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ENGINEERING'S PART IN THE DEVELOPMENT OF CIVILIZATION[1]

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SINCE the effects of engineering run all through living conditions, our topic is one of great importance to engineers and to engineering education. It is therefore appropriate for to-day's conference to be held here under the patronage of an important college of engineering and an organized society of engineers. The sub-topic ("The Social Significance of Engineering") which was under discussion this afternoon is a broad and pervasive one which means the import of engineering to society. The sub-topic also includes various others by implication. For example, it includes the social influence of engineering, which means the effect through the senses which engineering exerts on society; it includes the social implications of engineering, which means the intimate connections which relate engineering to social organization and social interrelations; and it also includes, among other things, the status or position of engineering as an entity with respect to society-organization as an entity. This evening I will go even more broadly into social relations and deal with the tripartite interrelations of engineering, social organization and civilization.

It is proper to here comment that true civilization grows as a consequence of community contacts among human beings, and intimate community contacts are (broadly speaking) made possible by and are dependent on the fruits of engineering. Such fruits became vaguely manifest many thousands of years ago and have steadily ripened and increased in scope and variety, through those thousands of years, down to the

[1] Evening address delivered as part of Symposium on "The Engineer's Place in Modern Civilization," held at Lehigh University on October 26, 1938, under the joint direction of the University and the Engineers' Club of the Lehigh Valley.

present time. Further ripening and variety-increases apparently will go on through future ages. I can not here go into the demonstration of the fundamental and continuous relations existing between social organization and engineering. I will refer those who may be interested to trace the growth of these influences to my six North Carolina lectures on "Engineering's Part in the Development of Civilization," which the American Society of Mechanical Engineers has thought worthy of publication, lecture by lecture, as a serial in its monthly magazine called *Mechanical Engineering*. This publishing began with the July issue and ends with the December issue of this year. In those lectures I have shown that community life was made possible by engineering; that some degree of civilization (which rests on principles of ethics and codes of morals) is a necessary accompaniment of community life; and, as a consequence, engineering is an inseparable companion of civilization. The increased responsibility for mutual sympathy and mutual welfare laid on individuals and on communities by the doctrines of the Christian religion have increased for engineering its opportunities to serve and its responsibilities.

The mental picture of the outcome of engineering usually held by human beings in the civilized world is of steam engines and what they have done for us; steam railroads; steam ships; electric telegraphs ("What hath God wrought!"); telephones; automobiles and hard-surfaced roads; radio sets and broadcasting stations; great structures like tall buildings, bridges, canals, harbors and irrigation works; potable water supplies and sewerage; manufacturing plants; manufactured products; and similar physical evidences. But these are only emblems, which are at the surface to-day. These are instrumentalities of engineering which have social significance, but it is inadequate, even superficial, to rest our attention with them.

To understand truly the social significance of engineering and the part that engineering has played in the development of civilization we must go deeper into the problems of society and the moulding influences of engineering thereon. It is necessary to begin with the conditions of the earliest village life, which originated in prehistoric times but which have left their records in the development of community life and civilization. We can picture these conditions from artifacts and other remains that have come down to us. It was through village life that civilization began, and through engineering that village life became possible. The single family or small group, living in a more or less roaming and precarious stage, had no civilization; but village life led to community of interests from which sprang the development of ethical principles and codes of morals that are the basis of civilization. It was thus that civilization germinated out of social organization.

Having germinated, it expanded over the world along with the movements of peoples, as sailing and rowing ships and maritime commerce grew up, and as extending trails and roads made some land commerce possible. Man seems to have been a natural trader in commerce after his gregarious period had arrived. The foundation development of civilization required a growing state of material and social well-being among men, with which there became associated a sympathetic mutual interest between individuals, and by individuals for the community welfare, in villages. It is the community of interests, which arises from integration of groups of people, that develops the qualities which characterize civilization; and conditions for living which make decent village life possible depend on engineering. Conscience and morals arise out of the social contacts in the family, clan and community, and civilization germinated in the community. Thus engineering was a frontier influence on civilization and social relations and it has been expanding that influence ever since.

The influences of metallurgy, of other engineering inventions, of agriculture, of domestication of animals, of written language became of great force among the early peoples; and community concentration became greater. Aided by engineering factors, trade between communities grew up and caused further extension of human contacts which depend for their amity on ethics and morals. Tools and simple weapons are evidences of artisanship, as also are crude pottery, weaving, simple agriculture and some domestication of animals. But the trail of rudimentary-structures, foresighted judgment regarding desirable village-locations and planned metallurgy, which trail was already trodden by some communities at the dawn of history, is the pathway of engineering—that is, it is the trail of the use of intellectual processes to bring together and combine the physical elements known to artisanship or science into a coordinated unity (such as a structure or process) for the convenience of man.

Add complex machines to these other engineering features, as is ultimately done in engineering, and we step far along in the possibilities for social relations. At the dawn of history man had come to the stage when security of life and livelihood could be sought after with some expectation of success for the most powerful few. Each step forward in the progress of engineering invention which contributed to the security of life and property for early men gave further impetus to the tendency toward community living, and this led to further emphasis also on ethical relations between man and man and tribe and tribe, and to furthering security of life and livelihood for man. In this connection the

importance of the ethical relations is to be remembered. Power to control men's life and property without restraint gives power to control their subsistence, and this is equivalent to power over their will. Out of this condition most of the autocrats and dictators of the world have made their hold secure. Let us beware.

Civilization connotes harmonious cooperation of many human beings and also mutually sympathetic, helpful and elevated relationships. For early men, this civilization (such as there was) went hand-in-hand with the crudely growing engineering arts. This was because the engineering arts enabled groups of people to become closely associated for the purpose of securing their safety of life and ease of living without sacrificing either existing conveniences or major comforts, as far as conveniences and comforts were then available. The group association of people proved the need of rules and customs of the nature of ethics and morals and a practical application of those rules to life. Generation after generation, with hesitations, recessions and recoveries, somewhere in the world further steps in engineering improvements have been accomplished, with accompanying greater human intimacy and morality. The relations disclosed in our day show that there is still far to go before the goal is reached. Acceleration of the progress is desirable, but all records of experience show that incautious haste in reform measures is a fruitful cause of confusion and that it actually tends to delay the pace of progress in its major ways. It would be well for some of our "brain trusters" and "new dealers" to take these precedents in mind and restrain their impatience lest they bring us to disaster through egoistic lack of deliberation.

Each step forward in the progress of invention looking toward security of life and property for early man gave further impetus to the tendency toward community living, and this further forced a growing respect for simple mutual interests. However, it was only after the stimulus for making inventions had resulted in an easier life with regard to life-security, food and shelter, and also had released to individuals more time for cultivating physical ease, that growing ethical relations between man and man and tribe and tribe became strongly evident, and community living became smoother. The early aims of each human being seem to have included security (*i.e.*, safety for life and limb, sufficiency of food, adequacy of shelter from the elements) for self and family, such as characterize the objectives of most mammalian animals. Then man gradually came to desire the permanent establishment of health, recreation and contentment (or perhaps the correct word would be happiness) as part of his "place in the sun."

At the present period of our nation, our people are overdoing the shout for government supported "security" maintained for individuals without aid of their own contributions accompanied by sweat of the face. Nevertheless, reasonable security of life, livelihood, health and happiness is the stuff out of which civilization is made. Man has sought and still insistently seeks security of life with its concomitants, and also the greatest degree of convenience and comfort which may be derived from any given expenditure of energy.

When reflecting on this, we must remember that, as Sancho Panza says, "Good fare alleviates care." Engineering plays a strong part in meeting fundamental human aspirations. It is a human and intellectual affair. It deals with forces and materials provided by nature, and adapts them to human service for the satisfaction of human needs and aspirations as they are felt in each particular period, and in our period all commerce depends deeply on engineering. Gathering of raw materials, manufacturing, transportation, storage and even the handling of goods have become the children of engineering. Even farming (at least in America) has become permeated with the effects of engineering.

Moreover, as engineering achievements extend, the process of satisfying aspirations and needs stimulates human society (as individuals and as groups) to formulate additional aspirations, picture additional needs and claim their fulfilment. One's needs seem to increase along with one's opportunities, and failure to immediately satisfy the seeming needs, to the full, causes disappointment that seems like suffering. To safely qualify under such conditions, engineering must live under the guiding influence of the social philosophy of the successive periods, while always controlled by the restraints which characterize exact science.

This combination is a lively cause of friction. The stimulus of their aspirations and felt needs leads most human beings to press for an immediate fulfilment. This ambition often is encouraged and supported by theorists who have failed to observe that too great rapidity of change in social organization leads to ultimate harm instead of permanent satisfactions. Life in the aggregate is a composite of multifold relations and always has been. Revolutionary changes of social organizations usually leave a train of wreckage and hardship for all, including those most in need of improved conditions. Sound judgment demands that changes be made considerately, gradually and with careful forethought. Thoughtful consideration is the way of wisdom. The records of history make these relations plain, but time does not permit the exposition of those records here. During the past 150 years our engineering improvements which are competent to afford convenience and comfort for all people have come rapidly forward, but our legislative acumen and foresight have not advanced in equal degree in the same 150 years. Alexander Hamilton wrote in the *Federalist* 150 years

ago that, "Necessity, especially in politics, often occasions false hopes, false reasoning, and a system of measures correspondingly erroneous." Hamilton's pregnant cautionary words still carry a significance equal to the significance which they held in his life-time.

As citizens, we of this nation are proud of the education from which we profit. There is considerable justification for the pride, but instances arise which show that the results of education have not fully permeated among the citizenship even for the most elemental affairs of life. I will cite an extraordinary illustration which was disclosed to me as a bona-fide occurrence. A married woman from low-income circles appeared almost annually at a hospital for delivery of a child until the family was an even dozen. Again she came, and (as she was leaving this time) the attending physician said, "I presume we will see you again next year." "No, ye'll not," said she, "me husband and me has just learned what makes them." This is quite on a level with the ignorance among some of the primitive aboriginal tribes of Australia and elsewhere, of which the natives "do not recognize sexual intercourse as a cause of conception" and give other specific causes.

If we still have in our midst such ignorance of fundamental biological phenomena which arise out of our personal intimacies, is it reasonable to expect a general sound knowledge of the less concrete phenomena of economics and society? Even our most expert citizens confess shortness in assurance regarding the latter phenomena. Therefore, the acute frictions (such as arise, for example, in the industries as a consequence of the close intimacies brought about so rapidly by the engineering inventions of the last two centuries) are likely to be the unhappy outcome of ignorance and prejudice. Such being the case, they are causes calling for sympathetic, man-to-man adjustment with such mutual forbearance as can be marshalled. The old-time destructive violence guided by violent minds, which was associated with industrial combats of my youth, is now outmoded in the minds of many of our citizens and must be brought to condemnation by all. Progress that is being made is the result of recognizing from all sides the advantages of man-to-man negotiation. Education which tends to the diffusion of truth, and thereby eradicates ignorance and prejudice, may come to the rescue.

A much fuller recourse by industries to plain, factual, impartial expositions to the public of their internal organizations, their external relations and their difficulties, widely circulated by means of advertisements, in my opinion, would help. Some industries have successfully utilized this process, although considerable advertising apparently intended for the purpose is so general that it is publicly accepted only as propaganda and has little influence. In many instances local advertising is excellent, but generally-flung advertising from the same sources often is superficial and is received by the public only as propaganda. Some writers of advertisements seem to give more weight to "catchy" wording than to accuracy of content. Many important industries limit their statements of factual character to periodical formal reports to owners (stockholders) and bankers, and these reports receive little general, public attention even when they are reasonably complete. Employes, customers and owners of industry and their families make up a goodly proportion of our population, and we may add to the three named categories those other members of the population who are often denominated the "public at large" as also parties in intellectual interest regarding industrial and other corporations. These should be catered to.

The factual and disclosing information which might enlarge knowledge and allay prejudice in this field is not readily available from books, monographs and magazine articles. Fuller measures of factual disclosure are needed so that honest and adequate information may be before the public in general. When we have in use in this country some nine tons of steel per capita of all our population and this figure grows faster than the population (I use estimated figures published by the American Iron and Steel Institute) we all are interested in the processes related to this important background of many affairs in our daily life.[2] I infer no criticism of the advertising displayed by the steel industry. Few industries do so much or so well, but I wonder whether the steel industry might not serve the public (and also the stockholders) by doing more. Constantly applied, careful efforts at making facts known throughout the nation, in my opinion, is a shining means for forestalling the effects of ignorance and prejudice and for thereby ameliorating a sore spot in the social relations occurring as a consequence of engineering. An uninformed public usually is influenced by predetermined notions and prejudices; but the American public, when it feels itself rightfully informed and has had time to reflect on its knowledge, usually proves itself to be fairminded. We are likely to forget that success in impressing the intelligence of great masses of people requires that clear, factual expositions shall be repeated again and again; although demagogic or inaccurate eloquence, once or twice expressed in fluent nonsense trickling from the speaker's tongue, may emotionally carry the same people into great error.

The inseparable relation of engineering to civilized society and to effective social adjustment is seldom given enlightened attention, and much of the fault of

[2] Since the delivery of this address, competent critics have expressed the opinion that the figure of nine tons is too high; but in any event the total steel in actual use per capita is an important figure relating to our mode of life.

some ardently preached social doctrines is due to popular misunderstanding of the true sources for enlarging material wealth. It is an unavoidable reality of nature that increases of permanent wealth are gained fundamentally only from what is grown on the surface of the earth, and taken from within the earth, from the waters of the earth or from the air surrounding the earth; and that the processes of securing the wealth require muscular and mechanical power directed by the minds of men. For the populations to cease to work would mean that they would cease to live. We must keep industrious with minds and muscles or we can not live in the comfort and plenty which is an ideal among western nations—evolved to different degrees in different nations but existing in all. It is important also to remember that joy in useful accomplishment, by the individuals composing a society, is essential to the realization of the best social adjustment. How to achieve the desired end of inciting joy in accomplishment is indeed a problem; but the engineering of machinery to more and more lift long hours of muscular labor from the shoulders of men, associated with spreading mental effort more generally among men, is a promising path to the solution. Moreover, an increase of leisure which is so ardently desired by most people can only be accomplished by substituting in all practicable situations mechanical power for muscular power, by means of inventions which make the substitutions possible at moderate capital expense so that an extra margin of saving is produced, from which all concerned may profit. The phrase "all concerned" includes workers and customers as well as owners. It here is to be noted that scientific discoveries and engineering inventions which lessen the cost of useful processed products or which provide useful new products usually increase the rate of the production of new wealth.

Engineering is a process of planning, organizing and executing work concerned with directing the forces of nature to the service of mankind; while the word civilization connotes well-established, sympathetic ethical and moral relationships in society. The latter relationships develop only where considerable numbers of people work together for common ends, and means of community living or other community contacts are provided by engineering for the grouping of the people in harmonious unity and providing for their material needs. This must not be mistaken for communism. It is quite the contrary. Full civilization connotes harmonious well-being based on mutual sympathy associated with ethical and moral relations in society, while democratic independence of the individual is maintained to the limit of conscience expressed without external restraint. Communism, on the contrary, suppresses individual independence; and it may destroy mutually sympathetic relations while providing for livelihood in common.

The human mind, in mass, is very slow to change in character; and stable improvements of mutual relations can not be rushed to success by the vaguely applied efforts of professional reformers or dilettantes in social affairs. Such improvements may only be successfully produced slowly, in association with sounder-growing mass-thought regarding living affairs in both material and ethical relationships; and here the influence of engineering in showing the ways to material betterment is of primary importance. Following in the wake of material betterment and increased leisure, intellectual improvement also usually comes as an ultimate contribution to social welfare.

By living in ready contact with each other, we have come to recognize (in at least a glimmering degree) that the best living is when life is put to intelligent use in mutual advantage. We yet have much to learn before this is realized at a reasonable level, but ultimately we will be able to mould our engineering so as to achieve the wished-for ends. Sound progress connotes aid in bringing forward those persons who need aid and are willing to cooperate in the effort at aid. It also connotes unrestrained encouragement of the practices of those who are competently proceeding with ethical consideration along their individually chosen creative courses. Unless American politicians can be brought again to follow such tenets, instead of following the hysterical urgings of professional reformers, we will be justified in persistent pessimism regarding human affairs in this nation.

One who studies with concentration the changes which have occurred in the living conditions of the populations of European nations during the last two hundred years, or of our people during the existence of our own nation, must be impressed by the great change for the great proportion of the people from sordidness and insecurity of life and livelihood to relative security, comfort and happiness. In these days, certain of our fellow citizens point to Sweden as a notable example of economic and social welfare. In a relative way, they are right; for Sweden has come forward in an admirable manner out of an age of sordid living and misery for most of its people. Means for ready and economical transportation, means for quick transmission of intelligence, means for generating and transmitting power, means for sanitation and other great engineering achievements have changed the face of the people. The sordid and miserable have been raised and the disparities in security and happiness which formerly existed between the few and the many have been notably lessened by improving the lot of those formerly miserable.

The same miracle has occurred to the people of the

British Isles, France and other nations. The changes have been gradual but effectual, and they continue their course. The sound results have come from utilizing cautiously applied measures for lifting the many. Where tearing down the superior economic and security status of the few has been practiced, it has always left in its train a legacy of disadvantages and misfortunes that affected people in all conditions of living.

Our experiences have not been without analogy to the experiences of European peoples and we may well examine the sign boards of their history. We started later, with a pioneering people whose active utilization of their restless intelligence in a favorable setting did much for them. Our utilization of engineering achievements has been correspondingly active, and engineering invention has gone on at a high pace. The living conditions for our healthy and industrious citizens have been at a high level compared with the corresponding citizens of Europe. If one third of our citizens are inadequately provided with food, clothing and shelter (as viewed from our accepted standard of living), as has been alleged, I presume with truth, they are among those who need betterment and should be shown practical means by which they can come to betterment. But the precedents show that no general gain is secured by pulling down some with the object of raising others, nor by over-fast efforts at general reforms such as have been pressed forward by our professional reformers and some of our politicians during the past several years. Our social changes, if they are to be truly serviceable, must proceed at the pace which characterizes natural improvement of thought in an environment of encouragement, and they must not be unethical, or our results in the end are likely to be adverse for those who should be helped instead of affording the betterment which is desired.

Politics in this country are seldom free from false slogans of which the unsoundness would be exposed by exacting analysis. We now are suffering from the effects of various partially or wholly false slogans that relate to the fields of government, engineering, education and security, which have been formulated to satisfy the supposed slogan-hunger of the majority of mankind. For illustration, the false doctrine that civilization is decaying has been asserted again and again during the period from several thousand years ago to the present time and people still volunteer their ideas for saving civilization. The answer is plainly spread before us. If decay had in fact been going on over this long period, there would be mighty little civilization left with us to-day—instead of which we have in the best parts of the western world a civilization which is superior, in the sense of being more comprehensively helpful to man, than that existing anywhere in any of the preceding centuries. This statement rings true when it is tested by comparison of to-day's conditions of the great mass of people with earlier conditions, whether two generations, two centuries or two thousand years back.

If moral relations and security of life mean anything in happiness, as most of us believe, there is more happiness in this country to-day than heretofore in any country of great population. There certainly are more comforts in life than in any earlier time, and more leisure for most people, mostly brought about by engineering applications of science. And even from this level, progress continues in a clear pace. Trying to over-accelerate that pace by poorly conceived political nostrums harms instead of helps. Efforts put forth to save civilization are only folly and are not needed. What are needed are efforts to deepen and enrich the spirit of sympathetic understanding between men, so as to better the conditions for negotiating the amelioration of those differences which may injuriously arise because of our more constant and intimate mutual contacts.

Engineering processes and engineering devices have been (and are being) abused by use in warfare, but not by choice of the leading minds of the engineering profession. The profession, with few exceptions, stands on the conviction that war is tragic, expensive, inefficient and unnecessary. However, as world affairs display themselves, we must be prepared in an organized way as a nation to stand against aggression from without in case aggression should arise in spite of friendly negotiations planned to prevent forcible action. Convince man that war will not ultimately result in greater wealth, security and stability for himself and his nation and the tendency toward organized war will be weakened. Especially will this be achieved if other sufficient routes are kept open on which men's love of risk and adventure can be fully expended, while the paths to selfish profit during war are closed. It lies with us to hold so steadfastly to the duty of more fully developing the peaceful occupations of agriculture, industry and commerce that the minds of our people may be turned away from contemplating aggressive expansion and warfare. Engineering favorably influences all those peaceful occupations, and we engineers have an obligation to ourselves and our fellow citizens to encourage the highest practicable development of these ethical aspects of engineering.

That is the attitude of engineering in this aspect of its social relations. The defects in human relations which arise in local, national and international affairs are due neither to faults in the fundamental ideal of a complete civilization, nor to engineering which has set up and continues to maintain the stage for a possible realization of that ideal. A grave responsibility rests

on critics of our status, who are failing in the call for agitation and education of the public to a realization of the relative fitness of things. This is a personal and group matter to achieve, and it can not be achieved by partisanship or foul play.

Much has been accomplished in the long-time development of civilization. Much is yet to be accomplished. The accomplishment can not be secured in any nation by legislation alone. The solution can be obtained by joint use of two paths. One of these leads to continued emphasis on sympathetic negotiations between man and man, or group and group, before going to extremes. Much progress for our country has been made in this path during the past half century. Such progress has been notable in our engineering industries, but nevertheless it is yet insufficient, and more sympathetic relations must be fostered. However perfect a coin may appear on one face, if it is suffering from corrosion on the other face it is defective and needs reminting. Social reminting in an engineering world with its democratic qualities, however, requires a depth of consideration and range of cautious adjustments which immeasurably transcend the requirements for the machine-reminting of coins.

The other path leads to the joint problem of education in engineering and political economy which is now crying for solution in order that the social problems may be smoothed and society may be aided to make progress in the best sense. Our national needs are, on the one side, a moratorium on loosely drawn legislation, careful simplification of laws which we have, and primarily emphasized efforts to make ethical principles a guide in both the observation and the administration of statute-law. Abstract justice is an ideal, but enforcement of law according to ethical principles can be made a very practical thing.

On the other side, our national needs include a careful nurturing of the results of scientific research and discovery in the fields of natural science and of so-called social science, which may stimulate engineering invention and engineering practice out of which still further improved living conditions may arise. Many endowments for research in natural science and in economics and sociology exist, and our need is for an endowment to promote the study (including research and exposition) of the joint relations of engineering and political economy, having for its purpose to establish an understanding of the most helpful relations which may be built up for a prosperous social welfare. This is a need indeed, and a donor can make the nation his never-ending debtor by establishing an endowment to this end.

OBITUARY

EDWARD SAPIR

THE death of Edward Sapir on February 4, 1939, when in mid-career, marks a loss of leadership in anthropology and linguistics. It will be difficult to find another who possesses his distinctive assets of originality, profundity and insight.

Born in Lauenburg, Pomerania (January 26, 1884), he was brought to the United States as a little child. His formal training was at Columbia University: A.B., 1904; A.M., 1905; Ph.D. in 1909 under Franz Boas. His initial professional appointments were as research assistant, University of California (1907–08) and instructor in anthropology, University of Pennsylvania (1909–10). During this period, he was concerned with analysis of several western Indian languages (Yana, Wishram, Takelma, Southern Paiute).

As chief of the division of anthropology, Geological Survey of Canada (1910–25), his own research was primarily with the language and culture of several northern Indian groups: Nootka and Athapascan. These remained preoccupations through his life, the latter especially giving rise to an extended comparative study of the far-flung Athapascan stock and its Sinitic connections. It was at this time that he developed an interest in psychological and psychoanalytic insights into linguistic and cultural behavior.

In 1925 Dr. Sapir began a systematic teaching career: assistant professor of anthropology (1925–27), professor of anthropology and general linguistics (1927–31) at the University of Chicago; Sterling professor of anthropology and linguistics at Yale University (1931–39). His enthusiasms fired a group of highly competent linguistic students who will, without question, give continuity to his views in the next generation.

He received manifestly deserved academic recognition: honorary Sc.D. from Columbia, 1929; membership in National Academy of Sciences, American Academy of Arts and Sciences, American Philosophical Society, Société des Américanistes de Paris, Reale Accademia della Scienze (Bologna); and was elected president of the Linguistic Society of America (1933) and the American Anthropological Association (1938).

His ethnographic studies were, for the most part, incidental products of his linguistic work. But this gave them a distinctive quality, namely, a constant illumination from linguistic insights. This approach marks his principal contribution to ethnological method, "Time Perspective in Aboriginal American Culture" (1916). His published ethnographic reports are few and brief, but a deftness and incisiveness make them models of description. His two little papers on