

Stage Q of
A thru T.*

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A study in a series of manuscripts on the
social relations of engineering and related
philosophical questions dealing with the
interaction of science and society. Dis-
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consideration for possible publication.

"EQUILIBRIUM BETWEEN ORDER AND DIVERSITY AS
A CRUCIAL FACTOR IN THE DEVELOPMENT OF
DEMOCRATIC INSTITUTIONS."

by

Frederick B. Wood, Ph.D.

P.O. Box 5095
San Jose, California 95150

*This set of symbols means that this project is at Stage Q in a
series of stages running from Stage A through Stage T; such as:
Stage A, searching for background material;
Stage H, formulation of preliminary hypotheses;
Stage J, collection of new data or setting up experiments;
Stage Q, experimental use of ideas with small groups of
specialists and/or laymen;
Stage T, preparation of more technical versions for
social science research.

#SEPR No. 56-B is the third version of File 56 in a mixed subject/
partially chronological file of research problems. Most reports in
this series are unpublished manuscripts available only by photoprint
or Xerox. A few that have been printed or presented at public meetings
are listed below:

SEP No. 1 & SEPR No. 27-A, "The Social Responsibility of Engineers
and Scientists." 1959 Proc. of the Western Joint Computer Conf.
pp. 310-313. & Progressive World, vol. XIII, no. 12, Feb. 1960 &

Equilibrium Between Order and Diversity as a Crucial
Factor in the Development of Democratic Institutions.

Of the various classifications of stages or eras of human history that have been conceived, the one which breaks human history into three eras -- force, power and communication -- seems the most useful for understanding the present problems of our civilization. The characteristics of these eras are summarized in Table I.

Table I: Three Main Stages in the
Development of Human Civilization. (4)

ERA	CHARACTERISTIC	TECHNOLOGY	IDEAL
Force	Man's own strength plus others as slaves.	Amplification of force by lever & pulley.	Longing of prophets like Isaiah for world without war.
Power	Steam engine, electric motor, etc. eliminated need for slaves.	Power amplifiers associated with expansion of science.	Colonial powers will gradually develop world league of nations.
Communication	Radar, television and computer-communication systems.	Intelligence amplifying systems.	Transition from power politics to theory of human development maximizing communication.

From the emergence of homo sapiens at the end of the last glacial age up to about three hundred years ago most major social and political arguments were settled by force, i.e., by the political leader who could organize the largest number of soldiers, slaves or workers. The force of the slaves was enhanced by force multiplying devices such as the invention of the lever, wheel, and pulley.

Starting with invention of the steam engine, the application of gunpowder in weapons, the development of other explosives, and the invention of electric motors and generators, a qualitative change occurred in human society. The resolution of major conflicts was shifted to those who organized the most energy converters or power amplifiers. Society ceased to be so dependent upon the force of

Abstract

Statistically it is observed that a diversity of personality types occur in each generation of human beings. Throughout most of history the small fraction of a percent of people -- who were non-conformists were usually eliminated by society. On rare occasions a non-conformist would survive the brutalities of the force era to give mankind a new concept or invention. It has been pointed out by Rashevsky(1) that in areas where there was more access to transportation large cities developed and the the population of the cities permitted the non-conformists to join forces for protection.

The rise of fascism in Germany and Italy between World War I and World War II represented a new attempt by society to apply the new technology of the power age to eliminate the non-conformists from society. Also Joseph Stalin's concept of "revolution from above" led the Communist Party to excesses which also attempted to eliminate non-conformists.

The development of electronic information processing techniques used in radar, sonar, and related bombsight techniques tipped the balance in World War II in favor of the democratically oriented nations. This victory in favor of democracy signalled the entry of the human race into a new era -- the information or Communication era. Marshall McLuhan proclaims it as the electronic age.(2) If this is truly a new era, we should expect the mathematics of communication theory to show us the form of significant features of the social structure of this new era. The mathematics of Information Theory and Cybernetics should give us the insights necessary to perceive abstract models of sociological development which could help us direct our political, economic and social activities toward maintaining the proper balance between order and diversity to maximize the growth of democratic institutions.

We examine one electrical communication theory model known as the continuous channel (an abstraction of a telegraph cable) and find that, if we substitute the probability of finding people and resources related to different political views for the probability of different signal voltages occurring on a telegraph line, and then use the mathematical formula for maximizing the transmission of information over the telegraph line as an operator on the probability distribution of political views tolerated in a given country, we find that by analogy we have a measure of what we might call "dynamic-justice" -- a measure of how well the country maintains a balance between order and diversity.

It turns out that this mathematics predicts that for low levels of economic development that a high level of order with small tolerance for diversity is stable and that as the economic level rises as measured by the percapita electric power production, the optimum diversity of political ideas tolerated increases, leading to a more democratic system as the optimum for higher power levels. This theory says we don't have to settle for the increasing conformity empirically extrapolated by Clark Kerr, Industrialism and Industrial Man,(3), but by use of analogies from electrical communication theory we can point the way to a more humanistic and democratic world.

#(cont.) Bulletin C.N.O.F.(Paris), Mai 1964, pp. 19-24. & SSRS Pamph.#6.
SEP No. 20-B, "The Two Cultures and the Social Responsibility of Engineers." (privately printed, 10/5/62, 3pp.)
SEP No. 65-D, "Proposal for a Book on 'Communication Theory in the Cause of Man.'" 10/28/62, 30pp. U.S.Dept.H.E.W., N.I.H. Proposal GM-11277-01.

numbers of soldiers or slaves, but became more dependent upon the technology of the invention of power amplifiers.

Let us examine some features of this change. Back in the force era when most of the world's population was located in small villages, the normal distribution of people by political views might be as is shown in Fig. 1. The leaders of society in the process of organizing society normally liquidated the non-conformists who were the potential inventors. The social processes in the force era tended to cut off the tails of the distribution of types of individuals so that individuals conforming to the center portion of the distribution shown in Fig. 2 would survive. As more travel and communication developed between villages and larger towns and cities developed, the same percentage of non-conformists meant more actual non-conformist individuals/so as shown in Fig. 3, that in large towns or cities the non-conformists could get together and defend themselves. This saving of the non-conformists led to a faster development of science and technology.

The dominant social organizations still derived from the force era where there was a scarcity of resources to fight over, utilized the new power amplifiers to generate more devastating wars. In the interim between World Wars I and II the rise of fascism brought new applications of both the force era and power era techniques to bear on the destruction of human freedom. The democratically oriented countries responded to the challenge of fascism by the organization of scientific research and development in the cause of democracy which resulted in the development of advanced radar systems in World War II. The development of large scale electronic information processing through the extensive development of radar was the major new feature that turned the balance in World War II in favor of the democracies. This did not mean that the elements of previous eras were no longer needed, but that the addition of the feature of the new "Information Era" turned the tide of battle in Western Europe.

VILLAGE OF
NON-CONFORMIST 1000 PEOPLE.

SCALE
THIS AREA:
[] = 100 PEOPLE

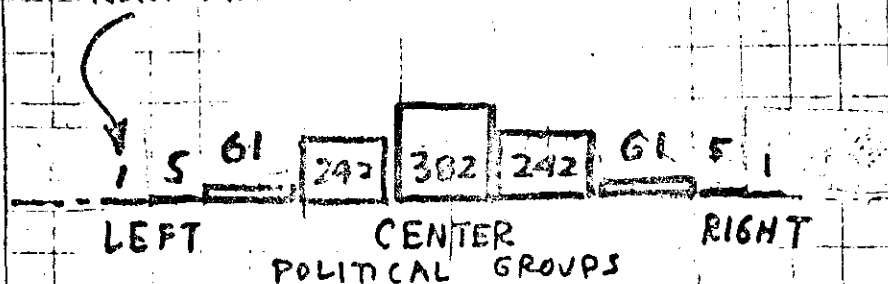


Fig. 1. NORMAL DISTRIBUTION OF PEOPLE BY POLITICAL VIEWS.

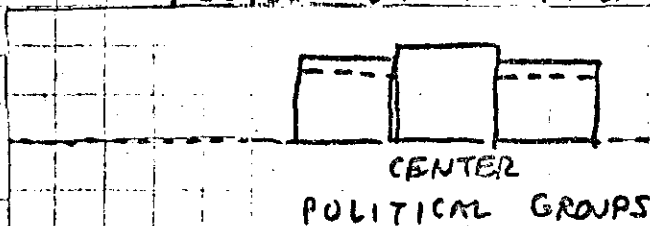


Fig. 2. EFFECT OF SOCIAL PROCESSES LIQUIDATING NON-CONFORMISTS AND APPLYING PRESSURES TO INDEPENDENTS

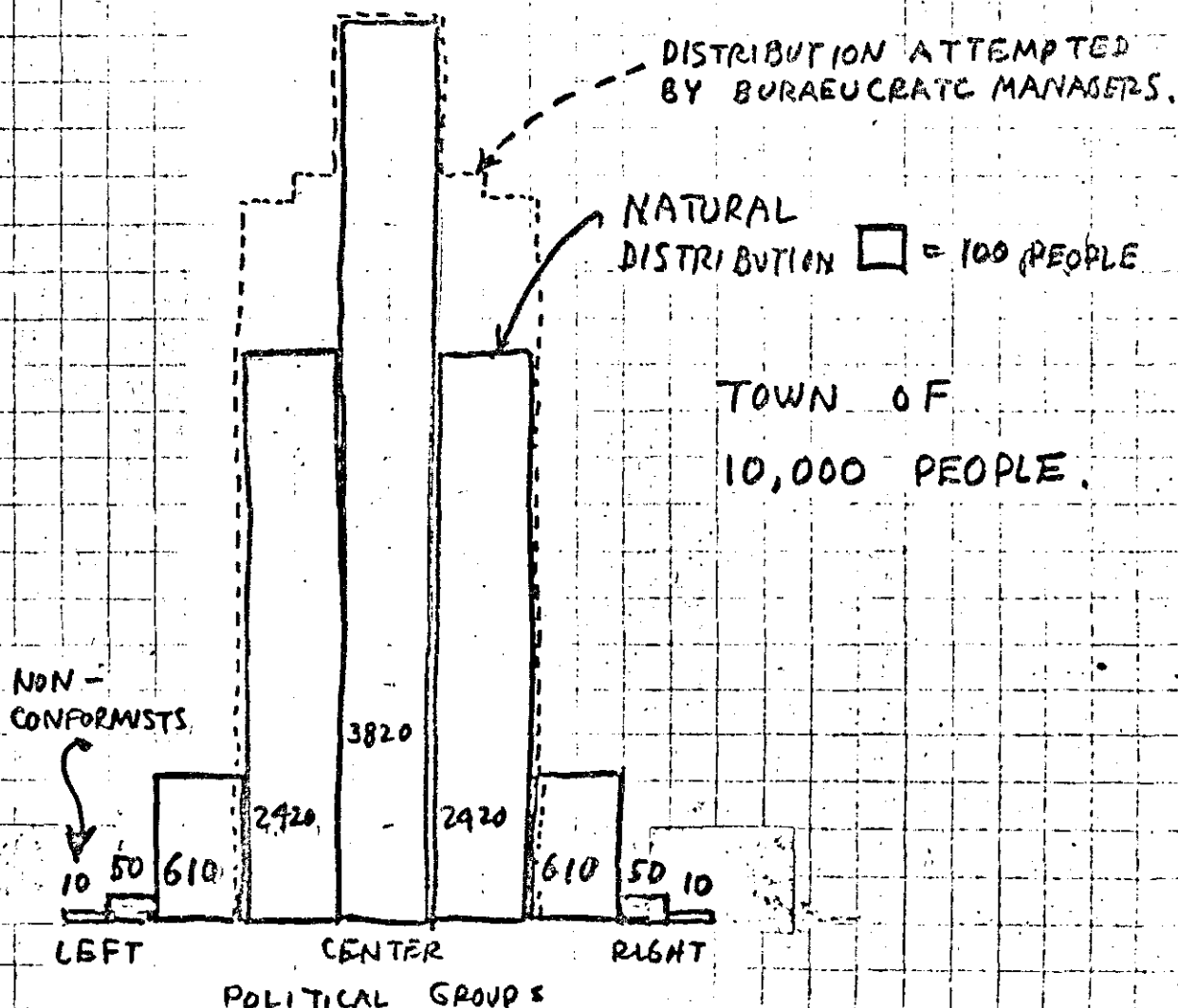


Fig. 3 DISTRIBUTION OF PEOPLE BY POLITICAL VIEWS IN LARGER POPULATION

On the Eastern Front the sieges of Stalingrad and of Leningrad ran into conditions where elements of the earlier era -- the force era became more dominant when the supporting supply lines for the technology of the power era became too long. On the Western Front the development of radar enabled the British to track and shoot down the German V-1 rockets. The early introduction of experimental radar by the U.S.A. materially reduced the menace of the German submarines.

Now the victories for the more democratic countries of America and Europe came in 1943, 1944, and 1945 which heralded the beginnings of the "Information Era." At the same time N. I. Vernadsky of the (5) Academy of Sciences of the U.S.S.R. perceived a transition into the "Noösphere" in which he used the terminology of Teilhard de Chardin to describe this new era we were entering. Three years after the end of World War II the developments of the new "Information Era" reached a more firm theoretical base. Claude Shannon published his articles on "The Mathematical Theory of Communication" in the Bell Systems Technical Journal (6) in 1948, and Norbert Wiener published his book Cybernetics or Control and Communication in the Animal and the Machine. (7) Particularly Norbert Wiener's analysis implied that the new developments in our understanding of the processing of information would have far reaching implications in all fields of sciences extending from physics and chemistry to biology to psychology and even to sociology.

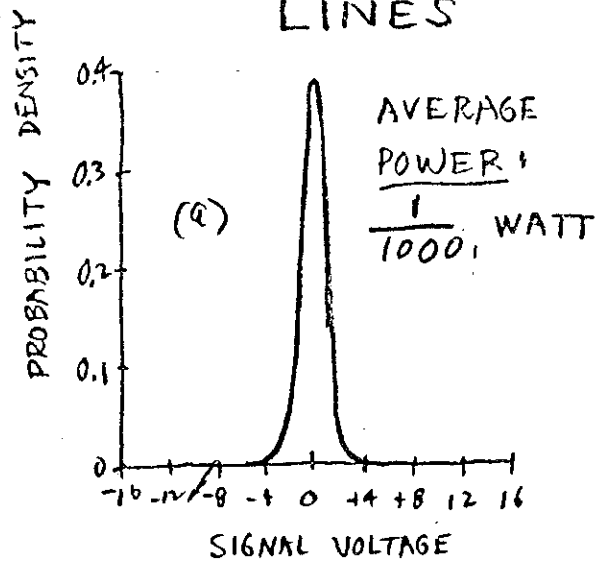
After a rush of enthusiasm to apply cybernetics to everything, people lost interest in some of the broader scope of the developing Information Era. At a later date Norbert Wiener suggested that the broad application of new concepts takes approximately twenty years to accomplish on a sound basis. (8) Also some of the earlier enthusiasts failed to utilize the available resources in the philosophy of science relative to how thematic hypotheses in science are developed and (9)

tested.

Now after approximately twenty years of applying the concepts of Information Theory and Cybernetics to military weapons systems, we are on the threshold of applying these concepts to sociological systems as predicted by Norbert Wiener back in 1948. If we look at a telegraph line, radar system, or a set of computer instructions and study the set of probabilities that different telegams are sent, the probabilities of different radar signals, or the probabilities of different computer instructions being used, we find some interesting analogies for what Shannon calls the continuous channel model in electrical communication theory. For a given electrical power level in a communication system Information Theory predicts an optimum probability distribution of signal voltages for maximum transmission of information. In Fig. 4 we have plotted some such optimum distributions of signal voltages. Next let us look back at Figs. 1 and 3 on the distribution of people by political views in a social system before the non-conformists have been liquidated. There is an approximate similarity between the curves and graphs in that if one averaged the political view distribution graphs the smooth curves would have the same shape as the electric signal voltage distribution curves.

Now in Fig. 5 we have constructed some ideal political view distribution curves by using the formulas of electrical communication theory in which the power production per capita in a state or country replaces the electric power level of the telegraph line and the probability of occurrence (or tolerance) of different political views in the social system replaces the probability of occurrence of different signal voltages.

TELEGRAPH LINES



SOCIAL SYSTEMS

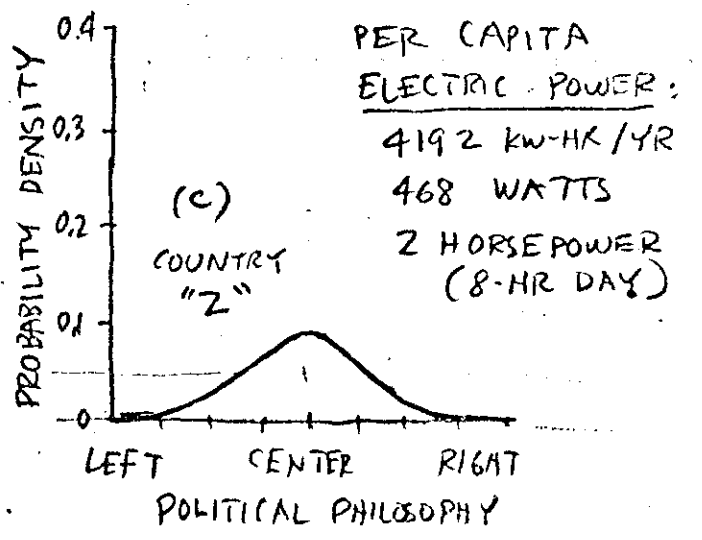
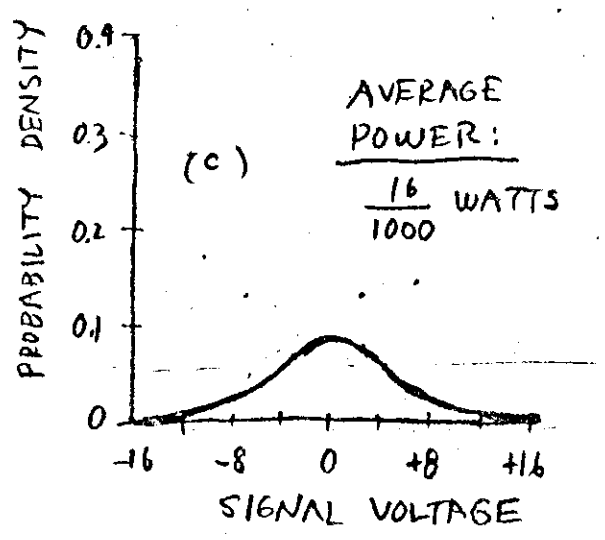
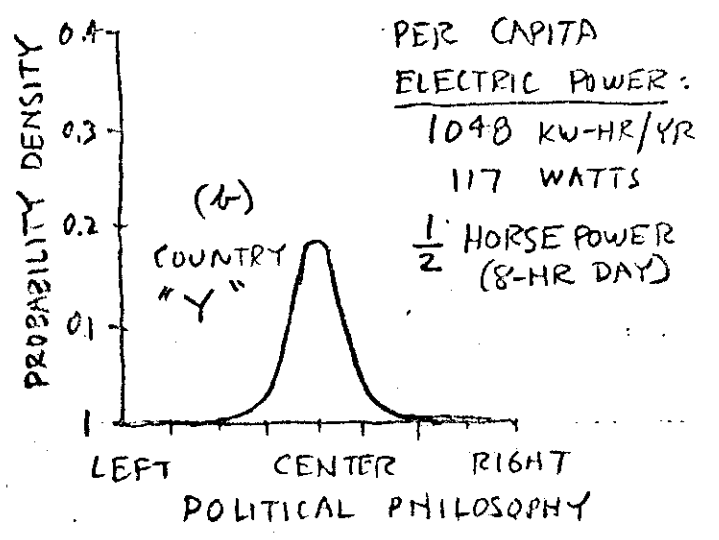
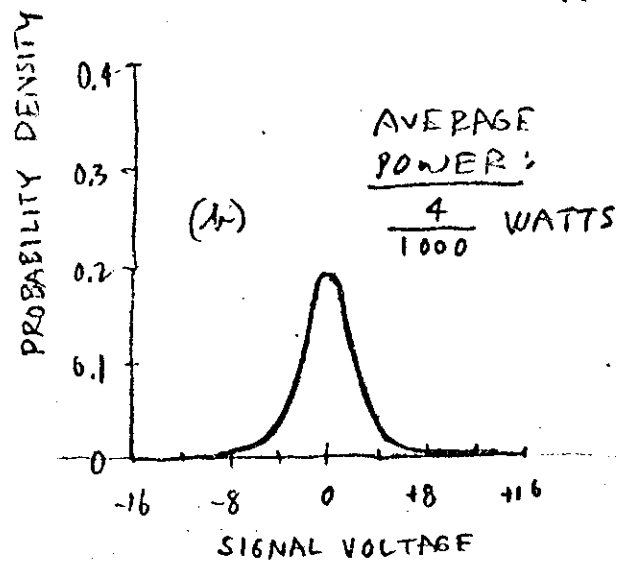
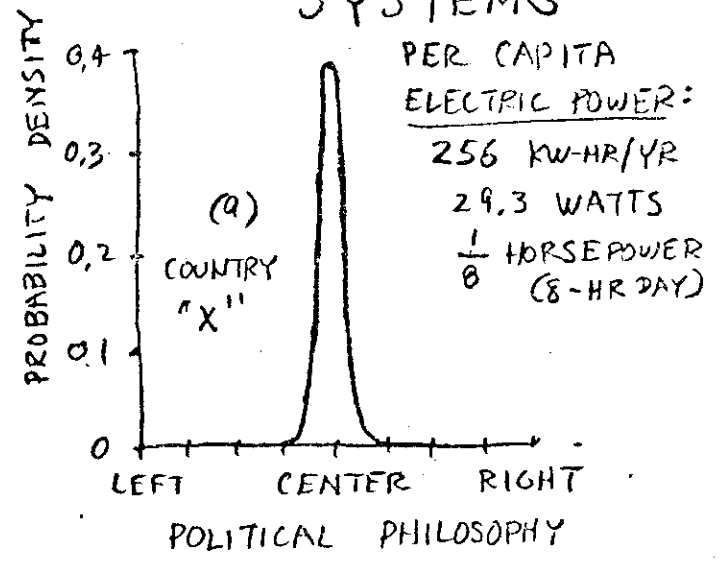


Fig. 4. OPTIMUM SIGNAL VOLTAGE DISTRIBUTION FOR TELEGRAPH SYSTEMS.

Fig. 5. OPTIMUM DISTRIBUTION OF POLITICAL POWER FOR SOCIAL SYSTEMS.

This analogy leads to a hypothesis that communication theory can form the base for a more humanistic society by its mathematical analogies with the maximizing of the transfer of information -- the criterion of an equilibrium between order and diversity. This can lead to a theory of how the forces for order and for freedom can be balanced in order to maximize human communication in social systems.

There are applications being developed to the following problems: (1) Civil rights, (2) Disarmament, (3) Foreign Aid, (4) Stability of Developing Governments, (5) Capital Punishment, (6) Birth Control, and (7) Alternative Military Policies. When these applications are more fully developed we may find that we have a new political ideology that works in a positive way to help develop more democratic institutions in our world.

An example for the case that countries X, Y & Z having populations of 6, 216, and 192 million respectively is shown in Fig. 6. The solid curves are the optimum distributions of electric power for the countries. The dashed curves are approximations to what might be the real distributions of power under political systems using an power era concepts in the information era. If countries Y and Z are afraid of each other and devoting a large part of their budgets to military weapons systems, and are also trying to find a path toward disarmament, they must first demonstrate concrete steps to move their own systems closer to their respective optimum curves. Then they can easily develop more confidence in each other, which in turn would make it easier to negotiate terms for disarmament. Also if they are competing for ways to influence the smaller country X to their respective political views, they could benefit more by searching for ways to help Country X to come closer to its optimum power distribution, than to attempt to switch Country X from communist to capitalist or vice versa.

SOCIALIST COMMUNIST CO-OPERATIVE CAPITALIST ANARCHIST

$P \cdot \sigma^2 \cdot p(x)$
[KWH/MEB]

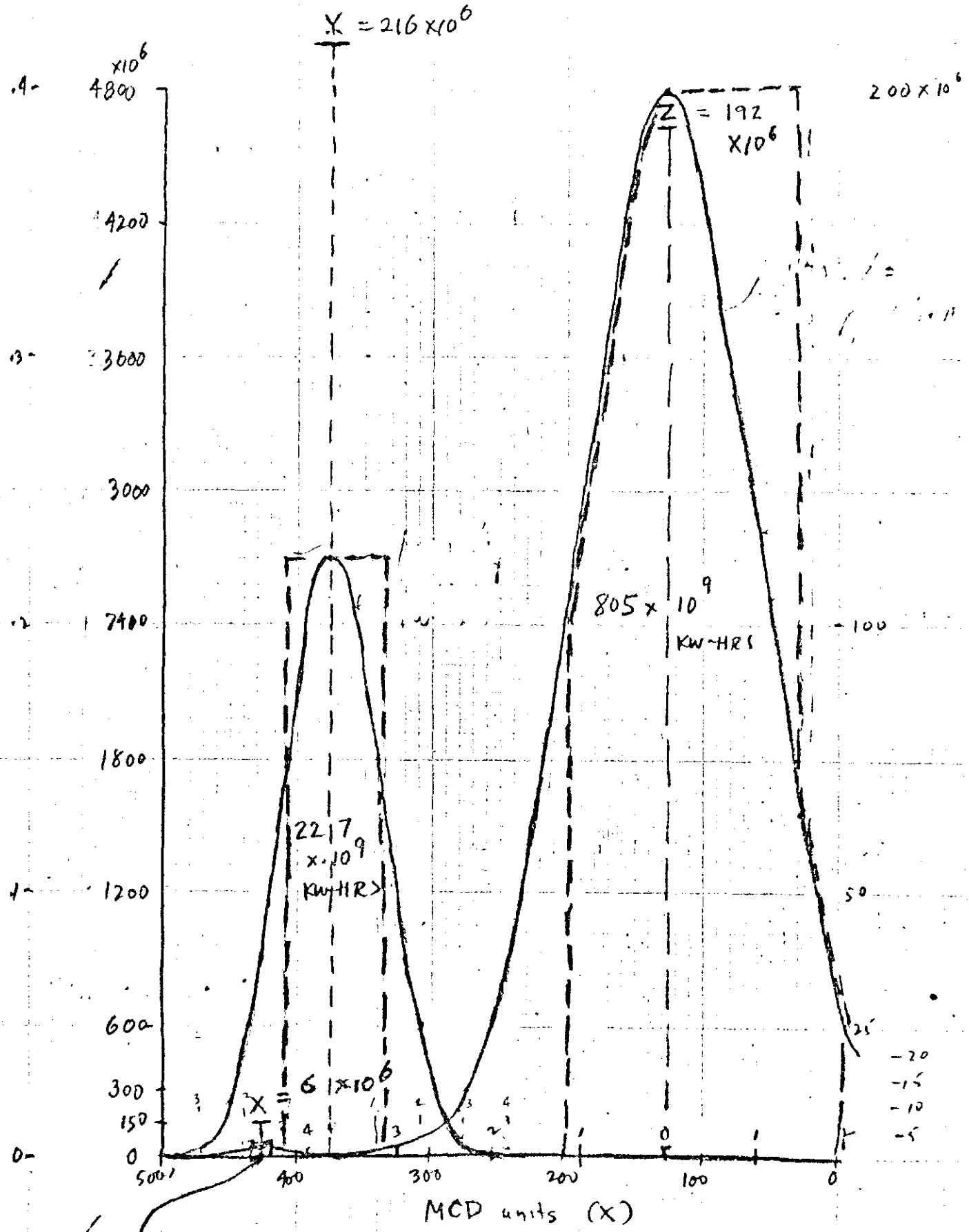


Fig. 6 POWER DISTRIBUTIONS FOR COUNTRIES X, Y, & Z.

References:

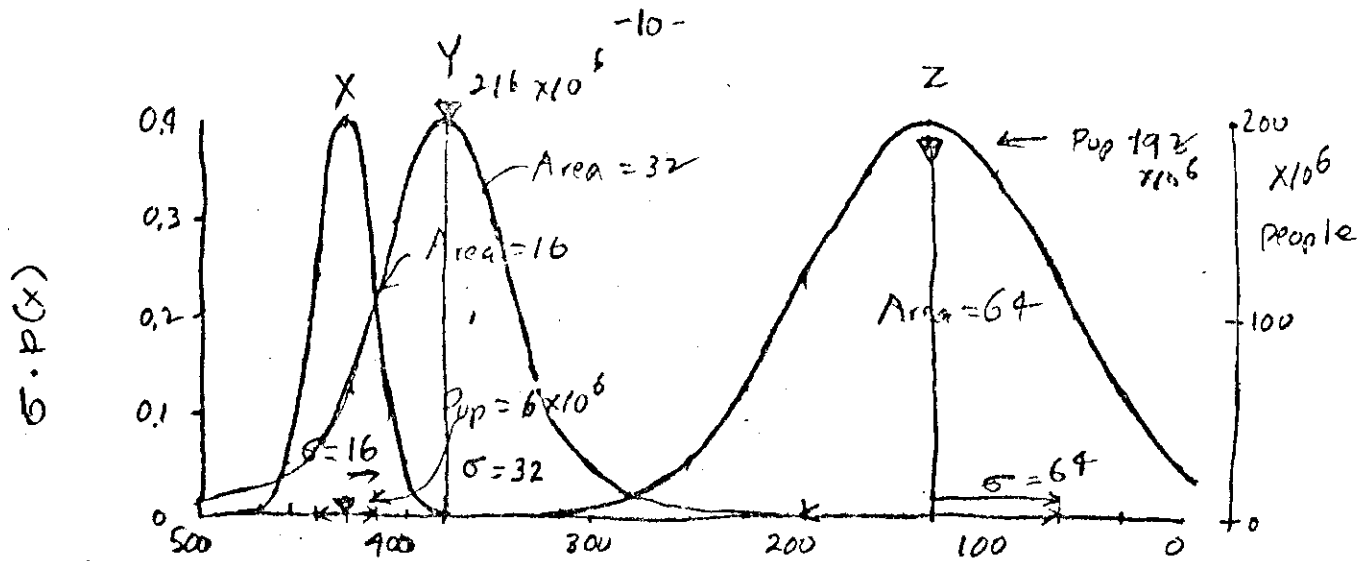
1. Nicolas Rashevsky, Committee on Mathematical Biology, University of Chicago, had a paper read for him at the AAAS Section K-1, AAAS Committee on Social Physics, December 27, 1954, Berkeley, in the session on Diffusion Theory. His paper included concepts of shore line to land area as an index of the probability of non-conformists diffusing into the developing large cities where they could organize for their own protection. (* If this reference is not correct, the material was covered at Behavioral Science Center, Stanford)
2. Marshall McLuhan, Understanding Media. N.Y.: McGraw-Hill (1964)
3. Clark Kerr et al, Industrialism and Industrial Man. Cambridge: Harvard University Press. (1960)
4. Adapted from A. Rapoport. "Mathematics and Cybernetics," Chap.87 in S. Arieti, editor, American Handbook of Psychiatry. N.Y.: Basic Books (1959), pp. 1743-1759, esp. p. 1747.
5. W. I. Vernadsky, Member of Academy of Sciences U.S.S.R., "The Biosphere and the Noösphere," American Scientist, vol. 33, no. 1, Jan. 1945, pp. 1-12.
6. Claude Shannon, The Mathematical Theory of Communication, reprinted with explanatory appendix by Warren Weaver, Urbana: Univ. of Ill. Press (1949)
7. Norbert Wiener, Cybernetics. N.Y.: Wiley (1948).
8. Norbert Wiener, "The Mathematics of Self-Organizing Systems," pp. 1-21, Appendix III: On the Function of Science in Society, pp. 18-21, in Robert E. Machol and Paul Gray, Recent Developments in Information and Decision Processes. N.Y.: Macmillan (1962)
9. For information on "thematic hypotheses" see Gerald Holton, "On the Thematic Analysis of Science: The Case of Poincaré and Relativity," In Mélanges Alexandre Koyré, vol. II, Publication XIII in Histoire de la Pensée, Paris: Hermann (1964), pp. 257-268.

Appendix on Technical Terminology.

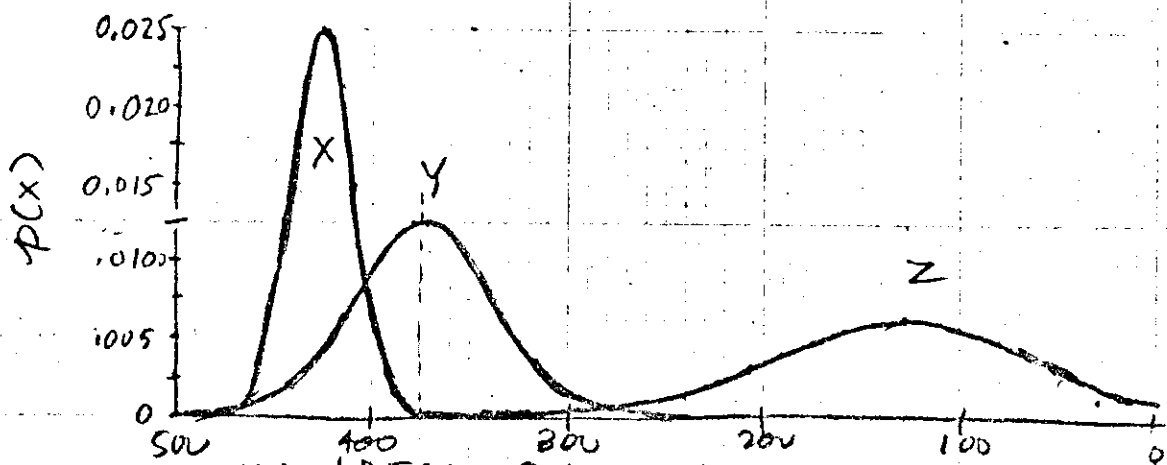
The measure of information transmitted over a communication channel is referred to by different scientists as "entropy," "negative entropy," "negentropy," or "communication entropy." For a discussion of 'Information Interpreted as Entropy' see Colin Cherry. (10)

10. Colin Cherry, On Human Communication. N.Y.: Wiley (1957) pp. 212-216.

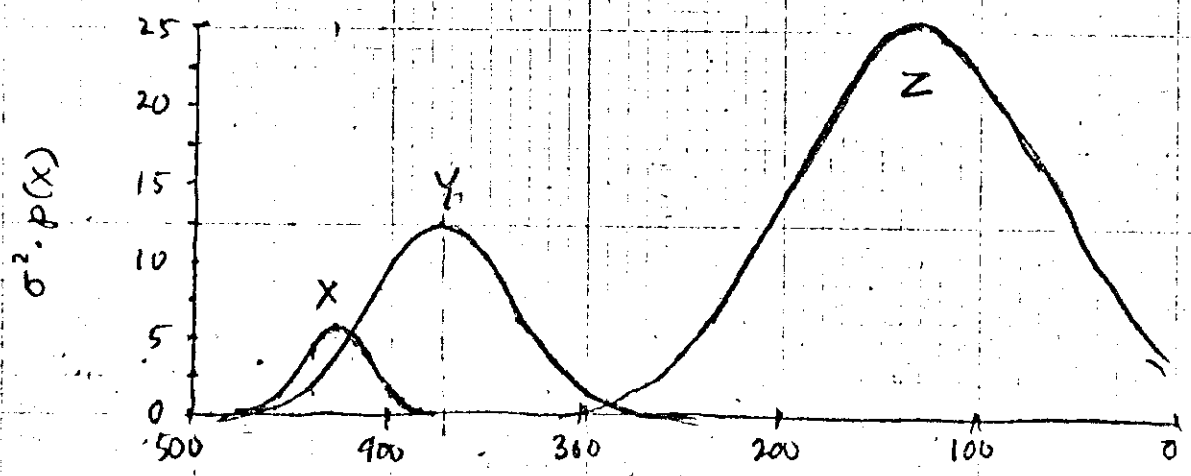
The mathematics for the communication channels represented in Fig. 4 is developed in Shannon and Weaver (ref. 6), pp. 55-56. Curves used in constructing the example of Fig. 6 are attached as Fig. 7.



(a) PROBABILITY DENSITY GENERATING FUNCTIONS AND POPULATION.



(b) IDEAL POLITICAL IDEA DISTRIBUTION DENSITY



(c) PER. CAPITA POWER DISTRIBUTION

Fig. 7. Reference Curves Used in Constructing the Curves of Fig. 6.

[Number of People per MCD unit = $\frac{0.34 \times \text{population}}{\sigma}$]

Further details of this analysis are given in the following conference preprint:

SEPR No. 92-B, "A General Systems Theoretic Model For The Estimation Of The Negentropy Of Sociological Systems Through The Application Of Two Isomorphic Electrical Communication Networks." presented at First International Congress of Social Psychiatry, London, August 17-22, 1964. 24 pp.

Another example relating more to freedom and civil rights:

SEPR No. 88-B, "Negentropy and the Concepts of Freedom, Democracy and Justice." Presented at the Society for General Systems Research meeting at the AAAS Convention, Cleveland, Dec. 27, 1963. 32 pp.

The methods of testing these hypotheses were discussed at the December 1965 AAAS Meeting, General Systems Sessions:

SEPR No. 96 (2 page abstract), "A Comparison of the Complexity of Testing Thematic Hypotheses in the Physical Sciences and the Social Sciences."

There is a parallel development of thought reported by R. B. Lindsay in his book, The Role of Science in Civilization (Harper & Row, 1963), which has a chapter on Information Theory and concepts from Thermodynamics. Dr. Lindsay asks, can there be a science of ethics? He reviews the Golden Rule, the Ten Commandments, Immanuel Kant's Categorical Imperative and then develops a "thermodynamic imperative":

"All men should fight always as vigorously as possible to increase the degree of order in their environment, i.e., consume as much entropy as possible, in order to combat the natural tendency for entropy to increase, and for order in the universe to be transformed into disorder, in accordance with the second law of thermodynamics. (p. 212.)

The above thermodynamic imperative is illustrative of the kind of ethical concept that can be derived by analogy from the science and mathematics at the base of our technological society. However I feel that Professor Lindsay, in translating the word entropy into order for the layman, has lost part of the meaning. When one uses a communication theory model to impliment Lindsay's thermodynamic imperative, it becomes apparent that "increase the degree of order" should be replaced by "optimize the order-diversity balance", and that after disorder in the second from the last line, one should insert "and diversity to be transformed into conformity." Thus the use of an electrical communication theory model makes the thermodynamic imperative a more useful hypothesis.

Frederick B. Wood