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# THE SOCIAL ADVANTAGES AND DISADVANTAGES OF THE ENGINEERING-SCIENTIFIC APPROACH TO CIVILIZATION[1]

By HENRY A. WALLACE

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I SUPPOSE you are all more or less familiar with that concept of the cyclical rhythm of civilization which has been popularized in recent years by Petrie, the Egyptologist, and Spengler, the German philosopher. According to this analysis, a civilization takes its origin in a profound, but as yet unexpressed new attitude on the part of a virile, agricultural people toward the universe. This profound, original feeling gives the bias to subsequent events throughout the life of the civilization. First, it manifests itself in great cathedrals and sculpture, next in painting, literature and music, followed by science, mechanics and wealth, and finally it manifests itself in dissolution, which comes because of a lack of faith in the worth-whileness of the original attitude toward the universe and because of disgust with the material results which have finally been inspired by that attitude. According to this analysis we have now come to the late fall, the eventide of this civilization, and the coming of the engineer is like the coming of Indian summer in late October just before the cold and dreary days of winter.

Philosophical analysis of this sort, even when backed up by archeological research, can of course be merely suggestive. But after our experience with the world war and the depression of the past four years, we are led to question the American credo, based as it has been on faith in progress unlimited, derived from endless mechanical invention, improved methods of mass production and ever-increasing profits. Without accepting either the implicit pessimism of the Spenglerian twilight philosophy or the Pollyanna optimism

[1] An address before the American Association for the Advancement of Science, Boston, Massachusetts, December 29, 1933.

of the old-fashioned American go-getter, I would ask you to examine superficially with me the contributions of science and engineering, the dilemma thereby created and a possible way out.

For one hundred years the productivity of the so-called civilized world has increased at the rate of about 3 per cent. annually. Correcting for increase in population, the output per capita has increased at the rate of about 1 per cent. annually. In the United States the rate of increase of material wealth has perhaps been a little faster than this. But everywhere there has been apparent a little slowing down during the world war and especially since 1930. And so we have, on the one hand, those people who proclaim that inevitably the pre-depression trend will be resumed, and those who, on the other hand, say that the time of the quantitative expansion of man's control over nature is now rapidly coming to a close.

Engineering and science, combined with the division of labor, have made it possible for an hour of man labor on the farm to produce several times as much as it did a hundred years ago. In company with the rest of you I have from time to time marveled over the tremendous contribution of the reaper, the binder, the combine, the truck, the tractor and the gang-plow, but inasmuch as we have now come to days of real soul-searching about all the things which we have hitherto called progress, I think it is high time for all of us to analyze these various labor-saving devices a little more critically. Do they really save as much as appears on first glance?

True it is that the farmer puts in only a mere fraction of his own labor in producing wheat, as compared with one hundred years ago, but what about the labor of the men who made the combines and the plows and the tractors? What of the labor of the men who transport the wheat the thousand miles to market, of the vast distributing and advertising machinery which seem to be necessary if we are to operate on the broad scale apparently required by the modern adaptations of engineering and scientific discoveries? Personally, I am inclined to think there is a real net gain, but it is a gain of a sort which can easily be lost altogether, unless certain social adaptations are very rapidly perfected.

The change from the back-breaking cradle of our forefathers to the modern combine ought to mean a tremendous release of human energy on the farm for something besides growing and harvesting a crop. The days when wheat was broadcast by hand, perhaps from a saddle horse, in retrospect seem quite romantic, but to the farmer who had to spend days at seeding-time where he now spends hours, the romance probably wore pretty thin. The grind of the harvest of years ago, the sweat of men in the fields and women in the kitchen, was an honorable thing, and even celebrated in song and story; but it didn't leave much time for living. The engineers and the scientists have given us the instruments and the methods whereby we can escape much of the grind; theoretically, there ought to be far more time for living and far more with which to enjoy life. Yet the reverse seems to be poignantly true.

The men who invented our labor-saving machinery, the scientists who developed improved varieties and cultural methods, would have been bitterly disappointed had they seen how our social order was to make a mockery of their handiwork. I have no doubt they felt they were directing their talents to free mankind from the fear of scarcity, from the grind of monotonous, all-absorbing toil and from the terrors of economic insecurity. Things have not worked out that way.

I do not mean to imply that there have been no gains. Of course there have been net gains, even if incommensurate with the hopes and promise of science. Plainly we must hold those gains, and add to them rapidly and extensively; but I think we can do this only if the planning of the engineer and the scientist in their own fields gives rise to comparable planning in our social world.

So far as science and engineering themselves are concerned, I see no reason why the rate of expansion which characterized the Century of Progress should not be increased, at least for a time. While there are certain ultimate limitations in our supplies of coal, iron, petroleum and soil fertility, it is obvious to most of us who are close to any particular phase of scientific research or technical organization that there are imminent discoveries which, when applied, will increase *per capita* output enormously. Nearly every technical man knows in his heart that from a purely scientific, engineering point of view the most amazing things could be done within a relatively short period. Of course, in the world of hard fact the full effect of any revolutionary invention is not felt typically for 15 or 20 years. But I feel safe in saying that our scientists and inventors to-day have enough new stuff within their grasp or just around the corner so that the world thirty years hence could easily have a total productive power twice that of to-day.

It is almost equally possible that the total wealth-producing power of the world a generation hence will be less than it is to-day. The trouble, if it comes, will not be in the inability of scientists and technologists to understand and to exploit nature, but in the ability of man to understand man and to call out the best that is in him. In solving this limitation the scientists and engineers have all too often been a handicap rather than a help. They have turned loose upon the world new productive power without regard to the social implications. One hundred years ago the power looms of England destroyed the cottage weaving industry, and during the early years of that impact misery strode over the countryside of England in proportion as the nouveaux riches gained capital to exploit their gains over the entire world. That kind of thing has been done again and again, and we have called it progress because the power of man over nature was increasing and because in the long run the common man shared in this increase. What happened to the common man in the short run, of course, could be of no concern to a laissez-faire society.

Most of us, whether scientists, business men or laborers, have until recently looked back on the Century of Progress and called it good, but to-day the afflictions of Job have descended upon us and we must of necessity argue with Bildad, the Shuhite, and set ourselves right with our God before we go forward into a prosperity seven times that which we enjoyed before.

Acting perhaps in the capacity of Bildad, I would like to suggest that the very training which made possible the enormous material expansion of the past century may to some extent have made impossible the building of a just social system for the prompter and more uniform distribution of the wealth produced by the system. Most of the scientists and engineers were trained in laissez-faire, classical economics and in natural science based on the doctrine of the struggle for existence. They felt that competition was inherent in the very order of things, that "dog eat dog" was almost a divine command.

The power discovered by the scientist and inventors was applied in the United States by a race of men who had developed a concentrated individual will-power and an extraordinary thriftiness as a result of several generations of pioneer agricultural training and Protestant church-going. As a result, human power of high spiritual origin, but debased by the sophistication of the "devil take the hindmost" economics of the colleges, took command of the exploitation of the discoveries made by the scientists and inventors. The scientists and inventors have an intense kind of religion of their own—certain standards to which they like to be true—and as long as they could get enough money to pursue their researches, why should they care how some one else handled the social and economic power derived from these researches? Perhaps that is putting the matter unkindly, but other explanations that might be advanced are not much more flattering. Those who delved too deeply into social and economic problems got into trouble, and so many of the best scientists felt it was not good form to do things which to certain types of mentality seemed impractical and which might endanger the financial support of science.

It is my observation that previous to 1933 more than three fourths of the engineers and scientists believed implicitly in the orthodox economic and social point of view. Even to-day, I suspect that more than half of the engineers and scientists feel that the good old days will soon be back when a respectable engineer or scientist can be an orthodox stand-patter without having the slightest qualm of conscience. It is so nice to feel that there are great supermen from whom, directly and indirectly, you draw your own sustenance, who, sitting Jove-like above us lesser mortals, make possible the free functioning of the law of supply and demand in such a way that their profits enlarge at the same rate that our research expands. Like most of you in this audience, I rather like that kind of a world, because I grew up in it; in some ways, I wish we could get back to it. But both my mind and my instinct tell me that it is impossible for any length of time. Of course, if prosperity returns within the next year or two, it is possible for us to think that we are back in that old world again. But unless the people who make profits and direct capital allocation to different productive enterprises have seen a great light, or unless we move forward into certain highly centralized forms of industrial and governmental control, we shall sink back into our former trouble.

There ought to be more than a little hope, it seems to me, in the fact that our engineers have demonstrated so successfully their skill in planning. In many great industries, the engineers have been able to mark out the contours of expansion and development ten to fifteen years ahead. If in the past they seemed to be guided by purely material and mechanical considerations, that has doubtless been because such considerations were necessarily the chief ones so long as we were conquering a continent. To-day it is becoming increasingly evident that we must take into account the qualitative as well as the quantitative expansive aspects. This would suggest that in the engineering courses of the future the engineers should be given an opportunity really to enrich their minds with imaginative, non-mathematical studies, such as philosophy, literature, metaphysics, drama and poetry. Of course so long as an engineer is burdened with the necessity of putting in 18 hours a day mastering calculus, mechanics and the complex theories of electricity, he simply can not give any effective attention to the cultural aspects of life. And if by accident an engineer, exposed to studies of this sort, should be enthused by them, he might for the time being become somewhat less effective as an engineer. We are thus exposed to a dilemma, which I would be tempted to solve by saying that probably no great harm would be done if a certain amount of technical efficiency in engineering were traded for a somewhat broader base in general culture.

It is difficult to see how the engineer and the scientist can much longer preserve a complete isolation from the economic and social world about them. A world motivated by economic individualism has repeatedly come to the edge of the abyss, and this last time possibly came within a hair's breadth of plunging over. Yet science, all this time, has been creating another world and another civilization that simply must be motivated by some conscious social purpose, if civilization is to endure. Science and engineering will destroy themselves and the civilization of which they are a part unless there is built up a consciousness which is as real and definite in meeting social problems as the engineer displays when he builds his bridge. The economist and the sociologist have not yet created this definite reality in their approach; can you, trained in engineering and science, help in giving this thought a definite body?

To-day, when the industrial nations of the world have skimmed most of the cream off the backward nations and the backward classes and when there are no longer any challenging geographical frontiers to be conquered, it becomes apparent that we must learn to cooperate with each other instead of joining together in the exploitation of some one else. This means building a social machinery as precise and powerful as an automobile engine. How extraordinary is the patient vigor of thought which enables a group of engineers to blue-print and execute a new design. And how sloppy is our economic blue-printing and execution by comparison!

But it must be said in defense of the economists that their problem is infinitely more difficult than that of the engineer. The economic engineer has never had any excuse to exist until recently, because no one gave him any orders for blue-prints. Even yet the objectives are so loosely defined, the popular will is in such a state of flux, that the designing of the economic engineer is about like that of an automotive engineer who discovers after he has completed his engine that it was to go into a tractor instead of an automobile.

As I have said to many farm audiences, we are children of the transition—we have left Egypt, but we have not yet arrived at the Promised Land. We are learning to put off the hard-boiled language of the past, but we have not yet learned to speak the cooperative language of the future. One is as different from the other as a human being is different from an animal. There need be nothing impractical, there need be nothing foolishly idealistic about a Christian, cooperative, democratic state. But I fear it will take us as long to build a public consciousness fitted to run such a state as it is taking the Russians to build efficient factories and train their people to run them.

We know that there must be a balance between productive power and consumptive power, and that excessive profits used to expand productive power beyond consumptive power are sure to lead to a breakdown. We know that the continued insistence on heavy exports in excess of imports by a creditor nation is bound to lead to disaster. We know to-day that the great unemployment is in the so-called heavy industries, and that this could be remedied if faith in a profound new excitement swept the country like the railroad-building boom of the early eighties, or the automobile boom of the twenties. This boom might take the form of totally new railroad equipment, or the popularization of new and better airplanes, or the making fashionable of winter homes and winter industries for every one in the South and a duplicate summer set in the North. In any event, whatever is done to stimulate the heavy industries it is to be hoped that the bonds issued to pay for the stimulation will be on a long-term, amortized, low-interest basis.

We know that we must have a monetary system which will bring about a better balance between debtor and creditor and between productive power and consumptive power. These things can be measured and social machines can be built to deal with them, but before success can be expected, there must run through the rank and file of the people a feeling that amounts to a profound determination to deal with social problems.

There is something about engineering which tends to lay emphasis on logical, cold, hard, lifeless facts. Nearly all engineers have suffered the common punishment resulting from the remorseless discipline of higher mathematics, physics and mechanics. No man has to work as hard in college as the engineer. As a result, the engineer sometimes imputes a value to precise mathematical reasoning which it does not always have. There is such a thing as life, and the mathematics of life is as far beyond the calculus as the calculus is beyond arithmetic.

We can see in Mendelian genetics a complex algebra which has proved to be of some analytical use in determining the mechanism of heredity. Nevertheless, from the standpoint of producing superior plant and animal organisms, the engineering mathematical approach to life has not yet been especially successful. It seems to me that the emphasis of both engineering and science in the future must be shifted more and more toward the sympathetic understanding of the complexities of life, as contrasted with the simple, mathematical, mechanical understanding of material production.

The quantitative answers produced by the science of the past hundred years are not enough. They merely increase the speed of life without increasing the quality. Would that we had some one with the imagination of Sir Isaac Newton to develop the higher calculus of the engineering of life which is so necessary if our increased productive power is to increase total human happiness!

Haven't you sometimes wondered whether this whole Century of Progress might not be just a superficial and temporary phenomenon after all? The increase of physical output in three generations is so extraordinary that we've tended to think that this is what man is meant for. It seems to me a terribly inadequate yardstick of civilization. A man has food, clothing and shelter; wherein does he differ from the beasts of the field? Surely these are not the things which distinguish the civilized from the uncivilized. Food and shelter and the other necessaries in any rational order ought to go without saying. They ought to be as automatic and as universal, in this day of technological achievement, as the air we breathe. It is from this point on that life begins.

A characteristic of the engineer is his willingness to face the cold truth about the task to which he addresses himself. Engineers have brought to their jobs a more fully developed intellect than any other class of our citizenry. Sloppy, opportunistic thinking is simply inexcusable in the engineering world. I would be the last to suggest that the engineer abandon the precision of his thinking and his honesty in facing facts. I am merely asking that the same qualities be brought to bear in so far as possible on the more complex situations which have to do with living organisms and our social life. I fear, however, that in our social and economic life the objectives must always come from that mysterious realm which all engineers and scientists should treat with the greatest respect but with which engineering and scientific methods are totally unable to grapple.

In brief, then, we wish a wider and better controlled use of engineering and science to the end that man may have a much higher percentage of his energy left over to enjoy the things which are non-material and non-economic, and I would include in this not only music, painting, literature and sport for sport's sake, but I would particularly include the idle curiosity of the scientist himself. Even the most enthusiastic engineers and scientists should be heartily desirous of bending their talents to serve these higher human ends. If the social will does not recognize these ends, at this particular stage in history, there is grave danger that Spengler may be proved right after all, and a thousand years hence a new civilization will be budding forth after this one has long laid fallow in a relative Middle Ages.

# SCIENTIFIC EVENTS

## RADIO OBSERVATIONS OF THE ECLIPSE

ON February 14, 1934, a total eclipse of the sun will be available for observation, being total at noon on Wake Island in the Pacific Ocean. During the last total eclipse, August 31, 1932, radio observations of the ionization of the upper atmosphere (90 to 200 km above the earth's surface) were made by many observers, including J. T. Henderson and D. C. Rose[1] in Canada, H. R. Mimno and P. H. Wang,[2] G. W. Kenrick and G. W. Pickard,[3] S. S. Kirby and L. V. Berkner[4] in the United States, and T. R. Gilliland and K. A. Norton[4] at Sydney, Nova Scotia. An analysis of the results indicates that such observations determine the recombination coefficient of the ions in the upper atmosphere as well as the magnitudes and relative importance of the various ionizing forces in the upper atmosphere. The recombination coefficient was only approximately determined by the 1932 eclipse, while the results indicate that most of the ionization in the layers with maximum ionization at about 115 and 180 km was due to ultra-violet light from the sun. However, a small part of the ionizing force in the 115-km layer, and most of the ionizing force in the 220-km layer, were not eclipsed by the moon at the time of the normal light eclipse. A more acurate determination of the recombination coefficient and a further study of this non-eclipsed ionization would be of the utmost importance, shedding light on the constitution of the ionosphere and on the theories of the variations of terrestrial magnetism, etc. Recent technical advances[5] in radio methods of observation of the ionization of the upper atmosphere would greatly facilitate such observations. It is hoped that facilities for radio observations will accompany any expeditions for the observation of the February eclipse, since the conditions are peculiarly favorable to success, the sun being near the zenith and the date near a sunspot minimum. The success of radio observations, being independent of the presence of clouds, is a function only of the care with which preparations are made and the past experience of the observers.

Any observers must leave very shortly in order to be at the proper place in the Pacific in time for the eclipse work.

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U. S. BUREAU OF STANDARDS

[1] *Canadian Jour. of Research*, 8: 1–36, January, 1933.
[2] *I.R.E.*, 21: 529–546, April, 1933.
[3] *I.R.E.*, 21: 546–567, April, 1933.
[4] *Bureau of Standards Journal of Research*, December, 1933.
[5] T. R. Gilliland, *Bureau of Standards Journal of Research*, July and October, 1933.