United Nations

Abstract of
A Research Plan for a Book on

"COMMUNICATION THEORY IN THE CAUSE
OF MAN."

May 22, 1963

"....AND MEN SHALL BEAT THEIR SWORDS
INTO PLOWSHARES, AND THEIR SPEARS INTO
PRUNING HOOKS;   NATION SHALL NOT LIFT
UP SWORD AGAINST NATION, NEITHER
SHALL THEY LEARN WAR ANYMORE."

Isaiah 2:4

'Beat swords into plowshares'

The transition from VIOLENCE to NONVIOLENCE
must be accompanied by a conceptual trans-
ition from "Power Politics" to a "Theory
of Human Development."

This emerging theory of human develop-
ment consists of two parts: the psy-
chology of individual personality
development, and a complementary
socio-economic theory. The
task is to utilize the
physical and mathematical
concepts now used in the
design of Military Weapons
and Command and Control
Systems-----to develop the
philosophical concepts needed
to expedite development of
the socio-economic phase.

The principal conceptual weapons
available are "CYBERNETICS"
and "INFORMATION THEORY," which
have potential use in developing
"thematic hypotheses,".......
implimented by COMPUTER SIMULATION.

Computing
Center

Scientific
Programmer

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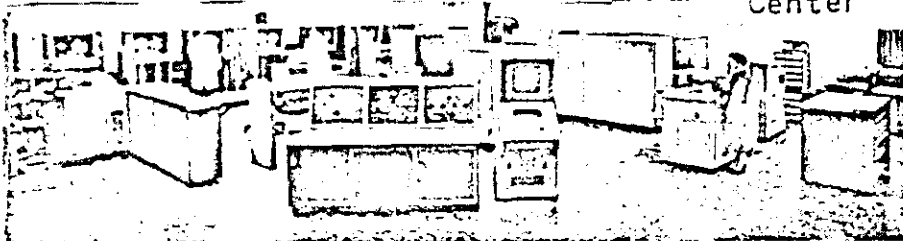
OBJECTIVE

The objective of this proposed project is to produce a book on:

"Communication Theory in the Cause of Man."

It is conceived as a study in the Philosophy of Science from an "Engineering" Viewpoint with emphasis on Communication Theory including Information Theory and Cybernetics plus necessary fundamentals from Mathematics and the Scientific Method in a way which gives promise of bridging the gap between "The Two Cultures" of the Humanities and the Sciences.

CURRENT STATUS

Current Status of Work in This Area - The need for such work was stated many years ago by Archibald MacLeish (1) and has been discussed more thoroughly in recent years by C. P. Snow (2), and by Gerald Holton. (3) Dr. Holton states the problem very clearly:

> "......only very rarely does the professional feel a sense
> of responsibility toward, or of belonging to, a larger
> intellectual community. This loss of cohesion is perhaps
> the most relevant symptom of the disease of our culture,
> for it points directly to one of the specific causes. As
> in other cases of this sort, this is a failure of image.
>   Every age has been shaped by intellectuals of the stamp
> of Hobbes, Locke, Berkeley, Leibnitz, Voltaire, Montiesqieu,
> Rousseau, Kant, Jefferson, and Franklin--all of whom would
> have been horrified by the prospect that cultivated men and
> women could dispense with a good grasp of the scientific
> aspect of the contemporary world picture. This tradition
> is broken; very few intellectuals are now able to act as
> informed mediators...........
>   To restore science to reciprocal contact with the concerns
> of most men--to bring science into an orbit about us instead
> of letting it escape from our intelluctual tradition-- this
> is the great challenge that intellectuals face today!" (3)

RATIONALE

Rationale of This Approach - This investigator feels that some of the failures to extend mathematical communication theory further into the behavioral sciences are due to two factors which have not had adequate attention. Firstly, it may be more fruitful to search for the philosophical equivalent of methods of the mathematician, instead of trying to transfer mathematics from one field to another. Secondly, in the history of science some areas of science led to numerous applications or engineering developments before the stage was set for further basic advances. The first of these leads one to examine the techniques of the mathematician in defining his space and

proving that integration is possible. The second leads to following
an applied science or engineering approach, in which various analogies
are tested for usefulness to people concerned with the sociological
problems characteristic of our increasingly complex civilization.

AIMS

Aims of the Work - The specific objectives are:
a. To determine to what extent analogies from the physical
sciences can accelerate applied research as contrasted to
basic research in the social sciences,
b. To explore ways of improving the communication between dif-
ferent cultural groups in the world so that it will be
easier to develop non-violent techniques of solving national
and international problems,
c. To explore how the conceptual tools already available might
be used more effectively by groups devoted to the cause of
peace and freedom, and
d. To develop better techniques of evaluating alleged applica-
tions of cybernetics to social problems so that correct
applications can be utilized more broadly and incorrect ones
such as "Cybernetics Attacks Religion" (12) can be properly
criticized.

The above specific objectives are conceived as preliminary stages
for the development of ways to utilize future teaching machines,
computers, and terminals to prevent Dr. Donald Michael's dire predic-
tions from developing (Ref. 13, p. 44):

> "In twenty years, other things being equal......... the research
> realm of the scientists, the problems of government, and the
> interplay between them will be beyond the ken even of our
> college graduates......   There will be a small, almost sep-
> arate, society of people in rapport with the advanced computers.
> These cyberneticians will have established a relationship with
> their machines that cannot be shared with the average man any
> more than the average man today can understand the problems of
> molecular biology, nuclear physics, or neuropsychiatry. Indeed
> many scholars will not have the capacity to share their know-
> ledge of feeling about this new man-machine relationship....."(13)

Stated another way, the objectives are to develop a new synthesis of
the relevant components of the sciences and the humanities to bring to
the educated layman a coherent grasp of the world. If our decision
makers and educated layman have better tools with which to analyse
what is happening in the world, the dangers of another war would be
materially decreased.

METHOD

The studies will start as a review of incomplete manuscripts related to the earlier studies which led to the 1959 Western Joint Computer Conference paper, "The Social Responsibility of Engineers and Scientists." (15)

Since the presentation of the social responsibility paper, the author has given considerable thought to the second or more powerful approach of extending the common forms of negative feedback loops of cybernetics, the form of channel capacity curves from information theory, and the coding processes of information theory across the boundaries of the different fields of specialization.

[A] CONCEPTS

Covering Theorems(Mathematics) -The mathematician is very careful and precise in defining the space in which he is working. When the mathematician wants to integrate functions over a particular space, he examines the space very carefully. He develops "covering theorems" which define the properties of the space, how he can sub-divide the space, and how he can count the points in the space. This careful preparation permits him to go on to establish theorems on how to integrate functions in the space.

Partial Derivatives and Series Expansions(Mathematics and Mathematical Biophysics). - When a mathematician has a problem properly defined on a space, i.e., he has the space defined, the boundary conditions are known, the basic differential equations governing the phenomena are known, it still may be difficult to find an exact solution. When the mathematician cannot find an exact solution in closed form he must choose as to what incomplete answer would be of value. He may decide it is important to find a complete solution for a region lying within a certain radius of a particular point in the space, or he may decide that solving for one particular partial deriv-ative will give him the needed information on how the system changes with one particular parameter.

Coding Theory(Information Theory) - This material would be an elementary discussion of binary coding of messages in English, particularly illustrating the redundancy involved. Then it would be shown how the redundancy can be removed, and new redundancy added in the form of error-detection and error-correction coding which is more efficient for machine coding and decoding.

Entropy(Information Theory) - This would be an elementary description and definition of entropy as used in thermodynamics, sta-tistics, and information theory.

Negative Feedback and Positive Feedback Circuits(Cybernetics) - This section would be an elementary description of negative feedback circuits of cybernetics similar to parts of Guilbaud's little book(21). To be of deeper value to the layman, particularly for extension to different types of phenomena, some graphical illustration of positive feedback is needed.

Testing of Hypotheses(Scientific Method) - First we must inquire how the scientist decides to accept a particular hypothesis like the Einstein Special Theory of Relativity. In many fields of science we never have absolute proof of a law, but have to be satisfied with testing hypotheses and using the hypothesis which is most consistent with the known facts. Maxwell's equations haven't been derived from more fundamental laws, without assuming one relationship that comes from knowing Maxwell's equations.

[B] EXAMPLES

(1) Allocation of Public Exhibit Space by Negentropy of Membership Statistics.

A public policy of allocating display space in accordance of the negative entropy of the membership distribution could help prevent the democratic ideal from being distorted to allow the majority group to suppress minority ideas. This proportional representation in the community activities building should help maintain a respect for the right of individuals in a society which emphasizes conformity.

Another approach would be to describe the different viewpoints on ethics with an amount of space proportional to the negative entropy of the statistical distribution of the different viewpoints. An example of this is as follows: Consider an hypothetical city of 100,000 adults (children not counted in this study). The distribution of adult members of the different religious faiths is as follows:

City D

Religious Group	N Members	p_i Probability	$-p_i \log_2 p_i$ negentropy
1. Roman Catholic	60,000	0.600 0	0.442 0
2. Protestant	20,000	0.200 0	0.463 0
3. Lutheran	15,000	0.150 0	0.411 0
4. Protestant Episcopal	3,000	0.030 0	0.152 0
5. No Church	1,000	0.010 0	0.066 5
6. Budhist	600	0.006 0	0.044 3
7. Unitarian	230	0.002 3	0.020 2
8. Jewish	100	0.001 0	0.009 96
9. Eastern Orthodox Catholic	60	0.000 6	0.006 4
10. Ethical Culture	10	0.000 1	0.001 33
Totals	100,000	1.000 0	1.616 7

Fig. 1 shows the distribution of space to scale for the above statistical distribution of religious groups. Consider the situation described in "San Jose 2008 A.D.," SEP 2, P. 7, where The First National Bank Building is devoted to an experiment in practical democracy. Suppose that a 100'x30' section of the main lobby is devoted to exhibit space consisting of four feet wide bulletin board around the room. Then 16,167 unit squares of Fig. 1 correspoond to 1040 sq. ft. Each unit on Fig. 1 is 9.4 sq. in. This makes the Group No. 10 (Ethical Culture) space of 13.3 units correspond to 116 sq. in. or one legal size sheet of paper.
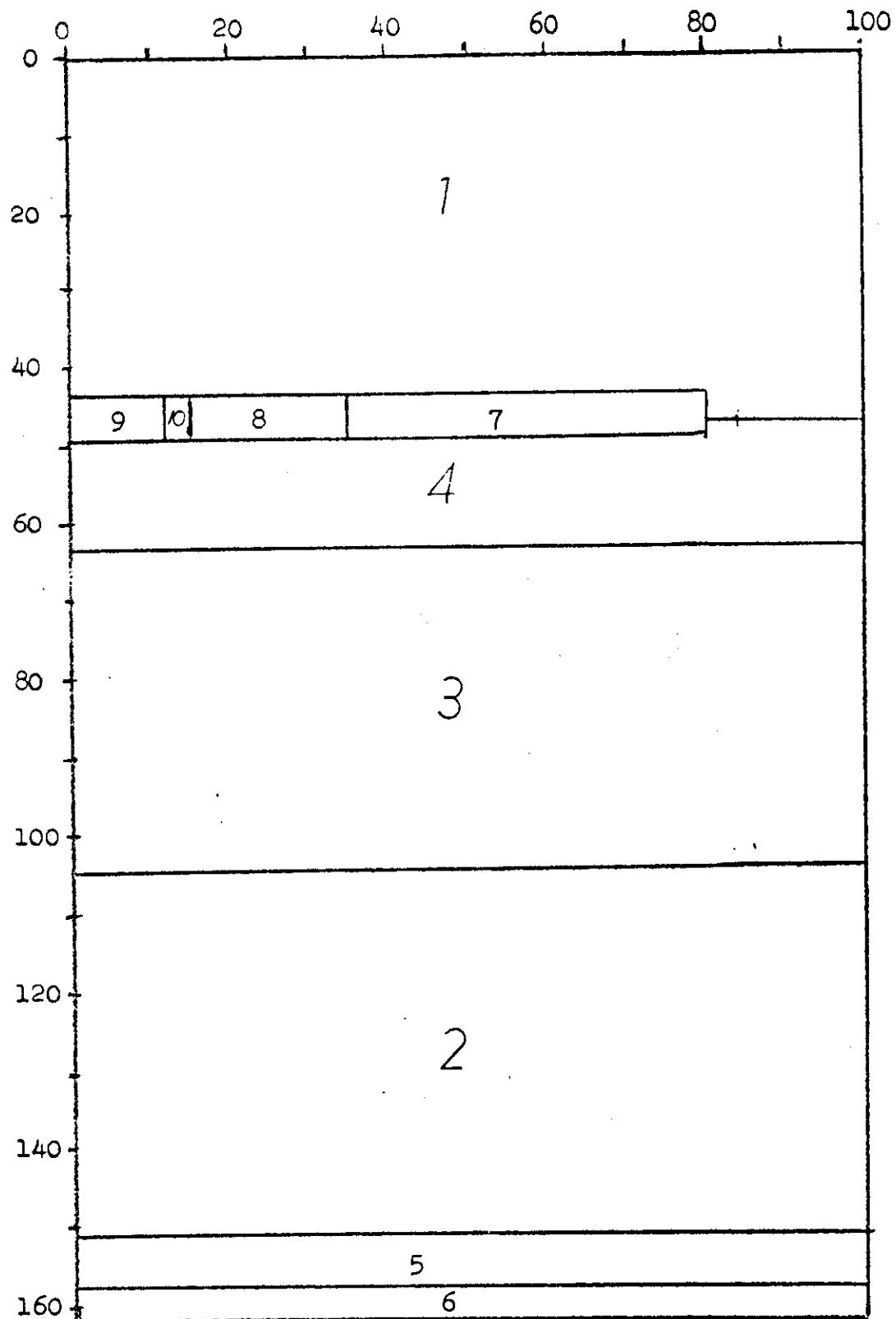
Fig. 1. Sample Distribution of Community Exhibit Space
Determined by Negative Entropy of Membership Statistics.

16,167 unit
squares

Suppose one individual developed some new ideas he wished to
advertize in the community exhibit space. on the scale of the
sample in Fig. 1, he would be entitled to one third of a page space.
On this he could put a brief statement and list his address for
inquiries about further information.

(2)   Feedback Loops in Individual Development and in
      Group Relationships.

As an example, let us start with the general statements about the
potential use of feedback circuits given Norbert Wiener in his books
and articles.

Norbert Wiener, Cybernetics -- or Control and Communication in the
Animal and the Machine. N.Y.:Wiley(1948)

Norbert Wiener, The Human Use of Human Beings - Cybernetics and
Society Second Edition, N.Y.: Doubleday Anchor(1956)   .

Norbert Wiener, "Eight Years of Cybernetics and the Electronic Brain,"
Pocket Book Magazine, No. 2(1955) pp. 45-60, esp pp. 56-60.

Without going into details, one reading the above references can
see that Wiener has pointed the way to the use of negative feedback
circuits in the study of many fields. For the next step someone
must draw some specific circuits or block diagrams. At the risk
of duplicating some ideas that my lack of knowledge of the social
sciences conceals from me, I draw the following diagrams as an
attempt to start discussion of the utility of cybernetics in
simplifying our understanding of the process of the maturing of a
human being. I don't expect to know how useful this process is
until I have broadcast about fifty to a hundred copies around the
world. Then there is a good probability that I will have got copies
to a few of the people (not yet known to me) who can competently
review the usefulness of these diagrams in the process of general
systems research.

A simple negative feedback circuit for representation of an
individual human being is shown in Fig. 2. Here the individual
stores and amplifies data received from the environment. The
individual transmits his reaction through his own standards to
his input to limit his amplification functions to a stable level
which limits his reactions to ones which are consistent with his
own ideas and the general standards of society.

The child who does not yet have his negative feedback loops
is shown in Fig. 3. Here the parents provide the control loops
while the child needs guidance. The transition of the growing
child is shown in Fig. 4. Here some resistance and capacitative
reactance is inserted in series with the parents control as the
growing child develops some experience and adopts some rules in
process of developing his own internal negative feedback loops.

The maturing youth is shown in Fig. 5 with the control of the parents
completely severed. The youth's own feedback loops - experience and
rules have become larger, so that he no longer needs the controls of
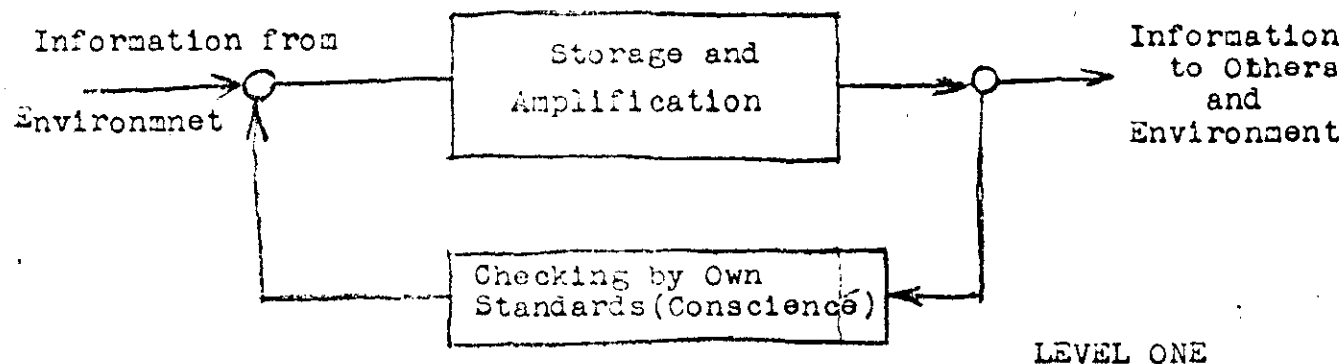his parents.

Fig. 2.   Negative Feedback Representation of a Human Being.
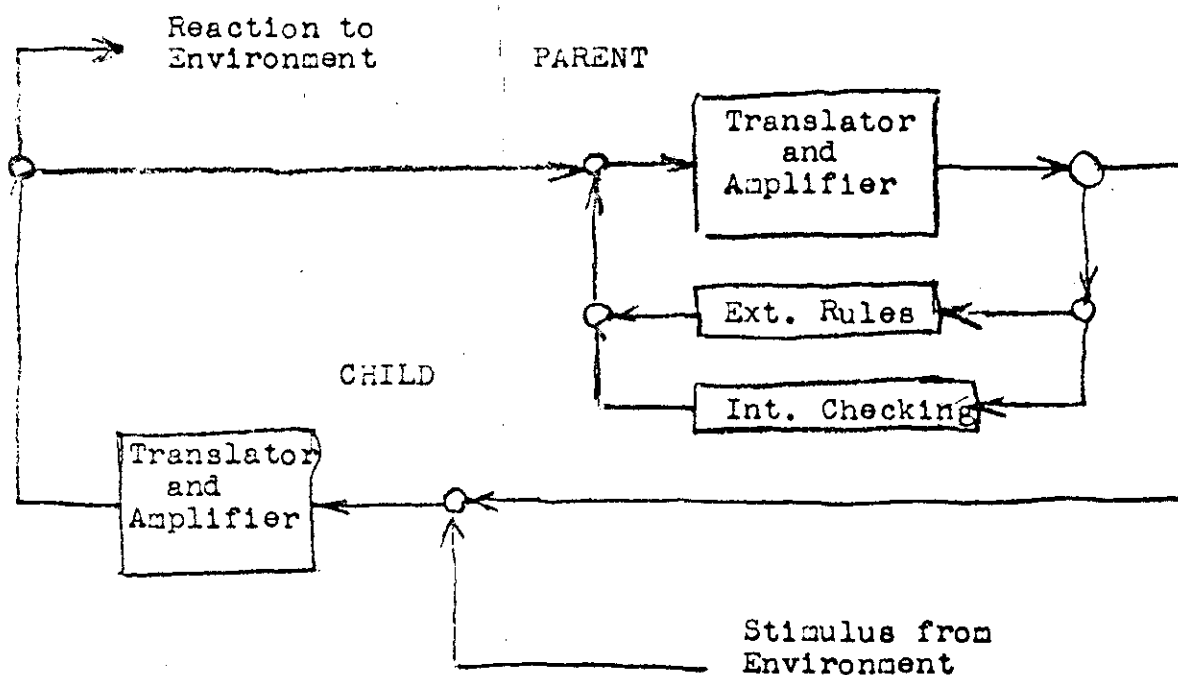

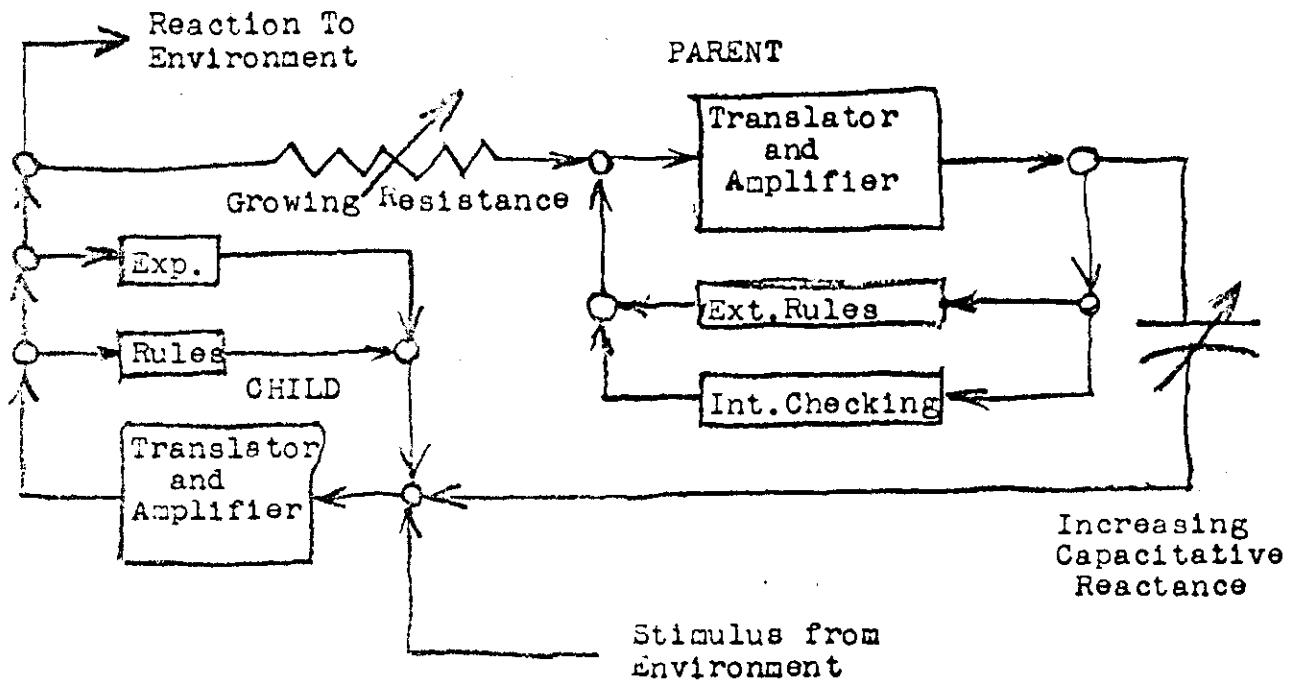Fig. 3.   Early Childhood While Parents Provide Controls.

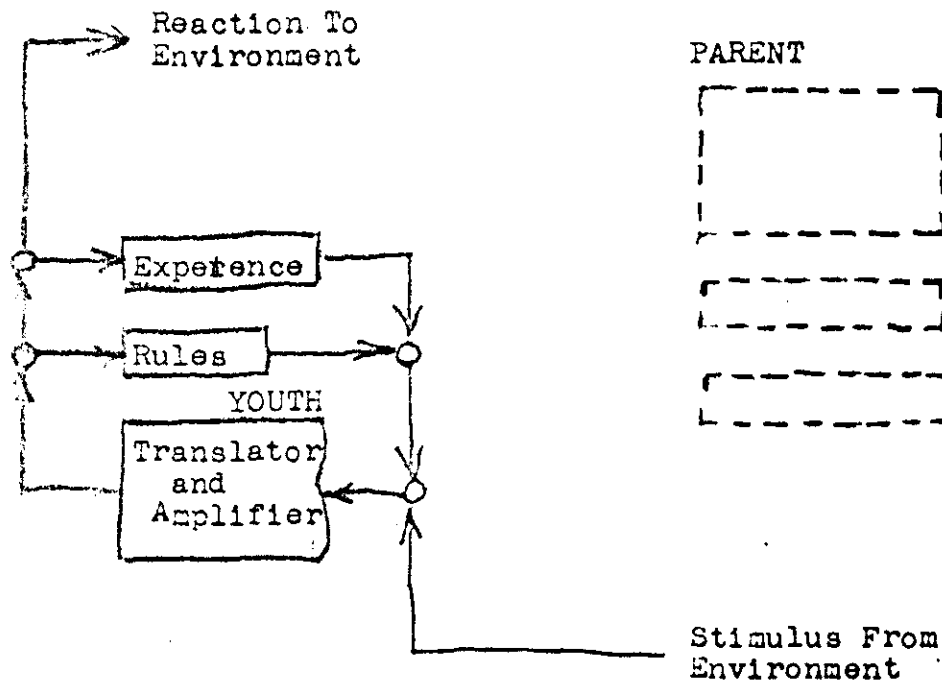Fig. 4. Transistion of Growing Child.
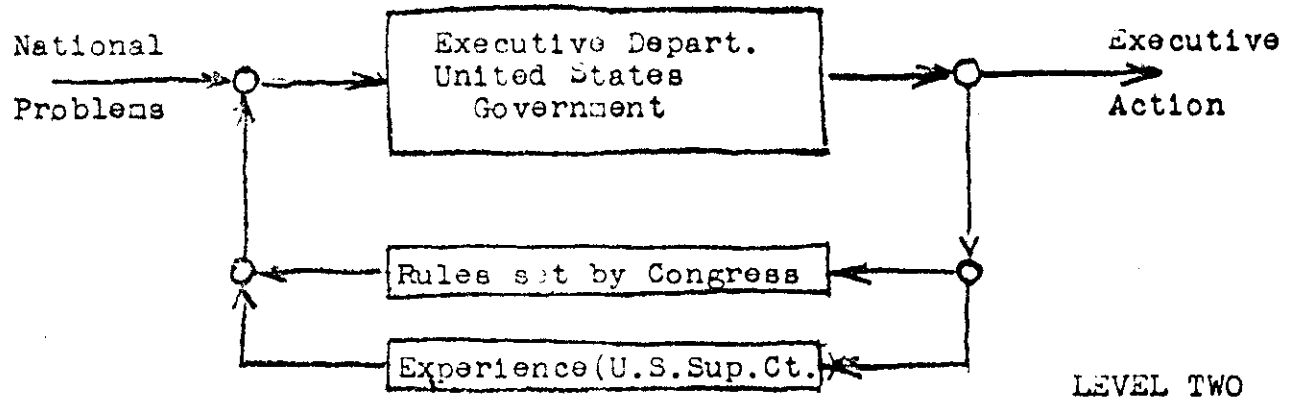

Fig. 5. Maturing Youth Becoming Independent.

Fig. 6. Negative Feedback Circuit Representation of United States Government (Executive Department).
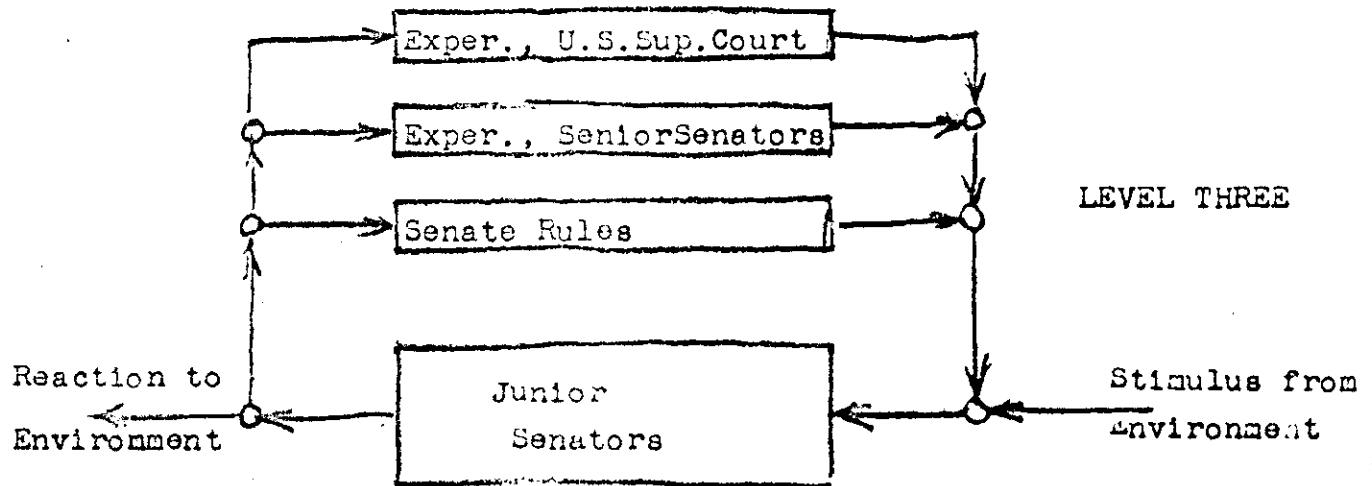

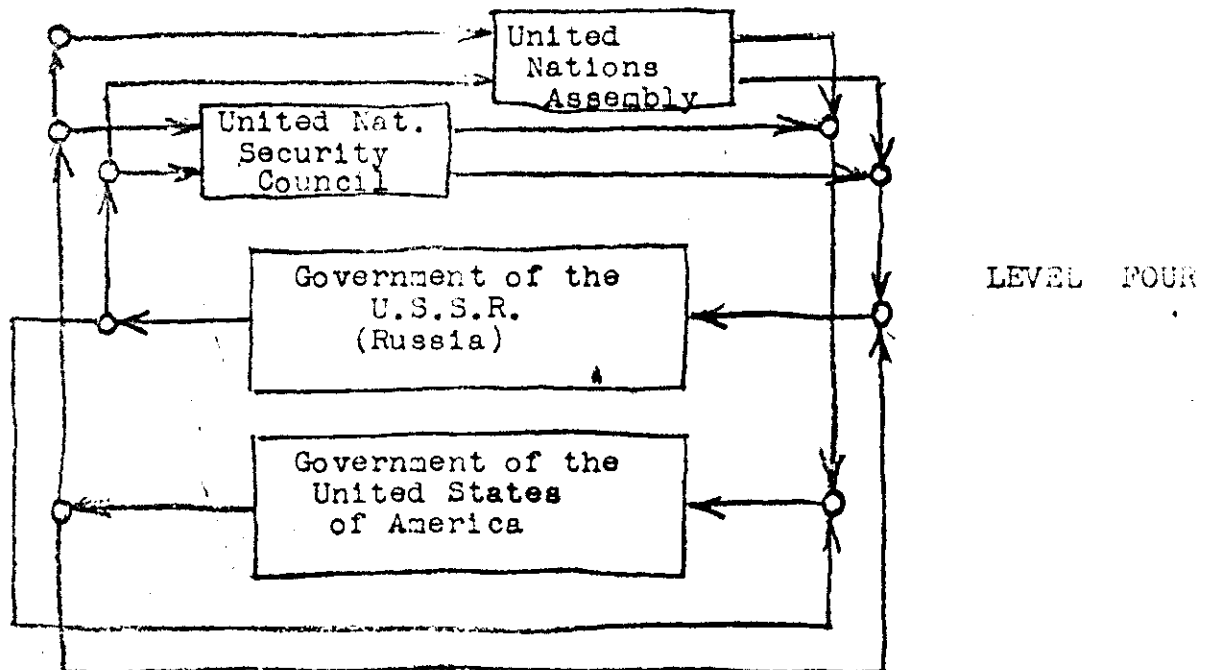Fig. 7. Feedback Circuit of Staggered Terms in U.S. Senate.

Fig. 8. Partial Feedback Loops of U.S.A., U.S.S.R, and U.N.

These negative feedback loops may also exist on other levels.
The previous series of feedback loops dealt with the invidual
and his maturing. It may be possible to construct useful feedback
loops to describe the family, groups, associations, corporations,
governments, and the United Nations in a series of levels of
organization, each of which can be described by a group of
feedback loops. The next few figures illustrate some first
approximations to some of these levles.

Fig. 6 illustrates the controls established by Congress and U.S.
Supreme Court decisions which stabilize the actions of the
executive department of the U.S. Government. Fig. 7 illustrates
another type of feedback loop where the senior senators instead
of the parents maintain controls on the junior senators instead of
the child. Fig. 8 shows a rough approximation to the interaction
of two world powers - the U.S.S.R. and the U.S.A. - within the
structure of the United Nations. The drawing of these diagrams
hasn't solved any problems, but I hope that they provide a
starting point for psychologists and sociologists to discuss
these representations of the problems.

(3)   Cultural and Economic Development Guided by Maximizing Negative Entropy.

Evaluation of the information theory developments in the Soviet Union as
reported at the Western Electronics Show and Convention (WESCON), August
1957, leads to some interesting hypotheses. Namely, the leaders of the
Communist Party of the Soviet Union were initially afraid of the political
implications of information theory. The most plausible explanation of the
opposition to pursuit of information theory, is the potential analogy of the
equation for maximizing the information content of a message in analysing
sociological systems.

In information theory the information content of a message of n symbols,
where each symbol has a probability of occurrence of p_n is:

$$H = \left[p_1 \log p_1 + p_2 \log p_2 + \ldots + p_n \log p_n \right]$$

The condition for maximizing H for a fixed n, is that:

$$p_1 = p_2 = \ldots \ldots = pn,$$

i.e., the probabilities for each symbol are equal[1].

Although sociological systems are much more complicated than a
simple telegraph message the potential analogy was apparently sufficiently
significant to the Russians to cause objections to information theory until
1953[2].

2.   P E Green. Jr "Information Theory in the U S S R "
          pp 47 - 83. IRE-WESCON Convention Record. Part 2,
          August. 1957

According to Dr. Green, the Russians withdrew their opposition to Information Theory in 1953 and since then have allocated substantial effort in this area. They have already developed an alternative proof of one of Shannon's Theorem which is a more rigorous proof.

It appears plausible to me that the Russians have decided that it is more important for them to be pioneers in science and mathematics than to suppress areas of science which might invalidate parts of their philosophy. Perhaps we should utilize the potential sociological analogy of information theory both to support our own democratic ideals and as a criterion in making judgements in our relations with other countires.

Life Process

Biological systems preserve or increase order, decreasing entropy.* The life process represents local reversals if the degradation processes predicted by the second law of thermodynamics. The units of information are related to both the life process and to negative-entropy (or "negentropy") in thermodynamics.

* E. Schroedinger   What is Life?

Consistency of Principle of Political and Religious Freedom with Maximizing Information or Negentropy

If we take the formula for information or negentropy and substitute n philosophical systems (or political systems) in place of the n symbols of a message, then the probabilities of occurrence of the respective philosophies among the population of a country.

If one philosophy is required by all on instruction or order of a dictator and this philosophy is number "k",

$$H = -(0 \ln p_1 + 0 \ln p_2 + \dots 1 \ln 1 + \dots + 0 \ln 0)$$

$$H = 0$$

Thus the requirement that people adhere to an official philosophy is equivalent to a zero contribution to the negative entropy or the "life process".

There are some discrepancies in the simple model of calculating the discrete negative entropies of the discrete probabilities. There are three paths to improve the model: (1) Consider the extension of "maximizing the negative entropy" using the continuous channel from electrical communication theory instead of the discrete channel, (2) Consider the finer structure of the political system by developing an equivalent circuit analysis such that the stability of the equivalent circuit can be analysed as an alternating current circuit, (3) Consider the economic sector of the system as a time domain problem to be analysed as a process flow diagram.

For case (1) above, the continous channel, the entropy is:

$$H_x = \int p(x) \, \log p(x) \, dx,$$

For an electrical signal carrying a message on a physical channel such as a pair of wires or a radio channel with random noise and an average power, σ^2, there is a theorem in Information Theory showing that negentropy is maximized when the message distribution is gaussian,

$$p(x) = [1/\sigma(2\pi)^{\frac{1}{2}}] \, e^{-x^2/2\sigma^2}.$$

For the social system I shall take as a "thematic hypothesis" that a similar theorem exists. In the social system the distribution may not necessarily be gaussian, but as a starting point I shall use a gaussian distribution as a first approx- imation. A convenient parameter to start with for plotting power distributions, say in respect to political views is

$$P(x) = \sigma^{-2} \cdot p(x).$$

See Fig. 9 for a sketch of some curves. The important feature of this model is that the "tails" on the gaussian probability distribution must be preserved in order to max- imize the negentropy. The average power (σ^2) in the electrical circuit may be analogous to the energy available per capita per year for a social system. Then as a country develops, the variance spreads out.

An example of the third approach is shown in Fig. 10. This oversimplified analog is proposed with some modifications for use in developing Lasswell's concept of the "social planetarium."

CONTINUOUS PROBABILITY DISTRIBUTION MAY BE

CLOSER REPRESENTATION OF SOCIAL ORDER.

PARTICULARLY WHERE BALANCE OF HUMAN NEEDS

MUST BE OBTAINED, SUCH AS:

ORDER   LIBERTY   OBEDIANCE
RESPONSIBILITY   EQUALITY   HIERARCHISM
HONOR   PUNISHMENT   FREEDOM OF
SECURITY   RISK   OPINION
PRIVATE PROPERTY   TRUTH
COLLECTIVE PROPERTY   ROOTS
LOVE

GAUSSIAN PROBABILITY CURVE FOR CONTINUOUS CASE.

$\sigma = 10$

$\sigma = 5$

DISCRETE PROBABILITIES.

P_1 P_2 P_3 P_4
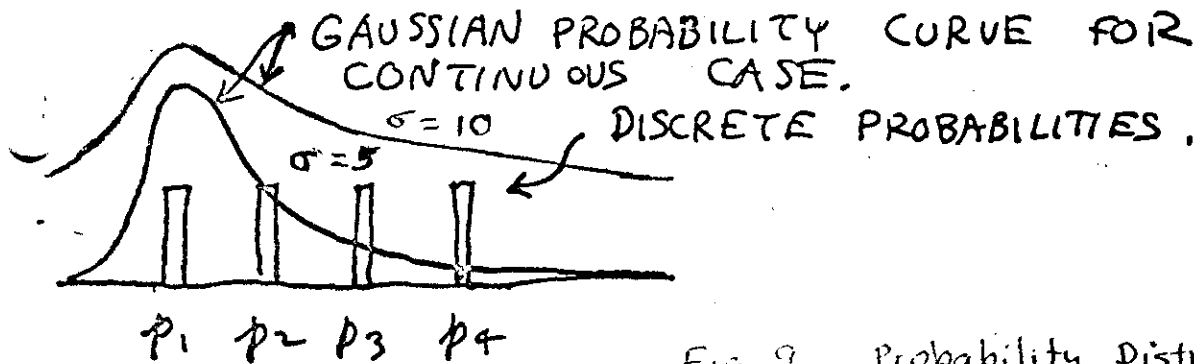
Fig. 9   Probability Distributions
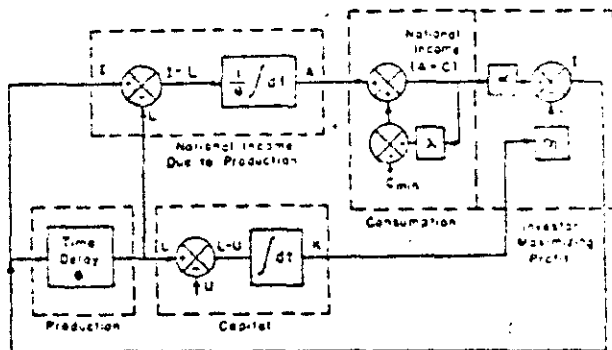
Slide 18   —Macrodynamic capital production analog.

Fig. 10. Analog of Economic System.

Slide 18 from O.J.M. Smith
Slide 19 from Hogbom

Slide 19 - TARGETS OF POWER PRODUCTION (IN TERMS OF COAL)
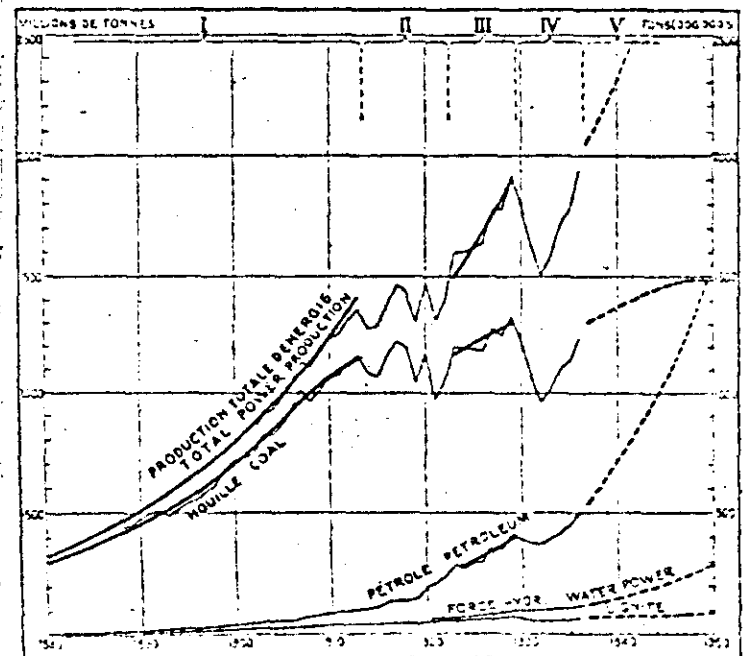
(4)   Engineering Sociology as a Two-Way Feedback Connection
between Science and the Rest of Society.

Fig 11 illustrates the gap in the structure of our organization
of science and engineering for which I suggest a field which
might be called "engineering sociology" should be developed.
This field would be closely allied with the 'behavioral sciences,'
and could be organized around a core of Cybernetics and
Information Theory.

Fig. 11,
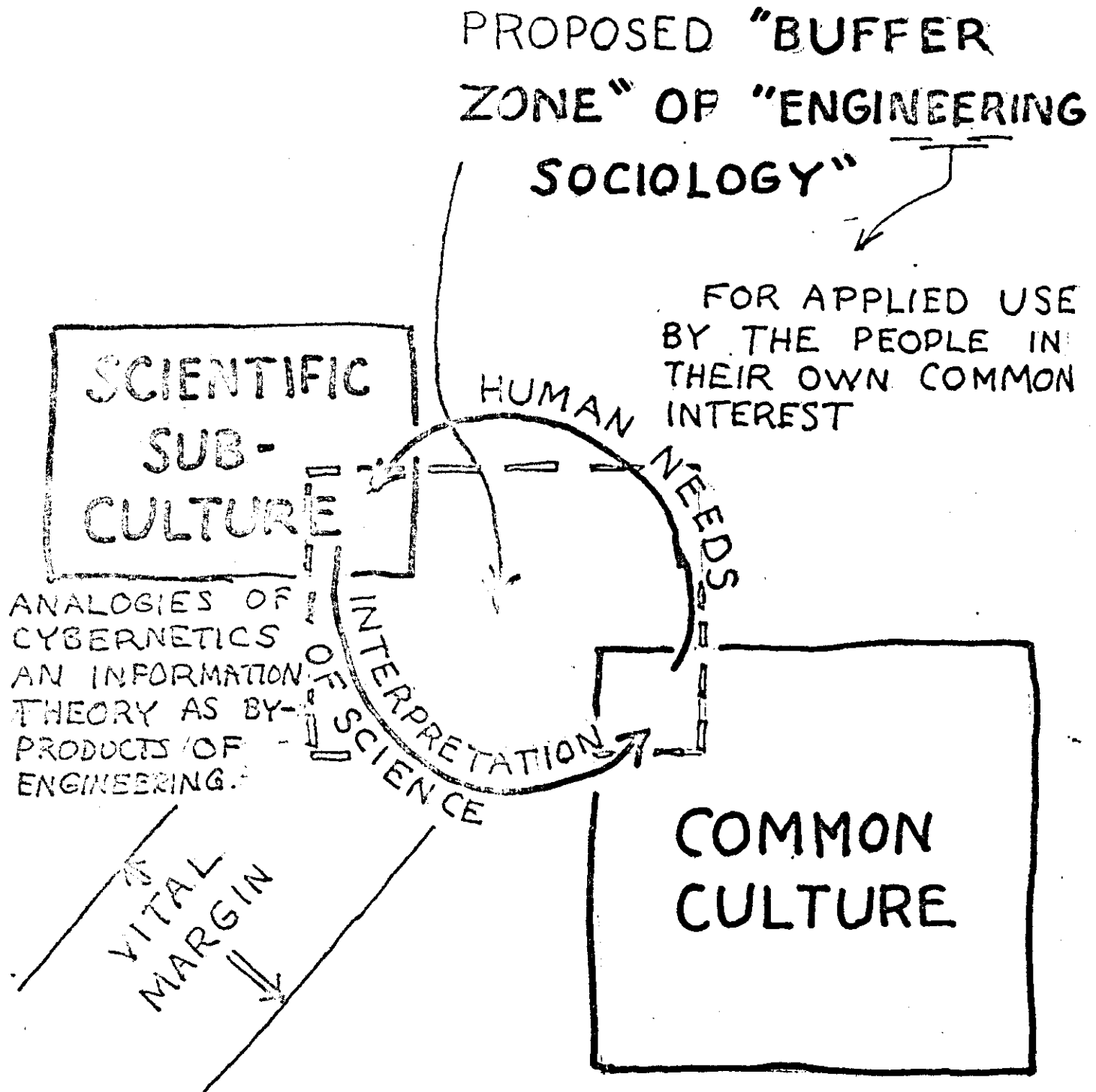
BOOK OUTLINE

Part I: Introduction (SEP No. 81)

1. Introduction. Diagrams based upon checking chart.
2. State of Western Civilization:
   Wisdom of Confucius, Ten Commandments of Moses, Teachings of Jesus
   Philosophy and Sociology of Auguste Comte
   Philosophical and Economic Theories of Karl Marx
   Sociology of Lester Ward
   Freud, Jung, and Adler
   'Out of Revolution' E. Rosenstock-Huessy(68)
   Notebooks of Simone Weil
   Alienation of Modern Man ' F. Pappenheim(60)
   The Noosphere of Teilhard de Chardin(70)
   Biogeochemistry of Vernadsky(56)
   Accent on Form, L. L. Whyte(71)
   May Man Prevail, E. Fromm(72)

Part II: Problems of Specialization and Irresponsibility
(SEP No. 82)

3. The Dilemma of Specialization
4. A Checking Chart.
5. Partial Derivatives of History.
6. Example of Checking Chart.
7. Special Responsibility of Engineers.

Part III: Information Theory and Engineering
Sociology (SEP No. 83)

8. Channel Capacity.
9. Ideology as a Coding Problem.
10. Distribution of Negentropy in Political Organization.
11. Balance of Obligation and Rights--Organization and Freedom(69).

Part IV: Cybernetics and General
Systems Theory (SEP No. 84)

12. Feedback Loops.
13. Capitalist and Socialist Systems.
14. Social Planetaria.
15. Computing as a Tool for Democracy.
16. Computer.Data Communication Systems and Economic Systems.

Part V: Human Values and Analogies of
Communication Theory(SEP No. 85)

17. Potentials of fruitful contact between competing economic and
    political systems.(74)
18. Conservation of Human Values: Information Theory provides
    principles and bounds; Cybernetics the form of institution
    to carry out the goals.
19. Summary: The Unitary Principle--The Next Development of Man.

Note: Consideration is being given to splitting the above
      material into two sections or volumes, the first
      non-technical directed for the layman, and the
      second technical with more precise information on
      the status of definitions and "thematic hypotheses."

SIGNIFICANCE

I feel that the judicious use of the potential analogies from Cybernetics and Information Theory can assist the United States in the following areas:

(1) Help establish a common philosophical base through which the idealistic church leaders of our country and the practical economists and military strategists can develop more constructive communication for the discussion of the problems of our civilization.

(2) Establish a base for a more powerful development of science in the U.S.A. through the improved understanding between social, biological, and physical scientists through use of analogous concepts in the different fields of science such as feedback loops (from Cybernetics), coding processes (from Information Theory), channel capacity (from Information Theory), and maximizing the negative entropy (from Information Theory).

(3) Establish a method of analysing the world political and economic system that recognizes the delicate transition going on from "power politics" to "a theory of human development." If components of W. W. Rostow's Stages of Economic Growth were translated into a mathematical model using Margaret Mead's concept of representing both the Soviet and the American (or Western) systems in "cybernetic terms," it should be easier to arrive at agreement with the Russians on international problems such as disarmament.

(4) Refute Dr. Don Michael's "Cybernation" predictions through development of new tools for educating the public so that true democratic discussion and voting can occur more easily. The kind of a tool I have in mind is the extension of computer simulation of political and social systems to the "social planetarium" concept of Lasswell.

(5) Restore deeper interest in the engineering profession in the role of the engineer as "an interpreter of science in terms of human needs" through the use of Cybernetics and Information Theory to broaden the scope of the engineers' conceptual tools. Such a development should be useful in reversing the declining enrollments in undergraduate engineering colleges (and other professions too).

Frederick B. Ward

REFERENCES

A more extensive bibliography of the communication theory
aspects can be found in F. Stumpers bibliography issued as
an MIT Research Laboratory of Electronics Report in 1953
and reprinted by the Institute of Radio Engineers, PGIT.
Three supplements have been published in the IRE Trans. on
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