# Why the Engineer?

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**The new conditions of life brought about by the material advances of recent times, which have been achieved primarily as a result of the work of scientists and engineers, have brought with them new and pressing problems—social, economic, political, and international. In this address,* Doctor Durand states that "we (engineers) cannot evade the responsibility which rests upon us to take our due share, even the lead, in the study of the problems which our own activities have, in a large measure, developed." He urges "a quickened sense on the part of the engineer, of his responsibilities, not alone in a purely professional sense, but as a citizen of his community, of his state, of his country, of the world."**

A SOMEWHAT trifling answer might be found in the reply, because the world has always had the engineer and cannot get along without him. Regarding the first statement, I like to look upon the engineer as, indeed, the oldest representative of the so-called profession—as one of those groups or guilds, the members of which play some specialized part in the advancement of our civilization.

In this sense there has come about, as we know, a specialized group whose particular function has been and is the utilization of the materials and the energies of nature in the service of man. Even if we go back to prehistoric times, we find that there have been, in this sense, engineers since the days of the palaeolithic age, when man first found a way to fashion flint chips into tips for his arrows and spears and learned how to utilize the potential energy of a distorted elastic system—a strung bow—through a rapid transformation from potential to kinetic energy, as the arrow sped toward its mark.

Again there have been bridge engineers since the time when some one found a way by fire or flint axe to fell a tree across a stream or to utilize a wild grapevine to carry his weight from one shore to the other—the far away prototype of the noble suspension bridges of modern times. There have been naval architects since the day when some one found how to hollow a log by fire and stone axe, and thus to utilize one of the basic laws of fluid mechanics. There have been metallurgical engineers since the days of Tubal Cain and long before.

If we go back to the great prototype of the engineer, we have Prometheus, who in Greek myth first learned how to bring down fire from heaven and subdue it into the service of man. A civilization without fire at its service is unthinkable, and down through the ages, both before and since the written record, its influence and significance can be plainly traced.

Enough on this phase. We surely have good ground, if we so choose, to consider ourselves as, perhaps, the oldest of those specialized groups into which the progress of civilization has forced the subdivision of those whose task it is to carry it forward. If, now, we turn to the second statement, that the world cannot get along without the engineer, the truth of this is perhaps obvious. At least, the world will not be willing to forego those things which the scientist and the engineer have jointly provided, in the advancement of what we call our civilization.

If, then, we as a group or guild must carry on, we come at once to the heart of our present inquiry. What is the engineers' part in the co-operative enterprise which we call civilization; what are its boundaries; are we occupying its full breadth and length, and what of the future? How may we better address ourselves to the task of a more adequate and perchance a better-balanced occupancy of this important domain of human activity?

The engineer has been defined as one who is concerned with the utilization of the materials and the energies of nature in the service of man. Amplifying, in terms which define his field of activity and which stand in the preamble to the constitution of American Engineering Council: "Engineering is the science of controlling the forces and of utilizing the materials of nature for the benefit of man, and the art of organizing and directing human activities in connection therewith."

Note may be taken of certain implied specializations in this definition: Thus, obviously, we are specially concerned with the constructive materials of nature and again with the inorganic energies. These may be accepted as limiting, in suitable fashion, the field of our work. On the other hand, this modern concept contains an amplification of the very highest order of importance. We are concerned with the "organizing and directing of human activities." That is, not only are we concerned with inanimate materials and inorganic energies, but also with the human agencies through which our ends are to be attained.

For our purposes in this brief statement, I should like to make some reference to 3 phases or aspects under which this broad subject might be considered.

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1. The terminal products of the activity of the engineer.
2. The raw materials from which such products are formed.
3. The social and broad humanistic problems which have resulted, at least in large measure, from the work of the engineer.

Regarding the first of these, I shall say only a word. We are all familiar with the terminal products of our own work. If we consider a period of only 200 years, say from the time of Watt, we have a world made over, at least as to the material content of our civilization. If we take a shorter period of say 50 to 60 years, we have a world almost made over as compared with the material content of life in the 70's and 80's of the last century.

My only point in recalling this phase of the work of the engineer is to emphasize its magnitude and the extent to which it has changed the conditions of life: social, economic, and politic. These conditions are known to us all; they are a part of our daily life, and in what I have further to say, they may simply be taken for granted.

Regarding the second of these, having to do with the raw materials comprising primarily the various constructive materials and energy, by some combination of which this transformation in the conditions of life has been brought about, some more extended word may be appropriate.

So far as the constructive materials of engineering are concerned, I shall, in the present admittedly brief and incomplete survey of the subject, refer only to the inorganic constituents of the earth's crust and outer envelope—in particular, to the mineral and metallic constituents of the earth's crust. So far as sources of energy are concerned, I shall refer only to heat as drawn from carbon and hydrocarbon sources and to falling water.

We must view the constructive materials as a bank deposit, not one drawing interest, but one out of which we are gradually and surely exhausting the principal. Only in part can our more important structural materials, *e. g.*, the ferrous compounds, be used over and over. Even with such multiple use, there is loss. We cannot completely capture the products of disintegration and reconstitute them into useful products. Neither is nature, so far as we can determine, now engaged in the enlargement of her initial deposits. The result is a gradual but continuous loss of our principal; and to that process, there is but one end—ultimate exhaustion.

The same is true with our carbon and hydrocarbon deposits used as a source of heat and transformed by our thermodynamic processes into useful work. We are gradually but surely exhausting our coal deposits and our provision of petroleum and natural gas.

Falling water—that is water caught up by the sun's heat into the upper air, carried over the high places of the earth, precipitated and caught and allowed to flow through our power-producing mechanisms—is the only source which partakes of the character of an annual dividend. Presumably as long as the sun radiates heat as at present, so long may we count on this seasonal or annual dividend, representing, as it does, a small bit of the energy which the sun is constantly radiating off into space and which, indeed in the end, will (in the absence of some cosmic interference) reduce that star to a cold dead state. The picture is not a cheerful one and I shall not dwell on it. In a sense, all our materials of construction and all our sources of power come from bank deposits which seem to be subject to inevitable and continuous depletion. Only in the case of falling water, among the sources of present practical importance, do we seem to reach out to sources which lie outside the earth itself.

All of this, of course, is well-known; but while well enough known, the question may at least be asked whether we, as engineers, have given the facts the weight which their significance deserves. We, in a sense, have appointed ourselves as custodians of these deposits. They constitute a trust. We cannot evade the responsibility for their wise and effective use. Have we in the past and are we now living up to the full measure of this responsibility? We can hardly, I think, answer in the affirmative.

However, two things may be said in attempted attenuation of our fault. First, for some of these deposits, the quantity is so large and anything approaching exhaustion is so remote that there is no occasion for worry; and in any event, new or substitute sources may be found long before such a condition begins to make itself felt.

While the supply in some cases may be large, as for example in coal and in iron ore, it is far from the same in other cases, as for example petroleum and natural gas. But, again, here come newly devised techniques for the transformation of coal into products similar to those which we now derive by preference from petroleum or natural gas. All of this, however, only serves to put forward the evil day; and these or like excuses form, in the last analysis, no valid justification for needless waste. The use of heat in the development of useful work is a one-way street. In order to transform a part of the heat into useful work, we must let down another and larger part from a high level to a low; and once at the low level there is no way of restoration to the higher level whence it came, except indeed, by the letting down of a still larger quantity to the lower level. Here the second law of thermodynamics imposes its rule—the ever-increasing entropy of a thermodynamic system.

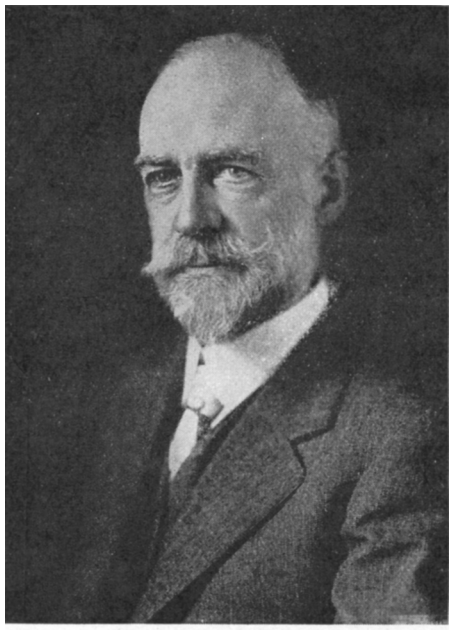
Much the same is true with the useful structural materials. Their utilization involves, at least to some extent, progress along a one-way street, marked by the inevitable loss of some part of that which we wish to preserve and use. As to new sources of energy, perchance the use of organic wastes or of organic material grown or prepared for the purpose, or again the direct heat of the sun or the internal heat of the earth, or again the internal energy of the atom, I make no present count.

The practical, efficient, and economic use of any of the first-mentioned sources, in substitution for those which we are now employing, seems difficult; and the possibility of our ever finding the key for unlocking the stores of atomic energy and of devising methods for its safe control seems remote. In any event, in none of these possible substitutes do we find excuse for waste in our present sources of supply.

Again, as an excuse, it may be urged that the

economic and wise use of the materials and agencies of nature is only in part the responsibility of the engineer. Such matters are more widely the concern of the public at large; of the law makers; of the moulders of public opinion. This is perhaps true, but we, as engineers, can scarcely find here an adequate alibi for failure to take our own share in all efforts directed toward the development of a wise and forward-looking policy governing the use of these gifts which nature has placed at our disposal.

And who is there outside of our own guild likely to understand the significance of waste in the use of the gifts of nature, and the end toward which such waste inevitably tends. We cannot escape the fact that, in a direct sense, we are responsible to society at large and to future generations for the wise and economic use of these gifts of Nature in the development and utilization of which we are now engaged, as our share in the work of the progress of civilization. If society needs to be awakened, if new laws are needed, we must remember that we are more than engineers; we are members of society and members of the body politic. We must take our part in arousing society and our due share in the work of framing, enacting, and enforcing salutary laws and regulations looking to the ends which I have indicated. If we do not, it can hardly be expected that others will. In this way lies plainly the open path of duty for the engineer.



Doctor Durand

May we now turn to a consideration of the social, economic, and political problems which have been, shall we say, a by-product or at least an outgrowth of the work of the engineer?

We have already seen that through the co-operative work of the scientist and the engineer, the world has, in a material sense, been made over. The enumeration of details is not necessary. Compare the material content of our civilization of the time just preceding James Watt, 200 odd years ago, with the present; or again, that of the period just following the Civil War between our states—within the memory of many of us—with that of the present time. In a large sense, the external world is new; but have we made commensurate and parallel progress in the adaptation of ourselves to these new external conditions? A changed world externally must call for adaptations especially in our nervous and emotional systems, to all these new appeals to interest and stimulus. There is here needed a growth in wisdom directed to the most beneficial use of these new conditions of life. We may indeed ask if we have grown in wisdom in the use of these new products of science and engineering, commensurate with the conditions themselves, which these new products have brought about.

It would be a brave man, I believe, who would be prepared to assert and defend the affirmative. If we mean by wisdom, a sense of values, an appreciation of the significant and abiding as contrasted with the insignificant and transient, a capacity for effective judgment based on accurate analysis of the elements into which our problems resolved themselves—then we can hardly say that we are wiser than our fathers or our grandfathers, or even wiser than those of centuries long gone by. We have enormously more information, but that is a different thing.

My question in brief is whether the world of today is indeed as well-adjusted to the material content of our present civilization as was that of, for example, 50 or 75 years ago, to the content of that day and age. This new environment, these new conditions of life which have been brought about by the material advances of recent times have brought with them new and pressing problems, social, economic, political, and international. The time available admits of no discussion in detail. The displacement of human operatives by mechanical agencies, the tendency toward the concentration of populations in large centers, the problems of capital and labor, the new conditions and agencies of warfare—these are only examples.

Now what is our responsibility as engineers with regard to these problems? It is clear that the responsibility is not ours alone; but it is equally certain a share is ours because here again no class or stratum of society stands nearer to the source of these problems than do we who have shared in the creation and production of their causes. We cannot evade the responsibility which rests upon us to take our due share, even the lead, in the study of the problems which our own activities have, in a large measure, developed.

What I am urging is a quickened sense on the part of the engineer, of his responsibilities, not alone in a purely professional sense, but as a citizen of his community, of his state, of his country, of the world; a responsibility in the fulfillment of which he will take such part as he may in the earnest study of social, economic, and political problems, and in particular of the special conditions which his own activities have brought about, to the end that we may attain some better condition of balance as between the material content of our present-day civilization and the uses which we are making of it.