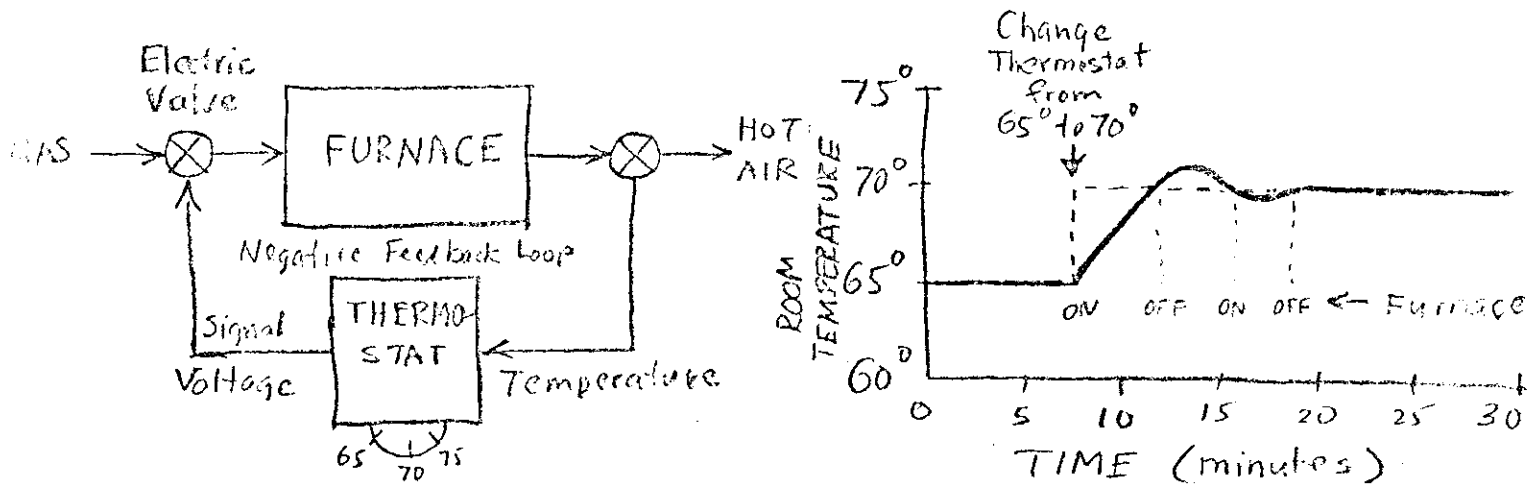


(a) Negative Feedback Loops of Cybernetics.

Cybernetics is defined as the science of communication and control in the organism and machine. It deals with the character and function of complex systems operation, including those that are self-organizing and adaptive.



The home heating furnace controlled by a thermostat is a simple example of one of the basic concepts of Cybernetics--namely the negative feedback circuit. The bimetallic thermal element of the thermostat measures the room temperature and provides negative feedback to the furnace, i.e., by sending a signal which turns off the gas when the room temperature is too high and a signal to turn the gas on when the room temperature is too low.

There are mathematically similar feedback loops in automatic control systems in manufacturing plants, chemical plants, communication systems, and computing systems. Analogous feedback systems occur in nature---in the complicated balance of the human glands, muscles and nervous system; in our psychological reactions; and in the interaction of groups of people in social and political systems. The further we go from physical and chemical systems into psychological and social systems the less detail we know for sure, but the feedback loop concepts help us in our research. The more complex systems like the inter-industry relationships in economics have so many potential feedback loops that it is impractical to show the relationships by drawing loops, but the relationships can be represented by mathematical matrices which can be processed by computers to give us important indicators of how our economy is functioning and what is significant for the market in specific sectors of the economy.

There are some arguments between specialists and generalists as to the scope of cybernetics. Norbert Wiener's definition of the scope of cybernetics is discussed by Dr. J. R. Pierce of Bell Telephone Laboratories in his book, Symbols, Signals and Noise, pp. 208-214.

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.

These negative feedback loops may also exist on other levels. The previous series of feedback loops dealt with the individual 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 levels.

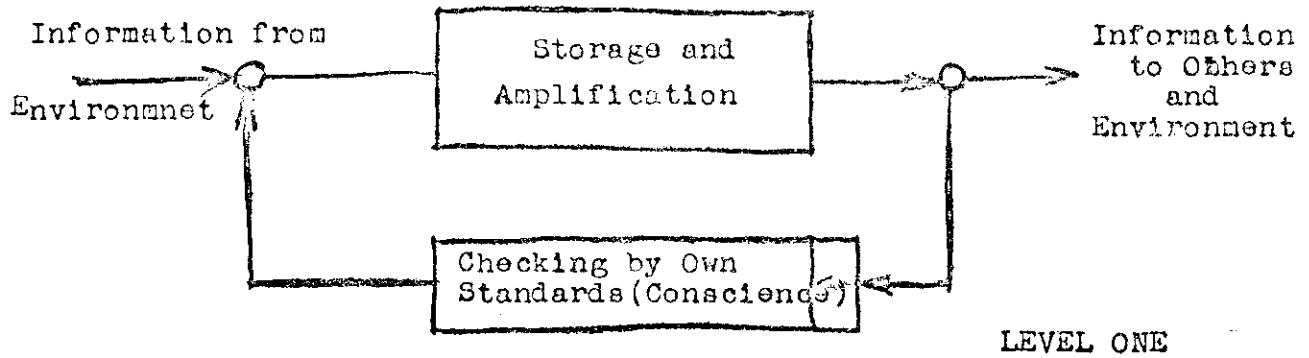


Fig. 2. Negative Feedback Representation of a Human Being.

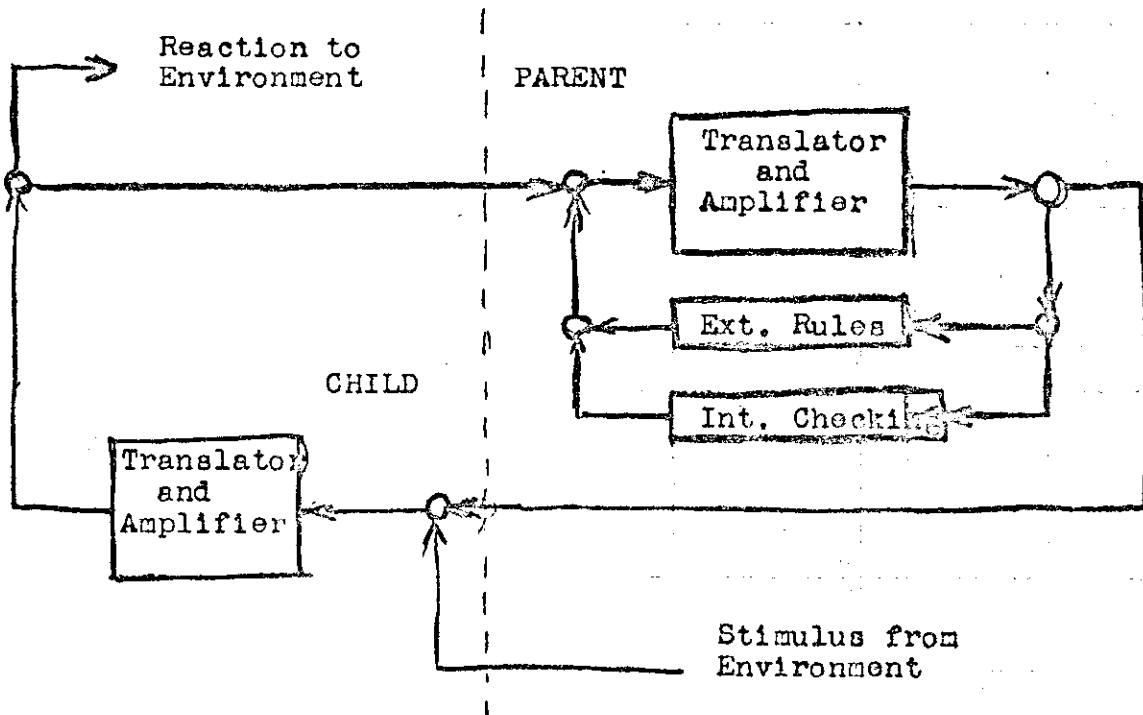


Fig. 3. Early Childhood While Parents Provide Controls.

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.

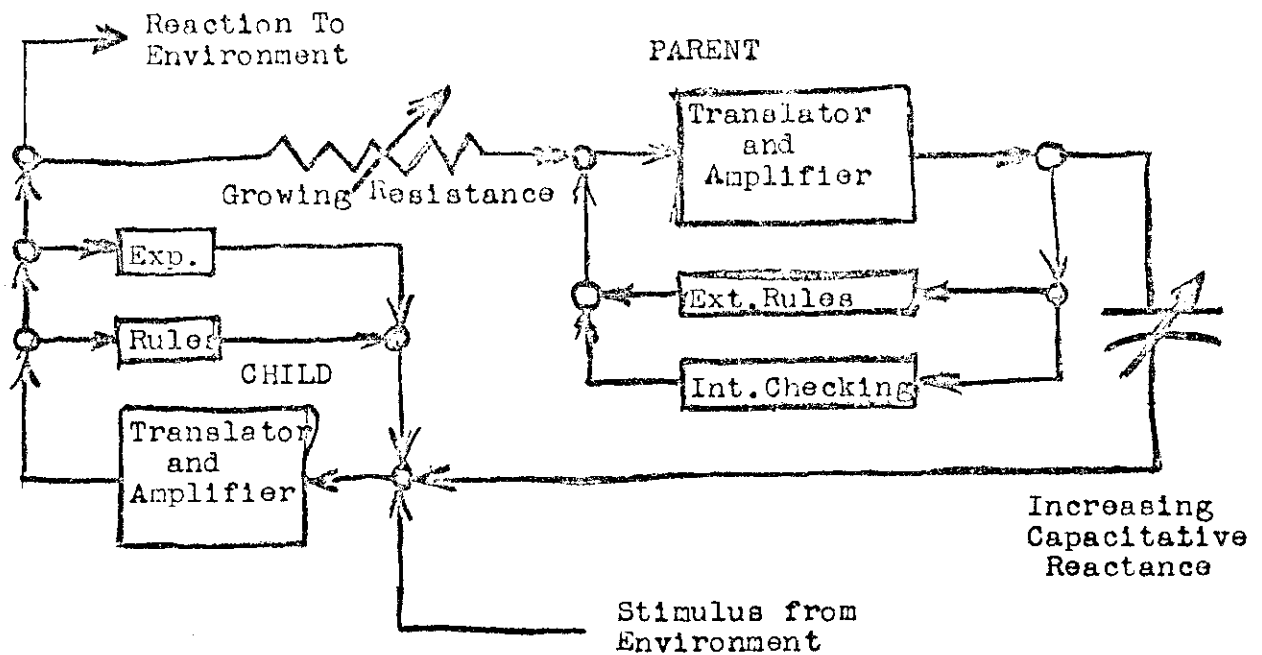


Fig. 4. Transistion of Growing Child.

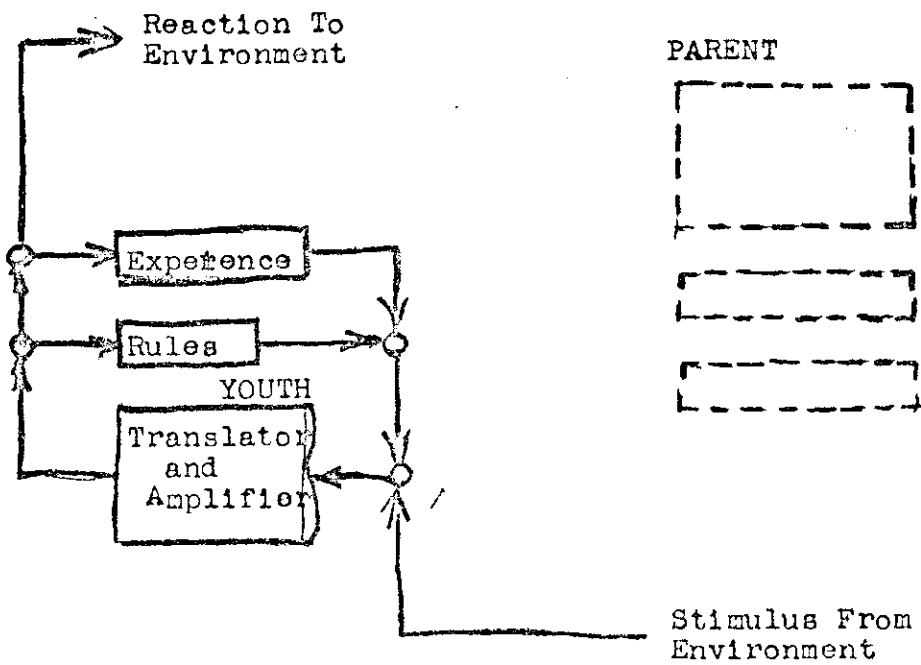


Fig. 5. Maturing Youth Becoming Independent.

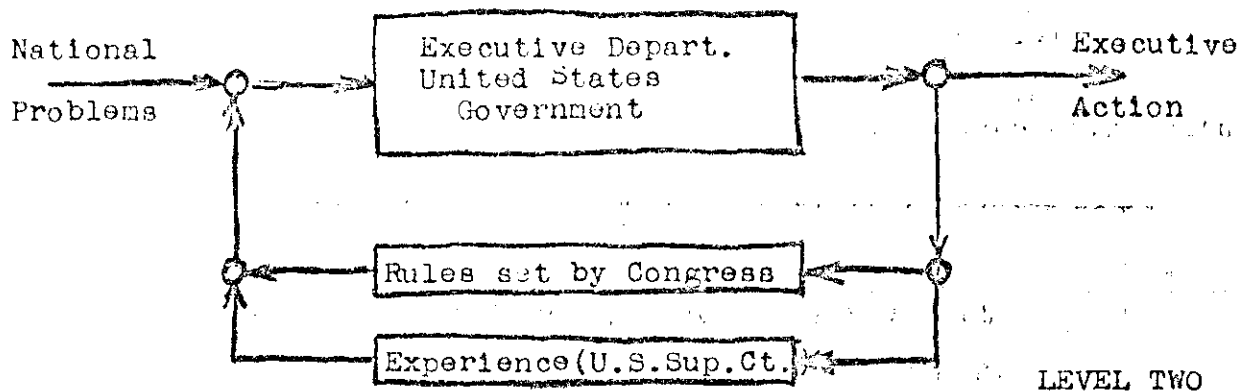


Fig. 6. Negative Feedback Circuit Representation of United States Government (Executive Department).

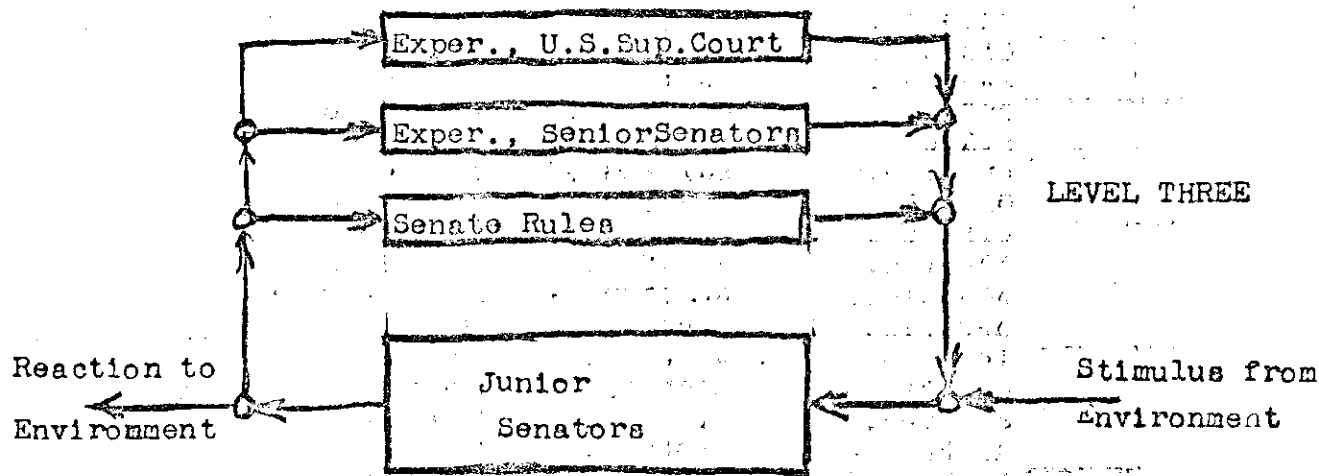


Fig. 7. Feedback Circuit of Staggered Terms in U.S. Senate.

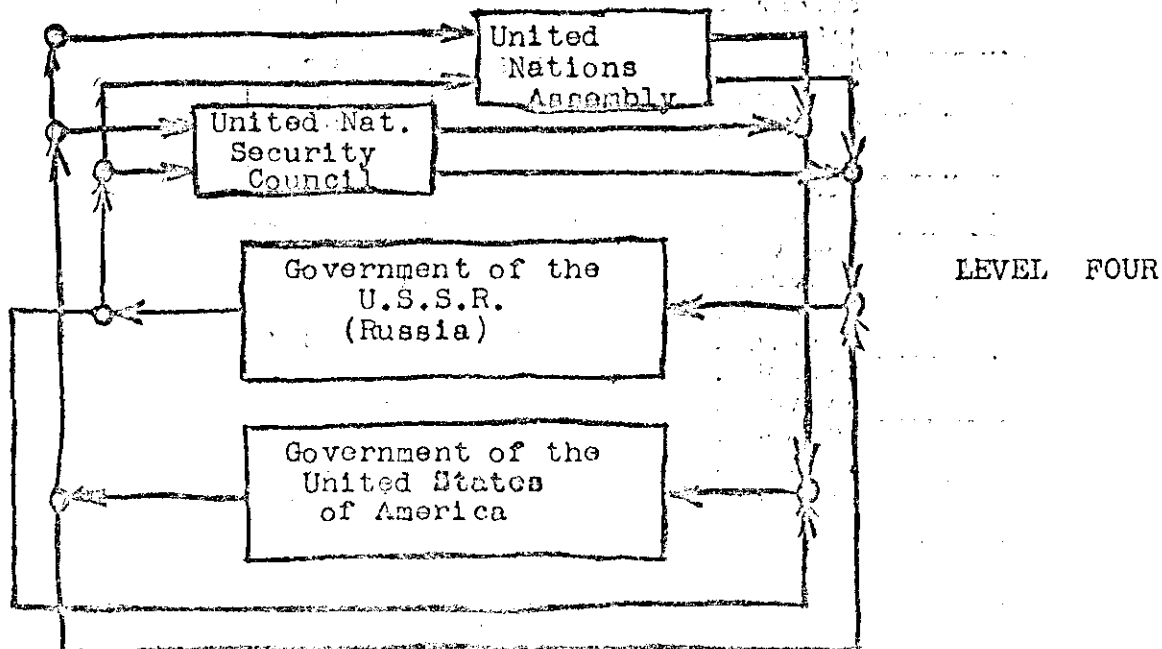


Fig. 8. Partial Feedback Loops of U.S.A., U.S.S.R., and U.N.

(b) Information-Theoretical Models of Sociological Development.

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 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.

NON-CONFORMIST 1000 PEOPLE.

THIS AREA:

□ = 100 PEOPLE

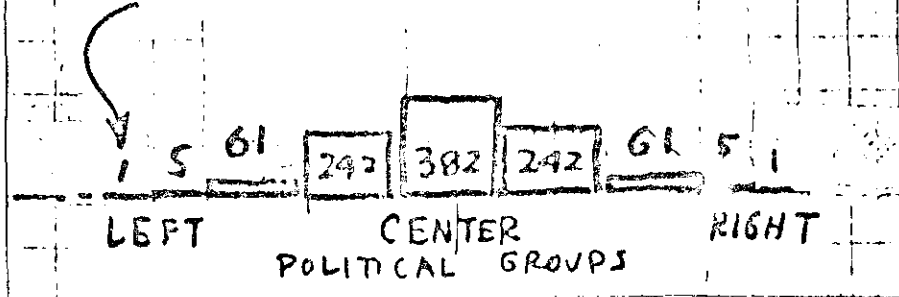


Fig. 1. NORMAL DISTRIBUTION OF PEOPLE BY POLITICAL VIEWS.

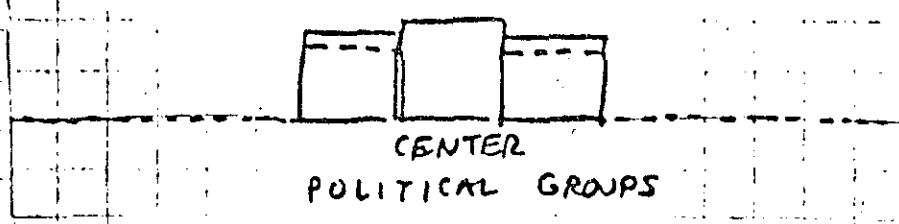
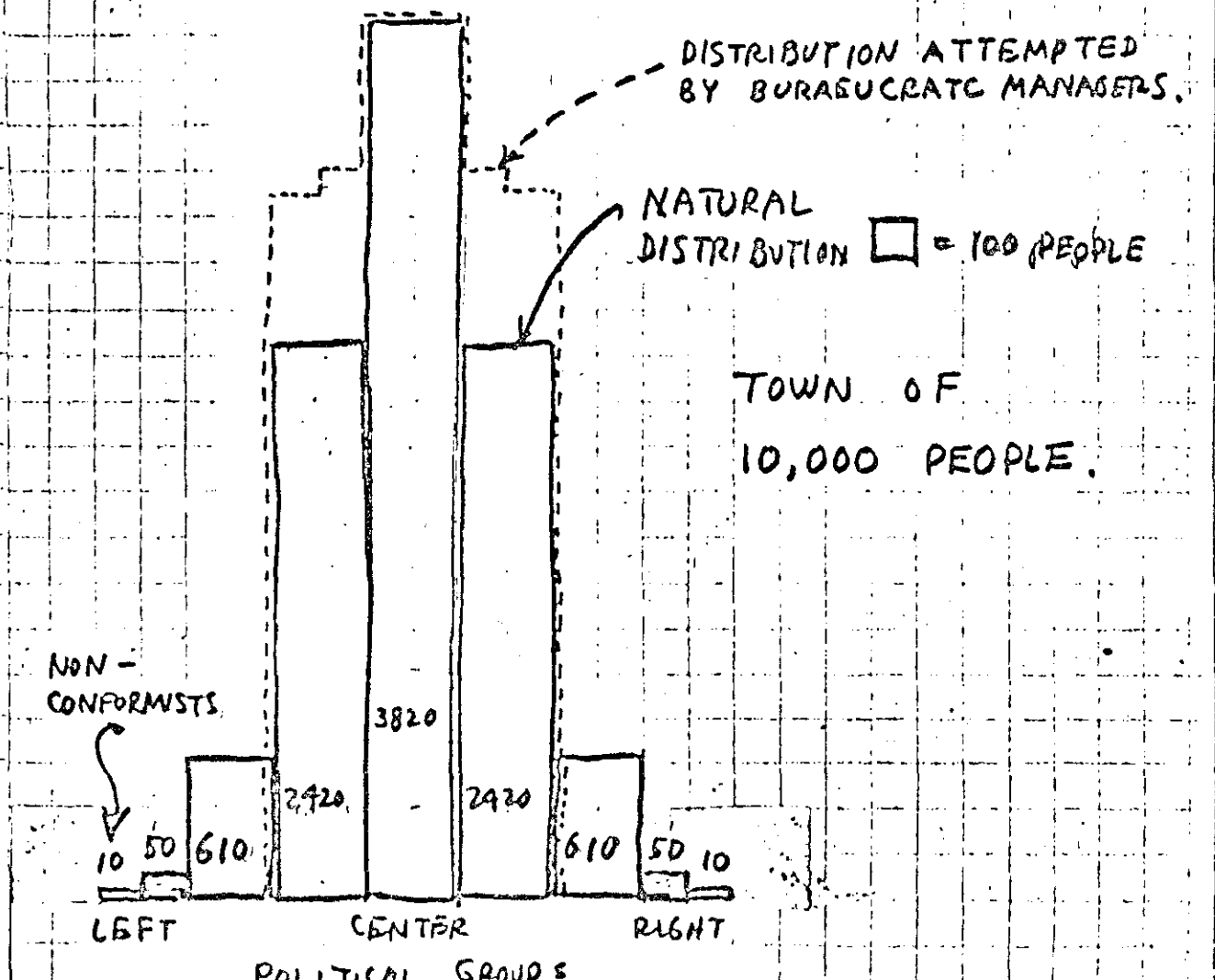


Fig. 2. EFFECT OF SOCIAL PROCESSES LIQUIDATING NON-CONFORMISTS AND APPLYING PRESSURES TO INDEPENDENTS



DISTRIBUTION ATTEMPTED BY BUREAUCRATIC MANAGERS.

NATURAL DISTRIBUTION □ = 100 PEOPLE

TOWN OF 10,000 PEOPLE.

NON-CONFORMISTS

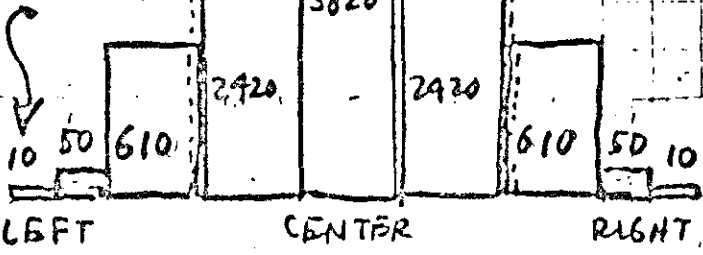


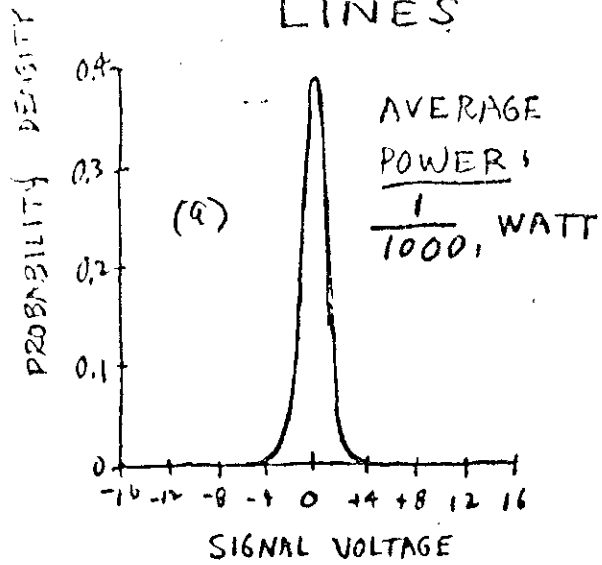
Fig. 3 DISTRIBUTION OF PEOPLE BY POLITICAL VIEWS IN LARGER POPULATION.

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

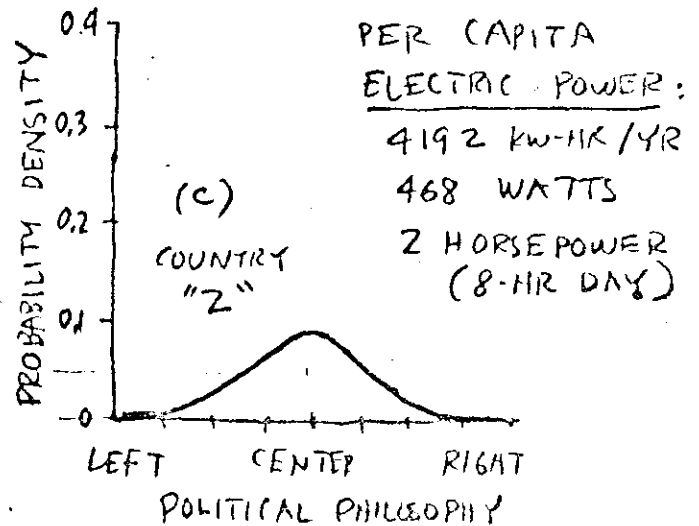
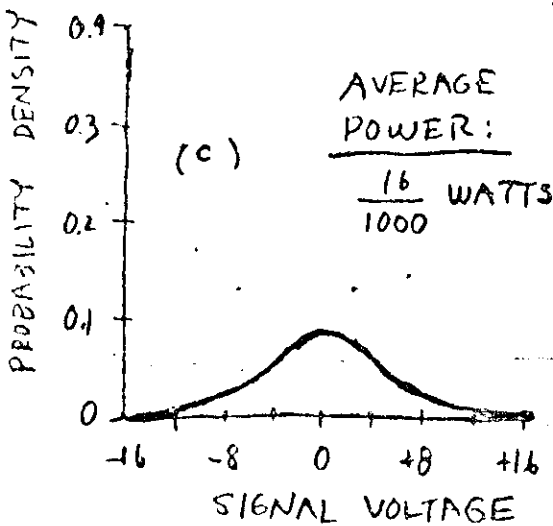
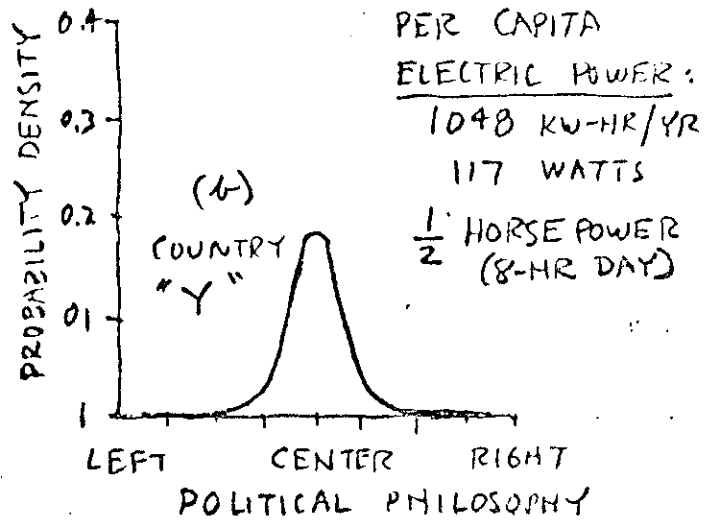
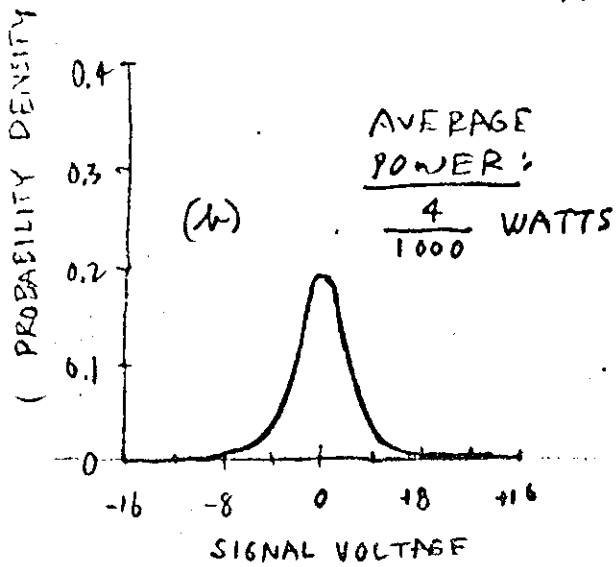
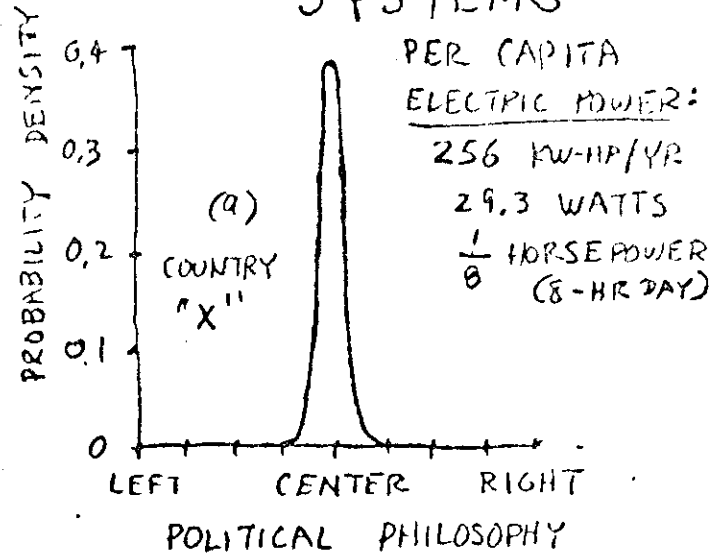


Fig. 4. OPTIMUM SIGNAL VOLTAGE DISTRIBUTION FOR TELEGRAPH SYSTEMS.

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.

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.