PROFESSOR R.H. PAUL MEMORIAL LECTURE 1990
THE ENGINEER'S OBLIGATION TO SOCIETY

by

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When Professor R.H. Paul held the chair of electrical engineering at the then University of Ceylon, I had the privilege of being an Instructor in Electrical and Mechanical engineering.

The benefit I derived from this long and gratifying association with Professor Paul, in different capacities, placed me in good stead in becoming a professional engineer. Therefore, I owe a debt of gratitude to Professor Paul and it was with great pleasure that I undertook to speak in his memory. I am very grateful to the Institution of Engineers, Sri Lanka, for providing me an opportunity to pay Professor Paul this humble tribute.

It was during the nineteen hundred and forties that Sri Lanka was able to indulge in higher level engineering education. To establish, for the very first time, adequate tutorial and laboratory facilities, and that too, to meet the rigid standards of the University of London, was no mean task. Professor Paul who was intimately connected with these efforts and who largely contributed towards them, was mainly responsible for obtaining recognition of the University of London for us to prepare students for the Bachelor of Science in Engineering Degree of the University of London. Had Professor Paul's contribution to the engineering education been limited to this single achievement, even then, he is certainly worthy of the appellation now being bestowed on him as the 'Father of Electrical Engineering Education in Sri Lanka'.

Dr. Robert Hoisington Paul, D.Sc.(honoris causa, Peradeniya); M.A.(Cantab); B.Sc.(Lond.); F.I.E.E.(U.K.); F.R.S.A.(U.K.); F.I.E.(S.L.), Emeritus Professor of Electrical engineering of the University of Ceylon, having made a singular contribution to the engineering education of this country, left us on the third of July, 1978. A man of high principles and of strict discipline, who was totally devoted to his calling in life, namely, the education and training of the engineer, is remembered by his many students and associates with undiminishing regard and affection. The existence of a large number of eminent engineers and their presence at this Commemoration Lecture, today, is a tribute to his eminence.

During the time of Professor Paul, the education and training of the engineer centred around the induction of proficiency in technical knowledge and the relevant skills. Today, however, the situation calls for a far broader based education. If we did have the privilege of having Professor Paul with us today, he would certainly be one of the very first to recognise the need to orientate the style and the content of engineering education to meet modern requirements. Therefore, in examining this aspect of the education of the engineer, we are in a way paying homage to this pioneer educator, Professor R.H. Paul.

Food, clothing and shelter are fundamental to the existence of any society. The effect of technology even on these very basic needs of mankind are, indeed, staggering. Technological processes have influenced the way we work, the way we take advantage of our leisure: sometimes beneficially and at other times unfavourably. It is therefore very essential that the application of technology should be indulged in with appropriate circumspection in order to ensure that such application will not be inimical to the interests of the society. Arising from this, a heavy burden and an important responsibility is cast on the modern engineer. Therefore, to discharge his obligations towards society the engineer has to possess not only technological knowledge and expertise but also an awareness of his social environment, the aspirations of his people and of their cultural constraints. It follows that the manner in which technology is to be applied differs from society to society. Unless the engineer has a broad-based education which helps him to identify the technological development that suits his particular society his contribution will very often be to the detriment of the society itself.

No doubt, the engineer has high technological competence and he is sure in his own mind that he has used his expertise to further the interests of society. Even so, today, he has to bemoan the fact that society does not recognise the engineer as being one of its benefactors. The reason for this sad state of affairs seems to be the fact that the status of the engineer in society is a reflection of his own contribution to society. To achieve such status, the make-up of the engineer has to be such that he has an informed awareness of the inter-relationship between society and technology. He can ill afford to continue in the belief that he is not eligible to speak-out on national issues. He has to consciously build up public awareness of the role of the professional engineer. If the education of the engineer is to continue being narrow and specialised, then the engineer will not be in a position to effectively participate in the policy-making processes of his society.

In this context, it is pertinent to examine whether the relationship between the engineer and the society was equally disappointing in the past. We speak of an Independence of forty two years. This is certainly misleading. Except for a few brief periods of foreign interference, we were an independent nation for thousands of years. We are not a people who suddenly fell from the skies: indeed, we possess written records of our activities which cover over two thousand years. Indeed, we have a technological and cultural heritage of which any nation could be justifiably proud.

Archeological investigations, supported by modern carbon dating techniques, has revealed the fact that 28,000 years ago, Sri Lanka was the home for the CRO-MAGNUM man: the first modern man. Excavations at Anuradhapura have now shown that a continuous civilisation, which was familiar with the use of metals, had been in existence since five hundred years before the birth of Christ.

The excavations at the Abhyagiriya complex have unearthed a number of gold melting furnaces along with the associated foundry and a number of statues that had been cast. These belong to the era of two hundred years before the birth of Christ. During the same period, the great dagoba, Ruwanwelisaya, was constructed and surmounted by a crystal. The pinnacle had been installed not merely to enhance the beauty of the dagoba but according to the commentary to the chronicle Mahavamsa, "for the purpose of destroying the dangers of lightning".

Coming to civil engineering matters, we find that the Jethawana dagoba, which is about four hundred feet in height and built four centuries after the birth of Christ, is the tallest brick edifice man has ever built. The ancient bricks are much larger than their modern counterpart and no less than sixty two million of those ancient bricks had been made use of for the dagoba. Built on bed rock its weight is six hundred and fifty seven thousand tons.

Irrigation technology of the past includes such unsurpassed feats as the 'Jaya-gange' (Yoda-ela), where the first seventeen miles of the man-made water-way have a gradient of only six inches per mile. Mr. H. Parker, a British civil engineer who served the Sri Lanka Irrigation department from 1873 to 1904, in his celebrated book 'ANCIENT CEYLON' has, inter alia, this to say about the genius of our ancient engineers.

> "Since about the middle of the last century, open wells called 'valve towers' when they stand clear of the embankments, and 'valve-pits' when they are in it, have been built at numerous reservoirs in Europe. Their duty is to hold the valves and the lifting gear for working them, by means of which the outward flow of water is regulated or totally stopped. Such also was the function of the 'BISOKOTUWA' of the Sinhalese engineers; they were the first inventors of the valve-pit, more than 2,100 years ago...."

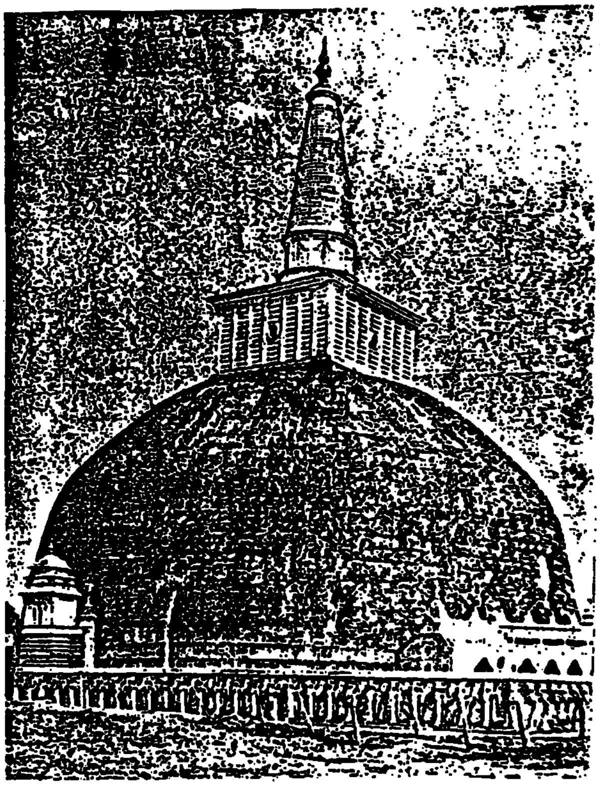
"Rajatharangani", the chronicle of Kashmir, mentions how, during the regime of the Kashmirian king Mihirikula, 700 years before the birth of Christ, gold lace embroidered silks of exquisite beauty were imported from Sri Lanka by this king for the use of royalty. The same chronicles go on to say, that 700 years after the birth of Christ, the Kashmirian king Jayapida, invited five 'RAKSHASA' engineers from Sri Lanka who designed and built for the Kashmirian king reservoirs and the fortress city of JAIPUR.

Perhaps, it is a good omen that recently, the ancient and modern technologies confronted each other at the Mahaweli reservoir projects. The following extract from the official records will, undoubtedly, be of interest.

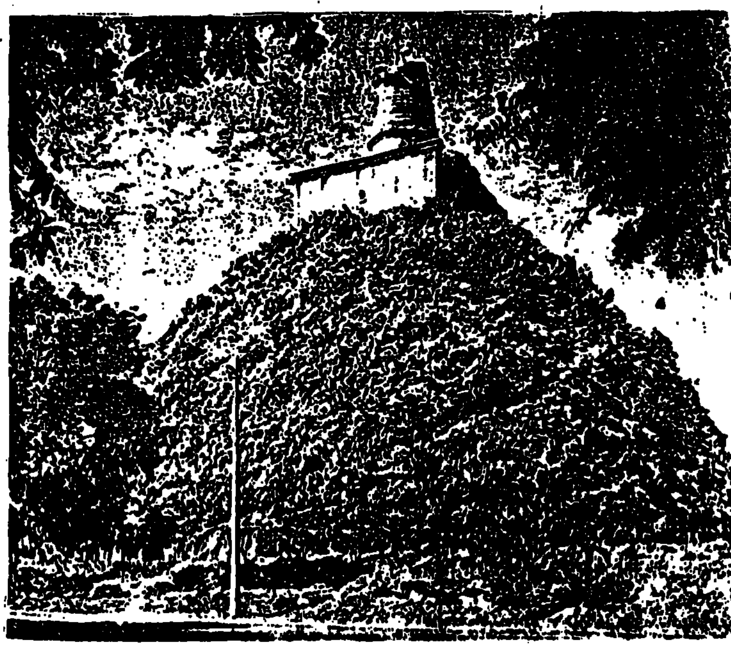
> "The right bank intake structure was located within the upstream shell of the main dam....., to reduce both the conduit length and the access bridge span. The objective was to found the intake and conduit on sound rock at the right abutment without excessive excavation. Hence, the location was not finalised until virtually all abutment stripping was completed in the area, to ensure that the major structures were advantageously located in a shallow cut.
>
> (Unfortunately, this optimisation led to a final alignment which discharged directly into the site of the Ancient Spillway discovered downstream of and parallel to the axis of the main dam....."

The foregoing extract refers to the Maduru Oya Reservoir Project of the development of the Mahaweli ganga. This, indeed, seems to be the confluence so to say, of the two respective streams of ancient and modern engineering technology of Sri Lanka.

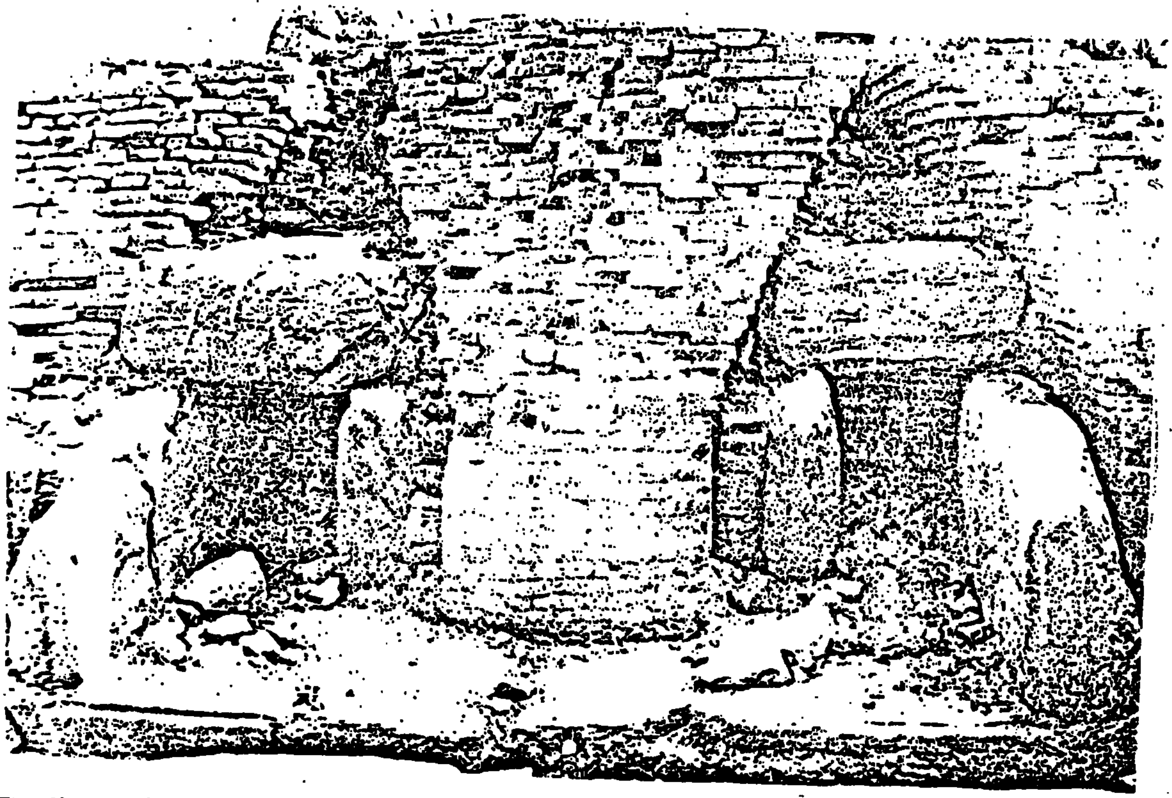
These are only a few glimpses of our past engineering prowess. Our chronicles contain sufficient evidence to show that our engineers of the past enjoyed the esteem of the people and that grateful sovereigns bestowed on them much wealth and honour.



Ruwanvalisaya



Jetavana Dagoba



The Maduru Oya project has attracted a great deal of interest since construction workers again chanced upon an interesting sluice structure in the old earthen dam.

Measures have been taken to preserve this structure and the ancient earthen dam in situ as artefacts of Sri Lanka's hydraulic civilization.

How then has this tradition of appreciation for the work done by the engineer dwindled? Why has the present day engineer to go unrecognised by the society they serve?

The engineers of the past, of course, did not rely on foreign funds, alien technologies, imported materials or finished products from abroad. More importantly their engineering skills and ingenuity were never used in a manner ill attuned to the ethos of our people. However, in spite of these well established traditions, the four hundred years or so of foreign domination weaned the elite of this country from their mother tongue, their cultural values and their national pride. This conditioned their mind to accept the myth that anything of value in this country should have had its origin in some foreign clime.

Arising from this sad state of affairs, critical examination became a lost art and the engineer became totally dependent on foreign thinking. The minimum the nation could expect from the engineer was for him to at least examine what was being introduced under the high sounding name of modern technology was appropriate to our environment, that local capability was available for the proper and adequate maintenance of the equipment, and that the system being introduced was capable of easy expansion to meet possible future needs. Unfortunately, even such basic monitoring was not the order of the day. So overwhelmed was the engineer by the glamour of the achievements of the western world, there appeared to him only one mode of approach, namely, to import and transplant the technological achievements of the west. It was as if the engineer had unwittingly donned some sort of mental blinkers which provided him with the dusk of complacency. Things were becoming easier for the present day engineer than to his ancient counterpart. For, if there was a problem a ready-made solution to it was available from the advanced countries.

It was, certainly, a very convenient solution. Of course, if the imported technology did not dovetail with the way of life of our people, then it was up to the people themselves to so order their life-style to fit the borrowed practices. It cannot, therefore, be gainsaid that such blind acceptance of inappropriate technologies, which were meant to benefit the supplier and not the user, eroded whatever regard the society had for the engineer. More importantly, the society identified the engineer as the party largely responsible for the debacle.

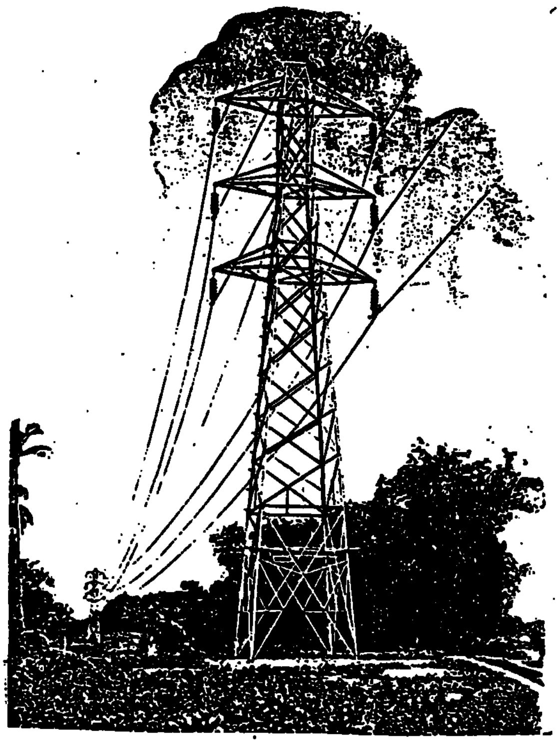
A professional engineer, by the recognised definition, is expected to be able to assume personal responsibility for the development and application of engineering science and knowledge and, among other things, capable of superintending and managing engineering works. His work requires the exercise of original thought and judgement. This prescription is, certainly, not fulfilled if techniques developed for other countries are blindly accepted and implemented in Sri Lanka. A couple of examples to illustrate this point seems in order.

Nearly five decades ago, a company in Sri Lanka, distributed its wares to the customers by using a bullock cart for the necessary transport. Amongst its other shortcomings, the bullock cart damages the macadamised surface of the road. To overcome this, in accordance with the aforesaid practice, changes to the bullock cart were effected on the basis of technology developed in the advanced countries. Basically, the two wooden wheels were replaced by metal wheels with hub brakes and pneumatic tyres. Everything went fine until the cart had to negotiate the hill at Hulftsdorp. Due to the steep gradient the gravitational force was a match to the effort of the bull and the tendency was for the cart to roll back. The natural instinct of the driver was to apply, the newly acquired luxury, the handbrake. The downward movement of the cart stopped immediately. But, this prevented the cart from moving forward either.

The aforesaid embarrassment had to be faced because of the blind application of imported technology. One of the main objectives was to prevent the fraying of the road surface by the iron rims of the cart wheels. The metal rims of the wheels cut into the road surface because the cart wheels tilt and meet the road surface at an angle. The total weight of the cart is then concentrated on a very small area thereby increasing the pressure applied on the road surface. Therefore, what was required was a device to prevent the wheels from tilting. This could have been achieved at much lower cost and inconvenience. This is a very simple example of the blind borrowing of foreign technology on a 'first choice' basis. Such action can hardly be considered as 'original thought and judgement' prescribed as a sine qua non of the professional engineer.

In this context it is also pertinent to draw attention to the fact that, in contradistinction, the ancient technology has decided advantages over the borrowed technology: the ancient technology consists of a very simple braking device. Indeed, it comprises two blocks of wood arranged to freely trail behind the two cart wheels respectively. Any tendency on the part of the cart to slip backwards is promptly arrested by these two blocks of wood and at no time will they impede the forward motion of the cart.

Perhaps, the foregoing example may not be considered adequate to underscore the need for critical examination of the technology being borrowed. Therefore, at least one example of more sophisticated borrowed technology will drive home the point. The picture given below is that of a steel tower of the 66,000 volt transmission line bringing electric power from Laxapana to the capital city Colombo.



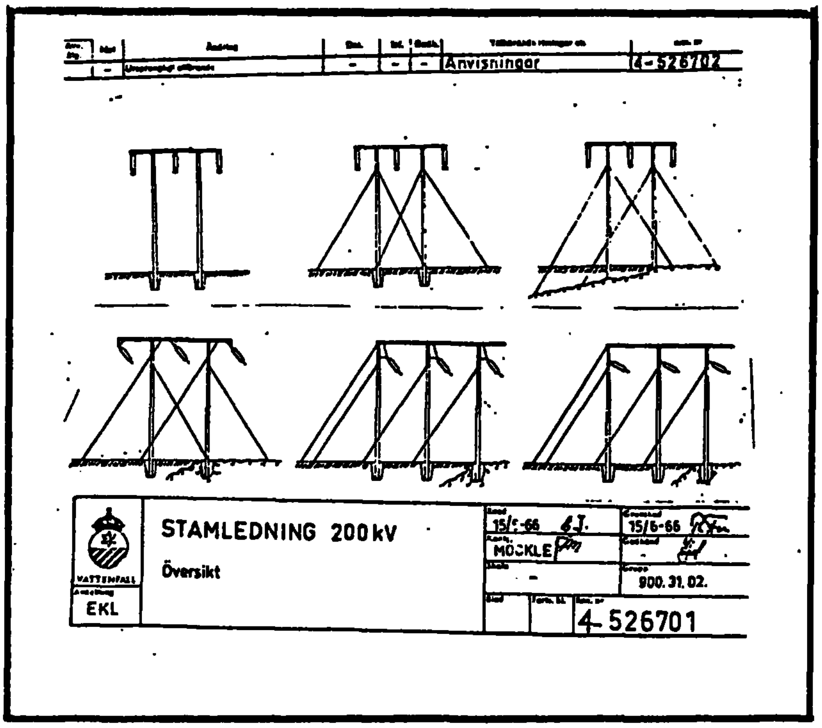
A steel tower of the 66,000 volt line
from Laksapana to Colombo

Besides this 66,000 volt line, there are the 132,000 volt transmission lines. These lines consist of much larger steel towers which are very expensive and certainly a drain on the foreign exchange reserves of this country. Also, for the proper erection of these towers, each of the four legs of a tower has to be anchored by using large mass concrete plinths; thus expending a resource such as cement which could be more profitably used for providing houses. It is true that on occasion steel towers have to be used in such instances where exceptionally long spans are called for; but that does not justify using steel towers for all the transmission line supports. It could be argued that steel towers are essential in order to accommodate double circuits. But, are double circuits really necessary? No serious study seems to have been made regarding this aspect.

An advantage of the double circuit transmission line is claimed to be the ability to maintain the supply through the remaining line when the other is defective. This, however, is a specious argument. Maintaining one circuit whilst the other continues to be alive at 132,000 volts is no simple task. Apart from anything else, it requires highly specialised staff competent to handle what is known as 'Hot Line Maintenance': an expensive exercise, indeed. However, if the tower itself gets damaged, there is no special advantage in having double circuits. This was highlighted during the recent terrorist disturbances when supply could not be restored for several weeks inspite of the double circuits.

In the circumstances what alternative did we have? Instead of having double circuits on the same transmission line supports we should have had single circuit transmission lines in the form of a ring circuit. In such an arrangement, even if a few towers were damaged, supply could be given through the two legs of the ring circuit. In the double circuit arrangement the transmission line goes through one route only whereas in the ring circuit the return leg of the ring could take an entirely different route thereby electrifying a larger area of the country. The objection that more towers will have to be used in the ring circuit thereby increasing the cost should not be taken seriously as, in the case of the single circuit, large steel towers are not necessary as the transmission line supports. What will be used is what is known as an articulated structure where two vertical poles carrying a crossarm is anchored by guy ropes. This is a simple structure which can be locally turned out in prestressed concrete at minimal cost compared to a steel tower which has to be imported.

Sceptics are bound to object on the grounds that such a simple structure is totally unsuited for an extra high tension transmission line of 132,000 volts. This is, ofcourse, not true.



The above diagrams show such articulated structures that are being used in transmission lines of 200,000 volts, which is a voltage far higher than the 132,000 volt lines used in this country. These structures utilising wood poles are extensively used in Scandinavian countries where the terrain is not always flat. If such technology is good enough for countries such as Norway and Sweden, whose affluence is not disputed, it is difficult to understand as to why such technology was considered unsuitable for a relatively non-affluent country such as Sri Lanka. The bare truth is that the first inclination on the part of the engineer is to readily accept what is presented to him as modern technology without any critical examination as to its suitability for use in this country.

What is of the essense is not whether one possesses expertise but how the exercise of the expertise serves the nation. It is the bounden duty of every citizen to act in the best interests of his country. This is more so in the case of the engineer particularly because the nation spends large sums of money on his education and training. The nation, therefore has the right to expect the engineer to effectively and intelligently discharge his duty towards the development of the country.

In the present context, this obligation cannot be effectively discharged by the engineer if his knowledge is restricted to the engineering sciences only. Apart from the fact that the engineer of today has to be well aware of the social implications of the application of technology, he has to have a high degree of managerial ability, particularly in the fields of financial and human resources.

Also, the engineer has to depend not only on his performance but also on the performance of several others in order to achieve his objectives. In this context he should possess qualities of leadership. He should be attuned psychologically to work amongst multi-disciplinary teams and not be reluctant to assume the leadership of such teams. It is therefore a matter for regret that some engineers are still prone to pursue the familiar insular approach. Perhaps, this stems from an inherent fear to join hands with entrepreneurs, accountants, architects and financiers and others belonging to many other disciplines. The reason for this may well be that the highly specialised and therefore necessarily narrow education of the engineer makes him feel inadequate and uneasy to indulge in professional intercourse with persons of other disciplines. Nonetheless, the engineer cannot avoid such participation when his objectives can be achieved only by the concerted efforts of a group of persons and more importantly the engineer providing the leadership to the group.

Therefore, if the engineer is to serve his country, he should come out of his technological shell, join hands with persons of the related disciplines and provide the much needed leadership. To ensure this, the education of the engineer should be appropriately broad based, providing in addition to a knowledge in the engineering sciences managerial ability in the fields of human and financial resources. Such an approach will extricate the engineer from the hazards of convergent thinking and provide him with the wherewithal to indulge in lateral thinking instead.

It is only when the engineer is equipped in the aforesaid manner that he can effectively discharge his duties and obligations towards the society. As far as the education of the engineer is concerned, Professor Paul and others have laid a firm foundation. It is now our duty to build a superstructure which will be in consonance with modern day requirements in the field of engineering education. Let us hope that due and proper consideration will be given to this essential aspect and the engineer encouraged to participate fully in the important task of nation building. Then and then only can the engineer stand up and expect to be counted. If such a day dawns, then the great efforts of the likes of ROBERT HOISINGTON PAUL would not have been in vain.