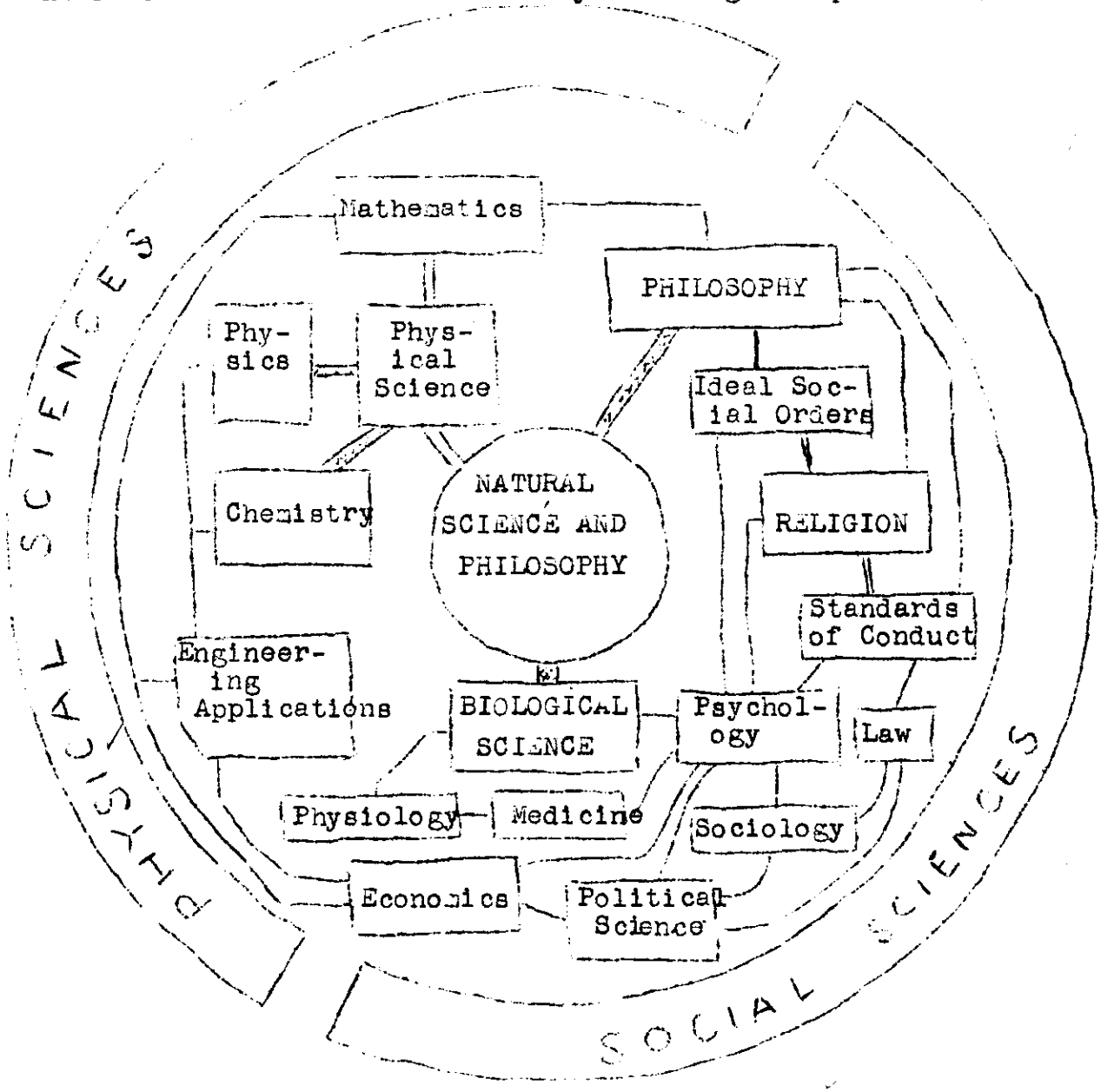
A W O R K I N G P A P E R D R A F T

SOCIO-ENGINEERING PROBLEMS

No. 1 August 1958

"The engineer may be regarded, therefore, as an interpreter of science in terms of human needs and a manager of men, money, and materials in satisfying these needs." --- from E.C.P.D.
The mention of"human needs" raises many sociological questions.



A preliminary attempt to organize a synthesis of the specialized fields of science to assist the engineer in deveioping an interpretation of science in terms of human needs.

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SOCIO-ENGINEERING PROBLEMS August 1958 No. 1

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SOCIO-ENGINEERING PROBLEMS - A NEW TEMPORARY AND INTERMITTENT MEDIUM OF COMMUNICATION

This is the first of a series of informal memoranda to be issued at irregular intervals on the subject of the social responsibility of engineers. In this series the responsibility of the engineer and scientist to mankind to do what he can to make democracy work more successfully is emphasized. These problems include the necessary development of a better understanding on the part of the engineer himself and the general public of the basic principles and significance of science and engineering. I consider that the social responsibility of the engineer to be a kind of coordinator to make certain that the social problems related to his physical engineering work are being studied and that there are provisions made by our society to explain the basic principles and significance of science to the voters in our democracy.

These studies neglect the second phase of the engineer as "a manager of men, money, and materials", since many engineers have developed into managers;little concrete analysis of the role of the engineer "as an interpreter of science in terms of human needs has appeared. I do not imply that the engineer and technician in our complex society are better qualified to make decisions on the social use of science and inventions. Specialists in engineering could easily neglect psychological factors involving human feelings in their concentration upon physical phenomena and devices. The studies in this series will be directed toward finding techniques which would help the engineer in discharging his social responsibility and in defining problems which the engineer can refer to social scientists. The ultimate objective is to help the citizen to acquire the understanding needed to make democratic decisions in our complex industrial society.

The function of this newsletter is to provide a limited distribution of some preliminary ideas for discussion prior to editing for submission to established journals and engineering societies. It is hoped that this series will serve a short but useful life in establishing better communications between engineers, social scientists, and people interested in solving the problems of our increasingly complex society.

For example the author plans to submit an abridged version of the

article starting on page 3, "The Nature of the Social Responsibility of Engineers," to an engineering conference. The probable time schedule based on the mechanics of obtaining the required approval, review, and revision is as follows:

August 12, 1958: Trial presentation of part of the material at a local engineering society meeting.
September 9, 1958: Submission of manuscript for institutional review.
October 1, 1958: Submission of paper to Technical Program Committee.
December 1, 1958: Author notified of acceptance, revision requirements, of rejection.
February 1, 1959: Final text to be submitted to Publication Committee.
March 3, 1959: Oral presentation at conference.
June 1, 1959: Printed proceedings available.

The author has another manuscript (No. B) in process which requires copies of No. 1 with it to be understandable. The use of this series, Socio-Engineering Problems, is intended to provide copies of cross-referenced materials well in advance of the avilability of published versions. The proposed second paper may be of more interest to social scientists than to engineers.

August 30, 1958 Frederick B. Wood

OUTLINE OF MATERIAL PROPOSED FOR FUTURE ISSUES

No. B: "Supplementary Note on Factors Influencing My Study of the Problem of Social Responsib lity"
Cover Diagram on Physical And Social Science, Three-Dimensional Chart, Checking Chart, Social Obstructions to the Development of Contacts Needed to Fill In Checking Charts, Conditions Leading to a Re-evaluation of My Earlier Ideas on Social Responsibility, Reasons for Writing the Material at This Time in This Form, Future Issues.

No. C: "Feedback Loops in Human Maturing"
"Tracing a Specific Invention Through Physics, Electrical Engineering, and Sociology"

No. D: "Bibliography on Social Responsibility in Engineering"

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THE NATURE OF THE SOCIAL RESPONSIBILITY OF ENGINEERS

Introduction

Recently there has been some interest in the question of what is the social responsibility of engineers. A series of articles and letters to the editor appeared earlier this year in Computers and Automation [1]. The Western Joint Computer Conference at Los Angeles, May 6, 1958, conducted a panel on "The Social Problems of Automation" [2]. The Santa Clara Valley Chapter, California Society of Professional Engineers, conducted a panel on "Social Responsibility in Engineering" on August 12, 1958. Various authors have written articles on the social responsibility of engineers. I shall prepare a bibliography of such articles of the past ten years in a future issue of Socio-Engineering Problems.

1. Computers and Automation
Jan 1958 pp. 9-10. Discussion whether computers and automation are a "Curse or Blessing". What should a magazine do about arguing these subjects, accepting a social responsibility about them, or taking an educational stand on them?
Feb 1958 p. 3 "Co-operation in Horror" The editor declines to accept a paper dealing with "diffusion calculations" on the spreading of poison gas.
Mar 1958 pp. 13-14 "Destruction of Civilized Existence by Automatic Computing Controls" I: Admiral A. A. Burke, II: Dr. W. H. Pickering, III: From the Editor.
Apr 1958 pp6, 9 "The Social Responsibility of Computer Scientists"
May 1958 pp. 6, 31 Readers and Editors Forum. p. 22 "An Attempt to Apply Logic and Common Sense to the Social Responsibility of Computer Scientists."
(Abstracts of the above articles have been reprinted in S.S.R.S. Newsletter, No. 76, August 1958, published by the Society for Social Responsibility in Science, Gambier, Ohio.)

2. Abstract from Program of Western Joint Computer Conference, May 6, 1958:
"The Social Problems of Automation"
Chairman: H. T. Larson, Aeronutronic Systems, Inc.

"Electronic computers are being employed in steadily widening areas of activity. The outlines of these areas are now discernable. In the scientific and engineering fields, computers have proven to be powerful design and analysis tools. Computer design and application disciplines are having extensive effects on the very mathematical and engineering fields from which the techniques are drawn. These devices have become an integral part of the weapons, machines, and organizations building for wartime. The computer and its descendant, the data processor, are now being applied increasingly to business and industrial activities, in the office and in the factory.

"The total effect of this body of equipment is compounding rapidly, due to the daily discovery of new uses and the sharply increasing quantities of computers and data processors going into action. The impacts of these powerful new tools will be sufficiently great to create discernable changes and reactions in the American society. The adjustments and responses may well create difficult problems in the American business, scientific, and social systems.

"The opening session brings together a physical scientist, a social scientist, and a representative of the labor movement, to discuss the broad social problems arising from the introduction of computers and related automatic techniques into our industrial society. These men will present their views of problems they forsee, and will discuss methods for dealing with these incipient difficulties.

PANEL: Prof. Harrold D. Lasswell, Yale School of Law
Mr. E. J. Schaffer, Vice-President, Oil, Chemical and Atomic Workers, International Union.
Dr. Cuthbert C. Hurd, Director of Automation Research, International Business Machines Corporation.

Engineering Ethics

A starting point for discussing the nature of the social responsibility of engineers would be a review of codes of ethics of the various engineering societies. A less formal approach is to use the statement of the Engineers Council for Professional Development:

"Faith of the Engineer"

"I AM AN ENGINEER. In my profession I take deep pride, but without vainglory; to it I owe solemn obligations that I am eager to fulfill.

As an Engineer, I will participate in none but honest enterprise. To him that has engaged my services, as employer or client, I will give the utmost of performance and fidelity.

When needed, my skill and knowledge shall be given without reservation for the public good. From special capacity springs the obligation to use it well in the service of humanity; and I accept the challenge that this implies.

Jealous of the high repute of my calling, I will strive to protect the interests and the good name of any engineer that I know to be deserving; but I will not shrink, should duty dictate, from disclosing the truth regarding anyone that, by unscrupulous act, has shown himself unworthy of the profession.

Since the Age of Stone, human progress has been conditioned by the genius of my professional forbears. By them have been rendered usable to mankind Nature's vast resources of material energy. By them have been vitalized and turned to practical account the principles of science and the revelations of technology. Except for this heritage of accumulated experience, my efforts would be feeble. I dedicate myself to the dissemination of engineering knowledge, and, especially to the instruction of younger members of my profession in all its arts and traditions.

To my fellows I pledge, in the same full measure I ask of them, integrity and fair dealing, tolerance and respect, and devotion to the standards and the dignity of our profession; with the consciousness, always, that our special expertness carries with it the obligation to serve humanity with complete sincerity."

The above "Faith of the Engineer" is easy to interpret in respect to specific contracts and relations with client, employer, and government agencies. How is one to interpret "when needed" in respect to giving skill and knowledge for the public good? In a less complex society the "when needed" could be easily determined by obvious wars and economic crises. In our increasingly complex society there may be a continuous need for social concern on the part of the engineer so that crises will not reach such large magnitudes of severity.

A Perspective of the Sciences and Engineering

The chart on the cover of this report expresses some common observations of the interrelations between different special fields of science and other human activities. The interconnection of philosophy and the physical sciences through mathematics is obvious. The placing of "engineering applications" between "physics" and "chemistry" on one side and "economics" on the other side represents the role of the engineer in applying the results of basic science to the meeting of human needs which have economic significance. In respect to "standards of conduct" in human behavior, the

chart has been laid out to show the multiple influence of several areas of human activity such as ideals derived from religion and philosophy, understanding of how human beings function from psychology (and psychiatry), the relationship of individual standards of conduct to the organization of human groups as is studied in sociology, and the standards of conduct a given community sets as its goal by enactment into law.

The splitting of the cover diagram into two segments is symbolic of a gap between the physical and the social sciences. Historically this gap may be derived from the controversies between science and religion in the rapid growth of science in the last three centuries. This has led some people to feel that the social sciences are lagging behind the physical sciences. Some people have even suggested a moratorium on research in some areas of the physical sciences. I feel that stopping any area of research would be a loss unless ther is some danger to the future of the human race from some uncontrolled byproduct such as radioactive fallout. The real way to increase our understanding of ourselves and the universe is to increase the communication between physical scientists, social scientists, and engineers.

To return to the chart on the cover, we may ask whether this particular organization of human intellectual activities is the correct representation, or whether there are many alternatives for graphically representing these interdisciplinary problems. I think that this representation has no claim to being correct. I feel that it is only a working hypothesis which serves a useful purpose of opening up discussion of these important problems. I think others have developed different diagrams for a similar purpose. For example Dr. Ludwig von Bertalanffy of the Psychiatric and Psychosomatic Research Institute, Mt. Sinai Hospital, Los Angeles, has published a diagram of the sciences[3] which is different than the one I have proposed. Possibly he has developed a graphical representation that comes closer to the more immediate problems accessible to mathematical and experimental analysis. Perhaps my ideas have occured to many others in the past and have been superseded by hypotheses which are closer to reality. By communicating these ideas I hope to determine where they fit in a scale of usefulness to society.

Relationships between Physical and Social Sciences.

The cover diagram is a preliminary chart of the relationship of the physical and social sciences in respect to human aspirations. This type of chart expresses an objective and some feeling of the unity of different human enterprises, but it lacks specific utility in this problem of social responsibility. To develop a more concrete representation let us examine historical sociology. Perhaps the work of August Comte, Herbert Spencer, and Lester Ward of the last century will be of some use in organizing a

3. Ludwig von Bertalanffy "General System Theory" General Systems vol. I, pp. 1-10 (1956). Reprinted from: Main Currents in Modern Thought, 71, p. 75 (1955). Diagram labelled "Laws or Principles Apply to Systems" on p. 8 (Gen. Sys.)

better representation. Perhaps the following table[4] from Ward will be of value:

SOCIOLOGY
PSYCHOLOGY
BIOLOGY
CHEMISTRY
PHYSICS
ASTRONOMY.

As we go from the bottom to the top of this list we follow the historical order of development of the fields of science and to some extent the level of complexity.

The above classification of the sciences with some modification is useful in developing a new chart which is intrinsically simpler yet is capable of representing any complex field of science or engineering, since it is a three-dimensional code for representing a field of knowledge or experience.

The objective of making charts like this is to help people see the relationships of the different specialized fields. Perhaps some chart or table analogous to the periodic table of the elements in chemistry and physics could be developed for sociology and related fields. The "sky-scraper" type of chart of Figure 1 is proposed as a useful tool in the analysis of the inter-relationship of different fields of knowledge in respect to society.

The horizontal fields of knowledge are arranged in order of increasing complexity; with the study of energy and the basic particles of matter as the foundations in physics; the study of the relations between the fundamental particles and energy to make compounds of the elements in chemistry; the study of more complicated compounds which form living matter in biology; the study of more complicated living living things as animals in zoology; The study of man as the most advanced of the animals in physiology; the study of man's mental and emotional processes in psychology; and the study of man's relations with the rest of humanity through social institutions such as religion.

The vertical columns represent different modes of treating basic phenomena. For the scientist is interested in why; the artist in the effect of the form and the colors; the philosopher in the meaning; the mathematician in the equations; etc.

A third group, not shown on the "skyscraper" model of Figure 1, are the fields of knowledge which are formed by the intersection of vertical and horizontal columns and/or combinations of parallel columns. An example for Astrophysics is given in Figure 2A. An alternative form for the same is given in matrix form in Figure 2B.

Another form is illustrated in Figure 3, in which the development from one stage to another in our knowledge moves from simple things needed for survival through art, symbols, theories, proof (scientific) and then repeats the cycle on another level. As Civilization becomes more comples, what was earlier a luxury becomes a necessity, i.e., scientific proof becomes a necessity in a comples society.

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4. Samuel Chugerman Lester F. Ward, The American Aristotle Durham, N.C.: Duke University Press (1939) p. 192.

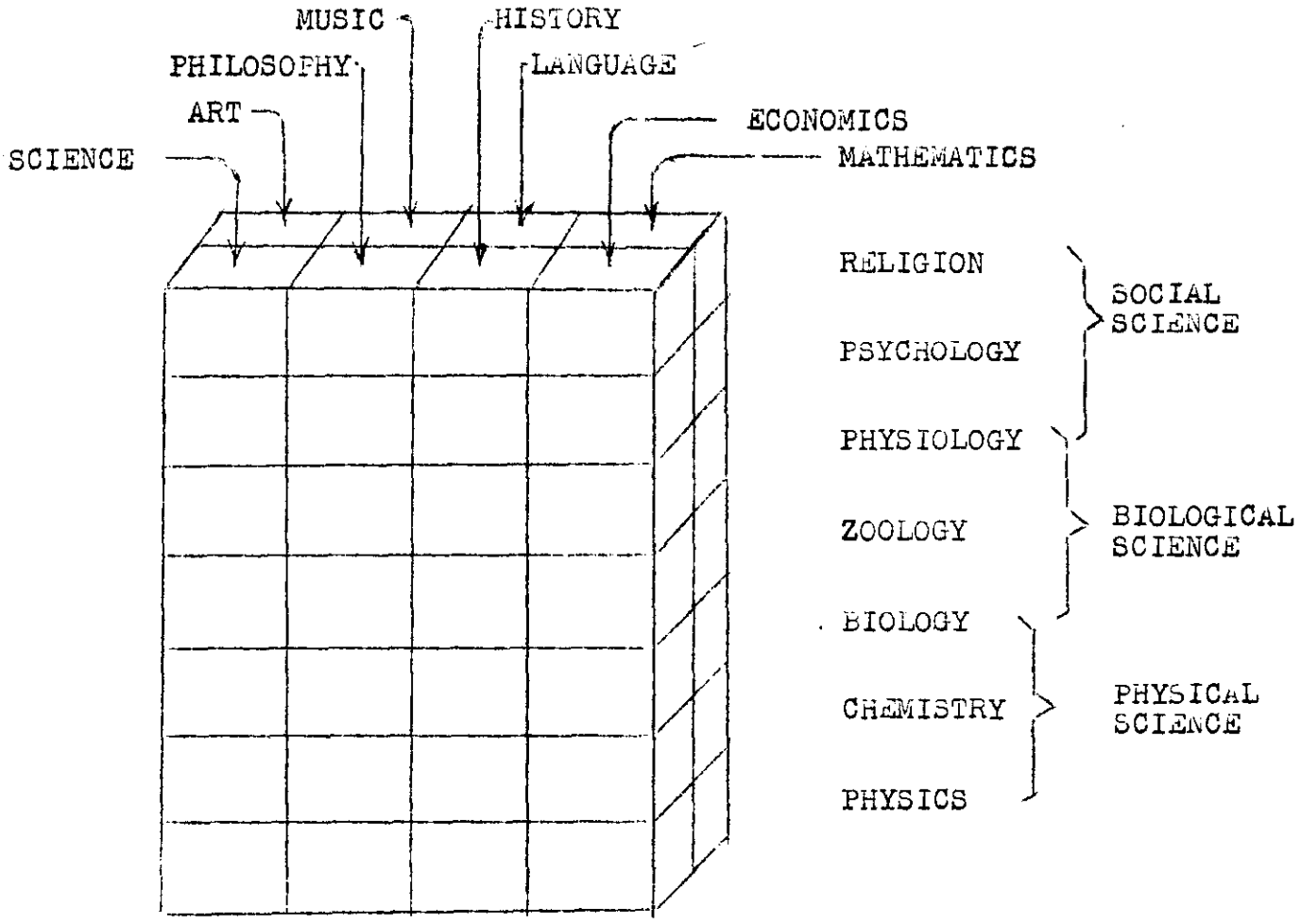


Figure 1. A Three-Dimensional Chart

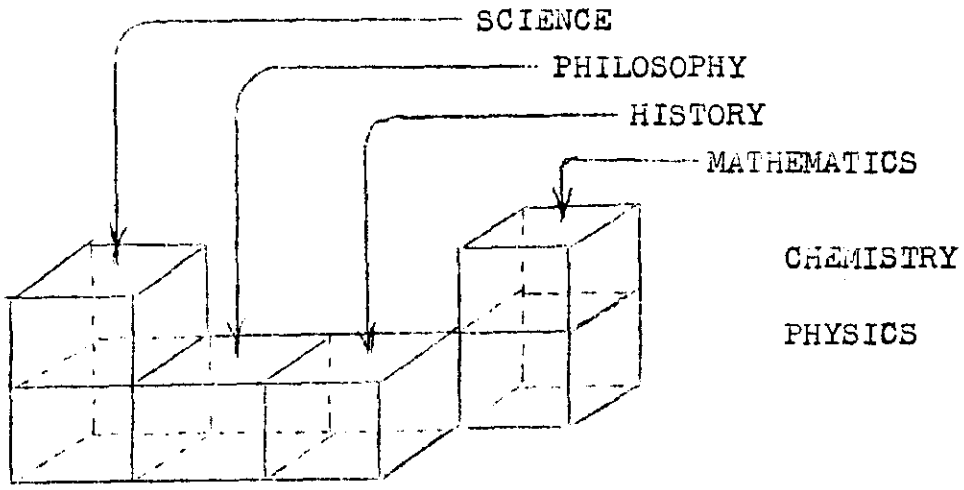


Figure 2A. Astrophysics

	A	Mu	L	Ma	E	H	Pl	S
R	0	0	0	0	0	0	0	0
Py	0	0	0	0	0	0	0	0
Ph	0	0	0	0	0	0	0	0
Z	0	0	0	0	0	0	0	0
B	0	0	0	0	0	0	0	0
C	0	0	0	1	0	0	0	1
Ps	0	0	0	1	0	1	1	1

Figure 2B. Matrix Representation of Astrophysics

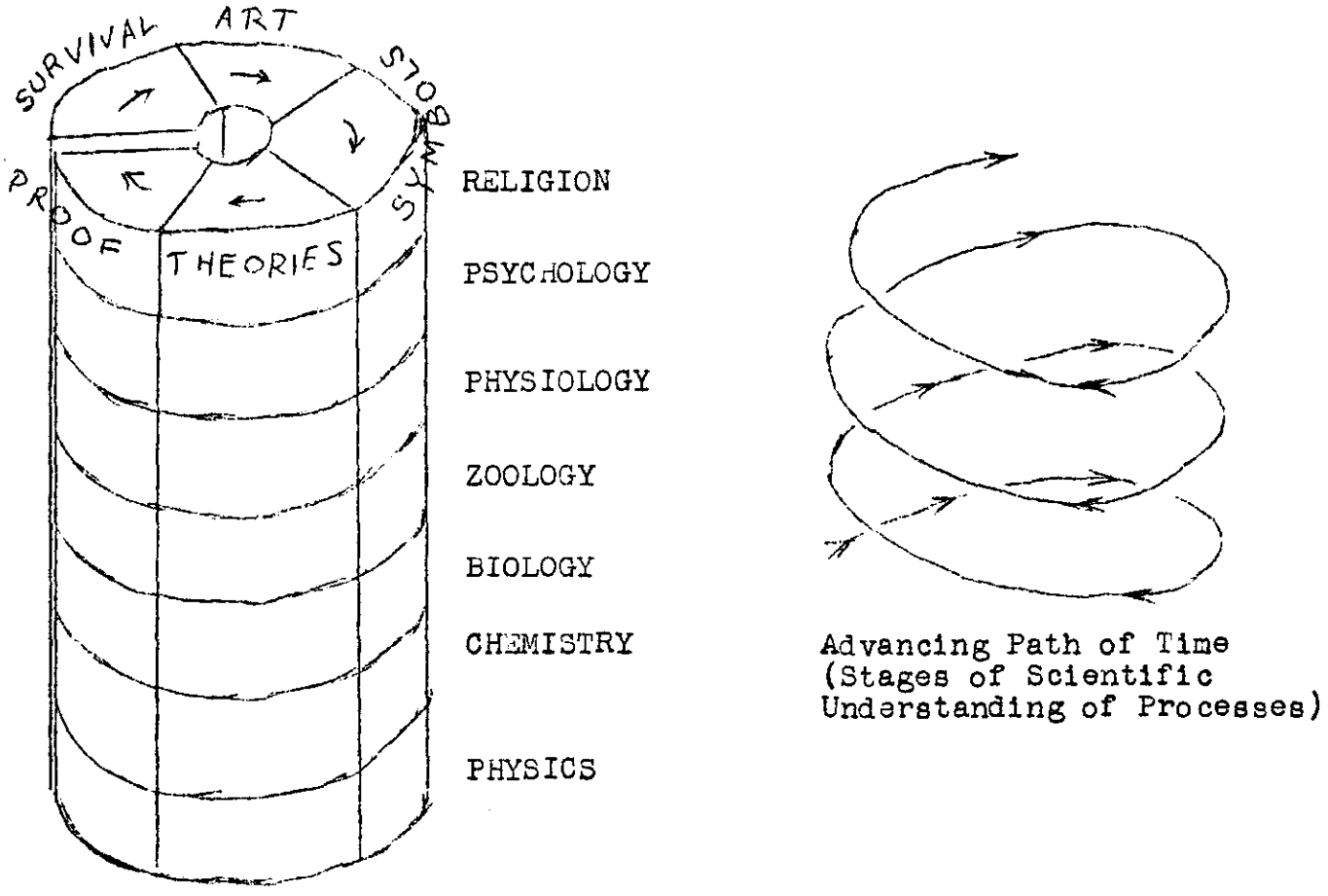


Figure 3. Alternative Form of Relationship of the Arts and Sciences.

A Checking Chart Derived from the Classification of the Sciences

From the classification charts of Figures 1 and 3 a simplified two-dimensional chart of Figure 4 has been derived for use in checking the extent of coverage or "completeness" of a particular analysis of a problem. This simplified form is intended to show more clearly the stages of development in different fields of knowledge that are required for the balanced application of some idea in society.

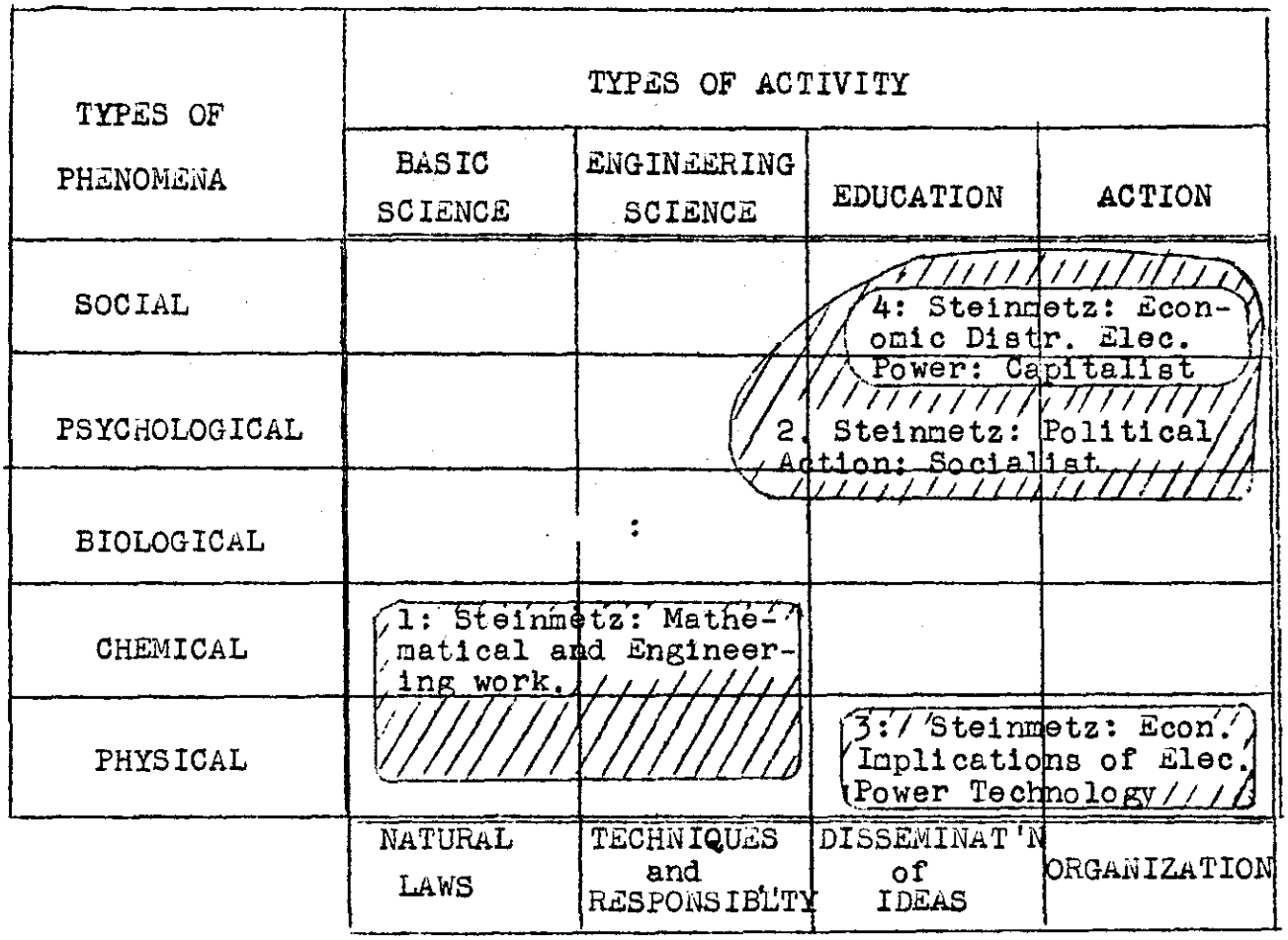
An example of some of the work of Charles P. Steinmetz is marked on the checking chart of Figure 5. Steinmetz's basic work involved research and development in the understanding and application of physical and chemical phenomena to electrical engineering design with extensive use of the tools of mathematics. This basic area is marked as section 1 in Figure 5.

Section 2 illustrates the domain of his political activities as a Socialist in which he held various city offices in Schenectady such as Chairman of the Board of Education and Chairman of the Common Council[5]. Under his leadership the Socialists instituted many reforms which we accept as commonplace now such as mid-morning milk for the school children, the construction of sufficient school buildings so all the children of the city could attend school, and provision of special teachers and facilities for tubercular and disabled children.

Section 3 shows the domain of his observation of the implication of his engineering work for how the benefits of electric power might be brought to the common people everywhere. Steinmetz concluded that to make electric power available at cheap rates required integrated electric power systems covering large sections of the country. He felt that under the conditions existing in the United States the best practical way to achieve the more general distribution of cheap electric power to the people was to support the trend toward large corporations which could acquire sufficient capital to build efficient power distribution systems.

The support to large corporations given by Steinmetz as a practical step was on the surface a contradiction with his direct political action in the Socialist Party, as is illustrated by Section 4 of Figure 5. If we examine the situation more carefully, we find that the Socialist Party was performing the role of experimentation and being pioneers. The reforms in school operation tested by the Socialists of Schenectady under the leadership of Steinmetz became accepted as standard practice. In the past the radicals such as the Socialists have provided ideas for social progress which have gradually been accepted and put into practice by the more conservative groups in our society. The existence of a foreign government using the word "socialist" in its name has made it more difficult for a socialist party to function in our country on account of the introduction of the question of "loyalty" in regard to groups suggesting new ideas.

5. John Winthrop Hammond Charles Proteus Steinmetz - A Biography N.Y.: The Century Co. (1924) The following quotation from the Preface, p. viii, is particularly significant: "And Steinmetz was an idealist. It was pure idealism that shaped his social philosophy. He sincerely desired a "Better World", socially and morally, as well as materially. He never hated his fellow-men; he always loved them and sought to do them good. His life had much of the pathos of the idealist -- the pathos of being sometimes being misunderstood, and the pathos of sometimes entering the lists on behalf of a cause foredoomed by existing conditions to defeat."



Cross-hatched areas on chart indicate areas covered by a particular analysis, project, or individual. Certain basic types of natural phenomena are arranged in horizontal rows in vertical order such that each is dependent upon the types of phenomena below it.

The basic types of activities required for the meeting of human needs in an industrial society are arranged in order such that the accomplishment of an objective is dependent upon stages reached in activities to the left.

Figure 4. Checking Chart to Indicate the Extent to Which a Particular Analysis Covers the Possible Phases of a General Problem.

Special Note: After typing the text, Figures 4 and 5 were consolodated into a single Figure 4.

Potential Use of Checking Charts by Ordinary Engineers

People may argue that Steinmetz was a genius and how can you expect the ordinary engineer to deal with both the engineering and the sociological aspects of his work. Furthermore, some people point out that Steinmetz was a bachelor without family responsibilities. My thesis is that any new discovery in science or invention in engineering has far-reaching implications throughout all human activity. Further I claim that the ordinary engineer,who does not have much spare time on account of his basic engineering work and his family responsibilities, can find short cuts to understanding the social implications of his work through devices such as the checking chart of Figure 4. I have faith that the engineer can fulfill his social responsibility to help make the results of his work be utilized in tune with mankind's highest aspirations[6].

To fulfill his social responsibility the engineer must understand that it is a responsibility he shares with many people both inside and outside his profession. He may not need to devote a tremendous amount of time and energy to the social implications of his work. The key to success lies in developing a fruitful perspective of the relationship of his work to the society in which he lives. The checking chart of Figure 4 is suggested as an aid to each engineer in developing his own perspective. The ordinary engineer need not expect his activity to encompass the range of Steinmetz marked on Figure 4. He may have a group of friends and correspondents who cover different areas of the checking chart or he may maintain contact with different organizations which cover different areas of the chart. A sample chart is shown in Figure 6, which illustrates the case of an electrical engineer who has established a network of communication channels which enable him to discharge his social responsibility with a minimum of effort. In this example of an hypothetical engineer, he does not by himself cover the whole area, but has friends who cover parts of the area and share with him their understanding of the problems of our complex industrial civilization.

In this example shown in Figure 6 our electrical engineer belongs to his technical society: American Institute of Electrical Engineers and his professional society: National Society of Professional Engineers (NSPE) or an affiliated state society. In addition to the normal newspapers and magazines he reads two magazines having opposing viewpoints: Fortune, representing the viewpoint of business management, and the Monthly Review, representing an independent socialist viewpoint. Our idealized "ordinary" engineer might also contribute financially to the Student Y.M.C.A. program or some equivalent group of his particular religious faith so that some engineering students having advisors of the "philosophy there's nothing-in-it school" might some communication channels available for contact with the history of mankind's cultural achievements and aspirations. He might subscribe to a news bulletin of the Democratic or Republican Party to gain a sense of what kind of issues the practical politicians are prepared to discuss.

Our electrical engineer could rely upon a physics professor friend who follows the activities of the United Nations Educational, Scientific, and Cultural Organization (UNESCO), and follows some of the projects at a neighboring behavioral science research center to tell him about special developments in these areas dealing with the application in society of new

6. A list of quotations illustrating the common ideals of the principal religions of the world is reprinted from an editoral from THINK Magazine on page 15 of this memoranda.

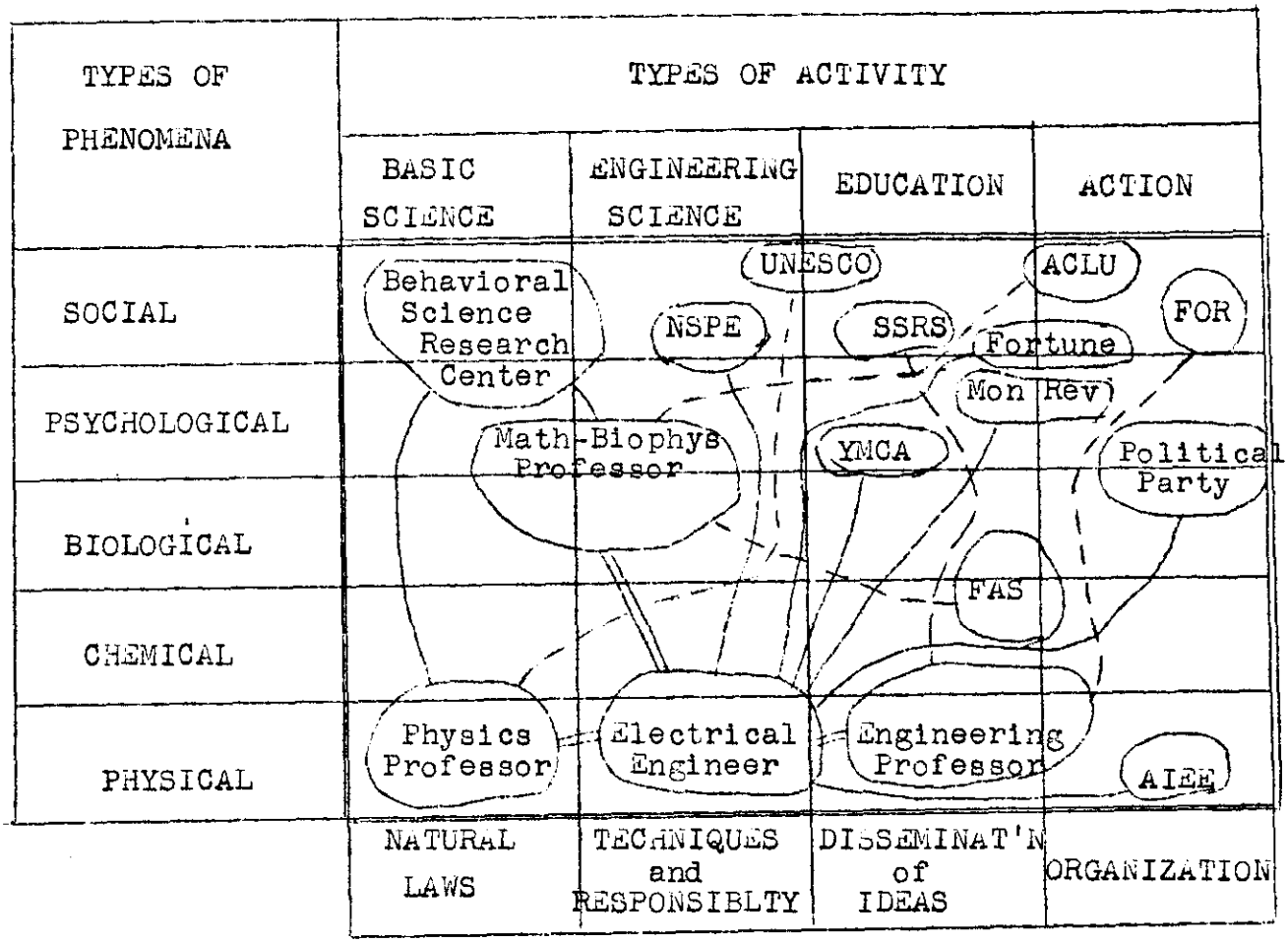


Figure 6. Example of Checking Chart Used to Show Coverage of the Areas of Social Responsibility

engineering products. Our engineer might also know a professor of mathematical biophysics who also maintained contact with the behavioral sciences and was a source of information on civil liberties and radiation fallout problems through his membership in the American Civil Liberties Union (ACLU) and the Federation of American Scientists (FAS).

Our electrical engineer in industry might maintain contact with an engineering professor whose conscience csuses him to take a pacifist stand. From this friend our engineer could occasionally get information about how organizations such as the Society for Social Responsibility in Science (SSRS) and the Fellowship of Reconcilliation (FOR) are tackling the problems of our society.

Conclusions

The recent interest in the social problems of automation and the application of computers in our civilization is a healthy sign that some engineers are developing a perspective of how their special field relates