COMMUNICATION THEORY in the CAUSE of MAN

VOL. II NO. 5

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Notes on the application of General Systems Theory, Cybernetics, Information Theory, and related fields of Communication Theory to the strengthening of democratic institutions on our planet.

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ERRATA

CTCM Vol. II, No. 4, p. 6: 4th par., 5th line, 4th word should be: "syzygy"

ACKNOWLEDGEMENT OF PERMISSION FOR USE OF COPYRIGHTED MATERIAL:

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pp. 18-22 Article by Frederick B. Wood	The HarBus News for article in CAREERS AND THE MBA 1969.

NOTE ON REVISIONS AND ADDITIONS TO CTCM:

'7' in File No. 100-F-7 indicates updating to August 30, 1970.
'10' in File No. 98-F-10 indicates updating to March 28, 1971.
'14' in File No. 97-F-14 indicates updating to March 5, 1972.
'15' in File No. 97-F-15 indicates updating to June 18, 1972.
'16' in File No. 97-F-16 indicates updating to July 16, 1972
'17' in File No. 97-F-17 indicates updating to January 1, 1973
'18' in File No. 397-F-18 indicates updating to March 18, 1973.
'19' in File No. 397-F-19 indicates updating to June 24, 1973.

In the middle of March 1973, I learned of a small informal group of professional people in the computer industry who were exploring the possibility of organizing an informal extracurricular task force to examine the more urgent problems of our civilization with a view to finding what people in the computer industry could do to help solve the problems. They were particularly concerned about the limits on growth impacting our country's exponentially rising demands for more energy. They had some thoughts about the possibility of designing a life style that would maximize personal satisfactions, yet not require increasing energy resources. They were planning three research groups on: (1) life styles, (2) support systems, and (3) implementation. During the last part of March I was organizing material from my files that might be of help to the group. After a few weeks of preliminary activities it was determined that the group did not have the critical mass sufficient to function vigorously. Since the group died out, I plan to publish an abstract of their approach to the problems in a future issue of CTCM so that other potential groups can benefit from this short-lived project.

At the beginning of April I thought I had enough material organized to get two more issues of COMMUNICATION THEORY in the CAUSE of MAN published this spring. Three corporations in which I own a few shares of stock had stockholders meetings scheduled within the month. It occurred to me that it might be feasible to apply R. B. Lindsay's principle of the "thermodynamic imperative" to some of the issues coming up at the stockholders meetings. I decided the best policy would be to only attack the analysis of issues for which there already exist sufficient data amenable to statistical analysis for the computation of the negative entropy (or communication entropy) in regard to some significant parameters. I added a further restriction that I would only attack issues that might lead to future articles for the magazine CTCM, so as to not cause a non-recoverable delay in the magazine publication schedule.

It was getting to late to make any serious analysis in regard to one corporation stockholders' meeting. The second corporation was adjusting to a major change in its charter and procedure for electing their board of trustees, so I concluded they needed to have a year of existence under their new charter, before tackling new concepts. The third corporation had two issues on their proxy notice that were potentially analyzable by the techniques of information theory. The first issue was a proposal to include stockholder minority group nominations for directors on the proxy notices in addition to the management nominations. The second proposal was to release more information on the operations of the corporation in the Republic of South Africa.

I started collecting material on these issues. The nomination procedure proposal was initiated by the Project on Corporate Responsibility of Washington, D.C., and the proposal concerning South Africa was initiated by The Domestic and Foreign Missionary Society of the Protestant Episcopal Church in the United States of America, New York City. I got some material by mail from the Corporate Responsibility people, and talked with an assistant bishop of the Episcopal Church. As I was starting to evaluate the material on these stockholder proposals, I received word from my bank that the informal way in which I have been running this magazine was not acceptable to them. They advised me that they could not cash subscription checks made out to the magazine unless I obtained appropriate governmental and/or court approval of my doing business.

I dropped my analysis of the corporation stockholder proposals to see a lawyer about getting the necessary approvals for my selling subscriptions to this magazine. I have now obtained an employer identification number from the Internal Revenue Service, and have filed and published the proper notices of doing business under a fictitious name, "COMMUNICATION THEORY in the CAUSE of MAN."

With the time lost in protecting my magazine business interests, I was unable to devote sufficient time to the stockholder proposals before the time for the stockholders meeting passed. Perhaps I can analyze the issues in time for the 1974 stockholders meetings. A serious obstacle

in the way of ever utilizing the available application of information theory in practical business decisions, is that much of the existing material is in research reports, journal articles, and books that are not readily accessible to the public. I have found that some of the materials I would need to refer to are not readily accessible to the students at University of California, Berkeley, but are available to faculty and graduate students through the Graduate Social Science Library.

In reviewing what material was available to the public on the non-technical aspects of the problems, I found an interesting article in one of the denominational monthly magazines:

> Robert Fuoss, "Churches Versus Corporations: The Coming Struggle for Power." Presbyterian Life Edition of A.D., February 1973, pp. 38-47.(Witherspoon Building, Philadelphia, PA 19107)

I believe that a number of issues that are becoming controversial points between business corporations and the churches will soon become amenable to more scientific analysis. Instead of having a big power struggle, it may be possible to use techniques from Henri Theil's Economics and Information Theory to resolve some of the questions, like the stockholder proposal regarding proxy notices. To illustrate such techniques, I plan to publish a number of articles in CTCM going in further depth in regard to allocation of bulletin board space. As the next step, I am reprinting my article on bulletin board allocation from CAREERS AND THE MBA 1969 in Section 2.6.1.

Provost George Maslach, University of California, Berkeley, brought an important article to my attention -- "The Uses and Abuses of Thermodynamics in Religion," by Dr. Erwin N. Hiebert, Professor of the History of Science, University of Wisconsin, in DAEDALUS, 1966, pp. 1046-1080. This article is of particular significance to the ideas being developed in this magazine, COMMUNICATION THEORY in the CAUSE of MAN. Prof. Hiebert reviews a series of incidents where distinguished scientists, and in some cases Nobel prize winners, have exptrapolated their work in the physical sciences into sociology and even into the promulgation of new religions without setting up procedures for testing their hypotheses. These in turn have stimulated philosophical studies by the religious establishment, which in some cases have led to heated arguments over the implications of the laws of thermodynamics.

I have included an abstract of Prof. Hiebert's article in Section 3.9.4. Where a number of the hypotheses discussed in CTCM may to the historian of science appear similar to some of the excursions of physical scientists into the realm of sociology and religion during the past century, I have a particularly difficult job of specifying how to test my hypotheses. Starting with the first issue of CTCM, I have examined the problem of testing of hypotheses, and reviewed how hypotheses are tested in the physical sciences, and in particular how the special theory of relativity is examined. I am particularly appreciative for Provost Maslach's reference to the Hiebert article which has helped me understand the importantce of my projected plans for testing my hypotheses.

Frederick B. Wood

This outline indicates the order in which sections of the issues of the magazine CTCM issued to date can be reassembled by File Number in order to make a loose-leaf book.

Note: Title Pages and Editorial Notes from Individual Issues of CTCM have been moved to Section 3.9.7 at end of book.

OUTLINE OF PROPOSED BOOK WITH PAGE NUMBERS FILLED IN FOR SECTIONS THAT HAVE BEEN PRINTED IN THE MAGAZINE CTCM.

BOOK ONE: INTERPRETATION OF CYBERNETICS, GENERAL SYSTEMS THEORY, AND INFORMATION THEORY FOR THE CITIZEN-LAYMAN.

(GREEN PAGES)

In the discussion of 'The Thermodynamic Imperative'(*)we talked about "consuming entropy" or "decreasing entropy" or "increasing negentropy." Let us consider a hierarchy of levels of phenomena in nature, namely:

Sociological Phenomena,
Psychological Phenomena,
Biological Phenomena,
Chemical Phenomena, and
Physical Phenomena.

I assume that Professor Lindsay was primarily talking about decisions in the domain of sociological phenomena. For us to understand what entropy means on the sociological level, it is probably necessary to develop at least a superficial understanding of how the concept of entropy is used on the other four levels.

As a first step, let us look at the original use of the concept of "entropy" in physics. Let us consider the elementary case of heating a room with a hot water radiator. For this elementary analysis, we shall omit a number of details, and consider only the tank of hot water at boiling temperature radiating heat to the air in the house at room temperature(70 degrees F.).

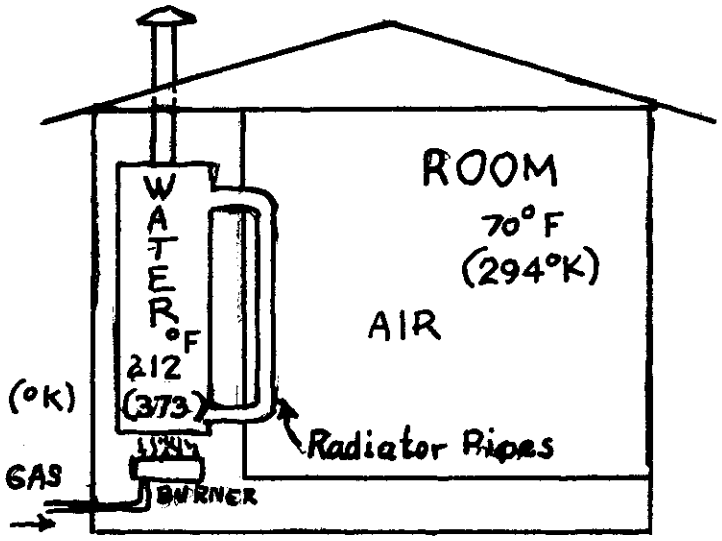


Fig. 1 - Boiling water radiator heating a house.

* CTCM Vol. II, No. 1, pp. 5-6, File No. 102, The Thermodynamic Imperative - A Star To Steer By In A Disconnected Society.

Now let us simplify the problem as shown in Fig. 2 to illustrate the significance of the concept of entropy in analysing a heating system. We shall assume that the house in sufficiently insulated, so that 4000 calories per hour will maintain the room temperature of 70 degrees F.

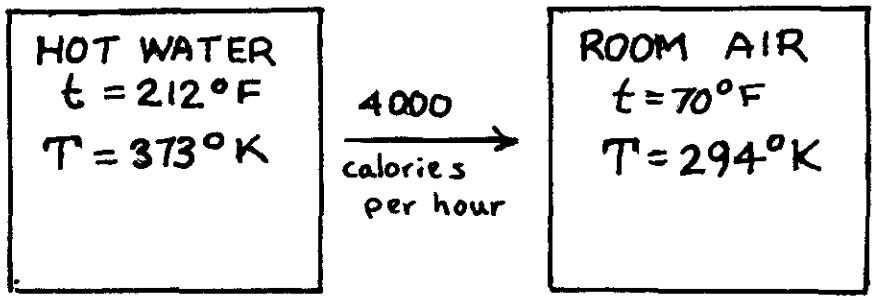


Fig. 2 - Simplified Model of Heating System.

The entropy change in a heat transfer process like this heating system is the sum of the heat gained by each body in the system divided by the temperature of the particular body. The entropy changes for the water and the room, plus the net enrropy change of the universe due to this heater and room are plotted in Fig. 3. The 2.9 calories per degree increase in entropy indicates the amount of energy that could have been converted to useful work, but instead was dissipated. Theoretically 850 calories could have been converted to mechanical work, if an efficient hot water engine was invented.

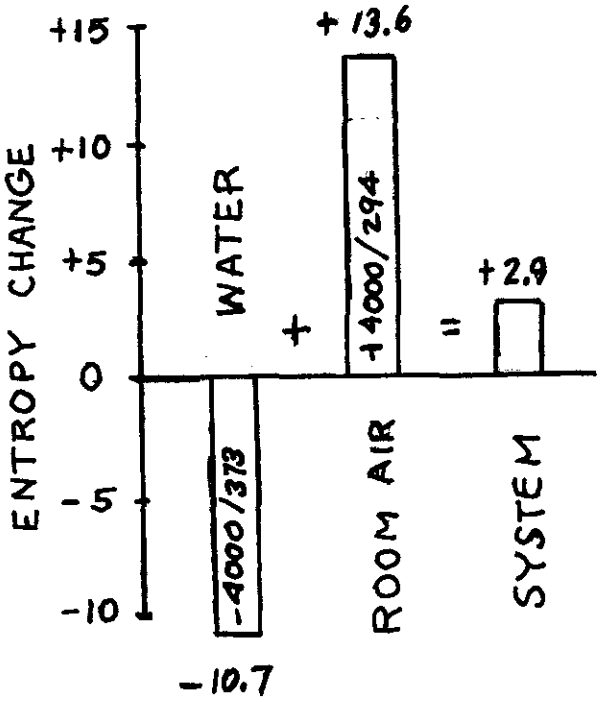


Fig. 3 - Entropy changes for heating system.

Is there a way to allocate space on bulletin boards in semi-public places, such as shopping centers and office buildings, that is equitable and free from bias? There is a potential method worth considering. Allocation of space on bulletin boards in proportion to the product of two factors can result in a simple procedure for allocation of space that is free from political bickering. An example for religious group notices in a public building was given in CTCM Vol. I, No. 3 4, pp. 9-11 (File No. 124, pp. 1-3).

Let us consider a bulletin board in an office building or factory complex. If we give each tenant or employee a vote as to which organization he wanted to have space on the bulletin board, we might have a distribution like that in Fig. 1. In this case the Democratic Party gets one third of the space, but may not necessarily have that much to say. If we look at the top part of the Morse code table in Fig. 2, we see that the more frequently used letters have a shorter code for more efficient utilization of the telegraph lines. If we apply a similar principle to the allocation of bulletin board space, we

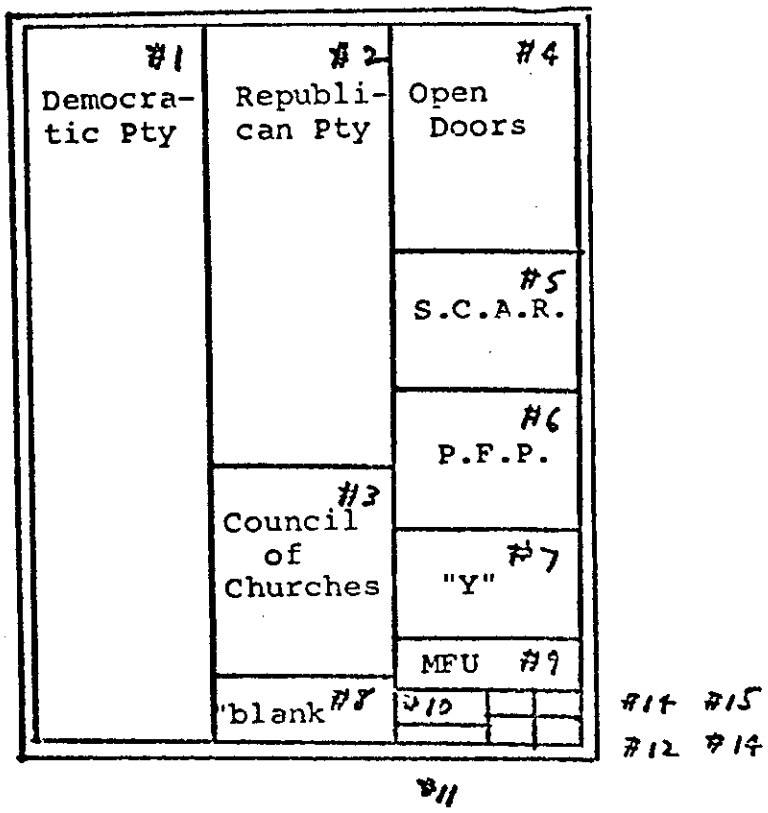


Fig. 1 - Distribution of Bulletin Board Space In Proportion To Probability Distribution.

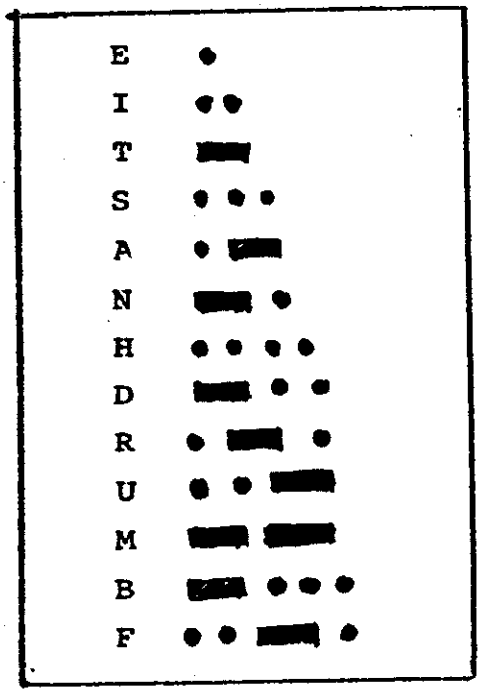


Fig. 2 - International Morse Code, Letters in Order of Frequency

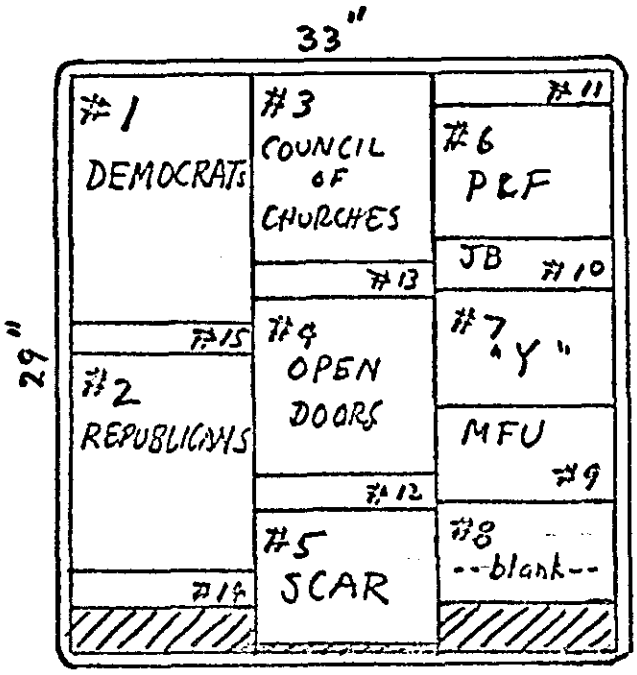


Fig. 3 - Distribution of Bulletin Board Space In Proportion to Weighted Probabilities(Proportional to Measure of Information)

can make more efficient use of the bulletin board space and at the same time give each organization an equitable share of the space, based on the product of the size of the organization multiplied by a factor proportional to amount of information that is new or relatively unknown to the public in the messages of the particular organization. Fig. 3 is an example of such an allocation. A more detailed discussion of this principle is given in Section 2.6.1. Sample calculations of the bulletin board space allocations are given in Section 3.2.0.

After a number of elementary cases such as bulletin boards, like this one, have been thoroughly studied and tested, it may be possible to apply similar logic with the assistance of information theory to more complicated problems such as allocation of space in corporation proxy notices in regard to nominations and proposed policies to be voted on at stockholder meetings.

There are possibilities that information-theoretical methods can also lead to solutions of allocation problems in places like the Republic of South Africa, where the present apartheid policies are leading toward an eventual violent conflict that would wipe out most of the whites in South Africa. However a number of studies have to made in regard to simpler problems, before we can properly apply these concepts to the more complex problems.

Reviews of books, reports, and articles formerly reported in Section 3.9.4 will now be reported in the following sections, depending upon whether the primary emphasis is on (1) explanation to the layman, (2) technical application to specific problems, or (3) philosophical and scientific testing of hypotheses and mathematical details:

Explanation for the layman:	Section 1.9.4;
Technical applications:	Section 2.9.4;
Testing hypotheses:	Section 3.9.4.

J. T. Fraser, "Some Reflections on Time, Science, and Man." 1971 Britannica Yearbook of Science and the Future. Encyclopaedia Britannica, Inc., Chicago. pp. 94-105. Includes sections on:

The limits of time...the very small and the very large
The limits of time...the very quick and the very dead
The entropy game...as played by the physical universe
The entropy game...as played by life
The uncertain future and the surviving past
The flight from time
Time, science, and the future

This article has an important elementary discussion of entropy in physical and biological systems.

LIFE Science Library, 26 volumes, N.Y.: TIME-LIFE Books(1967).

Selected references are tabulated below:

Cybernetics:	vol:	MACHINES, pp. 168,188; THE MIND, pp. 173-180, 188-189.
Entropy:	vol:	TIME, pp. 169-175; ENERGY, pp. 59-60, 68-69;
Feedback:	vol:	MACHINES, pp. 172-173, 178; SOUND AND HEARING, pp. 62; GROWTH, pp. 142; THE BODY, pp. 176; THE CELL, pp. 124;
Information Theory:	vol:	MATHEMATICS, pp. 50, 54; THE SCIENTIST, pp. 86, 87, 100, 147;
Systems Analysis:	vol:	THE ENGINEER, pp. 172-176;
Systems Engineering:	vol:	THE ENGINEER, pp. 77-89,93,101,172-174.
For more detailed references, see:	vol:	A GUIDE TO SCIENCE, an Index to the LIFE Science Library.

Oliver C. Cox, Capitalism as a System. N.Y.: Monthly Review Press(1964)

Dr. Cox shows that the capitalist system has a definable order and structure which determine and limit the sphere of action open to people, not only according to their status in their own societies but also according to the status of their society in the system as a whole.

Part I: Structure and Function

1. Structure of the System
2. The Social Matrix
3. The Role of Religion
4. Moral Aspects (I)
5. Moral Aspects (II)
6. Dynamics of the System
7. The Primary Force
8. How Much Foreign Trade?
9. Imperialism
10. Can Imperialism Be Abolished?

Part II Concpetions of Capitalism

11. The Narrowing Frontiers
12. Movements Toward Change
13. The Law of Motion (I)
14. The Law of Motion (II)
15. The System in Transition

Richard J. Barnet, Roots of War, N.Y.: Atheneum Publishers(1972); reprinted by Pelican Books(1973).

"This book is not about the Vietnam War but about the roots of a generation of war. What is there about mid-century America that has led her to pursue the national interest by spreading death, terror, and destruction? This analysis has grown out of a conviction that the United States has committed monumental crimes in Indochina and that these crimes are likely to be repeated unless we gain a much deeper understanding of what we have done as a nation and why we have done it.

The thesis of this book is that war is a social institution, that America's permanent war can be explained primarily by looking at American society, and that America's wars will cease only if that society is changed."

(Richard J. Barnet is cofounder and codirector of The Institute for Policy Studies.)

In CTCM I/3-4(File 124)* the use of negentropy was introduced as a tool to help make decisions on the allocation of scarce public resources. In this issue (File 294) a book by the economist, Henri Theil, is reviewed in which information theory is applied to a number of economic problems. In this section an important problem of human communication in our industrial society is examined.

This article, "The Use of Cybernetics To Solve An Employee Communication Problem," first appeared in the annual publication, CAREERS AND THE MBA 69, **issued by The HarBus News at Harvard Business School, Boston, Massachusetts.**

This material is reprinted at this time, because it is very important for the survival and growth of democractic processes in our civilization. In our stage of capitalist development where we have quasi-monopolistic domination of many sectors of the economy, we need some means of insuring sufficient communication between citizens to insure democratic political functioning. In socialist countries there is a need for some safeguards to insure democratic procedures. Information theory offers us procedures for measuring the degree of democracy and techniques of allocating bulletin board space and other communication facilities. Cybernetic feedback loop analysis offers us a better qualitative insight as to the problems of our civilization. When we are able to define all the significant variables in a social system, we can then develop computer simulation programs to help us evaluation alternative policies. Lacking detailed understanding of our civilization, we can at least take steps to improve the communication between people in our social system, so that people are aware of the problems and have the facilities for communicating proposals to their fellow citizens for discussion.

An important feature of the bulletin board allocation system developed in the following pages is that the corporation is provided with a formula for allocating bulletin board space as a function of statistics on membership, confidential questionnaire, or secret ballot. Thus the corporation is relieved of making any political decisions. They can rely on a formula from information theory for allocating space.

* CTCM, Section 1.2.4:"Public Bulletin Board Space," Vol. I, No. 3-4, Aug-Sept 1970, pp. 9-11(File No. 124, pp. 1-3)

The Use of Cybernetics To Solve An Employee Communication Problem

by Frederick B. Wood, Ph.D.
Cybernetics Consultant

John Jaguar, a fresh MBA, has just been hired by a large corporation to be a special assistant to the manager of one of their engineering development laboratories. The manager has just called Mr. Jaguar into his office and says:

"Welcome on board John. I've heard a lot about the case method at HBS. We've got another case study all ready for you, only this one is for real. Here is the problem;

1) We have a few engineers and computer programmers who are grumbling about various things. But they don't seem to be complaining about wages, working conditions, and the usual concerns workers complained about in the past. Now they are complaining because they cannot put notices on the company bulletin board about all sorts of external meetings that have nothing to do with the business of this corporation. They want to have luncheon speakers like Eldridge Cleaver, Caesar Chavez and Brigit Bardot.

2) We have this restrictive bulletin board policy to minimize the possible interference of outside organizations with the work of our engineering laboratory. Until recently we have had no significant objections to these bulletin board policies. We are puzzled why employees are now asking for bulletin board space for community meetings on race relations, problems of the ghetto, and political science seminars.

3) We hired an outside management consultant to examine this problem, but he died of a heart attack after a few days of study. The nurse at the hospital says his dying words were "Try Cybernetics."

4) We also checked out all the books on Cybernetics and Management and didn't find anything that clearly applies to this problem.

The laboratory manager then told Mr. Jaguar that he had thirteen days in which to come up with a proposed solution. Below is a copy of the report that Mr. Jaguar delivered to the laboratory manager on a Sunday evening fifteen days later.

Case Study: Cyber-0001

THE USE OF CYBERNETICS TO SOLVE AN EMPLOYEE COMMUNICATION PROBLEM AT XYZ CORPORATION

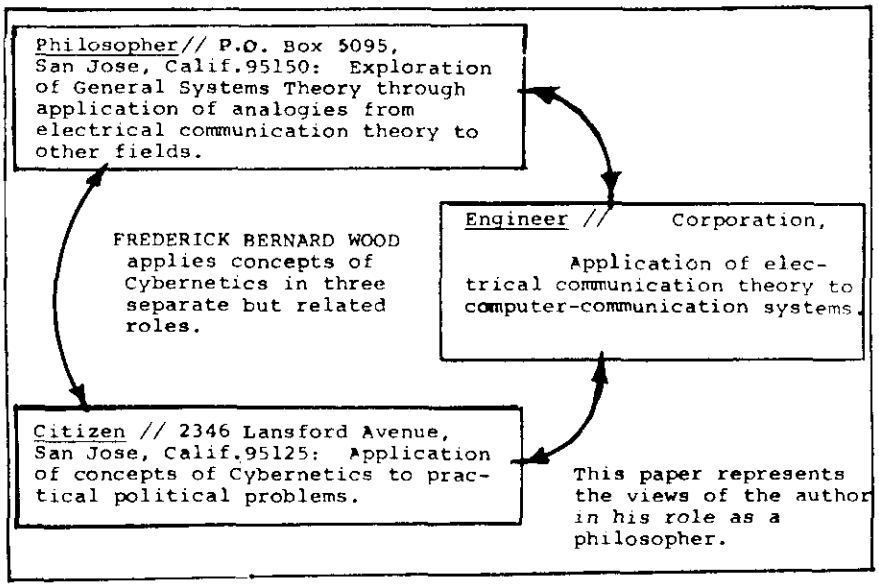
By John Jaguar

This problem centers around XYZ employee demands for bulletin board space within the plant – private property of the corporation – for activities not related to the traditionally defined "business" of the corporation. These new demands of the employees appear to be related to the problems Peter F. Drucker was talking about in *The Future of Industrial Man* (1942):

"In other words, the plant must be made into a functioning self-governing community. It must be made capable of serving industrial society in the same manner in which the village served the rural society and the market at the mercantile society (p205)".

Thus, given the dominant role of the industrial corporation in our society, it must provide greater opportunity for individual growth and development. These employees at XYZ want to communicate and interact in a meaningful way with each other. They are asking that through the bulletin board their roles as individuals as well as organization men be recognized. (See Fig. 1, Environmental Forces.)

The problem then for us is to find a possible solution which will allow room for both the corporate employee's role as an individual and as an organization man. Let us explore what the outside consultant meant by his dying words "Try Cybernetics," and see how the MBA can use his education to apply Cybernetics to the bulletin board problem at XYZ.



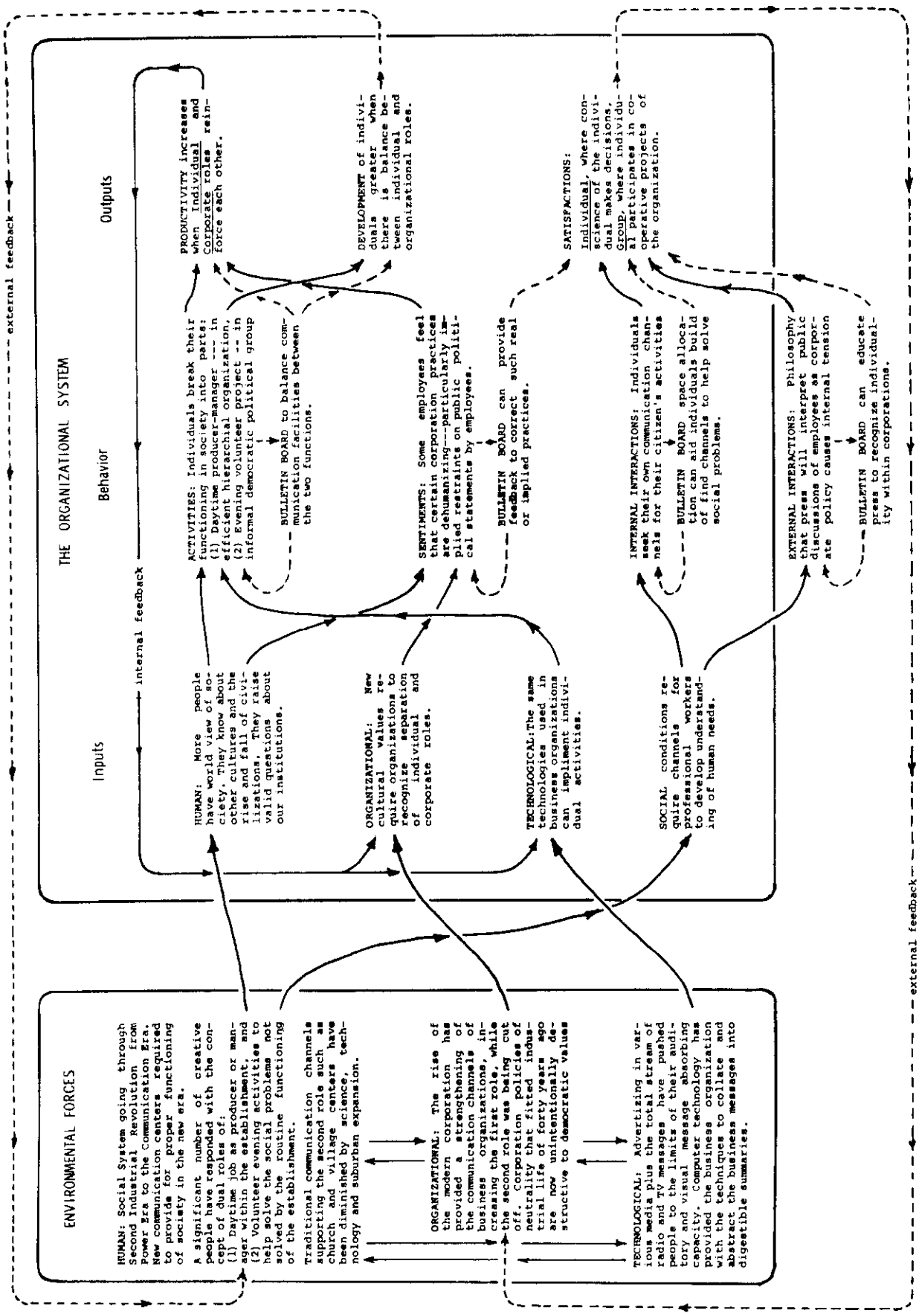


Fig. 1 - Diagrammatic Analysis of XYZ Corp. Employee Communication Problem.

Reviewing the literature of Cybernetics indicated two possible applications to our problem: (1) The qualitative clarification of the feedback loops in the business organization with regard to the bulletin board problem (similar to the analyses in our HBS human behavior courses), and (2) The quantitative calculation of the information content of the messages to be put on the bulletin boards through the extension of the probability concepts from the HBS course on statistics (MERC II-III) as extended by Shannon's book: The Mathematical Theory of Communication (1949).

Figure 1 outlines the qualitative structure of the feedback system involved in the employee communication problem of XYZ Corporation. Here we indicate the impact of changing environmental forces on the inputs to the organizational system. The potential impact of appropriate bulletin boards in satisfying the demands of employees for better communication is shown by the additional communication channels. The internal feedback and external feedback loops indicate how the bulletin boards could help stabilize both the inputs and the environmental forces in a

AFRO-AMERICAN PARTY	NATIONAL STATES RIGHTS PARTY
AMERICAN INDEPENDENT PARTY	PEACE AND FREEDOM PARTY
AMERICAN LABOR PARTY	PROHIBITION PARTY
COMMUNIST PARTY	REPUBLICAN PARTY
CONSERVATIVE PARTY	SOCIALIST PARTY - SOCIAL DEMOCRATIC FED
DEMOCRATIC PARTY	SOCIALIST LABOR PARTY
INDUSTRIAL GOVERNMENT PARTY	SOCIALIST WORKERS PARTY
LIBERAL PARTY	

Fig. 2 - Allocation of Bulletin Board Space with Equal Space for Each Political Party

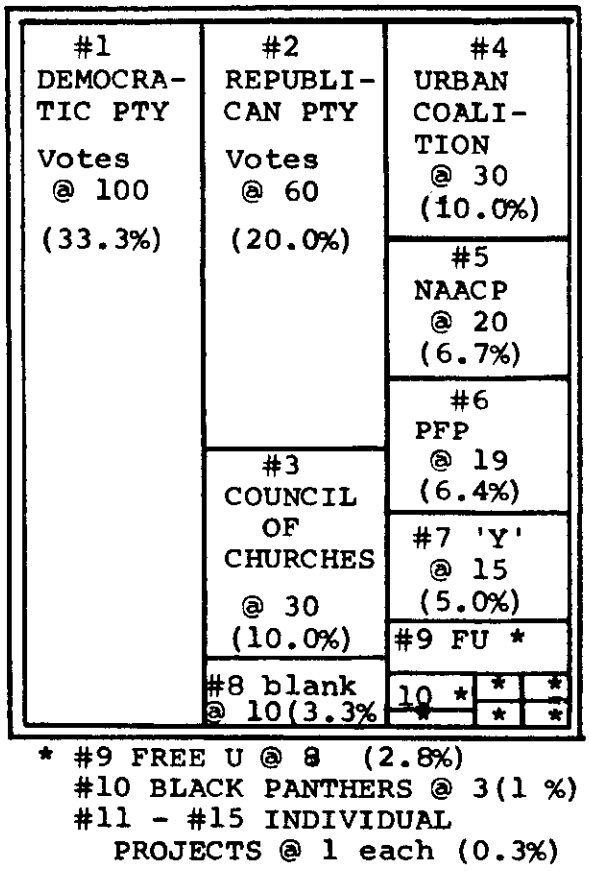


Fig. 3 - Distribution of Bulletin Board Space in Proportion to Preference Probability

constructive way.

For the moment let's assume that the manager agrees to expand human communication and provide some additional bulletin board space on the laboratory premises. We now have a decision to make as to the basis for bulletin board space allocation.

One way would be to give equal space on the bulletin board to each national party that ran a candidate for president in at least one of the last four presidential elections as illustrated in Figure 2.

However, a more effective basis for space allocation is to use internal criterion such as the distribution of preferences among the employees of the laboratory. Last week we made a survey by distributing a confidential questionnaire to all the employees of the lab. We distributed the questionnaire to all 350 employees, and received returns from 300. Of the 300, ten were returned blank or with comments objecting to the bulletin board project.

The results of the survey are listed by number of employee votes and percentages in Figure 3, and are plotted as a probability distribution in Figure 4A. In this survey we stated that preference could be given to any political party, religious group, social group, or even to a one-man project.

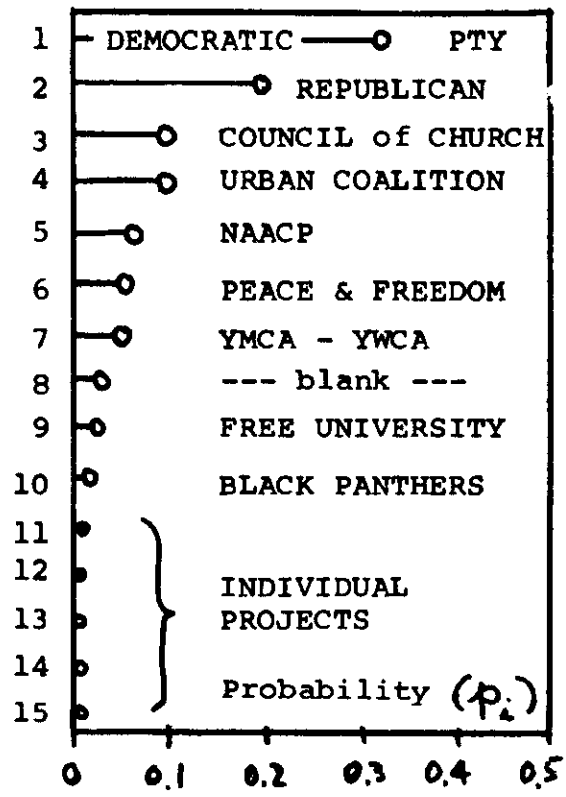


Fig. 4(A) - Probability of Different Preferences

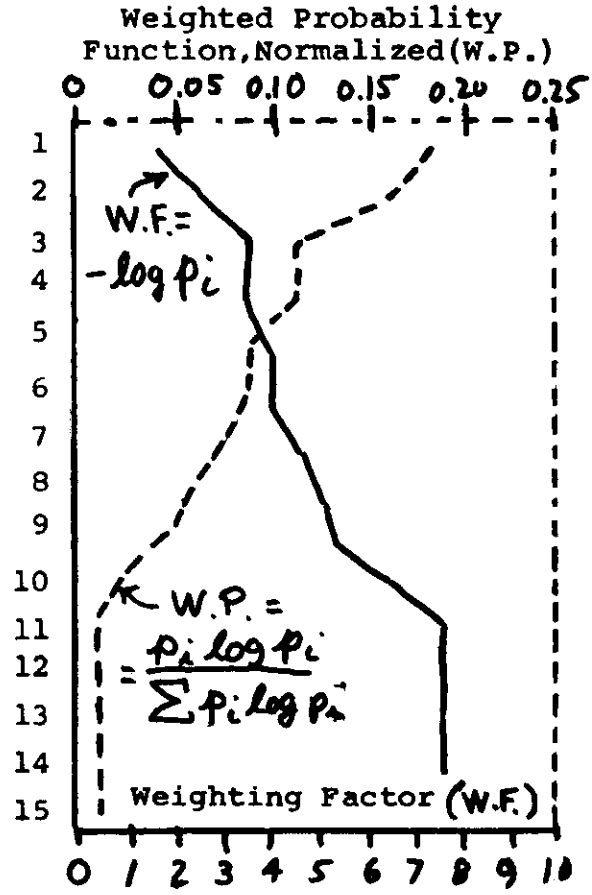


Fig. 4(B) - Weighting Factor and Product of W.F. and Probability for Space Allocation

The next question is what formula should we use to allocate the space. One simple way is to allocate the space in proportion to the votes employees in the lab gave to the indicated groups. The space allocation in Figure 3 illustrates this type of bulletin board. This allocation appears logically fair, but somewhat inefficient.

The Democratic and Republican Parties have more space than they have messages with which to fill the spaces. The Black Panthers and Individual Projects No. 1 through No. 5(11-15) have barely enough space to list their name and telephone numbers. Isn't there some way of weighting the probability distribution which will make more efficient use of the space and still be an equitable division?

The division of space on a bulletin board is similar to the design of a telegraph code. We can get a rough approximation using the technique used over a century ago by S. F. B. Morse used in designing the original Morse Code, or we can be more sophisticated and use Claude Shannon's definition of information as proportional to the logarithm of the probability.

Starting with the probability distribution of the preference of lab employees for particular groups in Figure 4A, we compute a weighting factor based on Shannon's definition of the measure of information in a message. In Figure 4B the weighting factor and the weighted probability distribution are plotted. Then a bulletin board layout with space proportional to the weighted probability function is shown in Figure 5.

Finally, let's apply one more famous Business School concept in evaluating the bulletin board as a solution to the

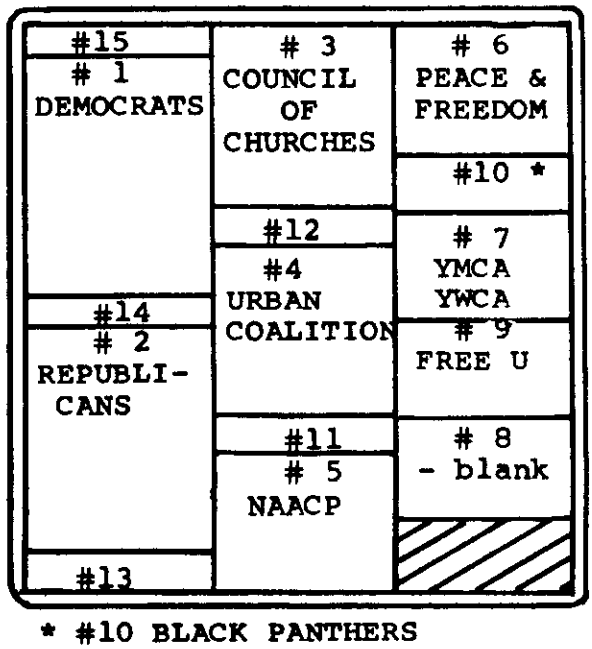


Fig. 5 - Distribution of Bulletin Board Space in Proportion to Weighted Probability Function.

employee communication problem. Figure 6 shows a decision tree and its related outcome table. Instead of the usual dollars gained or lost on the different branches, positive and negative effects on the system are indicated by plus (+) and minus (-) signs. To make the decision tree complete, the choice of no bulletin board is included, and such a decision has a negative outcome for the solution of our problem.

Assuming the manager opts for a bulletin board, the next decision concerns whether external or internal criterion (i.e., national or local employee interests) are to be used as the basis for space allocation.

If the manager decides to follow the second alternative, equal allocation for each political party, we have a positive outcome in three and a half columns of the outcome matrix. However, this alternative doesn't solve the original problem of employee complaints, because the list of national political parties does not relate to all of the local problems.

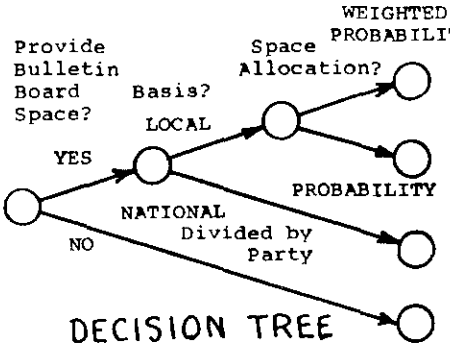
If the bulletin board space is allocated in direct proportion to the probabilities that local employees prefer different groups, we have the board of Figure 3, and we find that this gives a positive outcome in seven out of nine columns in Figure 6.

Finally we examine the probable outcome if the manager chooses a more efficient allocation, namely where space is assigned in proportion to the probability preference weighted by the information content of the group as shown in Figure 5. Here we estimate a positive outcome in all nine columns.

In conclusion, after studying the XYZ employee communication problem using the Cybernetic principles of feedback and feedback loops, we found that the expressed employee need for a bulletin board resulted from the environmental demand that corporations provide greater opportunity for individual growth and development and recognize both the individual citizen role and the organization man role of each employee.

And our decision tree analysis has indicated that this growth and development is facilitated by interpersonal communications which are in turn strengthened by media such as the simple bulletin board.

Finally, we found that efficient and equitable allocation of bulletin board space can be accomplished by using Cybernetic principles from communication and information theory combined with probability and statistics concepts from the MBA curriculum. ●



Resolve problem of employee complaints about bulletin board.	Provide bulletin board space for community projects in a neutral manner.	Fulfill Peter Drucker's specification of community communication center.	Provide pilot test of aid to international corporations to be socially responsible.	Protect corporation from charges of violation of constitutional rights of employees.	Promote respect for the individual in a mass society.	Promote natural development of communication feedback loops.	Promote individual social responsibility.	Be consistent with transition from "Power Era" to "Communication Era."
+	+	+	+	+	++	++	++	++
+	0	+	+	0	+	+	+	+
0	±	+	+	0	−	−	+	0
−	−	−	−	−	−	−	−	−

Fig. 6 - Decision Tree and Outcome Matrix

Economics and Information Theory by Henri Theil, Center for Mathematical Studies in Business and Economics, The University of Chicago. Amsterdam: North-Holland Publishing Co.(1967) and Chicago: Rand McNally **(Now distributed in U.S.A. by American Elsevier Publishing Co., New York)**
The author states that probability theory entered economics in three stages: (1) probability affected economics indirectly via the **statistical methods used;** (2) probability theory entered economics more recently in the development of decision making under uncertainty; and (3) more recently probability theory entered economics again in problems of the allocation of scarce resources.

This book deals with allocation proportions in economics. The author uses information theory as the method of analysis which is a part of probability theory. He uses concepts from information developed by communication engineers. A section on historical notes points to the origin of information in statistical thermodynamics, where the entropy concept was developed. Credit is properly given to R. V. L. Hartley as a forerunner of information theory("Transmission of Information", Bell System Technical Journal, Vol. 7(1928), pp. 535-563.). The largest stimulus to development of information theory is properly credited to C. E. Shannon("A Mathematical Theory of Communication," Bell System Technical Journal, Vol. 27(1948), pp. 379-423, 623-656.).

The basic connection between information theory and allocation proportions in economics is that given a scarce resource with n alternative uses where the fraction allocated to each use is p_1, p_2, ..., p_n; then it can be shown that these fractions are equivalent to probabilities. Then we can use the mathematics of information theory where we have a similar set of probabilities of different possible messages being sent on a telegraph line.

Theil states that the references he found on applying information theory to economics were mainly confined to the presentation of analogies. He points out that information theory is really something more general than a theory dealing with information concepts. He feels it is actually a general partitioning theory that provides measures for the way in which some set is divided into subsets. He points out that this was discussed by De Jongh(Egalisation, Disparity and Entropy. Utrecht: A. W. Bruna en Zoons - Uitgevers Maatshappij, 1952

The book consists of four parts. The first part introduces the basic technical **concepts** and illustrates them with economic examples:

Ch 1: The Information Concept
Ch 2: Expected Information
Ch 3: Economic Relations Involving Conditional Probabilities

The next part deals with specific classes of economic problems centering around the family household:

Ch 4: The Measurement of Income Inequality
Ch 5: A Statistical Approach to the Problem of Price and Quantity Comparisons
Ch 6: The Consumer's Allocation Problem
Ch 7: Empirical Implications of the Allocation Model of the Consumer

The third part of the book extends the analysis to the firm and to international trade:

Ch 8: Industrial Concentration and the Allocation Problem of the Firm
Ch 9: Input-Output Analysis and Its Aggregation Problems
Ch 10: information Measures in the Analysis of International Trade

The first three parts of the book deal with discrete probability distributions. The fourth part consists of one chapter in which information is defined in terms of continuous probability distributions.

Ch 11: Continuous Information Theory and a Multiplicative Decomposition of Prediction Error Variances

The book contains many examples which are amply illustrated with graphs and tables. Many interesting examples are given. In the first chapter the use of information concepts are illustrated by a discussion of the information gain of weather forecasts. Then it is extended to the analysis of the information gain of economic survey forecasts. Tables are given to illustrate the concepts in respect to different industries in Europe.

A formula is developed for the information inaccuracy of forecasts. The measure is applied to the input distributions.

The inequality of income distributions includes a number of examples. First entropy is used as a measure of equality. Then the entropy is subtracted from the maximum entropy to get a measure of inequality. Theil proposes this entropy difference measure of inequality as a better measure than Gini's measure of inequality. He includes projections of the population shares and income shares of 54 countries for the years 1949, 1957, and 1976 with a table of the calculated inequalities for the same years. There are also tables of inequalities for income of white and non-white families in the United States.

Another set of examples illustrates the entropy of passenger car production in the U.S. The table of entropy of passenger car production for the years 1936 to 1964 illustrates the dramatic disappearance of the independent car manufactuers in the last few years of the table.

The chapter on input-output analysis contains an excellent summary of the basic elements plus an analysis of the information content of the input-output table. From this the change in information due to aggregation of sectors into groups is calculated so that decrease of information can be reduced by optimum choice of industry sets.

Further there is an analysis of the prediction of trade flows between different countries and between the Common Market and the Rest.

(a) Sample Calculation of the Entropy Changes in the Heating System discussed in Section 1.0.3:

Ref: Henry A. Bent, The Second Law - An Introduction to Classical and Statistical Thermodynamics. New York: Oxford University Press (1965).

Introduction and Synopsis, pp. 1-5
Chapter 8: Temperature(II) - The Absolute Temperature, pp. 47-5

In the example illustrated in Section 1.0.3, the entropy decrease per hour for the hot water used in the heating system is:

$$-(4000 \text{ calories/hour}) / 373^{\circ}K = -10.72 \text{ cal}/^{\circ}C \text{ per hour}$$

The entropy increase per hour for the air in the room is:

$$+(4000 \text{ calories/hour}) / 294^{\circ}K = +13.6 \text{ cal}/^{\circ}C \text{ per hour}$$

The net increase in entropy of the system is:

$$\Delta H \text{ per hour} = -10.72 + 13.6 = +2.88 \text{ Cal.}/^{\circ}C \text{ per hour}$$

The absolute temperatures were calculated as follows:

Temperature of boiling water is 100° Centigrade or 212° Fahrenheit.
Absolute temperature is: $273^{\circ} + 100^{\circ} = 373^{\circ}$ Kelvin
Room temperature of 70° Fahrenheit is:

$$273 + 100 \times (70-32) / (212-32) = 272 + 100 \times (38/180) =$$
$$273 + 21.1 = 294.1^{\circ}K$$

(b) Sample calculations for the allocation of bulletin board space. for the examples in Section 2.6.1:

Table I summarizes the calculations for Figs. 4 & 5 in Section 2.6.1 on the distribution of bulletin board space.

Table I: Tabulation of Preference Probabilities, Weighting Factors, Weighting Factor Products, Weighted Allocation Probabilities, Print Lines, and Length of Space (Width 8½")

i	Preference Probability p_i	Weighting Factor $-\log_2 p_i$	Weighting Factor Product $-p_i \log_2 p_i$	Weighted Allocation Prob. P_i	Print Lines [Computer] N	Length (inches) $S=1+N/6$
1	0.333	1.58	0.5282	0.183	63	11.5
2	0.200	2.32	0.4643	0.161	54	10.0
3	0.100	3.32	0.3321	0.115	45	8.5
4	0.100	3.32	0.3321	0.115	45	8.5
5	0.067	3.91	0.2612	0.090	31	6.2
6	0.064	3.98	0.2512	0.087	30	6.0
7	0.050	4.32	0.2160	0.075	26	5.3
8	0.033	4.92	0.1627	0.057	19	4.2
9	0.028	5.25	0.1406	0.049	17	3.8
10	0.010	6.64	0.0664	0.023	8	2.3
11	0.003	7.45	0.0251	0.009	3	1.5
12	0.003	7.45	0.0251	0.009	3	1.5
13	0.003	7.45	0.0251	0.009	3	1.5
14	0.003	7.45	0.0251	0.009	3	1.5
15	0.003	7.45	0.0251	0.009	3	1.5
	1.000		2.8800	1.000	353	73.8

Thermodynamics is often applied broadly to mean the science which deals with the relation between thermal and the many other forms of energy. Since these other forms may be mechanical, electrical, chemical, or biological, the subject is a most extensive and fundamental one. In engineering thermodynamics normally means the study of converting heat energy into mechanical work, and vice versa. There are two fundamental laws of thermodynamics.

The First Law: The principle of conservation of energy. Energy cannot be created or destroyed: but all forms of energy are mutually convertible, wholly or partially.

When limited to problems in mechanical engineering relating to heat and mechanical energy, the first law can be stated: Heat and mechanical energy are interconvertible and can neither be created nor destroyed. However in nuclear physics the energy-mass equivalence must be taken in account. The essential idea of the first law is that energy may be changed in form but cannot be destroyed.

The Second Law: A closed system always evolves spontaneously in the direction toward the most probable state of matter and energy within itself. Alternatively the second law can be stated as: Within any closed system the direction of spontaneous change is always from order to disorder, with a maximum of disorder and entropy as the ultimate equilibrium state. (Most science textbooks also quote the original definitions: "It is impossible for a self-acting machine to convey heat from one body to another at a higher temperature(Clausius, 1850)." "It is impossible by means of any continuous inanimate agency to derive mechancial work from any portion of matter by cooling it below the lowest temperature of its surroundings(Kelvin, 1851)."

References:

LIFE Science Library, N.Y.: TIME-LIFE Books(1967):

Thermodynamics:	vol:	THE ENGINEER, p. 9; THE SCIENTIST, pp. 76, 88-89, 100, 146.
First Law of:	vol:	ENERGY, p. 38; TIME, p. 170.
Second Law of:	vol:	ENERGY, p. 58-59; TIME, pp. 169-170.

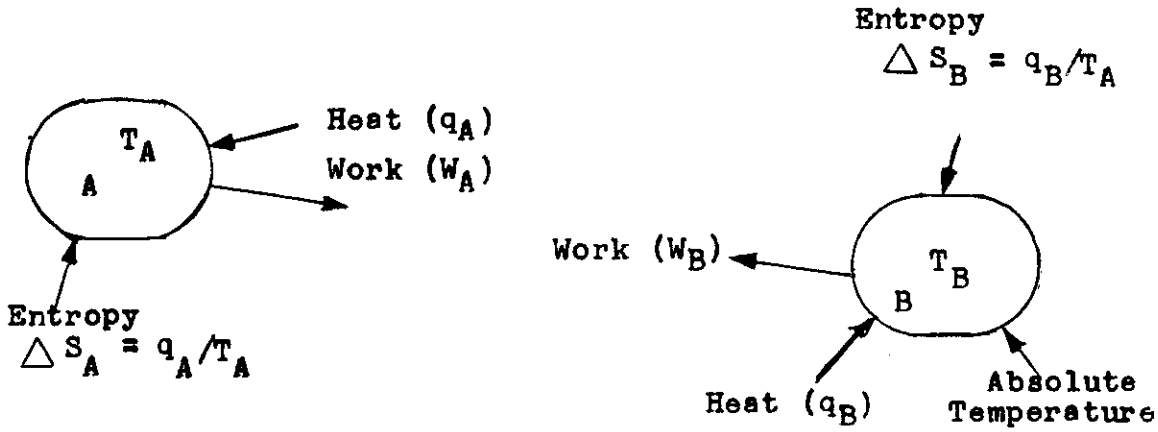
Isaac Asimov, The Intelligent Man's Guide to Science, N.Y.: Basic Books (1960). Thermodynamics, pp. 293-296.

A. Wilmer Duff, Physics for Students of Science & Engineering, Phila.: Blakiston(1932), 7th Rev. Edition, Thermodynamics, pp. 270-295.

William N. Barnard, et al, Heat-Power Engineering, Part I, Thermodynamics and Prime Movers. Third Edition. N.Y.: Wiley(1926). First and Second Laws, pp. 7-10.

Arthur N. Strahler & Alan H. Strahler, Environmental Geoscience: Interaction between Natural Systems and Man. Santa Barbara: Hamilton Publishing Co.(1973). Thermodynamics, first & second laws, pp. 18, 21.

The mathematical forms of the first and second laws are illustrated below in Fig. 1. This figure represents two bodies at absolute temperatures T_A and T_B. The arrows indicate directions of positive quantities of the quantities: heat, work, and entropy. An example is given in Section 1.0.3 where body A is the hot water in the radiator of the heating system, and body B is the air in the room of the house being heated. Sample numerical calculations are given in Section 3.2.0(a) for this case.



1st Law: $W_A - q_A + W_B - q_B = 0$

2nd Law: $\Delta S_A + \Delta S_B \geq 0$

If $T_A > T_B$, heat flow from A to B, no work

$$W_A = W_B = 0,\ q_A = -q_B\ ;\ q_B > 0$$

Then: $\Delta S_A + \Delta S_B = q_B\,(1/T_B - 1/T_A) > 0$

Fig. 1 - Thermodynamics

Erwin N. Hiebert, "The Uses and Abuses of Thermodynamics in Religion," DAEDALUS, Fall 1966, pp. 1046-1080.

The material covered in this article is briefly reviewed as follows:

I: The introductory section reviews the nature of the conflicts between science and religion since 1850.

II: Thermodynamics has entered many of the arguments between science and religion during the last century. The first and second laws of thermodynamics have been used, affirmed, rejected, manipulated, exploited, and criticized in order both to further and to censure religion.

III: The first law of thermodynamics -- conservation of energy -- was an independent, multiple discovery that burst forth among various European scientific investigators who were more closely tied to civil and military engineering, medicine, physiology, and brewing than to anything going on at the academic centers in the physical sciences. There is a concise discussion of entropy in this section.

IV: The laws of thermodynamics were slowly accepted at first, but by the end of the 19th century, thermodynamics became one of the main pillars of classical physics. In parallel with these solid applications, the energy conservation principle was used in some fairly untamed, speculative, and theologically grounded arguments by the physicist, William R. Grove(Correlation of Physical Forces, 1846, etc.), and the physiologist, William B. Carpenter("On the Mutual Relation of the Vital and Physical Forces," 1850).

V: Herbert Spencer(First Principles, 1862, etc.) promulgated a strange synthesis of ideas drawn from evolutionary theory, the principle of conservation of energy, and a humanitarian, religious metaphysics. The biologist, Ernst Haeckel applied the principle of conservation of energy to problems in philosophy and religion(The Riddle of the Universe, 1900). Haeckel propounded a "monistic religion," a monism connecting religion and science but freed from the dead and dried-up superstitions of traditional religions.

VI: Edward L. Youmans, an American self-taught promoter of science education was a devotee of Spencerian philosophy, and published articles on science claiming "to connect the mind of man with the Spirit of God." George Frederick Barker, some-time professor of chemistry, geology, et al, accepted the correlation of vital forces and physical forces, and then managed to twist the whole business to the glory of God.

VII: The German physical chemist, Wilhelm Ostwald propounded a non-theistic, monist, and humanitarian exploitation of the philosophy of energeticism as a way of life. Ostwald proposed the so-called doctrine of "energetic imperative" based on a "postulate of economy of energy," leading to an energeticism directive for the practical affairs of man in society.

VIII: There was an immensely spirited literature on the implications of thermodynamics for religious questions concerning the nature of free will, problems of death and immortality, etc., particularly around the turn of the century. The law of conservation of energy was commonly invoked to support arguments for the existence of a Deity who had ordered the world with perfect foresight, wisdom, and economy of action. Earlier the philosophy of mechanism had been a serious threat to theism. Now the accomplishments of 19th century thermodynamics threatened the authority of religion in other ways. In response to some of these developments, the Neo-Thomists developed a doctrine restricting the energy-conservation principle to statements that could not go beyond experimental proof. They developed a synthetic philosophy which was supposed to have solved the problems of free will, creation of the human soul, and departure of the immortal soul.

IX: The "heat death" of the universe predicted from the second law of thermodynamics was particularly upsetting to theologians. The correspondence between Arnold Lunn and J. B. S. Haldane in 1933-34 was representative of the criticism of the theological uses of the entropy principle. William Ralph Inge, Dean of St. Paul's in London, sometimes called "the gloomy dean," found the second law to be at odds with the theory of evolution. He concluded that the human species had on earth "no continuing city," and it should therefore "ascend with heart and mind" to its "citizenship....in heaven." The concept of an "end to man's history" raised a host of questions that occupied religious scholars for decades. (Inge, The Church in the World, 1928; God and the Astronomers, 1934.)

X: The French scientist-philosopher Pierre Duhem was involved in a discussion with Abel Rey over the extent to which Duhem's philosophical interpretation of physics and in particular the second law was influenced by Duhem's beliefs as a Christian. (Abel Rey, "La philosophie de M. Duhem," 1904; Pierre Duhem, "Physique de Croyant," 1905, trans. in P. Duhem, Aim and Structure, appendix: "Physics of a Believer." 1954)

XI: Evolutionary theory was equated with hope, with the cause of progress in the latter part of the nineteenth century, while entropy considerations prophesied a pessimism of despair. Ostwald stressed the aspects of the second law of thermodynamics which indicated spontaneous irreversibility of time, and ignored the gloomier aspects. Lord Kelvin excluded living organisms in his statement of the second law. Svante Arrhenius thought rare exceptions might occur to the second law, leading to the rebuilding of worlds. Many philosophers such as Nietzsche, Whitehead, and Russell dealt extensively with the impact of thermodynamics. Freud and Jung were influenced by their understanding of the laws of thermodynamics. Henry Adams thought the universe had been narrowed by thermodynamics such that history and sociology were now restricted.

XXI: "All kinds of private metaphysics and theologies have grown like weeds in the garden of thermodynamics." The religious frenzy generated by the definition of the first and second laws of thermodynamics eventually died out. Prof. Hiebert asks whether religion and science must always have relations with each other. If the answer is yes, we must then ask: What kind of relationship? And how is science to be built into the ceremony and life of religion?

This list is continued from
File No. 399-F-16 pp. 1-2 in
CTCM Vol. II, No. 2, pp. 23-24.

Vol. II, No. 2, Oct-Nov-Dec 1971(7/16/72) Special Issue for First Annual Meeting of Far West Region of Society for General Systems Research, "A Second Order Approximation to a World System of Nations Based on a Continuous Channel Model from Information Theory." Editorial notes on three groups of readers: citizen-layman; decision-maker; and scientist-philosopher. Four prime questions about our civilization. Applying Cybernetics to Maintain Social Balance between Freedom and Stability. The Use of Cybernetics to Help Connect Decision Processes with Ethical Values. Approximation to a Cybernetics Systems Interpretation of a Two Nation System. An Application of the Continuous Channel Model to the International System of Nations. Table of Three Eras. Sample Calculations for the Continuous Channel Model. List of reprints and back issues..... 24 pp. $1.00 per copy.

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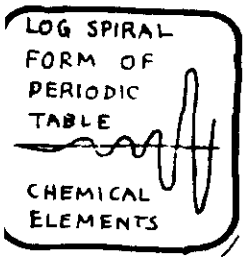

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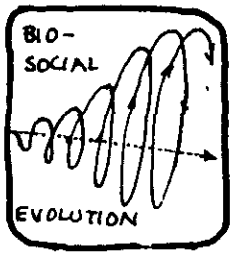

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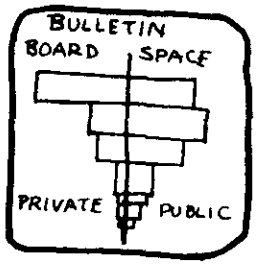

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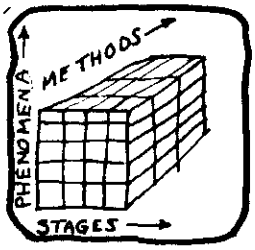

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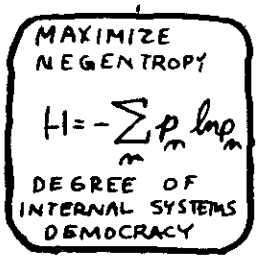

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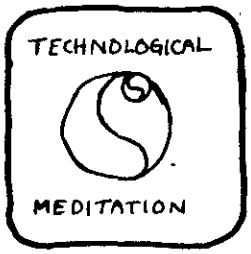

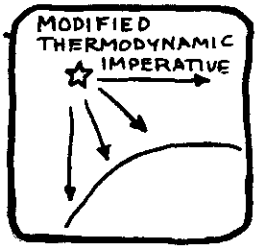

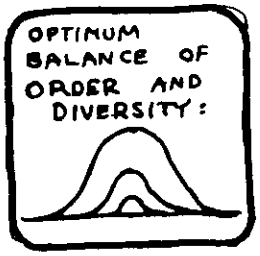

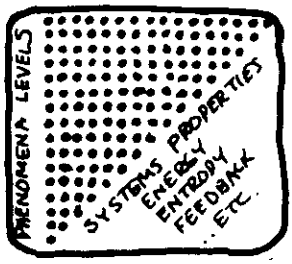

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