Stage G of A to T. A. Working Paper Draft SEPR No. 55 October 7, 1965

"SCIENCE, ENGINEERING & SOCIETY"

by

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The time has come, the Walrus said,
To talk of many things:
Of science -- of ethics and engineers,
Of colleges -- and kings.
And why they seem so boiling hot --
And whether pigs have wings.

Abstract

This working paper deals with the following topics: 1. Phenomena of disassociation; 2. Hebrew-Christian Ethics; 3. Unity of All Science; 4. Interaction; 5. Adjustment of Engineers; and 6. Cooperation of Engineering Scientists.

There is a phenomenon that sometimes affects engineers, which warrants considertion by reason of its occurance in significant places, rather than by its extent of prevalence. Data on this phenomenon is not easily obtainable and is usually incomplete. To understand this phenomenon, let us examine some cases.

Case One: A man who obtained his B.S. in engineering with an almost straight A record. He worked a few years in industry and quickly became regarded as a man of exceptional wisdom by his associates. However he gradually became dissatisfied. He began to wonder whether the production of more and more gadgets for more and more profits was serving any useful purpose. He noticed that the big executives were not happy men, but were rushing from this worry and to that worry and getting farther and farther away from sane healthful living. After a while he quit his job to take a job else where, with less responsibility and less pay so he could devote more time to thinking. It really disturbed him to examine the activities of many of our governmental officials and businessmen.

He couldn't understand why they do such stupid things, why they don't use some simple logic to try to solve some of the problems facing the world. He was last known to be angling for some editorial or writing job that might help him become a writer.

Case Two: A man who obtained his B.S. in engineering with honors and then took his M.S. in engineering and then went into industrial consulting work. When someone mentions any of the more important political or economic problems facing our country, he scowls, shakes his head, waves his hands in the air, and says he sees no hope in the immediate future.

Case Three: A man who obtained his B. S. in engineering, spent a year and a half in inddustry, and obtained his M.S. in engineering. After working a while on a government research project, he concluded he had made a mistake, his engineering work didn't seem to be producing anything of real value to our civilization. He was known to be studying industrial relations.

Case Four: A man who obatined his B.A. in mathematics and went into industria l research. After a few years he became so irritated at the inadequate way in which our social and economic problems are being handled that he decided to return to college to study sociology. After examining the material offered by various universities in the field of sociology and talking with a few sociology professor,he gave up that idea as not very practical. He was last known to be undertaking graduate study in physics while devoting a large amount of his time to the work of a political action committee.

In the above cases some information has been omitted in order to avoid easy identification of the individuals concerned. From the above cased, other cases not mentioned, and from my own experiences I conclude that ther exists some conflict between the customs of our civilization and the philosophy underlying the education of many engineers and scientists.

To remain true to the tradition of the scientific method, it is necessary to indicate the defiefences of the author in respect to the matefial here considered. The author has had no formal education in psychology, political science, history, sociology, anthropology, etc., so that deficiencies in this analysis are to be expected. The author discloses these ideas, even though incoomplete and based on elusive data, in order to facilitate the study of the problem thorugh cooperation fo those who are qualified to make more adequate analyses.

The organization of our educational system appears to be based on the assumption that in early childhood one receives his basic ethical training at home and at church school in parallel with receiving his basic education in thepublic schools. In such casss where this assumption is an actuality, the child may develop a deep understanding of the Hebrew-Christian tradition as interpreted by the particular faith or denomination of his parents and church school teachers. The following is a well known biblical text that has been translated into a vocabulary that indicates the type of attitude that frequently results from an understnding of the Hebrew-Christian tradition under present conditions(1946):

> We must love the truth with all our
> hearts and with all our minds;
> We must respect that which is known
> today of the natural law, but we
> must not be insensitive to new discoveries.
> We must love our neighbeos as ourselves.
> Of these two laws, the second is as
> necessary as the first, but does not
> suffice without the sustaining strength of the first.
> Upon these two foundations we build on the
> good of the past toward the awakening
> horizon of the future.

Although no statistical data is available, there are some indications that people of the types illustrated by cases one thorugh four have a better than average understanding of the Hebrew-Christian traditiob , altbough their individual way of expressing it may be quite different from the above statement.

Now let us look at the college educatoon of the engineer. In brief it is a process of learning what has been achieved by the scientific method in the physical sciences and the techniques of utilizing our knowledge of physical sicnece for the use of mankind. Although the scientific method is not usually taught to the engineer as a subject by itself, it permeates every engineering subject so that the engineeri learns the scientific method by example and practice. The resultant effect upon the thoughtful student may be approsimately as described by Karl Pearson in The Grammar of Science(Everyman's Edition, 1901, pp 16[1938 reprint])

> "Now this is the peculiarity of the scientific method, that when once it has become a habit of mind, the mind converts all facts whatsoever into science. The field of scienc is unlimited, its material is endless, every group of natural phenomena, every phase of social life, every stage of past or present development is material for science. The unity of all science consists alone in its method not in its material....."

So now the stddent has in theory develpped understanding of the Hebrew-Christian tradition and the tradition of the scientific method. In practice it appears that the extent of understanding of the Hebrew-Christian tradition differs greatly from engineer to engineer.

If he has developed a reasonably full understanding of both the Hebrew-Christian tradition and the tradition of the scientific method, it does not take much thinking to see that these two traditions are essentiallly in harmony wtth each other. However some distinction must be made between isstitutioons and the ideas they represent.

Next let us examene how the engineer adjusts to his work in industry. It apperars that he may get along well if one or more of the following conditions apply:

(1) His early training was such that he failed to develp much of an understanding of the Hebrew-Christian tradition,

(2) He only developped a superficial understanding of the scientific method,

(3) The organizaion of the corporation in which he works is such that he is detached from productionaand economic problems so that he may specialize in some narrow field without becoming disturbed by the general situation,

(4) He is such an expert in his field that the company considers him an asset even though he shows opern contempt for the failure of the company to act ina manner sonsistent with the Hebrew-Christian tradition and the tradition of scientific method.

The above conditions are probably only rough approximations to the truth, but can serve a useful purpose in the organizaion of a study of the problem.

According to some psychiatrists about one out of every ten people in the United States need psychia tric attention. This might indicate that there are similar difficulties in occupations other than engineering. When I consid er leaving engineering to study

the problems of society from the viewpoint of the social sciences, I run into the danger of loss of perspective. At present it apperas to me that the most useful approach to this problem of conflict between our educational system and our business and insustrial system is to study the development of a branch of physical science in connection with the realted social problems. The object of the study should be to develop some evolutionary process by which the Hebrew-Christian tradition and the scientific method can be usefully applied to industrial and business and political problems.

The procedure most promising appears to be that of establishing cooperation between engineering scientists in the fields which overlap with this problem. For satisfactory coooeration, I think there must be social scientists who posees a real knowledge of elementary physics and mathematics, likewise some engineering scientists in the physical sciences must havw some basic knowledge of the social sciences in order that useful cooperation canbe obtained.

SOCIO-ENGINEERING PROBLEMS REPORT NO. 55

Date: 11/30/46 3/22/61 6/30/61 11/29/61 7/7/63 10/7/65 1/26/67

Stage: Draft SEP 44 SEP S-7 SEP 55 SEPR 55 Edited Reissue

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"Science, Engineering and Society, Cont."

I shall start by quoting the concluding paragraphs of my note of November 30, 1946, approximately twenty years ago:

"At present it appears

to me that the most useful approach to this problem of conflict between our educational system and our business and industrial system is to study the development of a branch of physical science in connection with the related social problems. The object of the study should be to develop some evolutionary process by which the Hebrew-Christian tradition and the scientific method can be usefully applied to industrial and business and political problems.

The procedure most promising appears to be that of establishing cooperation between engineering scientists in the fields which overlap with this problem. For satisfactory cooperation, I think there must be social scientists who posses a real knowledge of elementary physics and mathematics, likewise some engineering scientists in the physical sciences must have some basic knowledge of the social sciences in order that useful cooperation canbe obtained.

In my presentation of a paper in the Univ. of Calif. Elec. Engin. 298 Seminar of May 26, 1947, I attempted to make some progress along this line of thought through the study of the history of electromagnetic theory. At that time I do not think either the professor in charge of the seminar or the other graduate students took my proposal very seriously.

Since taking the Dale Carnegie course, I perceive a better way to explain to people what I was doing back in 1947 in Professor Morton's Elec. Engin. 298 seminar. I gave a paper on the "History of Electromagnetic Theory" which started with the question of when in the evolution of the universe did the density of matter reach a range for which both electric and magnetic vectors could be propagated. Then I outlined a series of partial derivatives of history in whichstage by stage I narrowed down the subject to the more recent applications of electromagnetic theory.

I don't think many people understood what I was attempting to accomplish inthat study. I realize now that I did not explain a fundamental fact underlying the whole study. In the Spring of 1947 I was taking Economics 291 at Berkeley, an interdisciplinary seminar on international economic problems, which was an experiment in establishing cooperation between scientists in different fields, which I independtly proposed in SEPR No. 55(11/30/46).

The expansion of my EE 298 paper from its formal version of 1/10/47 to expanded version of 5/26/47 in I included more interaction with social phenomena was partly a result of my experiencing communication with scientists from other fields in the Economics 291 course. The next semester I worked out a method of studying mathematics which might be useful for preparing an individual for interdisciplinary studies.

I was taking some mathematics courses recommended by the chairman of the mathematics department. Some of the electrical engineering professors did not see the point. Also I was trying out an experiment in the learning of mathematics. This experiment consisted in learning each concept or theorem in the theory of functions of real variables first as an abstract philosophical concept, second as a representation of some specific electrical circuits, antennae, or waveguides, and thirdly as representations of models of sociological systems consisting of nations, states, families, and individuals. I found that the precise mathematical concepts had some discontinuities in respect to electrical circuits, and that in relation to sociological systems they became rather vague and fuzzy.

The late Norbert Wiener has referred to studies similar to my experiment in learning mathematics as projects which normally take about twenty years to evaluate, and hence are unlikely to succeed in getting support from industry, government, or even universities. Therefore many years ago, I adopted a policy of maintaining a continuing stydy of this interralationship of concepts in mathematica, engineeeing and sociology as a hobby. In May 1964 a Boston psychiatrist defined this type of study as "multidisciplinary" where one person organizes concepts for two or more disciplines in his mind, as contrasted to "inter-disciplinary" where a group of specialists work together.

I have worked out arrangements to report on some of the results of my "multi-disciplinary" experiemtents thorugh the Society for General Systems Research which is affiliated with ~~the~~ Section _ - History and Philosophy of Science of the American Association for the Advancement of Science.

Note: The chart used in the 5/26/47 talk is filed at 4691, cross-referenced at 6110.

SOCIO-ENGINEERING PROBLEMS REPORT NO. 55-A

Date: 11/29/65 1/27/67

Stage: Draft Revised

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Supplementary Notes:

In the Spring of 1947 I was participating in an experiment in interdisciplinary study supervised by Professor J. D. Coddliffe to see if a group of graduate students from economics, sociology, political science, history, art, chemistry, physics and electrical engineering could in a six months period develp a level of inter-disciplinary communication useful in making a contribution to the understanding of the problems of interantional control of atomic energy.

The experiemnt turned out to be too successful in that the U.S. State Department did not want our analysis published, particularly during the critical stages of arguments in the United Nations Atomic Energy Committee over the international control of atomic energy.

Professor Condliffe pointed out that in Europe, especially in England, a number of significant breakthroughs in physical science in the early days of science, and even in more recent times in the social sciences, have come from people pursuing the problems as a hobby while earning their living in some other occupation. Since our pilot study was censored, I decided that it would be wiser to carry on future sutdies as a hobby to maintain better independence in such studies.