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ENGINEERING IN AN AMERICAN PROGRAM FOR SOCIAL PROGRESS[1]

By Dr. KARL T. COMPTON

PRESIDENT OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

It is a great pleasure for me, on this notable occasion, to bring you the congratulations of your sister institution which I serve and to express the cordial best wishes for the even greater success of your engineering school in the next twenty-five years, which is the confident hope of your thousands of colleagues in sister educational institutions and in the engineering profession.

The Johns Hopkins University has been a pioneer and an example in much of the finest development of education in America, notably in such fields as chemistry, physics and medicine, and in postgraduate education. It attained this preeminence through concentration of its resources in a limited number of basically important fields, instead of dissipating its energies in an attempt to spread thinly over the whole field of knowledge or to pursue the ever appearing will-o-the-wisps of educational fashions. Its School of Engineering, though one of its younger departments, is of this basic character and has achieved distinction through the high ability and character of its staff and through its policy also of limiting its range of activities to those fundamental fields of engineering which it can cultivate with distinction within the limitations of its resources. While we all hope that ways and means may be found to increase its resources commensurately with its proven worth and opportunities, I trust that its wise policy of subordinating expansion to excellence will persist.

[1] Address on Commemoration Day at the Johns Hopkins University, February 22, 1937, celebrating the twenty-fifth anniversary of the founding of the School of Engineering at the Johns Hopkins University.

I would pay special tribute at this time to your two leaders, whom I am proud to claim as my friends. One of these, your dean, has served the School of Engineering from its beginning and has impressed on it his qualities of scholarship, of culture and that type of public service which he himself exemplifies in his important "extra-curricular" professional activities. The other is your "year-and-a-half"-old president, who is bringing to the service of this university those unusual qualities of clarity of judgment, creative imagination, decisive courage and statesmanship and warm loyalty to men and to objectives that are true and worthy, which I have so admired as I have come to know him in his leadership of organized science in the better performance of much-needed social service.

About a year ago I had occasion to discuss Science in connection with a symposium on "An American Program for Social Progress," arranged by the National Industrial Conference Board. On this occasion it seems appropriate to speak on the closely related subject of "Engineering in an American Program for Social Progress." For this twenty-fifth anniversary of the founding of the School of Engineering of this great university naturally turns our thoughts to an appraisal of the rôle of engineering in our society and to an attempt thereby to chart a wise course for the future, whereby engineers and engineering can best perform that service to the public which is the justification for their existence.

It is obviously not my function to chart the course for engineering at Johns Hopkins University. This is the responsibility of your trustees and administrative officers. But I can review some factors which are important in the consideration of engineering education, whether here or elsewhere, and which should be considered in the formulation of policies by any body which has to do with engineering. Government, university, business, labor, agriculture and the public generally all have a vital concern in these questions, as I shall show.

The outline of my discussion of these matters is exceedingly simple, for it is based on just two questions: "What elements are involved in the American program for social progress?" and "What is the proper rôle of engineering in each feature of this program?" But before dealing with these questions, it is well to consider briefly what engineering is and how it has developed.

On the walls of the national headquarters of the engineering societies in New York there hangs the definition: "Engineering is the art of directing men and controlling the forces and materials of nature for the benefit of the human race." This is so broad a definition that some may question its justification. But while there are many who do not call themselves engineers (as, for example, the President of the United States or the Secretary of Agriculture or the president of a steel company or the head of a labor union) "who direct men and control (or try to control) the forces and materials of nature for the benefit of the human race," nevertheless such men are really operating to a great extent in the field of the engineer. And to the extent to which they follow the methods of the engineer—in basing policies upon facts, in utilizing knowledge to achieve results, in depending on law rather than hunch, in giving attention to foundations before erecting superstructures, in using imagination disciplined by experience, in thinking through to the goal before starting on the way—to this extent will their efforts be "for the benefit of the human race."

That quality of the engineer of achieving results has been so notable as to have received recognition in the dictionary in the coinage of a new verb, "to engineer." For it is common parlance to say "he engineered a deal," or "we need some one to engineer this project." Such phrases reflect the common realization of the public that the methods of the engineer are sound and successful. The fact that this realization is tacit and almost subconscious is all the more evidence that it is derived from a long background of experience of undertakings successfully carried through by engineers.

It is this quality of performance in matters of practical importance that distinguishes the engineer from his close relation, the scientist. The pure scientist concerns himself with the study of the materials, forces and phenomena of nature. The applied scientist bridges the gap between science and its use, and his function is to interpret and extend in order that utility may ensue. The engineer bridges the gap between science and the public, and his function is to develop the applications of science in such manner that they may fit beneficially into the existing organization of civilization.

It is significant that the engineer is a relatively new actor on the stage of world progress: he is both the product and the cause of our technological age. I would not imply that there were no engineers in past ages; Archimedes, the Roman road and aqueduct builders and Leonardo da Vinci were great engineers. But as a profession, engineering is of relatively recent origin. Great universities in Europe have existed since antiquity, with their professional schools of law, medicine and theology. In America, Harvard celebrated last fall its three hundredth anniversary. But Rensselaer, the oldest engineering school in this country, was founded only 113 years ago, my own institution 72 years ago and your school only 25 years ago. Although there are now 155 degree-granting engineering schools in the United States, enrolling about one tenth of the country's college student population, most of these schools are relatively young and all started small. Thus, compared with other great professions, the systematic training of engineers scarcely extends beyond the lifetimes of the older men now in the profession. This fact serves to enhance the significance of the importance and success which engineering has achieved.

During this less than a century of development, the character of engineering education has undergone important changes. In the early days the professional curriculum consisted of pure science, the applied science of the day and the techniques of practical work in shops or in the field. As great industries developed, based on technological advances, the curriculum took on more of systematic training in the processes and techniques of these industries, became more crowded with newer and newer specialties, with some tendency to crowd out the basic sciences and much pressure to stuff the student with all the factual knowledge and techniques which he might later be called upon to use. This trend finally broke for two reasons: it became impossibly unwieldy and it became out of tune with industrial demands in the following manner.

In their early development, industries had to depend largely on the engineering schools to provide both the knowledge and the technical, often manual, training which their operations required. But now the larger industries can, and prefer, to do much of the training of their new employees in the particular techniques and operations which they use. Their great demand is for young engineers who are so well grounded in the sciences and in the fundamental theories of engineering as to be capable of grappling effectively with the new problems and ever-advancing arts that are associated with technological progress.

So the recent tendency of the engineering schools has been to reduce emphasis on shop practices—leaving most of these to the technical or trade schools and to apprentice training courses in the industries themselves; also to postpone the more specialized training into postgraduate years; and to concentrate chiefly on basic science and fundamental engineering, together with more attention to the economics and social science which are becoming more and more the concern of the engineer. In this program, such specialization as remains in the undergraduate curriculum is more for the purpose of training the student how to specialize than for producing a specialist.

We thus have emerging, to meet present and future needs, this type of undergraduate engineering school. In favorable situations such schools are being extended to rapidly increasing attention to postgraduate training in specialties and in research, and coincidently, increasing activity in assisting industry to solve some of its more obscure or forward-looking problems.

But industry requires both engineers and technicians—about four technicians to every engineer, according to a recent survey by the Society for the Promotion of Engineering Education. The situation is too complex for one and the same school to try to train both engineers and technicians, and do a good job with either. So the latter function is being more and more taken over by the industries themselves and by the technical and trade schools, as distinguished from the engineering schools. Naturally, however, all gradations between these extremes exist among the numerous engineering and technical schools of the country.

In this classification, the School of Engineering of Johns Hopkins University lies definitely in the category of the progressive engineering school. Undoubtedly this is due both to its youth and to the high scientific ideals of its founders, its administration and its environment in the university.

And now, against this background of the nature of engineering and the training of engineers, let us cast a picture of some major features of the American program for social progress. America needs work for some millions of unemployed. She craves protection against the perils of nature, such as floods and earthquakes and droughts, and against the man-made perils of transportation, fire and group violence. Wisdom urges her to seek conservation of her natural resources of soil, minerals and power. She needs better housing for large groups of her population. She realizes the advantages which would derive from a more efficient system of distribution of her products to her consuming public. Her people are striving, sometimes with violence, for higher wages, shorter hours of labor and a generally higher standard of living.

These are the things which are the major goals of our federal administration and our local governments and which are at any rate the most vocalized aspirations of our people. And every one of these things not only involves engineering, but can only be achieved through engineering, by engineers! This is a striking fact, of large significance in determining what should be our attitude toward the engineer and his training.

To emphasize this point let me suggest that good laws, proper financial adjustments, brotherly love and justice can all facilitate the happy attainment of these goals which I have mentioned, and their opposites can wreck us, but without engineering they are practically without avail to achieve the goals. As to their achievement, one might almost paraphrase the Holy Writ and say that, without engineering, laws and financial schemes are as sounding brass or a tinkling cymbal. For all these goals require the creation of physical things for the accomplishment of definite purposes. Laws and finances may give the setting, but the actual creation is the job for the engineer:

If I am right in this analysis, which I will proceed in a moment to defend, is there not lacking a sense of proportion and fundamental understanding in some of the efforts which are being so feverishly exerted by our national leaders in their campaign to raise standards of living through such devices as distribution of wealth, creation of artificial employment, regulation of wages and hours of labor or curtailment of production—while practically neglecting effective methods of stimulating science and engineering to lay a solid basis for future progress?

Now let us turn more specifically to those major features of the American program which I listed a moment ago. The first was:

Reduction of Unemployment

Far and away the greatest task which has faced the American people in the last four years has been to take care of the great group of unemployed which appeared with the depression in numbers two or three times as great as the normal unemployable population. There can be nothing but praise for the promptness and boldness with which this emergency was tackled by the Federal Administration, whatever may have been the faults typical and perhaps unavoidable in so great and so sudden an enterprise. With this program of providing emergency work and providing outright relief when necessary, we have come through to better times. The basic problem, however, is far from solved, for unemployment still stands at figures nearly double the estimated unemployable population. Perhaps our greatest national problem is still that of handling this unemployed population. We could cheerfully support almost any emergency measures if we could see that they were leading us toward a permanent solution. What is the permanent solution?

There have been several schools of thought in this question, falling between the extremes illustrated by two incidents. One portrays the share-the-work movement reduced to an absurd extreme. The other presents the extreme claim of those who foresee the solution in the creation of new industries, by engineering science.

In the early days of the depression in one of the western states, the legislature had voted an appropriation for road building to provide employment. During the discussion, one legislator moved an amendment to the effect that no labor-saving machinery of any sort should be used in the construction, so that the maximum number of people might be employed. One of his colleagues then jumped up to amend the amendment, to specify that the workmen should be equipped only with teaspoons, in order that the maximum number of them might be required to perform the job. Without any further argument, I think, we can assert that this idea of dividing the work, while it may be advantageously employed up to a certain point in some situations, does not hold the key to an ideal solution of the unemployment problem. It is essentially unconstructive and represents a move backward in man's development as a creative being.

The other extreme was typified in 1934 by a joint symposium of the American Institute of Physics and the New York Electrical Society on the subject, "Science Makes Jobs." Here the speakers, of whom I was one, drew a vivid picture of the tremendous employment which has been made available through the development of the telephone, the automobile, the electrical and the chemical industries, all products of science and invention within the last generation or two and now affording not only luxuries and new necessities of life but also affording a livelihood to a very substantial portion of our total population. One of the speakers quoted Dr. Kettering's remark that the "trouble with us was not the over-production of goods but the underproduction of new ideas." The audience was asked to consider how much earlier and more severely the unemployment problem would have struck the country if even one or two only of these great technological industries had not been developed some decades ago. From this the inference was drawn that the most positive direction in which to seek jobs for the future is through the science and invention which join in productive engineering.

Of course the argument is not quite as simple as this last statement would imply. For example, if the automobile industry, together with the subsidiary business like sales, service, and oil, did not now provide employment for some three millions of our population, it does not follow that these three million people would now be unemployed. Some of them would never have been born, because their parents would have been too poor to raise more children. Some of them would have died in childhood, because the community could not have afforded the present standards of sanitation and medical care. Certainly many of them would be unemployed, and all the rest would be competing for work in the remaining industries—holding down the wage scale and all struggling for meager existence. I think we can certainly say that had the automobile industry not developed there would have been much more unemployment than there is now; there would have been far more misery, and the general standard of living would have been lower. Thus the automobile industry and every new creative industry is a boon to labor, to the consumer, and in fact to all the public.

Out of all the thought and discussion which have centered around the problem of unemployment this year, it seems to me that two features typified by the two examples just mentioned stand out rather clearly. One is that we have a responsibility to share the work which is available to as great an extent as this may be consistent with good production and general economy. I shall have more to say about this point when we come to the subject of higher wages and shorter hours. The other feature is that the positive constructive cure for unemployment is to provide more really useful employment, which means to provide more things which people want and are willing to pay and to work for. Again we see that the constructive solution of the unemployment problem falls within the scope of engineering work.

When we consider the relatively small attention which has been paid to this constructive side of the problem of unemployment in the midst of the recent tremendous efforts to provide temporary relief, and to "prime the pump," I think we have food for some very serious thought. It does no good to "prime the pump" unless the well has been driven down to the ground water level; otherwise no water is pumped except what was poured in for priming. Similarly, unless the basis of emergency work reaches down to the creation and production of new things which people will work and pay for to possess, the emergency work is of little more value than a "setting-up" exercise. It is not only true that our policies have not devoted much attention to this basic and forward-looking problem of stimulating new industries for the future, but it is unfortunately true that there has been much, either directly or secondarily, in policies which have recently been put into effect for other purposes, which acts as a definite deterrent or penalty to constructive steps toward new industries and employment by private agencies. In other words the government has been relatively inactive and at the same time has permitted tax and code legislation which definitely inhibit action by private agencies in the directions which would bring ultimate employment.

However these things may be, one thing, I believe, is clear, and this is the main feature of my argument. It is that the engineer has a key position in the solution of the unemployment problem.

PROTECTION AGAINST PERILS

The second major feature of our American program is protection against both natural and man-made perils. Scarcely a year passes without some major catastrophe which takes the lives of hundreds, causes suffering and hardship to thousands and destroys millions of dollars worth of property. Within the past month we have had the greatest flood in the history of the Ohio River. Last year came great floods in New England. Two and three years ago drought and the dust storms devastated the great plains of the West. Earthquakes have done great damage in California on a few occasions, and cause the inhabitants continual uneasiness.

When we come to protection against man-made hazards, we have continually brought to mind the safety of the highways and of airplanes through almost daily news of fresh disasters; and on the larger scale we have the problem of national defense.

The significant thing about every one of these items of protection of large groups of people against peril and hazard is that each one is primarily the job of the engineer. It was the army engineers who directed and carried out the safety measures in the recent flood of the Ohio and Mississippi Rivers and under whose jurisdiction rests control of the waters of all navigable streams. It was Arthur Morgan as an engineer who directed the fine project of flood control in the dangerous Miami River Valley in such fashion that this region has never again been in serious danger. It will be engineers who will do what can be done for protection against drought on the great plains through water storage projects and measures for impounding water in the soil. The problem of highway safety is primarily one for engineers, both in the design of highways and in the design for automobiles. Safety in the air, while still carrying a large element of the human equation, is nevertheless ultimately a problem for the engineer to design planes of such stability and to steer them to their destination with such certainty and to construct them with such durability that they are dependable as machines and make safety largely automatic in the hands of the pilot. In our national defense the construction and operation of ships is an engineering job of the highest caliber, and the predominating engineering work of the army is shown by the fact that the United States Military Academy was founded as an engineering school and so continues.

One aspect of the engineer's work in protecting the public from hazards is illustrated in such elements as fire and earthquakes, for not only have the engineers designed fireproof structures, fire-extinguishing devices, fire alarms and fire-fighting equipment and have designed earthquake-proof buildings, but they have been largely responsible for the organization of the extensive system of fire, earthquake and similar insurance. This is a doubly advantageous arrangement, for not only does their training enable them to properly estimate the risks, but their training and self-interest both cause them to take the lead in devising ways and means to reduce the risks. The prominence of engineers in this field is illustrated by the fact that nineteen out of the twenty-three presidents of the Associated Mutual Factory Fire Insurance Companies are graduates of one signal engineering school, and for all I know the other four may also be engineer-trained.

If we consider the less spectacular but no less real danger which lurks in an impure water supply or a mosquito-infested swamp or a polluted stream, again we find that it is the engineer who is protecting the public from danger.

(*To be concluded*)

OBITUARY

FREDERICK VERNON COVILLE

DR. FREDERICK V. COVILLE, principal botanist in the U. S. Department of Agriculture, honorary curator of the U. S. National Herbarium under the Smithsonian Institution, and acting director of the National Arboretum, died at his home in Washington, D. C., on January 9, of coronary thrombosis sustained a week earlier. He was born in Preston, N. Y., on March 23, 1867, and was married in 1890 to Miss Elizabeth Harwood Boynton, who with three sons and one daughter survives him. He is best known for his achievements in botanical and agricultural research, but his interests were many and his contributions in widely different fields, particularly that of public welfare, were noteworthy.

After graduation at Cornell University (A.B., 1887), Dr. Coville taught there a short time, served as botanical assistant on the Arkansas Geological Survey, and in July, 1888, was appointed assistant botanist in the Department of Agriculture. In 1893 he succeeded Dr. George Vasey as botanist and as curator of the National Herbarium, then in the custody of that department. Upon the reorganization of scientific work within the Department of Agriculture in 1901 he was placed in charge of botanical investigation and experiment in the newly created Bureau of Plant Industry and, under varying titles, continued in that capacity during the remainder of his life.

Dr. Coville's most important field work was that as botanist of the famous Death Valley Expedition in 1891, the results of which were published two years later as "Botany of the Death Valley Expedition." This volume, one of the earliest critical studies of desert vegetation, is classic. It is a characteristically thorough piece of work, composed in the simple lucid style that distinguished all his writing, and aside from its precise identification of species is notable for the introductory chapters on ecological plant geography, based on personal observation and study, which present a searching analysis of the climatic and edaphic features of the region in their relation to its vegetation. Dr. Coville's keen interest in desert plants never waned. Later, as adviser to the Carnegie Institution of Washington, he procured the foundation of the Desert Botanical Laboratory near Tucson, Ariz., and at the time of his death was engaged in writing a popular but detailed flora of Death Valley, which should take account of much new material, including specimens collected by himself on three recent trips (1931–32).

In purely taxonomic work Dr. Coville devoted himself especially to the rushes (Juncaceae), in which he was long the acknowledged American authority, and to our native currants and gooseberries (Grossulariaceae), of which, jointly with Dr. N. L. Britton, he published a systematic treatment in "North American Flora." Many papers in his list of nearly 175 titles include descriptions of new species in other families, as well as discussions of nomenclature and matters of bibliography; others trace in detail the routes of early botanical exploration in the West; still others relate to ethnology and to the plants used by the American aborigines; and more than a few, based on personal studies in the western United States, deal with practical problems of grazing and forestry. Assisted by Mr. W. F. Wight and others he prepared the botanical definitions for the revised edition of the Century Dictionary. The final establishment of a National Arboretum was due largely to his perseverance and his unflagging devotion to the project. For many years also he served as chairman of the Research Committee of the National Geographic Society and thus was influential in determining its policy of exploration.

On the score of public service there may here be quoted an expression of opinion received from Gifford Pinchot, first forester of the United States:

> Until the Forest Service developed a body of experts of its own, Frederick V. Coville was the first and the earliest authority on the effect of grazing on the forest.
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> In February, 1898, the old Division of Forestry published a bold and masterly discussion by Dr. Coville on forest growth and sheep-grazing in the Cascade Mountains of Oregon, which went straight to the root of a very bitter controversy. In this study Dr. Coville laid down the essentials of a sound and far-sighted grazing policy.
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> When a vital issue arose, in 1902, between the irrigation farmers of the Salt River Valley in Arizona and the woolgrowers who ran their sheep on the irrigators' watershed, Dr. Coville's unequalled experience of grazing and plant life was called in. He and I made an extensive study on the ground, accompanied by representatives of the contending sides, and settled that and other questions. Our report rested on Dr. Coville's profound field knowledge of his subject, indefatigable thoroughness, and conspicuous fairness and common sense. He was already my friend, but that trip laid more deeply the foundations of a friendship which lasted throughout his life.
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> In 1905 the Public Lands Commission published Dr. Coville's proposals for the regulation of grazing on the public lands. Then and later his advice was in demand. His part in formulating a national grazing policy was that