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ENGINEERING IN CANADA

ENGINEERS are more appreciated than they used to be. It is through their efforts that the comforts have been provided which set today's standard of material living so high above that of past centuries.

The engineering profession has particularly wide opportunities and obligations in Canada, where sound, healthy expansion is based upon an abundant supply of natural resources. Science and engineering take these resources and develop them for the benefit of our people. At the same time engineers work for conservation of resources—the maintenance of soil, the perpetuation of water supply, the preservation of forests—so as to provide for a continuance of supply over coming centuries.

What exactly is engineering? It has been called the art which makes pure science useful. This is a far cry from the definition of "engineer" given by Samuel Johnson in his *Dictionary of the English Language* published in 1755: "One who manages engines, or directs the artillery of an army."

It is often difficult to draw sharp lines between the many different practices so as to define where engineering begins and ends. The title of "engineer" is a coveted one, and rightly so as long as it implies a long and difficult course of education and training.

In Canada engineering is regarded generally as a learned profession. The engineer analyses needs and then designs and supervises the building of things to meet them: railroads, bridges, radios, airplanes, automobiles, rockets, dams, power plants, engines, factories, pipe lines, atomic energy and thousands of other things.

Perhaps the shortest all-inclusive definition is given by a distinguished contemporary engineer: "Engineering is the art of the economic application of science to social purposes."

A person who is only a technician is, in the words of Sir Richard Livingstone: "a man who understands everything about his job except its ultimate purpose and its place in the order of the universe." The engineer, however, must follow problems through from origin to results, and find solutions. He must take account of the social effects of what he produces. He is exercised to see that the cost is not more than the benefit is worth.

Need for Engineers

Canada's need for engineers is expanding constantly, says Dr. L. Austin Wright, General Secretary of the Engineering Institute of Canada. Not only does industry keep increasing its needs, and the armed services their demands, but opportunity is opening new doors. Many small industries that never before used engineers are finding that they can get better results, and can meet competition more successfully, when they employ engineers.

What a change this is from the situation thirty years ago! Dr. Wright's predecessor in the Engineering Institute of Canada told the Montreal branch in 1923 that the profession "is overcrowded, and becoming more so every year." He went so far as to advise youths to seek other outlets for their energies.

These thirty years have brought about a revolution, and today graduating engineers are eagerly sought. One company numbers 350 graduate engineers among its 8,500 employees.

There are many openings in the government service. More than fifty per cent of the professional staff of the National Research Council and the Atomic Energy Control Board are engineers, and somewhere about 75 per cent of their budget is spent on applied science or engineering development work. When you move over into government departments which are charged with the practical application of discoveries made through research, the importance of engineers is seen again: there are more than 500 technically trained engineers in the Department of Mines and Technical Surveys; more than 250 architects and engineers in the Department of Public Works; and, of course, proportionate numbers in the departments of Transport and Resources and Development.

Engineers are holding preferred positions in administrative, legal, research and sales staffs of industries.

A recent survey in the U.S.A. revealed that 45 per cent of all administrative posts in industry were held by engineers.

Certainly, a young man's chances of making dreams come true were never better than now, if his dreams have to do with designing or building great structures, electronic wonders, rockets to probe the universe, or machines to produce things people want. But basic qualities are needed. Because a man is fond of digging in his garden, he mustn't on that account think himself the equal of a skilled gardener. No dub at measuring and calculating should expect outstanding success as an engineer; nor should the youth who is uninterested in physics, in chemistry, and in finding out the answer to "why?" and "how?" He must be willing to submit to a rigorous course of education, and to work hard at putting into practice what he learns of theory.

Conditions in Canada

While the opportunity for young men in engineering is undoubted, there is not the same shortage of men in all parts of the country or in all branches of the profession. The demand is mostly, says Dr. Wright, in specialized fields—noticeably in electronics.

Writing about the situation a year ago, the Chief of the Executive and Professional Division of the National Employment Office said that in 1952 the eleven Canadian schools of engineering graduated 1,750 engineers while at the same time he had demands for more than 2,350 graduates. He estimated that Canada's annual requirement for some years will be 2,000 graduates in engineering. The Rt. Hon. C. D. Howe, Minister of Defence Production, himself an engineer, told a University of Toronto audience last year: "I can foresee no possibility of the supply of engineering graduates ever exceeding the demand, in this expanding country of ours."

Not many engineers are leaving Canada. A report from the bureau of statistics showed only ten per cent of our university graduates in engineering going to the United States, and most of them were seeking post-graduate study. To offset this, there are from two to three times as many engineers coming into Canada from the United States. To this information Dr. Wright adds: "I don't believe that today the United States' salaries are an irresistible temptation to Canadian engineers. As a matter of fact there is an increasing number of inquiries from American students who propose working in Canada."

Confirmation of this is given by the result of a poll of placement officers at four Canadian universities. In their opinion, starting salaries which are offered graduates at bachelor level compare favourably, though they say that engineers with a doctorate degree are frequently able to secure better offers in the United States.

Saturday Night commented on a National Research Council advertisement in 1950 offering $5,000 to $6,300 a year for a "highly qualified physicist or mechanical engineer" to be head of "a group of physicists and engineers in applied research and engineering development related to design of atomic energy plants and plant equipment." The periodical said editorially: "If the National Research Council gets a 'highly qualified physicist or mechanical engineer' for this post on these terms it will be simply because some such person loves his country and his science too much to carry his abilities to a better market."

Production and Culture

Both in achievements and opportunities, engineering in Canada has had its ups and downs, but there is hardly a curve of engineering growth which does not turn sharply upward after 1900 and increase its gradient in the nineteen-forties.

Power plants and highways, mining and communication, chemicals and machines—all have set and passed new standards of quality and quantity. Their achievements have been the fruit of creative thinking based on original concepts, blueprinted and carried out by engineers applying fundamental physical laws with incredible ingenuity.

It may be said that the most important single factor in our national economy in the past thirty years has been the rising influence of engineering. To go further back, the rise of our culture has been coincidental with the rise of science and technology. Because of the production advantage given by engineered factories, the worker exchanges a fraction of his waking hours for hitherto undreamed-of freedom in all other areas of life.

Cultural activities must have such a solid base as that given a nation by its engineers and technologists. In the book *Engineering and Society* by Young, Innis and Dales, it is said: "Whatever gives a continuing and dependable basis of economic security stimulates humanistic interests and occupations. And so the technologist and the engineer in their practical pursuits are extending the opportunities to those who wish to rise above the tedium of daily toil." This book, published by the University of Toronto Press in 1946, is a unique attempt to give young engineers some knowledge of the important fields linking engineering, history, economics and geography.

The promise of technology is always fabulous, and our problem with reference to it is not to guess what the future holds for us but to answer the question: "what do we want technology to do for us?"

Engineering is Creative

Wherever one touches engineering, one finds creativeness. An engineer may be engaged in exploratory research, uncovering new fields, setting new goals, separating good creations from useless, and drawing patterns for further work. Or the engineer may exercise his special talent in fundamental and basic research, in data-gathering and manipulation, in providing facts upon which thousands of others will work. Or he may devote his knowledge and experience to design and development, working out for everyday use the theoretical concepts of others.

To be successful in whatever field he chooses, the engineer must think logically, visualize clearly, and evaluate in terms of reality. He needs to reject the thought that so-and-so is final, that such-and-such a process is perfect. He will realize that many facts of nature are still unknown to us. Charles F. Kettering, at the time Director of General Motors Research Laboratories, listed 25 unanswered questions, and said in an aside that the list might be extended to 25,000. Among the questions which engineers still have to answer are: what is friction? how do fuels burn in an engine cylinder? what is magnetism? what is electricity? what is fatigue of metals? what is the nature of the atom, the molecule and the electron? what is energy? what is a lubricant, and how does it work?

These and other questions either clamour for attention or whisper insistently around the fringe of engineers' minds. The fact that they remain unanswered does not mean that engineering cannot go on: engineers built stone arch bridges for at least two thousand years before they knew for certain what made them stand up.

There are traces, even in the most primitive engineering efforts, of the scientific spirit and a search for underlying principles, though engineers in general will agree with Lord Kelvin's dictum: "the life and soul of science is its practical application."

With us, in these western countries, the concept of science carries with it the idea of a power transforming material life for the good of mankind. We see it expressing its discoveries in techniques, in arts and in crafts. The engineer applies his experience to a theory with a practical objective, and the test of his product is that it works. It satisfies some of man's material wants and needs within the economic and social framework of the times.

Kinds of Engineering

These two engineering functions—theory and practice—display themselves in many diverse areas of human endeavour, and each one attracts men and women of diverse personalities. No matter what his particular bent, the man with an engineering-type mind can find a niche fitting him perfectly.

There are five major engineering categories: mechanical, electrical, civil, chemical, and mining and metallurgical. These are sub-divided by names which describe a great number of specializations, such as aeronautical, manufacturing, petroleum, radio and industrial engineers.

A review of technical personnel records, begun in 1951 and reported in 1953 by the Canadian Department of Labour, showed the specialties of 26,346 engineers and scientists in Canada. Here is the detail: civil engineering 4,425; chemistry and chemical engineering 4,319; physics 925; architecture 782; mechanical 4,273; electrical 3,941; agriculture 2,462; mining and metallurgy 2,052; forestry 1,015; biology 970; geology 651; aeronautical 270; mathematics 208; geography 53.

Every one of these professional crafts offers glamour and romance to the man who is specially interested in it. His interest may stem from his appreciation of the results in terms of benefit to mankind, or from the fact that he finds its problems fascinating.

Engineers in industry have a special role to play in an expanding industrial country like Canada. There is not a province that produces less than $20 million annually of manufactured products, and only two that produce less than $200 million worth, while Ontario and Quebec produced $6,823 million and $4,142 million worth of goods in the latest year of record, 1950. Expansion has been great since that time.

When manufacturing industry recruits young engineers it is looking for potential managers. It wants men with the sense of order, the quality of accuracy, and the enterprise in getting things done that are the marks of engineering education and training.

Engineers expend their talent largely in increasing the efficiency of others. They decrease the time consumed in making a product, thereby reducing costs so that markets can be expanded and new things introduced, with consequent increase in job opportunities. They bring about more efficient use of materials, contributing thereby to conservation of resources.

The engineering way—of gathering all the pertinent data, subjecting it to mental and experimental test, coming to a decision, and then doing something about it—contributes tremendously to the smooth flow of productive activity, the elimination of bottlenecks, the lessening of fatigue and tension, and the building up of commercial greatness.

These qualities are useful, too, in other than engineering and industrial fields. An engineering graduate who is a noted authority in dental bridge work claims that building a bridge across a river fifty feet wide and building one across a quarter-inch gap in a mouth are one and the same problem, one of loads and stresses, bending moments and abutments. Goldberg, the cartoonist, and Arthur Murray, the dancing teacher, graduated from schools of engineering. Engineers have served in municipal, provincial and federal government positions.

Education for Engineering

There have been men who reached enviable success in engineering without benefit of academic engineering education. In the early days there were no technical schools or universities with special courses, and young men secured their training by years of apprenticeship, or they applied themselves to some problem until they became master of the techniques of its solution.

James Brindley, an uneducated millwright (he never learned to read and write) built the Bridgewater Canal in England, and went on to construct many other waterways. George Stephenson, who made the steam locomotive a practical working mechanism, was an uneducated fireman in a mine, unable to read or write until he was 18 years of age.

These, however, are not typical of men who are successful in the profession today. An increasingly higher standard in the scientific training of those who are to be responsible for the applying of science in industry is being demanded, not only by industrialists but by engineers. Training in the *fundamentals* of engineering, before specialization, is urged by men high in the profession.

These experienced men also seek to have engineers educated broadly, so that they may have a wide understanding of our complicated society, how it works, and wherein it fails to work. They recall Milton's classic definition of an educated man: "I call therefore a complete and generous education that which fits a man to perform justly, skilfully, and magnanimously all the offices both private and public of peace and war."

Industry is extending help to engineering students on a growing scale, particularly in electronics, aeronautics, and chemistry. No all-inclusive list of scholarships in Canada is available at the moment, but the Canadian Committee on Counselling in Science and Engineering is preparing such a roster. As an example, the British Columbia Engineering Society listed for us 56 scholarship awards made through the University of British Columbia, totalling $6,580 a year.

Engineering Societies

It is difficult, too, to list engineering societies. There are many organizations of men who may or may not be engineers according to this or that definition. Certain societies are beyond doubt professional associations, and are doing splendid work. They have immeasurably raised the status of the engineer, and have protected the public from incompetence.

Because of the provisions of the British North America Act, which gives to the provinces the exclusive right to legislate on the practice of the professions, and because of the wide scope and diversity of engineering, it has not yet been found possible to have a single organization capable of catering to the economic, legal, social and technical needs of all professional engineers in Canada.

There are provincial associations serving our more than 20,000 professional engineers, 4,000 graduate engineers in training, and 6,000 engineering students. They have high standards which must be met before a man may call himself a professional engineer, or use the valued initials "P. Eng." after his name and practise engineering. The Dominion Council of Professional Engineers is the co-ordinating body of the provincial associations.

The Engineering Institute of Canada, the "learned society" of engineering, was organized in 1887 and now has 50 branches with 16,000 members. It is the oldest and largest of all Canadian engineering organizations, and it has agreements for co-operation with many other societies in the United States and throughout the Commonwealth.

Qualities of the Engineer

Prominent among the qualities needed by the engineer is skill in problem analysis. The engineer must be able to pull the problem apart and say: "Here is what we are trying to do." Nothing can be taken for granted in engineering: every detail must be accounted for.

Since nature makes no allowances, but demands absolute obedience to her laws, the professional engineer is trained to respect these laws. Any infraction is certain to bring punishment. He is not one who believes in "good enough to get by with". He can't do something and then cross his fingers and wish that it may turn out all right. He must be thorough, putting first things first while bearing in mind everything that contributes to a sense of balance in solving his problems.

This calls for rare judgment. At the base of the engineer's structure of knowledge there are the laws of nature; then particularized, personal knowledge; then professional knowledge and intellectual techniques acquired in university; then specialized skills learned in practice; and at the top, supreme in its function of modifying and guiding all the rest, sits judgment.

Judgment prescribes our highest ambitions and our loftiest moral beliefs, and these are the things which give meaning and direction to all our skills, our efforts and our knowledge. It is the factor which makes the difference between a man who does things only by recourse to text books, slide rules and precedent, and the man whose wits are sharpened by the determination to do things better.

No certificate of school or university or society makes an engineer. Some spark of originality, some creative spirit, must be added to technical skill.

Engineering cannot function always as a rigorous science, but remains in some respects an art. Imagination, visualization, and a realization of the goal, these cannot be overlooked in the professional development of an engineer.

The engineer's response to the thrust of responsibility upon him is well stated by Leopold Nadeau, P. Eng., who is General Secretary of the Corporation of Professional Engineers of Quebec. He says, in a letter, "Professional Engineers are fully aware of their tremendous responsibility and are continually striving to improve the ethical and technical standards of their profession to enhance its usefulness to their fellow men."

The engineer with his heart in his work will keep the faith: the faith of his client that he will not undertake what he knows to be beyond his skill, and that in the service he gives he will be conscientious to the limit of his ability. He will keep the faith of his fellow engineers that he will remain true to his science and will base his efforts for public recognition upon acquired knowledge, scientific attainment and excellent performance. He will keep the faith of his community that he will undertake no service inconsistent with public welfare.

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