence in saying so, the schoolmaster's mind is in its way one of the very narrowest. Other men see something of the two worlds. First the educational world in which they pass their earlier years, and second the practical, commercial world in which they spend the rest of their lives. The schoolmaster, however, never escapes from the schoolroom. First as scholar and then as teacher he spends his whole life there. Hence his view of men and affairs be-
comes one-sided and lacks proper proportion. To him "all the world's a school and all the men and women merely scholars." Could I have my way I would insist that all school and University teachers should after completing their so-called education and before entering on their life work have at least five, and better still, seven or ten years of occupation of a totally different sort amidst totally different surroundings. This I am convinced would broaden their minds and open their eyes in a way they at present little imagine. Taught then by such teachers the student on entering the University, puffed up by his examination triumphs and accepting as gospel the platitudes of the school speech days, has his conceit increased and his lack of sympathy for the people that do the useful practical work of the world deepened by every success and by the atmosphere generated by his merely academical professors. It was so in my own case. I well remember my school and University career was phenomenally successful, and my condition at its termination might be characterised an acute case of swelled head. But then came a blessing in disguise. With all my blushing honours thick upon me, I plunged into the cold outside world, which utterly failed to appreciate my useless knowledge and met me with the terrible question "What can you do." All the work the world would trust an inexperienced youth like me with was simple mechanical routine, but this it insisted upon being performed in enormous quantity, at great speed, and with absolute accuracy. And here I lamentably failed. I could not stand the strain of endless calculations involving but the simplest of mathematical principles, but bewildering and overwhelming in their oceans of arithmetic. I was slow, I made mistakes, I was hopelessly distanced by men of not one tenth of my education, and when my chief one day after I had let pass a somewhat serious error, informed me that my services were no longer required, I learnt my first painful and salutary lesson as to the worthlessness of mere examination knowledge and the overwhelming importance of that mechanical facility, reliability and endurance that comes only from practising the same simple operation over and over again, day after day, week after week, year after year. As to further steps in my disillusionment as I passed from the little unreal educational world to the great real practical world outside time will not permit to tell. Suffice it to say that, after forty years of varied experience, I look back upon myself and marvel at how wonderfully feeble, ignorant and useless an exceptionally brilliant University man may be. Do not, however, suppose that I hold my University course wasted time. By no means. It was a seed that in the course of years grew into a fair tree of professional success and scientific reputation, under whose branches I enjoy the evening of my days. But I fear there are cases in which the seed fails to grow. Now taking the student as I know him, and receive him from the schools, his complete out-of-touchness (to coin a very ugly word) with engineering is often most amazing. Not always, for some are
born engineers, who will walk miles on their own initiative to see a bridge built or a new locomotive tried. But often I am astonished to find how little is known and how little interest taken in the most familiar engineering objects and problems by successful State school scholars and other brilliant pupils, and I am strongly disposed to agree with a number of people in England who are asking that the student should, before commencing his college course, have at least one year of actual engineering work under practical conditions of hours, discipline, and pay. He would then know what his college professor was talking about, and have an idea of its value and importance, which at present he often lacks.

Then, again, the student, as I know him, has little idea of continuous work. He flits from flower to flower. An hour's geology, an hour's mathematics, an hour's chemistry, and so forth; but as to keeping on all day at one job, and finishing it right out, why he rebels against it. Further, the trail of the examination is over everything. To pass is the object, and not to know, and, to quote Huxley, "outraged nature is avenged, and they do pass, but don't know." Employ the most successful coach, grind up during the midnight hours with the aids of strong coffee and a wet towel round the aching brow, spout it out in the examination room, and then forget it as fast as possible. I have heard of a man who boasted the possession of an intellectual emetic whereby, after passing in a given subject, he could purge his brain completely of it, and so make room for something else. Now, this is not the way to do any good. The right way is to love your subject, to be continually thinking about it, to follow it all your life, make it your own, advance it beyond its present bounds if possible. So, and so only, can a man become of real use. But, of course, he can do this with one or two subjects at most—the rest, after passing the prescribed test, he has to let go. The conclusion is that an outgoing University man is apt to be a very unsatisfactory person. He is slow and unreliable in routine work, often conceited as to his scientific quasi-knowledge, with his head full of undigested and imperfectly understood mathematics, which he misapplies with extraordinary and disastrous results to practical problems, and so justifies and increases the prejudice of practical men against the mere theorist. He is the ugly duckling of the fable, but still give him time, and he may ultimately develop into the beautiful swan, the pride of the lake. But I don't say he always does so. The University degree, granted with great eclat to an immature youth, is, I think, open to criticism. It seems to me that the full degree in any faculty should not be given until the man became fairly mature and settled, and had shown that he had some judgment and initiative, and was something more than a mere machine for passing examinations. Give a small distinction to the lad of 20 years who has done well at his examinations, but keep the full credential for men of at least 30, who have proved themselves worthy by deeper and truer tests of capacity. Well, now, what is to be done to improve matters? Is the Government system to continue?
the University system to remain as it is, or can some intermediate way be discovered which can harmonise the two, and avoid the defects of both. This is a large order, and one that cannot be filled at this late hour. I would, however, direct attention to the valuable report of the Committee of the Institution of Civil Engineers, on p. 159 of Vol. CLXVI. This report is signed by representatives of all the leading engineering bodies in England, and its principal conclusions are:

(1) That the engineer should not commence his special training until he is 17 years of age.

(2) That History, Geography, Essay-writing, English Literature, French or German, and Elementary Latin should be required as school subjects. That Mathematics should be taught in a different and more practical way than at present.

(3) That an introductory workshop course at mechanical engineering workshops for at least one year should precede college education. That this work should be done under ordinary business conditions, the students being subject to discipline and receiving wages. During this year the lads may attend evening classes.

(4) That after this college courses should commence, as at present.

(5) That the mathematical work should be carried out with judgment and with adaptation to the varying capabilities of the students. That it should be remembered that "many who become competent engineers have not the power of acquiring the higher mathematics," and that teachers of pure mathematics should be well informed as to the application of mathematics to engineering, so that departments having no bearing upon engineering may not have given to them unnecessary time or attention.

(6) That degrees should not be granted on results of examinations alone, but considerable importance should be attached to laboratory and experimental work.

(7) That post graduate research of a practical kind be encouraged.

With all this I may say I fully agree. My desire is that the students should at the very earliest date be brought into engineering atmosphere or environment, and freed from the prejudices of the mere theorist. Also our mathematical and physical teaching hitherto carried on mainly by parsons, schoolmasters, and professors, should be rearranged and adapted to practical engineering needs. That in many directions the pruning knife should be applied, while in others it should be amplified and fitted to actual practical work. That practice and theory should be intermingled all through, the practice everywhere illustrating the theory.

Further, care should be taken that the teachers of scientific subjects, who are not engineers, do not in their zeal for their favourite studies so encroach on the student's time as to starve the
actual engineering work, and finally the ultimate controlling body of every engineering school should be engineers, and not people of merely scholastic or academic experience.

In this way we can, I think, lay in the course of about four years a foundation on which a broad, liberal superstructure of professional competency may be ultimately reared, and such a curriculum I think every young engineer should have in these modern days of scientific development and increasing specialisation.

To discuss the details of actual courses, and the division of the curriculum into civil, mining, electrical, chemical, and other branches would be a task far too involved for such a paper as this, and therefore I refrain from attempting it.