A GENERAL SYSTEMS THEORETIC MODEL FOR THE ESTIMATION OF THE NEGENTROPY OF SOCIOLOGICAL SYSTEMS THROUGH THE APPLICATION OF TWO ISOMORPHIC ELECTRICAL COMMUNICATION NETWORKS.

I. INTRODUCTION.

The object of this multidisciplinary (1) study is to develop some hypotheses regarding the relationship of individual freedom to the level of organization in a country, and in turn to the relationship of the stage of development of the country to the stage of development of the United Nations. This is a progress report on a pilot study to see if the General Systems Theory framework proposed by Ludwig von Bertalanffy (2) can be used to integrate the tools of modern science in a quest to promote a conceptual transition from "Power Politics" to a "Theory of Human Development."

First a set of axioms are developed regarding the procedures needed in a General Systems research project. Then an unsuccessful attempt to find an equivalent circuit model for a sociological system is reviewed to illustrate how in this case the following of the axioms led to a place in the knowledge perspective space where the present state of knowledge permits the finding of some limited but useful electrical communication networks isomorphic with sociological systems in respect to a few significant parameters.

An aim of this type of study is to provide the psychiatrist and the sociologist sharper tools with which to deal with the question of how much the individual should be encouraged to adjust to the existing social system, and how much attention should be focussed on improving the social system, so that individuals would have less restraints on developing their creative abilities. This study has a very interesting feature -- namely that the pursuit of a strictly mechanistic model derived from the mathematical theory of the transmission of messages over telephone cables refocusses attention upon individual human values through the concept of "entropy."* The analogy of metaphor between all four definitions of entropy is used in developing the analogy between physical and sociological phenomena. The specific calculations for sociological systems in this study are based upon definition (c) below, where "negentropy" is an abbreviation for "negative entropy."

The finding of the match between parameters of the sociological system and properties of electrical communication networks came from a scanning of all possible approached to limiting values or approximations after a failure to find a precise solution. The potentials and limitations of the "Information-Entropy Metaphor" are discussed by Anatol Rapoport in the American Handbook of Psychiatry. (3)

A. THE ROLES OF THE RESEARCHER.

In the physical sciences the scientist can usually separate himself from the subject of his research. In the behavioral sciences it is difficult to maintain such separability. The behavioral scientist is a part of the sociological system and also an individual human who can have similar problems to those of the people being studied.

*Definitions of "entropy:" (a) a measure of the unavailable energy in a closed thermodynamic system so related to the state of the system that a change in the measure varies with change in the ratio of the increment of heat taken in to the absolute temperature at which it is absorbed; (b) a measure of the disorder of a closed thermodynamic system in terms of a constant multiple of the logarithm of the probability of the occurence of a particular molecular arrangement of the system that by suitable choise of a constant reduces to the measure of unavailable energy; (c) a measure of the amount of information in a message that is based on the logarithm of the number of possible equivalent messages; and (d) the degradation of matter and energy in the universe to an ultimate state of inert uniformity.

Axiom One: The researcher is himself a part of the multidiciplinary study and hence there is a certain amount of uncertainty, because in behavioural science it is difficult to isolate the observer from the subjects of the experiments. Therefore the researcher needs some review of what role he is in to determine under what limitations he is functioning at a given time.

Fig. 1 illustrates this axiom in respect to the author of this paper. In this age of specialization it is necessary to group many of the multidiciplinary studies under the title of philosophy to avoid conflict with the separate domains of the specialist.

B. HISTORICAL PERSPECTIVE.

The Leipsig philosopher Eugen Rosenstock-Huessy pointed out in 1939 that a philosophy useful for one age may become destructive of human values at some future age. (4) It would be useful to have a graphical chart to help us keep track of where we are so we can better perceive when a transition is needed. The "Histomap"(5) gives us a chart of the past, but does not have space for the future. Combining some perspectives of G. Gamov(6) with the Histomap style through the use of a Gaussion probability scale (ξ) and including some of Rosenstock-Huessy's tecniques, we have a chart of the life span of the planet Earth in Fig. 2. The main steps in mankind's development of his communicating of Selden Smyser presented at a General Semantics Congress (7). Lined up with these stages on the right is a representation of the development of man's mind from Foulkes and Anthony's book on group psychotherapy. (8) The classification into Force Era, Power Era (from First Industrial Revolution), and Information Era (from Second Industrial Revolution or Cybercultural Revolution) is related to Rapoports's historical introduction to Information Theory in the American Handbook of Psychiatry. (9) The augementing of human intelligence indicated on Fig. 2 as the future stage of development in man's mental development is perceived to consist of two parts: [1] the growth of the individual's ego to keep pace with the more complex environment as discussed by Dr. William Gray in a paper at this (10) session, and [2] the development of computing and logic systems as tools to fulfill Ross Ashby's concept of an intelligence amplifier. (11)

Looking into the future, the rate of increase of complexity of society is such that mankind might destroy human life on earth before completing the 500 year period postulated by C. G. Jung (12) as the time needef for mankind to fully apply the discoveries of modern psychiatry.

Axiom Two: The researcher at the intersection of psychological phenomena and sociological phenomena, unlike the physical scientist, cannot separate himself from the social process, hence he needs an historical perspective against which to evaluate his own growth in respect to the main streams of civilization in time.

C. ORGANIZATION OF HUMAN KNOWLEDGE.

In addition to the time perspective, a "knowledge-space" perspective is needed. At a specific time in history a possible space perspective can be developed by placing the major problems in respect to a chart similar to those the founders of Sociology -- Auguste Comte, Herbert Spencer, and Lester Ward -- were accostomed to make in their classification of the sciences. (13) A chart suitable for the transition from the Power Era to the Information Era is shown in Fig. 3. The axes of this three-dimensional chart are determined as follows:

(1) The different phenomena which occur in nature, ranging from physical to social;

ξ A Gaussion probability scale as defined here is a scale that makes the S-curve integral of the Gaussion probability function a straight line. A sample Gaussion probability density curve and an S-curve are included in Appendix II, Fig. 19(a).

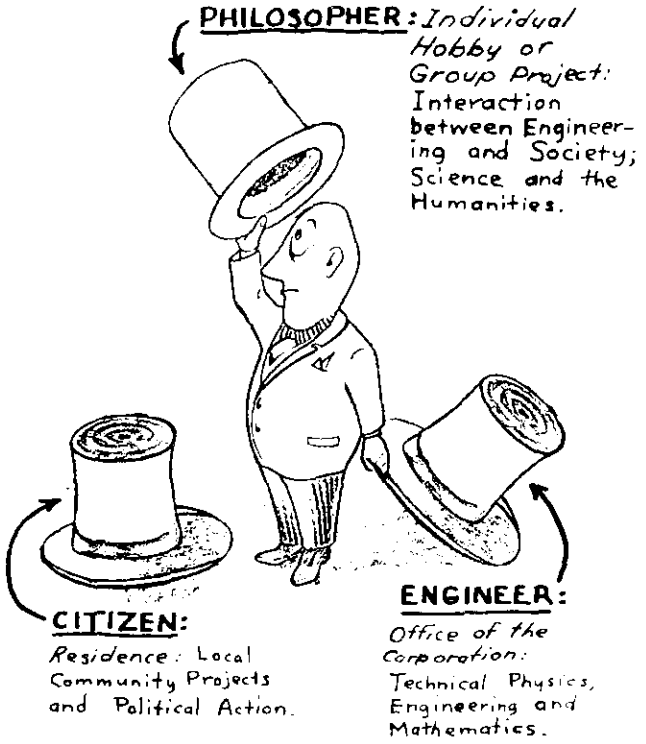

Fig. 1. The Researcher Changes Hats to Symbolize His Three Different Roles in the Research Project.

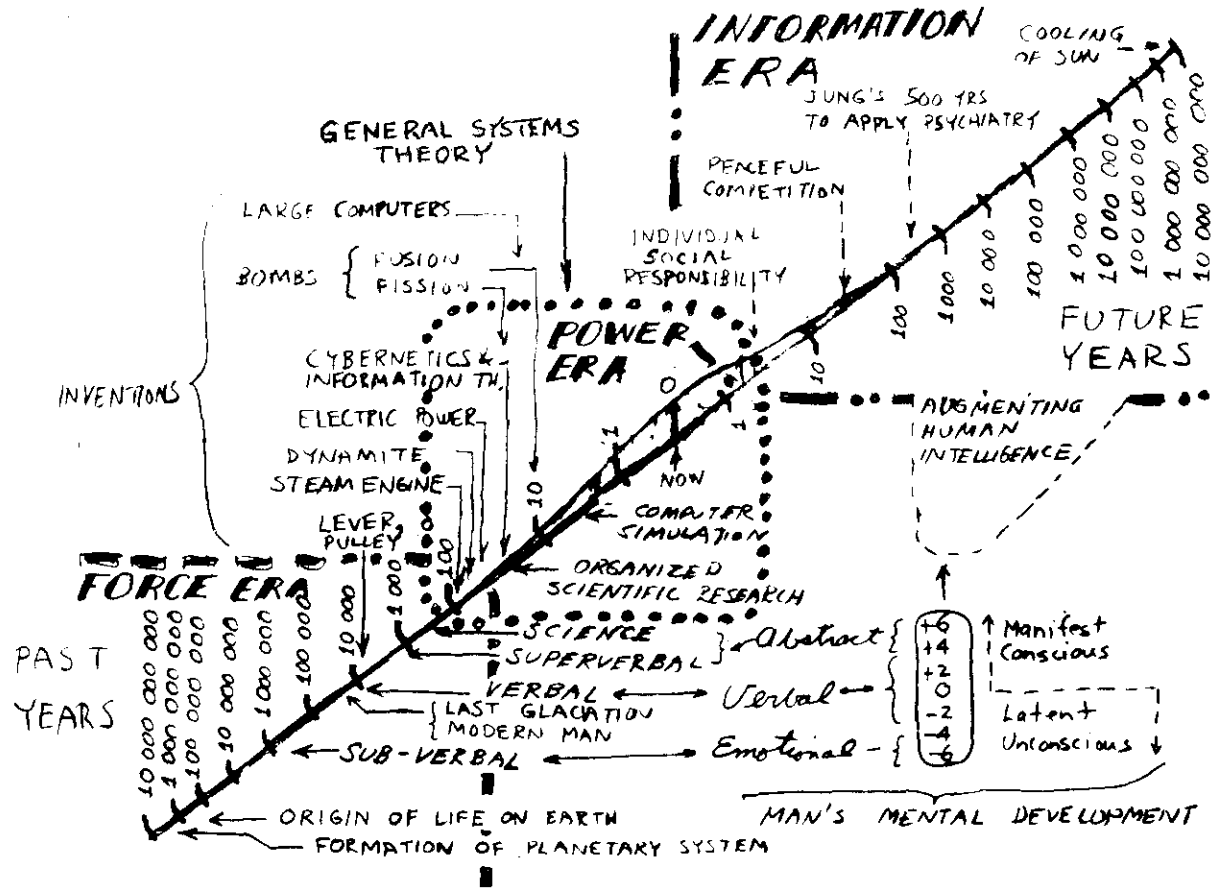

Fig. 2. Mankind's Mental and Social Development on a Gaussian Perspective Scale of the Life of the Planet Earth.

(2) The classes of human activity in respect to these phenomena, ranging from learning the basic laws of nature to applied science to education to decision; and
(3) The difference methods of value in the study and use of our knowledge, ranging from humanistic-intuitional through philosophical-abstract models through empirical science.

The first two dimensions were sufficient for an earlier study on the potential social consequences of computer-data communication systems, (14) but recent studies have required the inclusion of the third dimension to maintain adequate perspective of what is happening. This type of chart has been found useful in preparing for the crossing of boundaries of specialization cited as very important by Norbert Wiener.(Θ)

Axiom Three: In addition to the time perspective of the development of human civilization, some measure of the part of human knowledge being covered by a particular researcher is needed as a space perspective to help the researcher orient his own multidisciplinary work to the interdisciplinary work of the group to which he belongs.

D. VERTICAL INTEGRATION OF LEVELS OF PHENOMENA.

A method of using the three-dimensional chart of human knowledge to show the potential roles of negative feedback from Cybernetics and the roles of maximizing negentropy, channel capacity and coding from Information Theory is illustrated in Fig. 4. The same chart can also be used to pinpoint the bounds of the areas covered in the different roles of the researcher from Fig. 1. For example the principal engineering jobs of the researcher are shown in Fig. 4 on the physical phenomena level, marked "radar, telephone cables,(15) data transmission with feedback, (16) data transmission code standards, and computer components and programming."

The utility of the space perspective of Fig. 3 is illustrated in Fig. 4 by a combination of the organization of the researcher's own experience as noted above and the plotting of the domains of more basic theories such as those of Norbert Wiener and Claude Shannon on the same three-dimensional chart. In the first column the series of feedback loops symbolize Norbert Wiener's development of Cybernetics. The curving of the vertical line in towards the humanities plane in the upper levels of phenomena indicate that Wiener's extension of cybernetic concepts to political systems should be considered as still in the "humanistic-intuitive" stage of development. This stage of development is very important, even though we do not have the means of empirically testing such concepts rigorously yet.

The formulas for entropy in the second column symbolize a series of developments in which Information Theory has been applied to biological and psychological phenomena. (17-18) The series of "input-output" curves in the third column represent James G. Miller's work on "Information Input Overload and Psychopathology."(19) In the fourth column, the bottom circle "coding" represents the mathematics of coding summarized by W. W. Peterson.(20) Recent coding work is based upon the mathematical discoveries of Evariste Galois who died in 1832.(21) Following the coding principles vertically, we find that in the chemical and biological levels similar mathematical principles are involved in genetic coding.(22) In an abstract way the unstable transition between love and hate in human beings is analogous to some error conditions considered in electrical communication coding. On the sociological level we can see that a future problem to be investigated is the analogy of coding principles to the development of political ideologies, in which people try to reduce a complex political situation to an oversimplified model.

Θ Norbert Wiener, "Appendix III: On The Function of Science in Society," in article "The Mathematics of Self-Organizing Systems," in R. E. Machol and Paul Gray, Recent Developments in Information and Decision Processes. New York: Macmillian (1962), pp. 18-21.

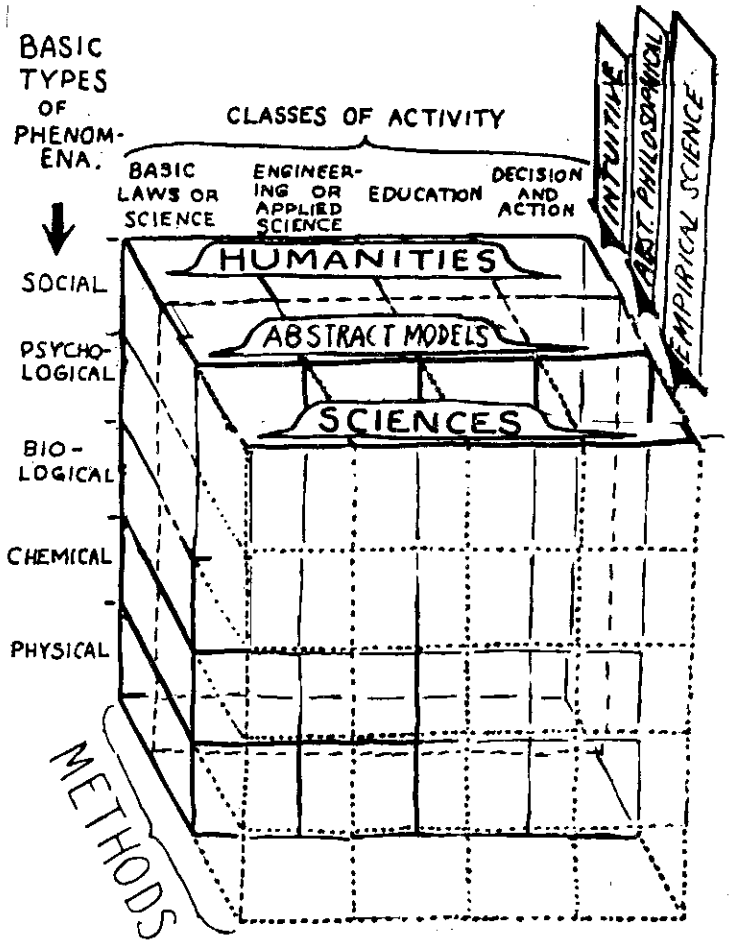

Fig. 3. A Three-Dimensional Human Knowledge Space Perspective.

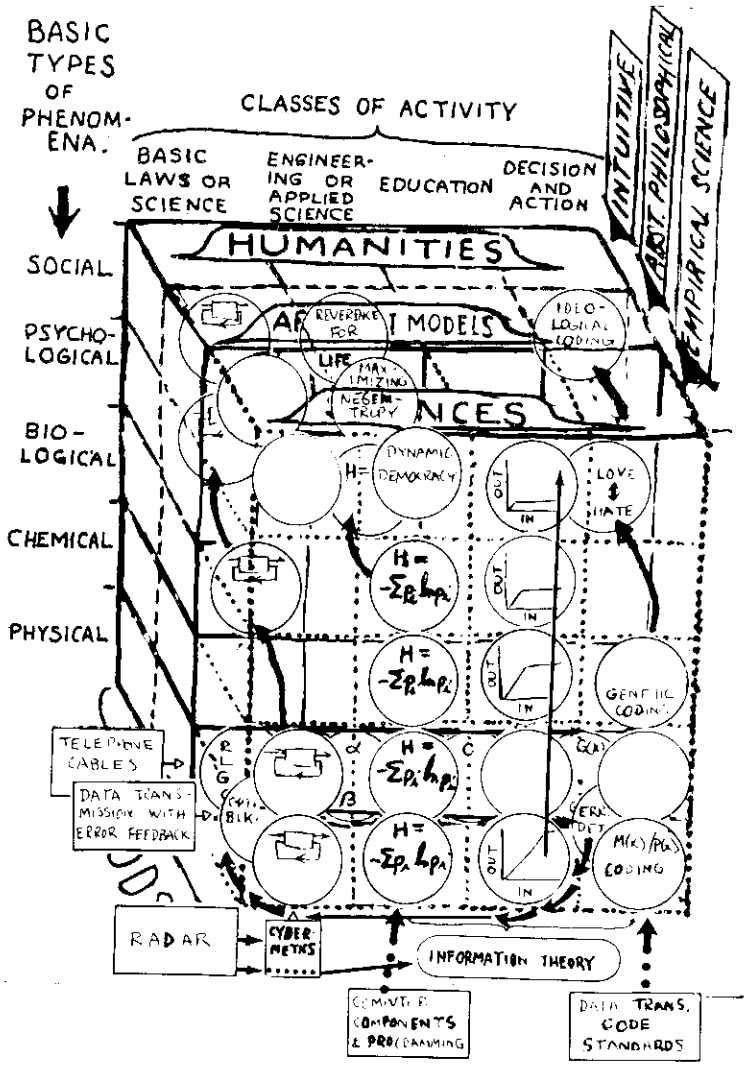

Fig. 4. Vertical Integration of Levels of Phenomena.

E. CONSTRUCTION AND TESTING OF HYPOTHESES.

This material is offered as a set of "thematic hypotheses" (23) on the usefulness of the concept of entropy as a tool of potential value to psychologists, psychiatrists, and sociologists. The results of this paper do not constitute a proof, but only show plausibility and consistency with known facts that this concept of "negentropy" * can be used as a guide to help mankind direct our social organization of man toward "maximizing negentropy" to come closer to fulfilling Albert Schweitzer's concept of "reverence for life." (24)

To test this "thematic hypothesis" is a formidable task, which will require the patient cooperation of many social scientists, physicial scientists, and concerned laymen. I do not expect that these hypotheses can be proved, but that our path of testing will be similar to the history of the testing of Einstein's Special Theory of Relativity. Namely that social scientists will apply these concepts to many observable phenomena and see which hypotheses are consistent with known phenomena, similar to the way physicists have compared a set of hypotheses regarding the relationship of electromagnetic fields and moving frames of reference and found that Einstein's Special Theory of Relativity was the only hypothesis consistent with all experiments. (25)

Axion Four: The procedural method in utilizing concepts like "negentropy" in General Systems Theory will be to establish plausible hypotheses concerning systems isomorphic between different levels of phenomena through use of all viewpoints implied by the axioms one through three and then cooperatively testing the working hypotheses.

II. A QUALITATIVE EXAMINATION OF EQUIVALENT COMMUNICATION NETWORKS.

Our first objective is to find an equivalent circuit on the physical phenomena level in the basic science column which is isomorphic with a group of people forming a system on the sociological level.

N. Rashevsky has been successful in obtaining mathematical equations for a number of special cases such as the influence of a large group on one individual or the interaction of two classes in society. (26-27) The work of Rashevsky should be of great significance to social psychiatrists. However in this study we are starting from the whole and working down through various levels of abstraction in an attempt to find the highest level of detail that is manageable with present techniques of General Systems Theory. The objective is to tackle the total world problems of our civilization at the first point where our mathematical tools begin to match the data available on the problems.

Fig. 5 illustrates an unsuccessful attempt to represent a large group of people by an equivalent electrical network. It was hoped that an equivalent network could be found that could be subdivided into interconnected parts, each part reducing to one of the canonical structures defined by Mesarovic. (#) This failure to find an isomorphic electrical network for the sociological system in the feedback loop or cybernetic sense, led to the consideration of shifting to equivalent transmission lines, with consequent loss in potential detail. Figs. 6 through 9 illustrate the steps in trying step by step less general networks until we arrive at the telephone cable which loses detail, but allows us to compute the average negentropy of sets of messages which could be sent over pairs of wires in the cable.

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* The term "negentropy" is an abbreviation for "negative entropy" coined by Leon Brillouin, Jour. Appl. Phys. vol. 22, p. 338, March 1951, (or ref. 35) to show the relationship of entropy-like parameters in physics, biology and electrical communication. It is the same as what R. M. Fano calls "communication entropy" in Transmission of Information, N.Y.: M.I.T. Press (1961), p. 42.

Mihajlo D. Mesarović, The Control of Multivariable Systems, New York: M.I.T. Press (1960)

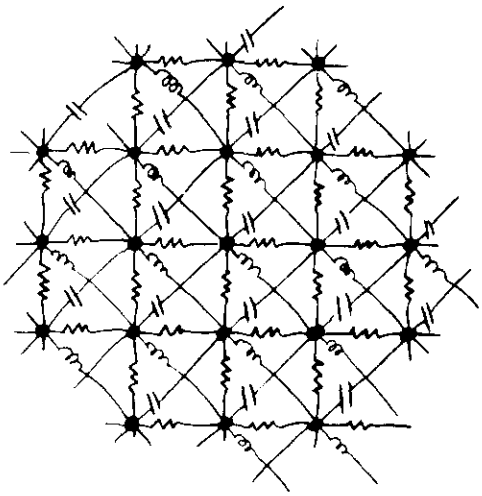


Fig. 5. An Unsatisfactory Equivalent Circuit for the Analysis of the Interaction of a Group of People.

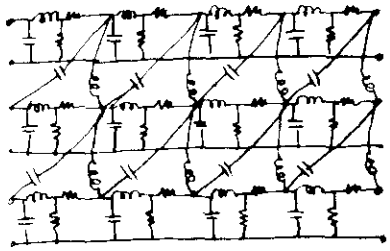


Fig. 6. A Reduction in Generality to Group the People Into Three Countries and to Limit the Interaction to Major Political Ideas.

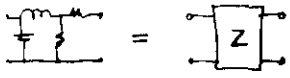


Fig. 7. A Shorthand Notation for a Segment of an Electrical Network.

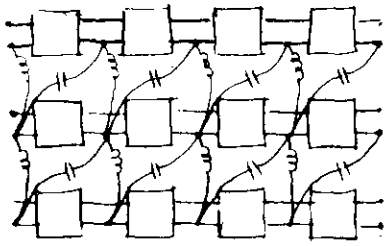


Fig. 8. A Simplified Equivalent Electrical Network of Three Telephone Lines with Some Leakage Coupling between Them.

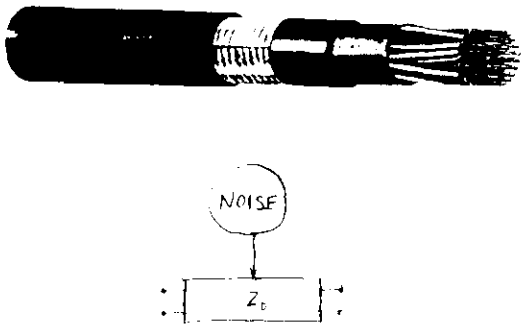


Fig. 9. Telephone Cable: (a) Physical Cable, (b) Equivalent Network of One Cable Pair with Leakage from Other Wires Lumped Together as Noise.

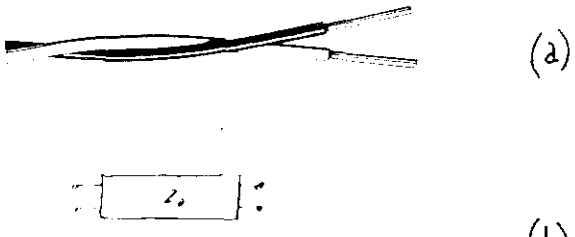


Fig. 10. A Telephone Pair of Wires: (a) Physical Pair of Wires, (b) Equivalent Network.

The next step is to consider one of the transmission lines alone and lump all the electromagnetic waves coupled into it as noise such that a single cable pair in Fig. 9(a) would be represented as a single network with noise as in Fig. 9(b). We can then specify a limiting average power for each cable pair such that the noise is negligible. This specification of a limiting average power in the cable pair, when put into the mathematical equation for the negentropy of the signal voltage distribution for the continuous channel, gives an optimum signal distribution which corresponds to the Gaussian bell-shaped curve. These properties described in Appendix II, will be used by analogy in developing Hypothesis Two on "Dynamic-Justice" in a sociological system. This development is equivalent to shifting from column one in Fig. 4 to the second column, "maximizing negentropy."

If we simplify the problem by one more step and consider only a single pair of wires as in Fig. 10(a) with no power limitation, we have an optimum message distribution in the discrete channel case, in which all messages have equal probability of occurrence. These properties described in Appendix I, will be used in developing a mathematical measure of "democracy." If some properties of a sociological system, namely a group of countries, are isomorphic with a useful set of properties of the telephone cable, we can use the formulas from electrical communication theory for negentropy of a set of messages on a telephone or telegraph line for the negnetropy of the corresponding set of properties of the sociological system. This is of the nature of an hypothesis which will take time to test.

III. A STATIC MEASURE OF DEMOCRACY IN A SET OF COUNTRIES USING THE NEGENTROPY OF A SET OF FREEDOMS.

The possibility that entropy from thermodynamics might belong both to the family of measurable quantities of science and the family of values such as beauty and melody was suggested in 1928 by Eddington. (28) At the same time Leo Szilard was thinking about the quantitive relationship between the entropy lost by a gas and information gained by a hypothetical "Maxwell's demon," (29) opening and shutting the door between two compartments to separate the high- and low-energy particles of a gas. (30) Dr. Szilard's paper was relatively unnoticed until the development of the mathematical theory of communication by Shannon (31) in 1948, which became known as Information Theory, and the partially overlapping concepts of Cybernetics developed by Norbert Wiener. (32-33)

Biological systems preserve or increase order, decreasing entropy in a limited domain (34), even though over a larger domain entropy is increased in accordance with the Second Law of Thermodynamics. The units of information are related to both the life process and to negative entropy in thermodynamics. (35) Physically entropy can be defined as:

$$S = k \ln P, \qquad [1]$$

where k is the Boltzman constant, "ln" means logarithm of, and P is the number of elementry states in which the system can be in.

Negentropy in Information Theory, a branch of electrical engineering and mathematics, in respect to a set of n messages is:

$$H = -(P_1 \ln P_1 + P_2 \ln P_2 + \ldots\ldots\ldots + P_k \ln P_k + \ldots\ldots + P_n \ln P_n) \qquad [2]$$

where P_k is the probability of occurance of message K. For a basic discussion of these concepts see Colin Cherry, On Human Communication (36) or J. R. Pierce, Symbols, Signals and Noise. (37)

If we take the formula for information or negentropy of a set of telegraph messages or computer instructions and substitute a set of n philosophical systems (or political systems) in place of the n messages or instructions, the probabilities of occurrence of the respective philosophies among the population of a country assumes a role analogous to the probabilities of occurrence of the n messages.

If one philosophy is required as the official philosophy by order of a dictator and this philosophy is number "k," then:

$$H = -(Oxl + Oxl + \ldots\ldots\ldots + lxO + \ldots\ldots + Oxl) =). \qquad [3]$$

Thus the requirement that people adhere to an official philosophy is equivalent to a zero contribution to the negative entropy of the political system or the "life process" of the evolution toward a higher order of life. If we go back to equation [2] to see under what conditions there is a maximum contribution to the negentropy or "life process," we find when all P_i's are equal such that $P_i = 1/n$ is the condition for maximum H. A curve for a sample case is included in Appendix I. Under these conditions $H = \ln n$. This corresponds to equal probability for each different philosophy, a condition approximating a democracy, provided that n is not so high that no decisions can be made by the country.

To assign a numerical value to "freedom" is a difficult task. There are many kinds of freedom, some of which are more valued than others. The ideal way to start this section would be to get some social psychologists to determine the relative weights to different types of freedom and the range of values to be expected in different political systems. Since such information is not presently accesible to me, I shall assume the following ten kinds of human freedom to have equal weight in order to obtain some trial calculations. See Table I for the list of freedoms.

TABLE I.

ASSUMED COMPONENTS OF HUMAN FREEDOM

Number (j)	Description
(1)	Freedom of speech
(2)	Freedom of religion
(3)	Freedom to print, broadcast, televise and listen
(4)	Freedom to find sexual partner
(5)	Freedom to obtain education
(6)	Freedom from job discrimination on account of race, religion, or origin
(7)	Freedom to build or buy own home
(8)	Right to vote
(9)	Right to trial by jury
(10)	Freedom to establish small business or farm

This analysis is a test of an hypothesis as to the analogy between "negentropy" and "democracy." At this stage it is incomplete, because of the lack of independent data. Our objective is to see, if replacing the probabilities of a set of messages by the normalized measure of freedom of the individuals in a social system will give a value of negentropy for the system which is a reasonable measure of the amount of democracy in the social system. If such a procedure gives a higher measure of democracy to a dictatorship than to an

democratic society, the hypothesis will have to be rejected. If however the resultant measures of democracy fall into relative positions consistent with common sense concepts and with the more sophisticated analyses of political scientists and sociologists, we can accept the hypothesis until another hypothesis is found that gives better agreement with the available facts.

Hypothesis One: The negentropy of a sociological system can be approximated by calculating the negentropy of a set of messages that might be sent over equivalent pair of wires such that the sociological system corresponds to the discrete communication channel in Information Theory, in which case the set of human freedoms in the sociological system correspond to the set of messages sent over the isomorphic electrical communication network.

The mathematical formula is obtained by replacing H in equation [2] by D and P_i by G_i, so we have:

$$D = -\left[G_1 \ln_2 G_1 + G_2 \ln_2 G_2 + \ldots + G_k \ln_2 G_k + \ldots + G_n \ln_2 G_n\right]. \qquad [4]$$

with the restraint that:

$$G_1 + G_2 + G_3 + \ldots + G_k + \ldots + G_n = 1.000 \qquad [5]$$

The subscript stands for a single individual unless otherwise noted. When a group of individuals are treated as a class without regard to individual performance, such as job discrimination on account of color, the subscript will refer to the group or class as a unit instead of to an individual. The negentropy measures of "democracy" for each of six hypothetical countries of 100,000 population each have been calculated and are displayed in Fig. 11.

Examination of Fig. 11 indicates a general agreement between our theoretical calculations of negentropy with the relative degree of democracy one would ascribe by common sense to the different types of social organization. This means that we can seriously consider using the calculation of negentropy to evaluate social systems where we do not have good common sense references. However we would have to check more rigorously the method of computing the normalized "freedoms" G_i. These functions are defined and sample calculations tabulated in Appendix I.

Another feature is that a democratic country like case B can have an appreciable portion of its population with seriously curtailed freedom, provided the restrictions are based on an individual basis related to individual performance and are determined by due process of law. For example having 10% of the population restricted in this way reduces the negentropy by 0.5%, while an equivalent amount of restrictions based on classification of people by race or national origin instead of individual performance reduces the negentropy by 16.4%.

Comparison of Countries E and F indicates that a rigid caste system or a one man dictatorship knock the negentropy down to one-fifth the ideal value. Another feature of interest is that a society run by a rigid set of rules can be almost as bad as a one-man dictatorship. This may also have relevance to centralized business and governmental agency accounting systems.

Another feature is that a substantial increase in negentropy results when a one-man dictatorship changes to a twelve-man oligarchy. This indicates the possibility of developing a more detailed measure of "freedom" to put into the negentropy formula to monitor changes in non-democratic systems to determine whether they are becoming more or less democratic.

Since the hypothetical countries were all taken to have a population of 100,000 each, it is desirable to be able to extend these results to other size countries. Curves for countries A and F over a large range of population change are plotted in Fig. 12.

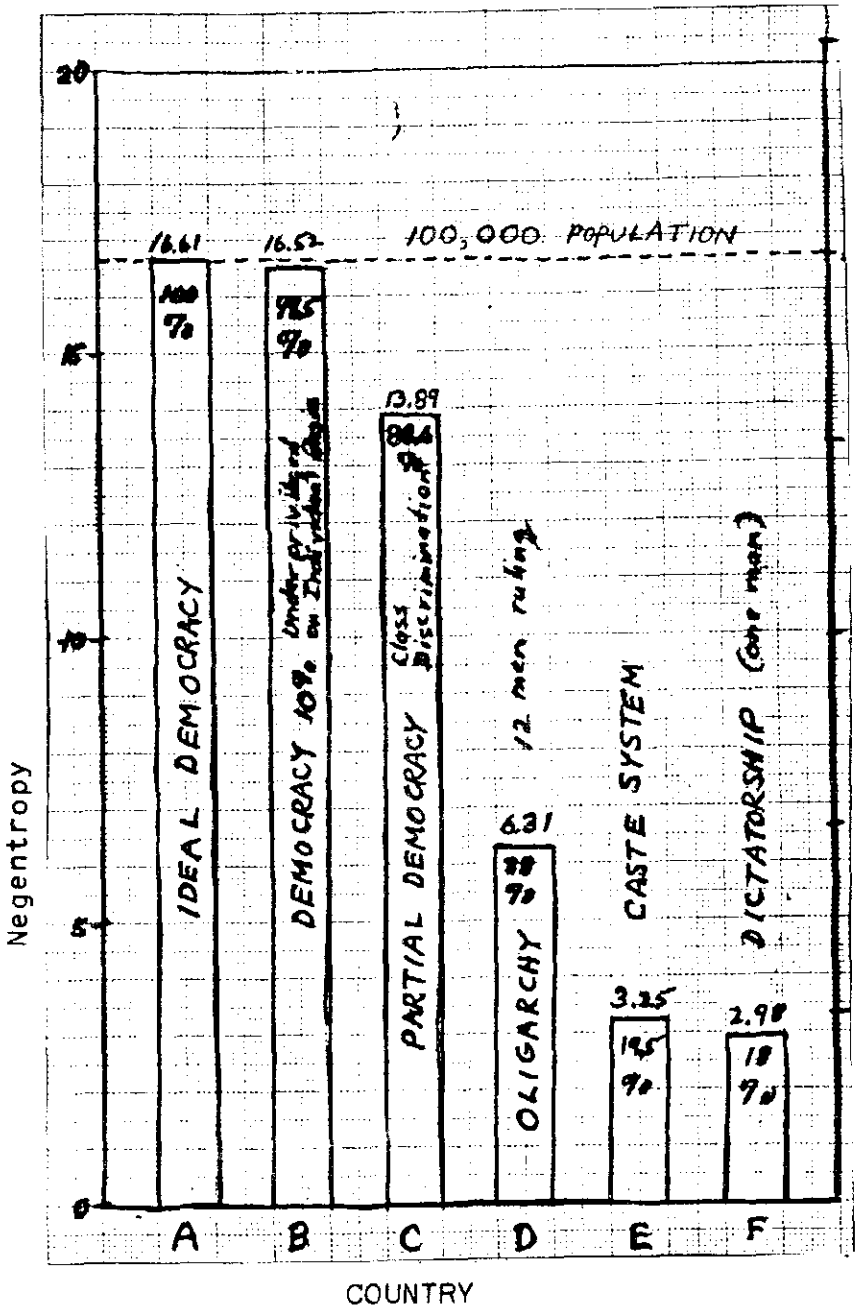


Fig. 11. Comparision of the Negentropy of Six Hypothetical Countries.

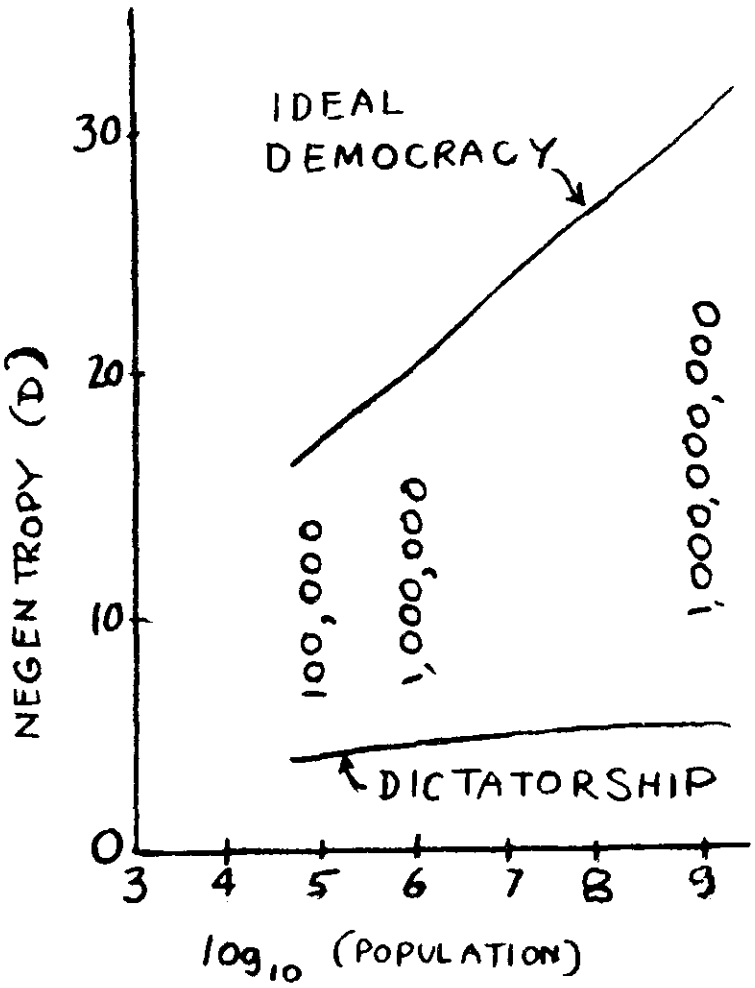


Fig. 12. Variation of Negentropy with Population for Ideal Democracy and for Dictatorship.

The model studied in this section based upon a pair of electrical wires using the discrete noiseless channel viewpoint from Information Theory gives us a good estimate of the negentropy or "democracy," but does not give an indication of the countries ability to withstand attack by external and internal enemies. In the next section another electrical communication network will be considered that will include a measure of the stability of the system.

IV. A MEASURE OF "DYNAMIC-JUSTICE" BASED ON MAXIMIZING THE NEGENTROPY OF A CONTINUOUS CHANNEL.

The term "dynamic-justice" is proposed for a combination measure of a balance of degree of democracy with organization to withstand external and internal aggression. The telephone cable of Fig. 9(a) will be used as a model for this analysis by specifying that the power level in each cable pair is limited to a specified average power. The nature of the model from the Information Theoretical viewpoint is that it is a continuous model without noise. To proceed with the analysis we need some measure of the power of the sociological system that will be analogous to the power level in the cable pair. To make trial calculations we shall assume that the electric power production per capita per year is a reasonable first approximation, and that the distribution of political ideas among the population is equivalent to the distribution of signal voltages in the cable pair.

For this assumption, we have from the continuous channel in electrical communication theory, a formula for the entropy, here defined as "negentropy:"

$$H_x = -\int p(x) \log p(x) \, dx. \qquad [6]$$

For an electrical signal carrying a message on a physical pair of wires, such as any pair in the cable of Fig. 9(a), with an average power limited to ^{2}, there is a theorem in Information Theory which shows that the negentropy is maximized when the message signal voltage has the following probability distribution:

$$p(x) = \left[1/ (2\pi)^{1/2}\right] e^{-x^2/2\sigma^2} \qquad [7]$$

This gives a maximum negentropy of:

$$H_{max} = \log (2\pi e)^{1/2} \sigma \qquad [8]$$

For the sociological system, I shall make the following hypothesis:

Hypothesis Two. The negentropy of the probability distribution of political ideas in a sociological system can be approximated by the negentropy of the message distribution on a telephone cable for the continuous channel with limited average power. The assumed scale of political ideas is taken as a "measure of collective direction" or MCD. The resultant negentropy is considered as a measure of "dynamic-justice" -- a balance between maximizing democracy and maximizing organization to keep the system stable. The telephone cable pair if considered isomorphic to the sociological system, when the limiting average power in the cable is considered equivalent to the per capita power production in the sociological system.

Sample calculations for a set of hypothetical countries are made in Appendix II. Some of the ideal curves for the hypothetical countries are plotted in Fig. 13. The area under the curves is proportional to the annual electric power production of the respective countries.

The important feature of this model is that the "tails" on the probability distribution of political ideas must be preserved in order to maximize the negentropy. Sample curves of distributions departing from the optimum are compared with the optimum in Appendix II. This type of analysis should help the countries of the world move from policies of "power politics" toward a policy of "human development" in which two countries like Country C and

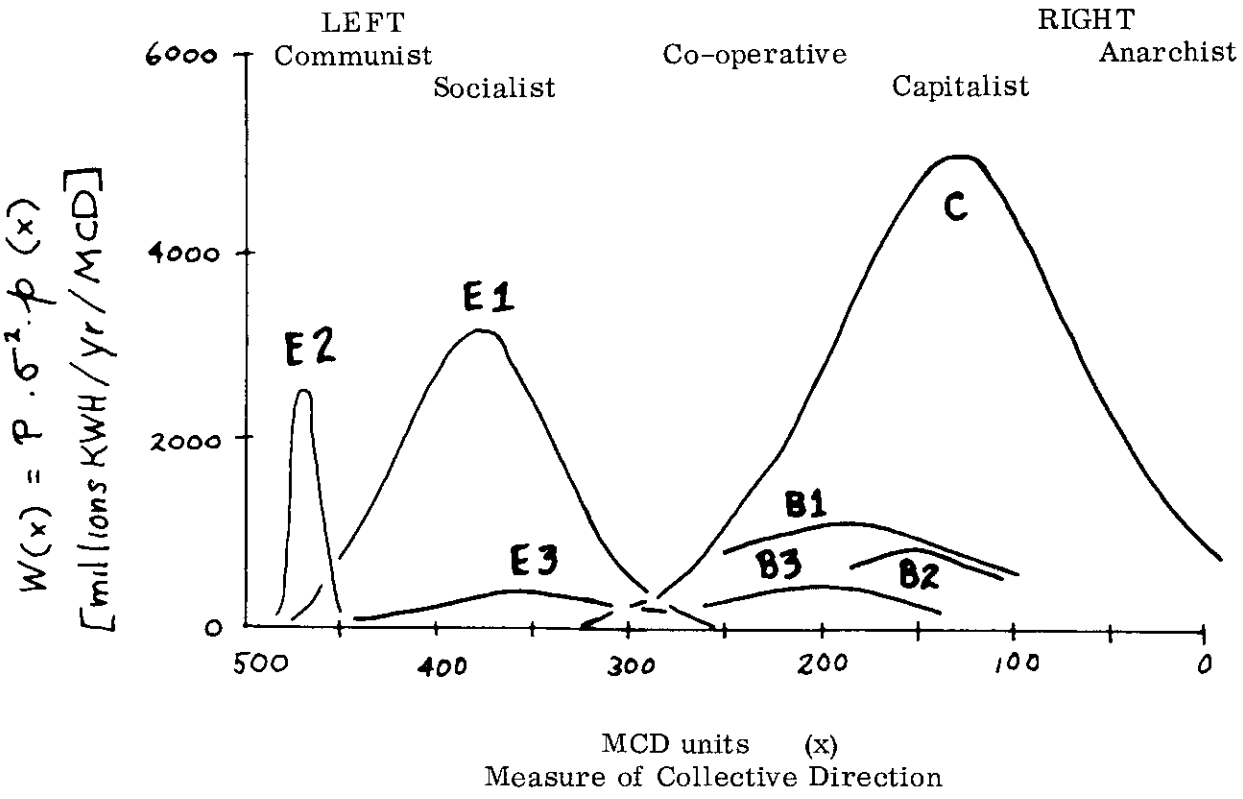


Fig. 13. Ideal Distribution Curves of Power versus Political Ideas for Some Hypothetical Countries.

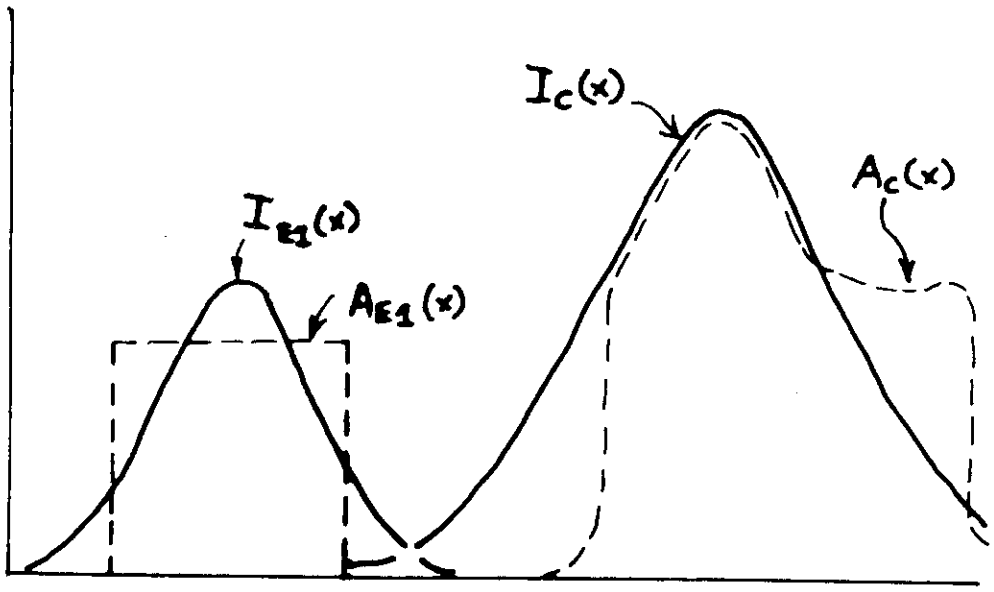


Fig. 14. Examples of Hypothetical Actual Power versus Political Ideas (A(x) vs. x) Which Depart from Ideal Curves (I(x) vs. x).

Country El in Fig. 13 could change from a power struggle between their two ideologies to self and mutual criticsm for not attaining the optimum political ideal distributions appropriate to their respective stages of economic development as measured grossly by their electric power production.

The dotted lines in Fig. 14 show some political idea curves which depart from the ideal shape. Country El is operating below its potential for its power level, because it has eliminated the tails on the left and right. Country C's elimination of the left tail and inclusion of the hump on the right make its negentropy depart from its optimum for its stage of development. This type of analysis makes it possible to get a start on determining whether a campaign of "peaceful coexistence" is a bonafide move toward peace or whether it is a propaganda trick. When a country is making progress in coming closer to its optimum curve, it is becoming both more democratic and more stable, so that it may be trusted by the other countries to follow a reasonable stable policy even though there is a large difference in its political ideas compared to its neighbors.

This criterion as to whether a country is approaching its optimum political idea curve should help the psychiatrist in determining the relative balance to put between helping patients adjust to the society and helping patients work to bring their society closer to its optimum distribution.

V. CONCLUSIONS AND FUTURE EXTENSIONS.

A set of four axioms for use in applying General Systems Theory to multidisciplinary problems have been developed. These axioms relate to the following aspects of general systems research:

(1) A careful review of the different roles of the researcher;
(2) The need for an historical time perspective;
(3) The need for a knowledge-space perspective; and
(4) Procedures for testing of hypotheses.

Examples have been given of the practical application of these axioms.

The unsuccesful search for an equivalent electrical circuit representation of sociological systems led to a series of steps of considering circuits with less degrees of freedom until two circuits were found to have isomorphic properties in regard to a few significant parameters with sociological systems. Then a shift was made from the circuit or cybernetic viewpoint to the information theoretic viewpoint in which these equivalent circuits isomorphic with sociological systems are looked at as communication channels.

Two electrical communication networks were found to be significant:

(1) a pair of telephone or telegraph wires considered as a discrete noiseless channel, and

(2) pairs of telephone wires in a cable with the average power limited in each pair to a particular value for that circuit, such that the pairs could be considered as continuous channels that are average power limited.

In the first case a set of human freedoms were considered equivalent to a set of messages that might be sent over a telegraph line, and then the average negentropy of the set of freedoms was found to be equivalent to a measure of the democracy of the system.

In the second case the distribution of political ideas in a sociological system was considered equivalent to the distrib ution of signal voltages in a telephone cable. Then computing the maximum negentropy gave an optimum distribution of political ideas in the form of a bell-shaped curve in which the "tails" on the left and the right are both important. The magnitude of the negentropy is considered a measure of the "dynamic-justice" of the

system, a balance between democracy and stable organization. The square of the width of the optimum curve found to be proportional to the limiting average power in the cable pair and on the sociological level equivalent to a measure of the electric power production per capita of the country being considered.

These results are stated as two hypotheses and are tabulated against various test in Fig. 16. Also there has been added space in the table for future more detailed developments. The third row is reserved for a more sophisticated model including the equivalent noise from the other cable pairs. The fourth row is reserved for a more detailed equivalent circuit analysis of networks built up out of cannonical forms of feedback loops.

This type of analysis should be helpful in balancing the degree to which individuals should adjust to society or work to make society come closer to the ideal appropriate to its stage of development. These concepts should also be valuable in shifting emphasis in international relations from "power politics" to a "theory of human development" by providing standards appropriate to the stage of development of a country.

TESTS / HYPOTHESES	Do Hypotheses Give Reasonable Values For: Ideal Democracy	Class Discrimination	Caste System	Dictatorship	Function of Population	Do Models Allow for Different Evolving Paths?	Does it Give a Good Static Measure?	Does it Include Stability?	Does it Permit Substitution of New Functions?
Hypotheses One "Democracy" & Negentropy (Discrete Chan.) Noiseless	Yes	Yes	?	Yes	Yes	Yes	Yes	No	
Hypotheses Two "Dynamic-Justice" Max. Negentropy (Cont. Channel Power Limited)	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
Analogy: "Dynamic-Justice" Negentropy (Cont. Channel with Noise and Power Limit.)				Not Yet Developed					
Homology: Cybernetic Feedbackloops Give Analysis of Freedom and Organization			Fine Structure Data Not Yet Developed						

Fig. 16. Table of Testing of Hypotheses.

APPENDIX I.

NEGENTROPY OF A SET OF FREEDOMS IN A SOCIOLOGICAL SYSTEM

Detailed calculations and assumed values of freedom used in the calculations are listed and discussed in this appendix. The list of freedoms used in the calculations are defined in Table II.

TABLE II.

ASSUMED COMPONENTS OF HUMAN FREEDOM

Number (j)	Description	Democratic Ideal Value
(1)	Freedom of speech	0.1
(2)	Freedom of religion	0.1
(3)	Freedom to print, broadcast, televise and listen	0.1
(4)	Freedom to find sexual partner	0.1
(5)	Freedom to obtain education	0.1
(6)	Freedom from job discrimination on account of race, religion, or origin	0.1
(7)	Freedom to build or buy own home	0.1
(8)	Right to vote	0.1
(9)	Right to trial by jury	0.1
(10)	Freedom to establish small business or farm	0.1
	Total F =	1.0

I shall assign to each person a unit of "freedom," $F_i = 1.0$. If he is deprived of some of his freedom, his F_i becomes less than one. For example, if a dictator reduces the freedom of his subjects to 0.5 each and there are 100,000 people under his control then the dictator's freedom is $F_1 = 50,001$.

To obtain a measure of freedom that behaves like a probability function, we define a normalized "freedom" function, G; to be substituted in equation [4] ,

$$G_i = F_i / n, \qquad [9]$$

where n is the population of the country sub-system. In the above case the normalized freedom for each subject is $G_i = 0.000005$ and that of the dictator $G_1 = 0.5$, i.e. the dictator has 100,000 times the freedom of a subject of his. The distributions of freedoms used in these calculations are tabulated in Table III.

The variation of negentropy for two states in a discrete channel are shown in Fig. 17.

TABLE III.

DISTRIBUTIONS OF FREEDOMS USED FOR SAMPLE CALCULATIONS OF NEGENTROPY

population of 100,000

Country A $F_i = 1.0$ $G_i = 1.0 \times 10^{-5}$

Country B

j	Group 1 (10%)	Group 2 (90%)
1	0.05	0.11
2	0.10	0.11
3	0.05	0.11
4	0.05	0.10
5	0.01	0.11
6	0.01	0.11
7	0.01	0.11
8	0.01	0.10
9	0.03	0.10
10	0.02	0.112
	$\overline{F_1 = 0.34}$	$\overline{F_2 = 1.072}$
	$G_1 = 0.34 \times 10^{-5}$	$G_2 = 1.072 \times 10^{-5}$
	$0.10 \times 0.0.34 = 0.034$	$0.90 \times 1.072 = 0.966$

Country C

j	Group 1 (10%)	Group 2 (80%)	Group 3 (10%)
1	0.05	0.1	0.15
2	0.10	0.1	0.10
3	0.05	0.1	0.15
4	0.05	0.1	0.15
5	0.01	0.1	0.19
6	0.01	0.1	0.19
7	0.01	0.1	0.19
8	0.01	0.1	0.19
9	0.03	0.1	0.17
10	0.02	0.1	0.18
	$\overline{F_1 = 0.34}$ 10%	$\overline{F_2 = 1.0}$	$\overline{F_3 = 1.66}$ 10%
Class	$G_1 = 0.034$	80 out of 100,000	$G_3 = 0.166$
Individual		$G_2 = 1.0 \times 10^{-5}$	

Groups 1 & 3 are considered as classes, not by individuals, while Group 2 is treated by individual case.

TABLE III (cont.)

DISTRIBUTIONS OF FREEDOMS USED FOR SAMPLE CALCULATIONS OF NEGENTROPY

Population of 100,000 each country.

Country D

j	Oligarchy (12 men)	People (99,988)
1	700.0	0.01
2	1.0	0.01
3	700.0	0.01
4	1400.0	0.05
5	700.0	0.02
6	700.0	0.01
7	700.0	0.03
8	700.0	0.00
9	0.0	0.00
10	1400.0	0.02
	$\overline{F_o = 7001.0}$	$\overline{F_p = 0.16}$
	$G_o = 0.07001$	$G_p = 0.16 \times 10^{-5}$
	$12 \times 0.07 = 0.84$	$10^5 \times 0.16 \times 10^{-5} = 0.16$

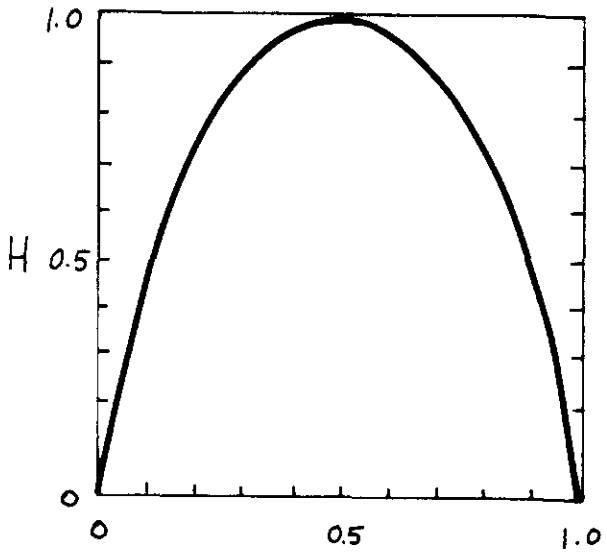
Country E Caste 1 $F_1 = 0.34$ G_1(class) = 0.34 10%

Castes 2 -9 $F_i = 1.0$ G_i(class) = 0.10 10% each

Caste 10 $F_{10} = 1.66$ G_{10}(class) = 0.166 10%

Country F

j	Dictator (one)	People (99,999)
1	8500	0
2	8500	0
3	8500	0
4	8500	0.10
5	8500	0.01
6	8500	0.01
7	8500	0.02
8	8500	0
9	8500	0
10	8500	0.01
	$F_1 = 85,000$	$F_i = 0.15$
	$G_1 = 0.85$	$G_i = 0.15 \times 10^{-5}$



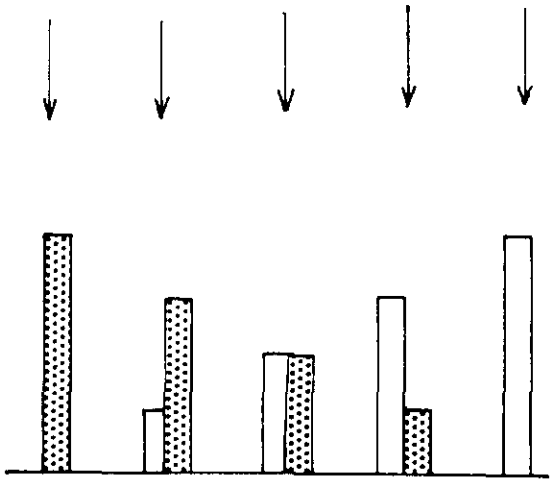
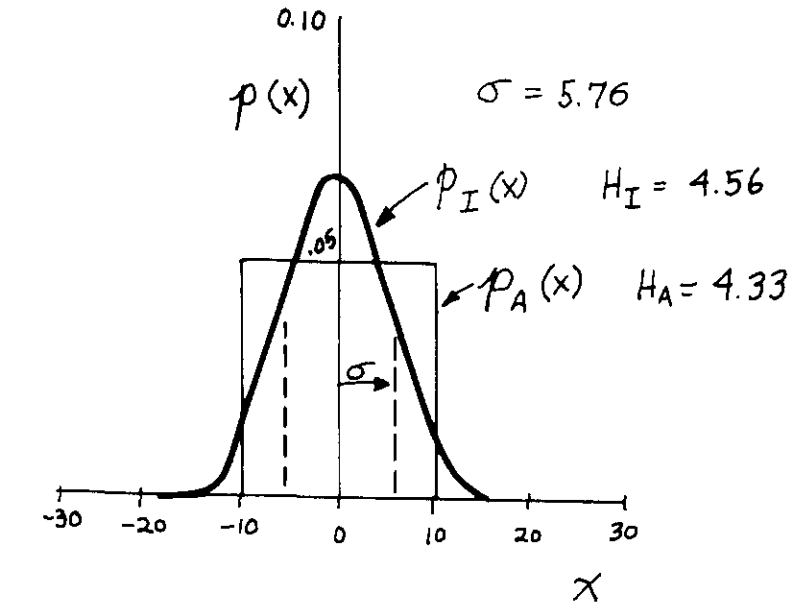
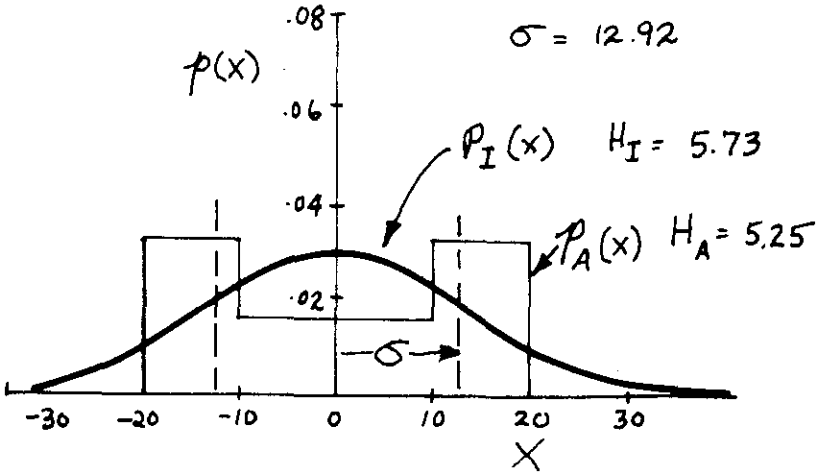


Fig. 17. Negentropy for Different Proportions of Two Discrete States.





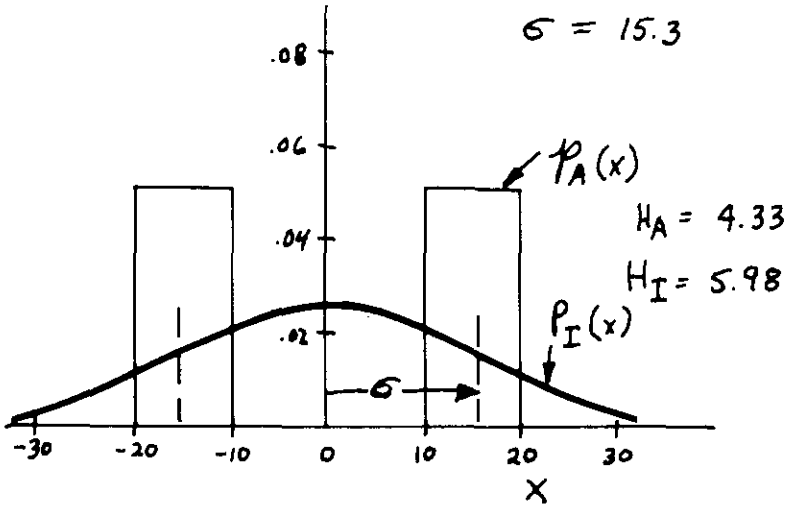


Fig. 18. Examples of Ideal and Non-Ideal Continuous Channel Signal Distributions

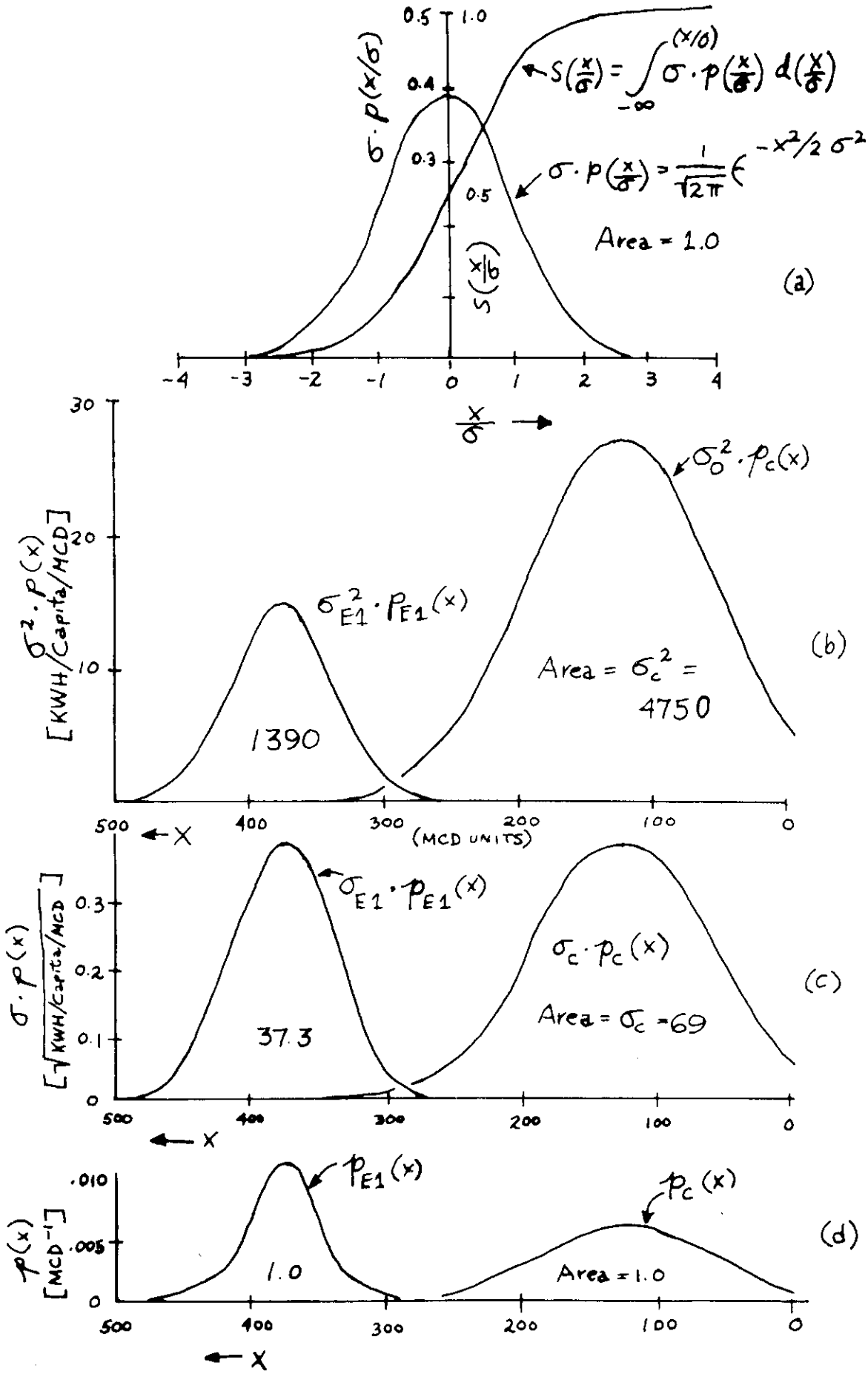


Fig. 19. Different Methods of Plotting Distributions

APPENDIX II.

NEGENTROPY OF THE CONTINUOUS CHANNEL WITH LIMITED POWER POWER AS A MEASURE OF "DYNAMIC-JUSTICE."

Sample calculations of ideal and non-ideal probability distributions are shown in Fig. 18. The differences in negentropy are indicated for each set on the drawing. The figures used in calculating the ideal curves in Fig. 13 are tabulated in Table IV.

TABLE IV.

PARAMETERS OF SOME HYPOTHETICAL COUNTRIES FOR USE IN THE CONTINUOUS CHANNEL MODEL.

Country	Measure of Collective Direction MCD	Population [millions]	Electric Power Prod. [millions K.W.H./yr]	Elec. Pwr. Per Capita $\sigma 2$ [KWH/cap/yr]	Std. Dev. [σ]	People per MCD unit [thousands]
B1	200	50	137,000	2750	52.5	324
B2	150	45	72,000	1600	40	382
B3	200	17	114,000	6700	81.8	70.6
B4	100	52	116,000	2350	48.5	364
B5	263	92	115,000	1250	35.4	882
B6	200	7	34,000	4900	70	34
C	125	177	840,000	4750	69	870
D1	225	402	20,000	50	7.1	19,400
E1	325	210	292.000	1390	37.3	1,920
E2	463	720	55,000	76	8.7	28,200
E3	350	16	40,000	2500	50	272
E4	375	29	29,000	1000	31.6	313

The different ways of plotting the ideal curves are shown in Fig. 19. At the top is the universal gaussian probability curve. Ideal curves are plotted for Countries C and E1 in three different ways, namely $p(x)$, $\sigma\ p(x)$, and $\sigma^2 \cdot p(x)$.

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