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"A Proposal for Using Concepts from Cybernetics to Help Solve an Employee Communication Problem Concerning Company Bulletin Boards."

by

Frederick Bernard Wood, Ph.D.

Contents

Introduction

In a survey conducted within International Business Machines Corporation during the summer of 1968, reference was made to seven IBM Corporate Principles. This proposal presents a sample of how concepts from Cybernetics can be used to help implement the following two from the set of corporate principles:

> "IBM wishes to play a constructive role in furthering the progress of the communities of which it is a part. We accomplish this by conducting ourselves as good neighbors, respecting and observing ethical standards in our dealings with others, cooperating with local authorities, contributing our share to worthy community philanthropies, and encouraging our people to take an active part in public affairs."

> "IBM is conscious of its responsibility as a corporate citizen of the nation and the world. The nature of our business makes us contributors to social change. It also equips us to help control some of the impacts of change and to improve the quality of our society..... IBM has a unique opportunity to be in the forefront of those companies which help to make our world a better place to live in."

In order to carry out the above principles somebody has to learn more about the social sciences. This brings up the question of how well can business and engineering leaders communicate with social scientists. First let us examine what is available in business and engineering to meet the social scientists halfway. Then let us examine the trends that we can find in the development of the social sciences that make interdisciplinary communication easier.

The methodology I will use comes from the field of engineering defined by Norbert Wiener as "Cybernetics." Since the mathematics of cybernetics is a generalization of more elementary concepts that don't need higher mathematics for their representation, I shall first examine the histirical roots of the concepts, and then I shall make an abbreviated overview of the relation between the social sciences and technolcgy, before developing the analysis of the bulletin board problem.

Historical Roots of Cybernetics

As a reference, let us note Webster's Dictionary definition of cybernetics: "Comparative study of the automatic control system formed by the nervous system and brain and by mechanical-electrical communication systems."

The two major concepts used in cybernetics are:
(1) the principle of negative feedback communication which provides stability or keeps a system moving toward a specified goal, and
(2) the measure of information transmitted on direct and feedback communication links.

These two concepts were developed empirically by practical inventors long before the mathematics of cybernetics and information theory was formalized. The concept of negative feedback was developed before 1790 by James Watt in the form of the flyball mechanical governor for steam engines. A precise mathematical analysis of the governor was published by James C. Maxwell in 1868. In the early 1940's the concept of negative feedback was applied to servomechanisms for controlling the direction of mechanical devices. And in 1948 Norbert Wiener predicted that the concept of negative feedback was applicable to biological and social sciences.

A measure of information was used empirically in 1835 by Samuel F. B. Morse in developing an efficient telegraph code. He went to a large print shop and counted the number of type slugs for each letter of the alphabet to determine the relative frequency of the letters of the alphabet. He then assigned the shorter combinations of dots and dashes to the most frequently occuring letters and the longer combinations to the least used letters. Thus Dr. Morse was able to design an optimum code that transmitted words efficiently over the telegraph lines. In 1948 Claude Shannon published a paper on the mathematical theory of communication in which he generalized the procedure used by S. F. B. Morse a century before him. Since then the measure of information defined by Shannon has been used to define information in chemical, biological, psychological and social systems.

Since the bulletin board system we are about to study is a social system, it is desirable we at least take a birds-eye look at the trend of interaction between tecnology and the social sciences to be sure there is a possibility of communication between this engineering type analysis and the procedures of the social sciences.

A Perspective of the Relation Between Technology and the Social Science.

To observe a trend in the social sciences, I have selected some pioneering social science books and papers. I have listed them in Table A with notes on the significance of the contributions.

Table A - Pioneering Check Points in the Social Sciences in Relation to Technology as Observed by One Engineer.

Year	Book or paper	Author (field)	Significant contents and Interpretation.
1937	The Making of Society - An Outline of Sociology.	V. F. Calverton (sociology)	History of social philosophy and value systems from Ten Commandments, Code of Hammurabi, Sermon on the Mount, the Koran to modern social philosophies.
1948	Society, Culture and Personality- Their Structure and Dynamics.	P. A. Sorokin (sociology)	Traces changes in cultural values over a 2000 year period. Introduces empirical quantitative measure of percentage of dominance of different values in each century. Plots curves of number of scientific discoveries and inventions per century, as a start to examining the relation between technology and culture.
1959	Chapter on "Mathematics and Cybernetics" in American Hndbk of Psychiatry.	A. Rapoport (mathematical biology)	Emphasizes the qualitative changes in technology in connection with the First and Second Industrial Revolutions. Discusses the potential analogies between information theory(cybernetics) and biological systems.
1969	Paper on "A Systems View of Value Problems" in Record of the IEEE Systems Science and Cybernetics Conf. October 1969.	C. W. Graves (psychology)	A psychologist using general systems concepts develops a theory of how man's value systems change. It is particularly significant that this paper on psychology was presented at a workshpp at an engineering society conference.

The principal point we observe from Table 1 is that there is a trend from social scientists writing only about value systems and human relations -- toward taking account of the technology associated with the social system. This trend takes on more significance when in 1959 we seen comments about analogies between conceptsfrom the physical sciences and concepts in the biological sciences(and later social sciences.) Then in 1969 we see a further development of the trend -- a social scientist reports on using general systems concepts, which historically came from the physical and then the biological sciences, to make progress in understanding the different values systems in social systems.

To give us some kind of perspective in respect to earlier civilizations, I [illegible] number of scientific discoveries and [illegible] ury from 5000 BCE to 1969 AD. For Greece and Rome and Western Christian Civilization, I have used tables from P. A. Sorokin. For Arabia, I have used a count of the number of prominent scientists per half-century from Sorokin's interpretation of data from Sarton. For the time before Greece, I was not able to find data, so as a first approximation, I have extrapolated the trend backwards in time to the level of one invention per century.

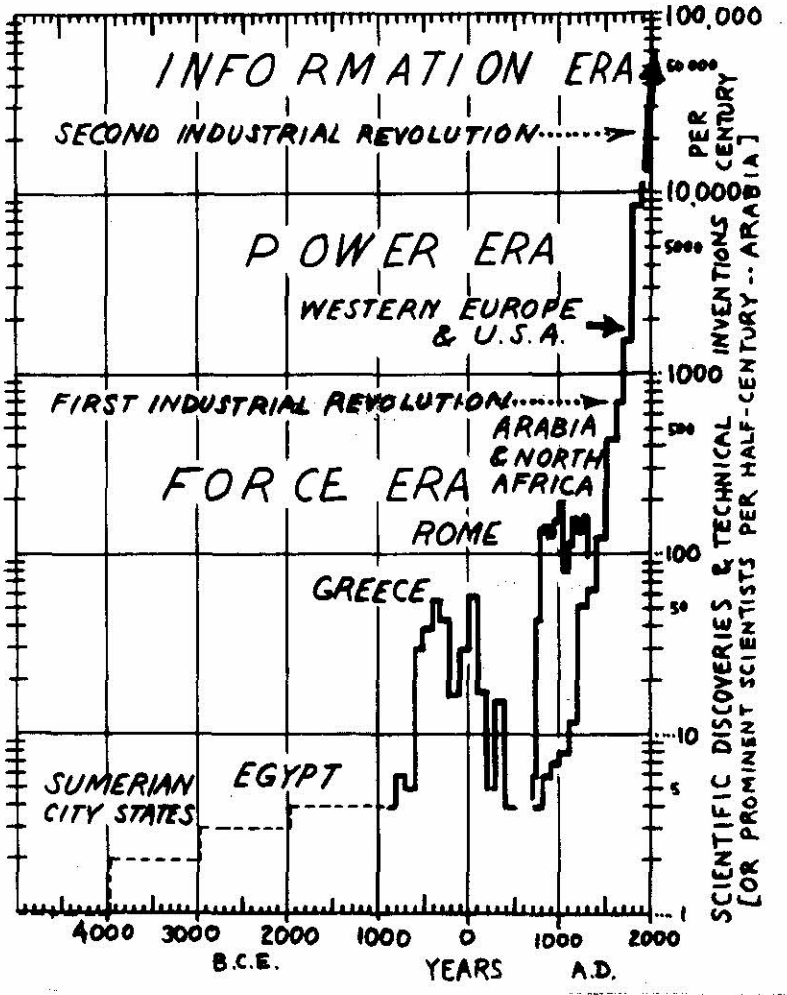

Figure A- "Historical Trend of Number of Scientific Discoveries and Technological Inventions Per Century."

The source tables are from P. A. Sorokin, Society, Culture, and Personality. N.Y.: Harper(1947), pp. 664-665. The transitions, marked "First Industrial Revolution," and "Second Industrial Revolution," are described by Anatol Rapoport, "Mathematics and Cybernetics," in Silvano Arieti, editor, American Handbook of Psychiatry, N.Y.: Basic Books(1959), Vol. Two, pp. 1743-1759(Chap. 87).

Figure A, even though it has not been brought up to date, shows graphically how we are making a transition from the 'Power Era' to the 'Information Era.' From the figure, we can see that both Greece and Rome didn't make it. Our civilization has made the transition from the Force Era to the Power Era, but we are having a difficult time during the transition to the Information Era. IBM's statement of goals is timely for promoting better understanding of the changes society is going through.

The 1969 paper by Dr. Graves points out that people develop through a series of different value systems. This has particular significance to IBM in respect to implementing the two quoted goals. Where most IBMers have seven levels of management above them, it is possible that in many cases that due to people being at different stages of development of their value systems, that the employee and several levels of management may have different interpretations of how to implement these goals.

The specific problem I will address in this proposal is: How to can IBM achieve a balance and equitable distribution of IBM bulletin board space for "public affairs" notices(i.e. notices of individual or group employee interest or involvement in community, social, political, economic or personal projects and activities) which concurrently avoids an unacceptable risk to IBM Corporation or individual IBMers.

The Problem

The first IBM principle quoted in the introduction includes "encouraging our people to take an active part in public affairs." Often IBMers who are interested in public affairs, and who wish to let other IBMers know about their particular projects or activity, have difficulty communicating with their fellow employees because:

1. employees are physically scattered throughout neighboring communities and thus have little opportunity for informal contact outside of working hours,

2. community news media generally do not cover very much news of this nature, and

3. employee project activity notices of a "public affairs" nature are usually ruled ineligible for posting on IBM bulletin boards.

One logical reason why public affairs notices are currently excluded from bulletin boards is the legitimate concern that one political party or interest group might dominate the bulletin board space at a particular location resulting in implicit IBM suport of a project or activity that may not represent either the position of the corporate officers or the views of the other employees at that location.

The problem of bulletin board space allocation is not unique to IBM, but is a special case of the more general problem confronting any democratic society which wants to maintain balanced and equitable communication between diverse individuals and groups.

A Solution

The second IBM principle quoted states that "IBM has a unique opportunity to .... help make our world a better place to live in." Indeed, IBM has a unique opportunity to utilize the concepts from Cybernetics mentioned by Dr. Rapoport in the American Handbook of Psychiatry for the establishment of a balanced and equitable allocation of bulletin board space. This is particularly convenient for IBM, since these concepts from Cybernetics* and Information Theory* are used by engineers and computer scientists to measure the efficiency of a set of messages sent over a communication channel such as a telephone line or telegraph line, and in some cases the efficiency of a set of computer instructions.

Cybernetics offers us an analogy between:
(1) computation of the relative efficiency# of a set of messages sent over a communication system, and
(2) computation of the efficiency of the space allocation on a bulletin board.

My proposal is to allocate bulletin board space in proportion to the information content of each set of notices, which is determined by the statistical probability that a given notice brings information to an individual that he did not know previously.

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* Work in the field of cybernetics may not be visibly identified as such, because of long-standing argument over the definition of the boundaries of the field of cybernetics.

\# 'relative efficiency' is more accurately defined by the 'entropy', 'hemetropy', or 'communication entropy.' In this non-technical paper I have tried to avoid using technical terms unnecessarily.

Procedure

The first step is to establish a bulletin board of a size suitable for the maximum allowable number of notices at a given location. For example, in this proposal, bulletin board dimensions are assumed to be 2-1/2 feet vertical height by 5 feet horizontal width which allows a maximum of 300 2" x 3" notices.

The next step is to set the minimum group size qualifying for bulletin board space. Three examples are given below:

Number of Employees	Minimum in Group	Minimum Notice Size	Maximum No. of Notices
300	1	2" x 3"	300
1500	5	2" x 3"	300
3000	10	2" x 3"	300

In this proposal, the minimum group size is assumed to be one person to be consistent with traditional IBM policy of respect for the individual. This of course requires more or larger bulletin boards. But the incremental cost is well worth the benefit of insuring that any sinble individual who has an idea for a "public affairs" project can get bulletin board space.

After establishing the bulletin board and the minimum group size, the third phase is to carry out the following procedure:

1. Distribute a questionnaire or ballot to all employees in a particular building, department, laboratory, or plant asking "For which public affairs organizations, projects, or activities do you desire space on the public affairs bulletin board?"

2. Tabulate the results of the questionnaire.

3. Compute the preference probability (p_i) of each organization, project, or activity which has one or more employee seeking space on the bulletin board.

4. Multiply the preference probability by a weighting factor($- \log p_i$ as derived from Cybernetics for the computation of the average information of a set of messages on a telegraph line) and compute the space to be allocated for each organization, project, or activity in proportion to the probability time the weighting factor ($- p_i \log p_i$).

5. Notify the respective organizations, activities, and projects of the allocated bulletin board space available.

6. Assign each a position on the bulletin board in order of highest probability starting from the upper left hand corner of the bulletin board. When more than one group has the same preference probability, use a random number generator computer program to determine the order within the set of equally probable groups.

7. Post the notices by putting them in the center of the allocated bulletin board space. The notices could be entered on a remote typewriter console to a computer and be centered in the allocated space by a computer program algorithm.

Examples

Seven examples using the preceding procedure are illustrated in Figures 1 to 7. The first example shows what would happen, if all the employees voted only for themselves instead of any public affairs organizations, activities, or projects. In this case, as shown in Figure 1, each employee is allocated the minimum bulletin board notice size of 2" x 3". The employee notice positions on the board are first arranged in alphabetic order, and then rearranged in random order by the random number generator, because they all have the same preference probability in this case. In Figure 1 the numbers in the notice squares are the position the notice would have had, if left in alphabetic order.

Random sequencing, in addition to determining the position of equal-probable groups, also insures that one group (political, economic, social, etc.) will not get more than a limited fraction of contiguous bulletin board space. In these examples the limit is 6%.

Figure 2 demonstrates space allocation for two equal groups each having 48% of the votes and eight smaller groups each with about 1/3 % of the votes. Note that groups of equal probability are positioned in random order on the bulletin board within the section for that set of groups.

In Figure 3 space is allocated for one large group representing one-third of the employee votes and a series of smaller groups of decreasing size.

Figure 4 shows how space would be allocated to ten groups with size varying between 8% and 14%. Figure 5 shows how space would be allocated when one group represents 70% of the employees. Note how the weighting factor ($-\log p_i$) scales down the space for the large groups and scales up the space for the smaller groups.

Figure 6 shows what would happen, if all employees voted for a single group, either by real preference, or as an organized joke. The formula ($-p_i \log p_i$) would allocate zero space in this case. Finally Figure 7 shows how the random sequencing of notice position would prevent a group of employees from gaming the system in the event they tried to organize

their individual notices as "cards" similar to a football rooting section card-stunt.

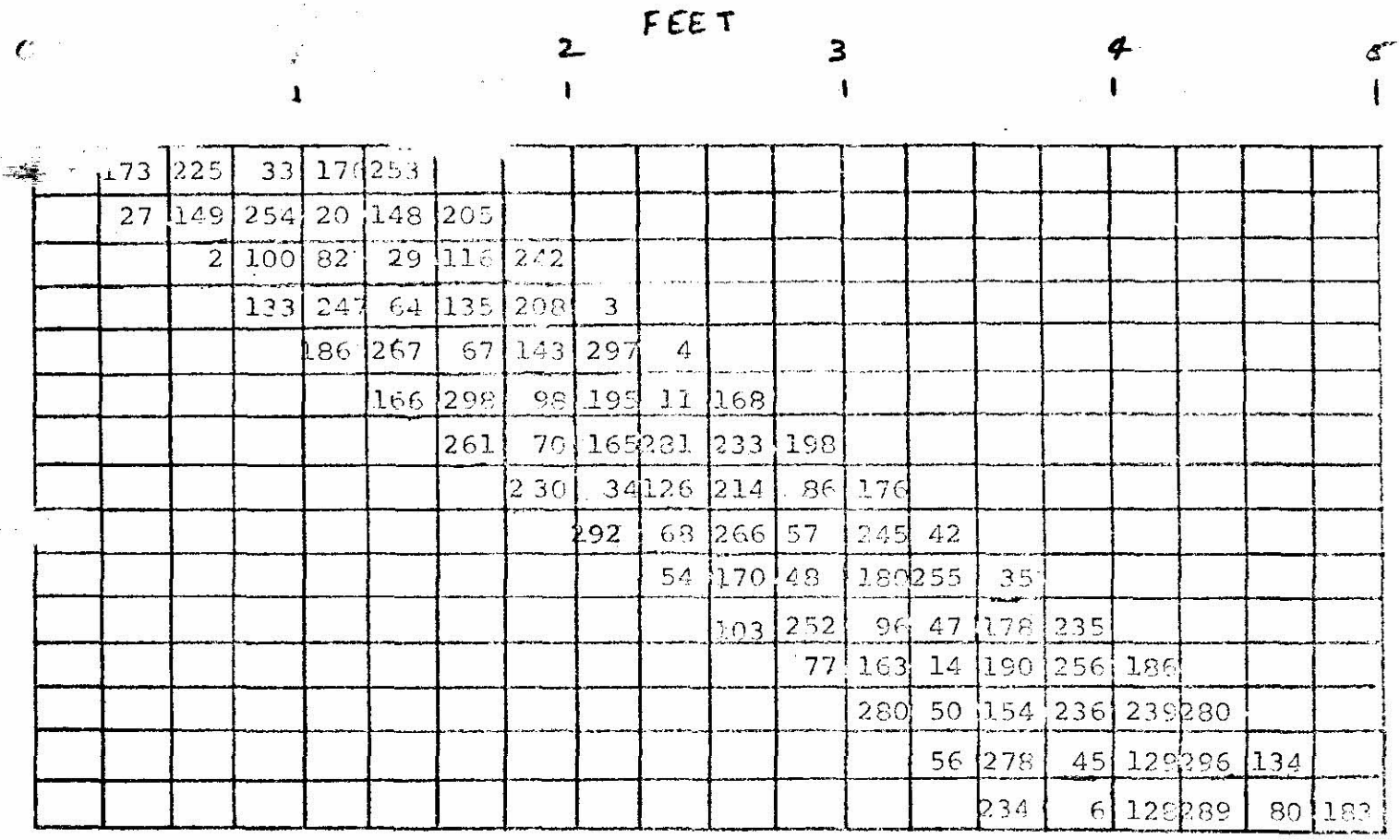

Figure 1 - Allocation of Space on Bulletin Board When All 300 Employees Vote for Themselves Instead of a Group.

Table 1: Tabulation of Votes and Calculations for Fig. 1

Group-Name	Number of Votes.	Probability p_i	Weighting $(-\log p_i)$	Rel.Space $(-p_i \log p_i)$	Squares 2"x2"
1	1	0.0033	8.22	0.0274	1.5
2	1	0.0033	8.22	0.0274	1.5
⋮	⋮				
299	1	0.0033	8.22	0.0274	1.5
300	1	0.0033	8.22	0.0274	1.5
	300	1.000		8.22	450

One "entropy square" = 1.5 / 0.0274 = 54.8 units of 2"x2"

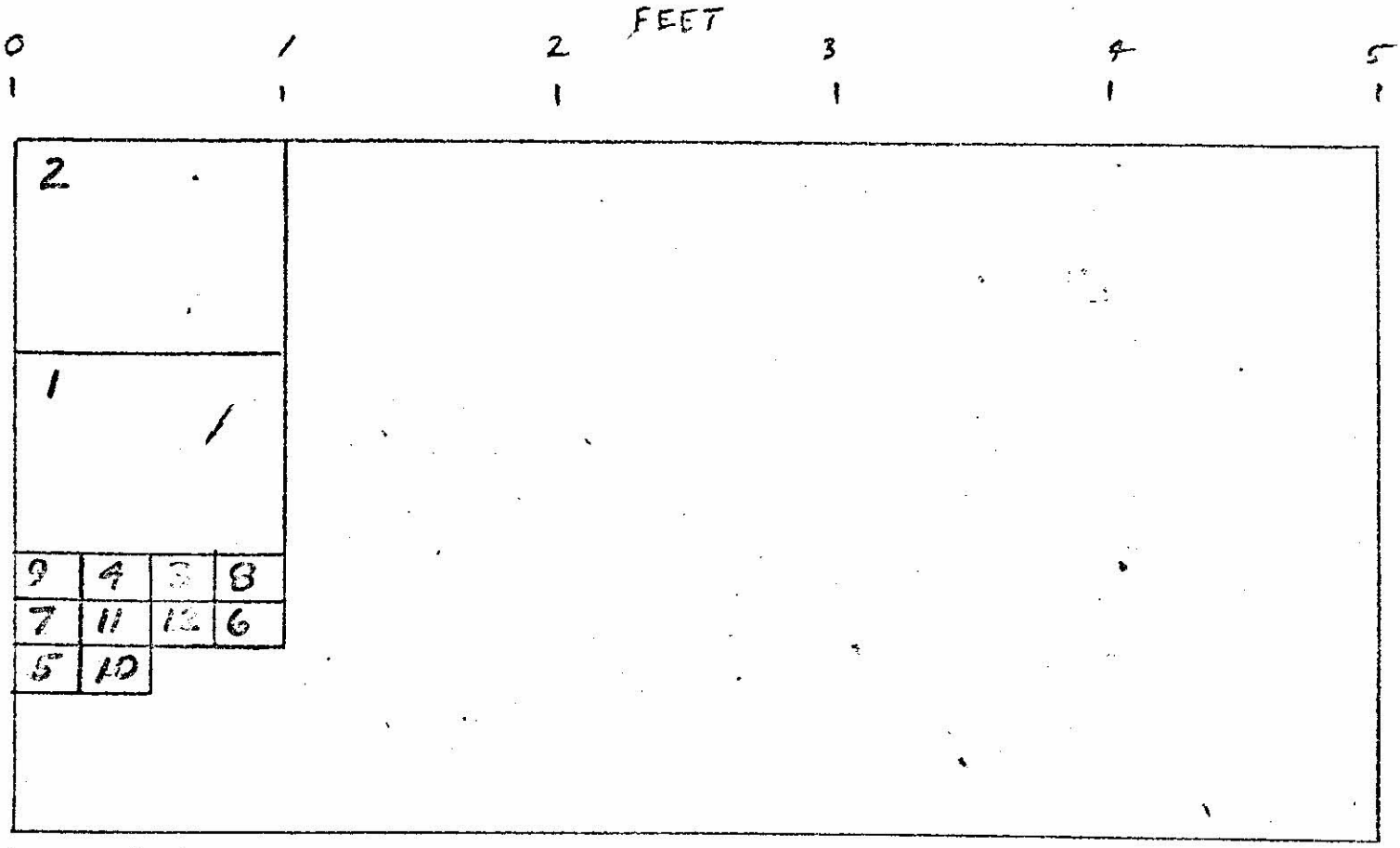

Figure 2 - Allocation of Space when There Are Two Large Groups with 48% of the Members Each, plus Eight Smaller Groups.

Table 2: Tabulation of Votes and Calculations for Fig. 2

Group-Name	Number of Votes.	Probability p_i	Weighting $(-\log p_i)$	Rel.Space $(-p_i \log p_i)$	Square 2"x2"
1	145	0.484	1.05	0.503	27.5
2	145	0.484	1.05	0.503	27.5
3	1	0.0033	8.22	0.0274	1.5
4	1	0.0033	8.22	0.0274	1.5
⋮	⋮	⋮			⋮
11	1	0.0033	8.22	0.0274	1.5
12	1	0.0033	8.22	0.0274	1.5
	300	1.00		1.280	70.0

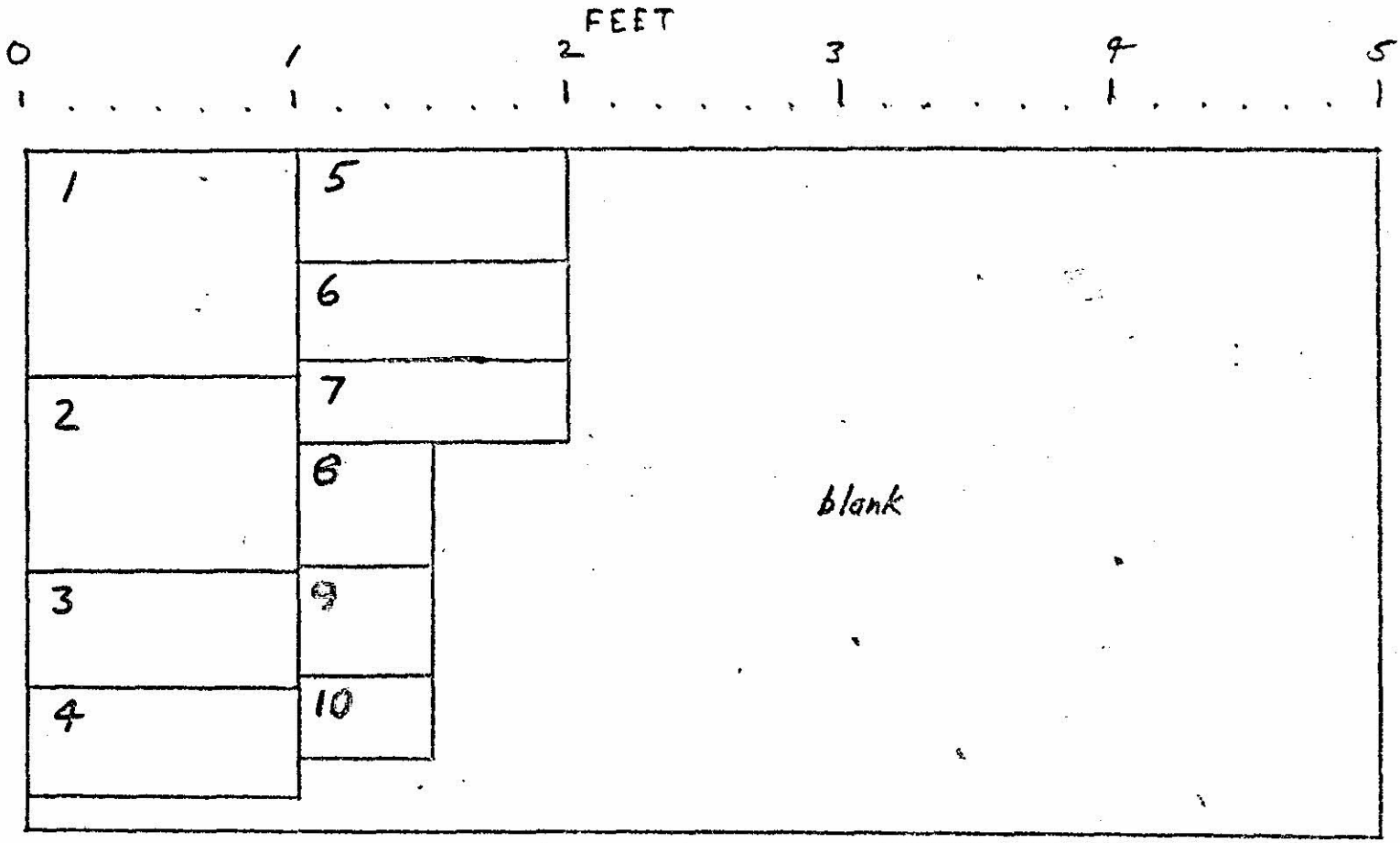

Figure 3 - Allocation of Space on Bulletin Board for One Large Group Plus a Series of Smaller Groups of Decreasing Size.

Table 3: Tabulation of Votes and Calculations for Fig. 3

Group-Name	Number of Votes.	Probability p_i	Weighting $(-\log p_i)$	Rel.Space $(-p_i \log p_i)$	Square 2"x2"
1	100	0.333	1.6	0.532	29.2
2	60	0.200	2.34	0.469	25.6
3	30	0.100	3.34	0.334	18.3
4	30	0.100	3.34	0.334	18.3
5	20	0.067	4.00	0.250	13.6
6	20	0.067	4.00	0.250	13.6
7	15	0.050	4.35	0.218	11.9
8	10	0.033	4.93	0.163	8.9
9	8	0.027	5.18	0.145	7.9
10	7	0.023	5.44	0.125	6.8
	300	1.000		2.820	154

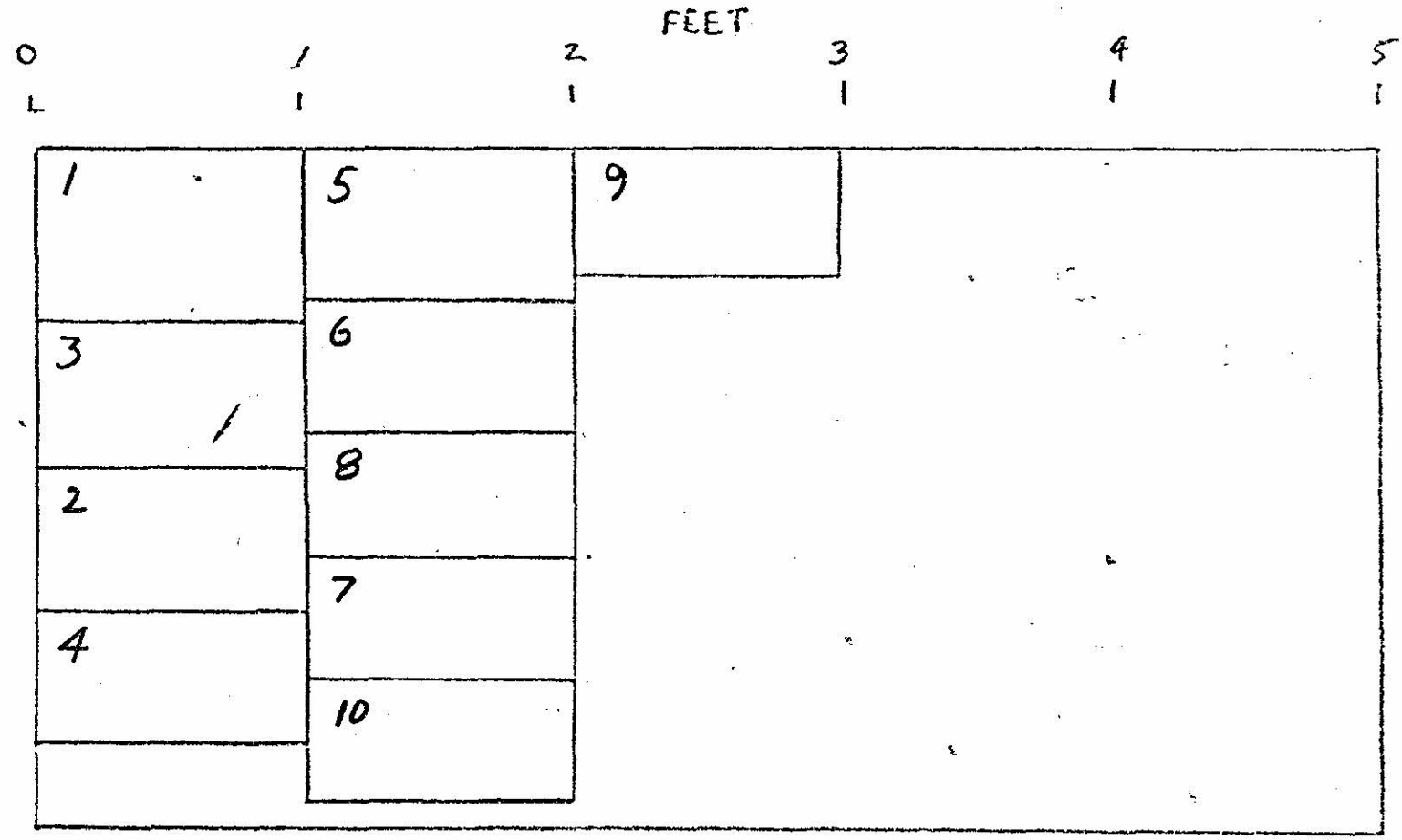

Figure 4 - Allocation of Space on Bulletin Board When Ten Groups Are Almost the Same size each (8% to 14%).

Table 4: Tabulation of Votes and Calculations for Fig. 1

Group-Name	Number of Votes.	Probability p_i	Weighting $(-\log p_i)$	Rel. Space $(-p_i \log p_i)$	Square 2"x2"
1	42	0.14	2.85	0.400	21.9
2	33	0.11	3.20	0.352	19.3
3	33	0.11	3.20	0.352	19.3
4	30	0.10	3.34	0.334	18.3
5	30	0.10	3.34	0.334	18.3
6	30	0.10	3.34	0.334	18.3
7	27	0.09	3.50	0.315	17.2
8	27	0.09	3.50	0.315	17.2
9	24	0.08	3.66	0.292	16.0
10	24	0.08	3.66	0.292	16.0
	300	1.00		3.320	182

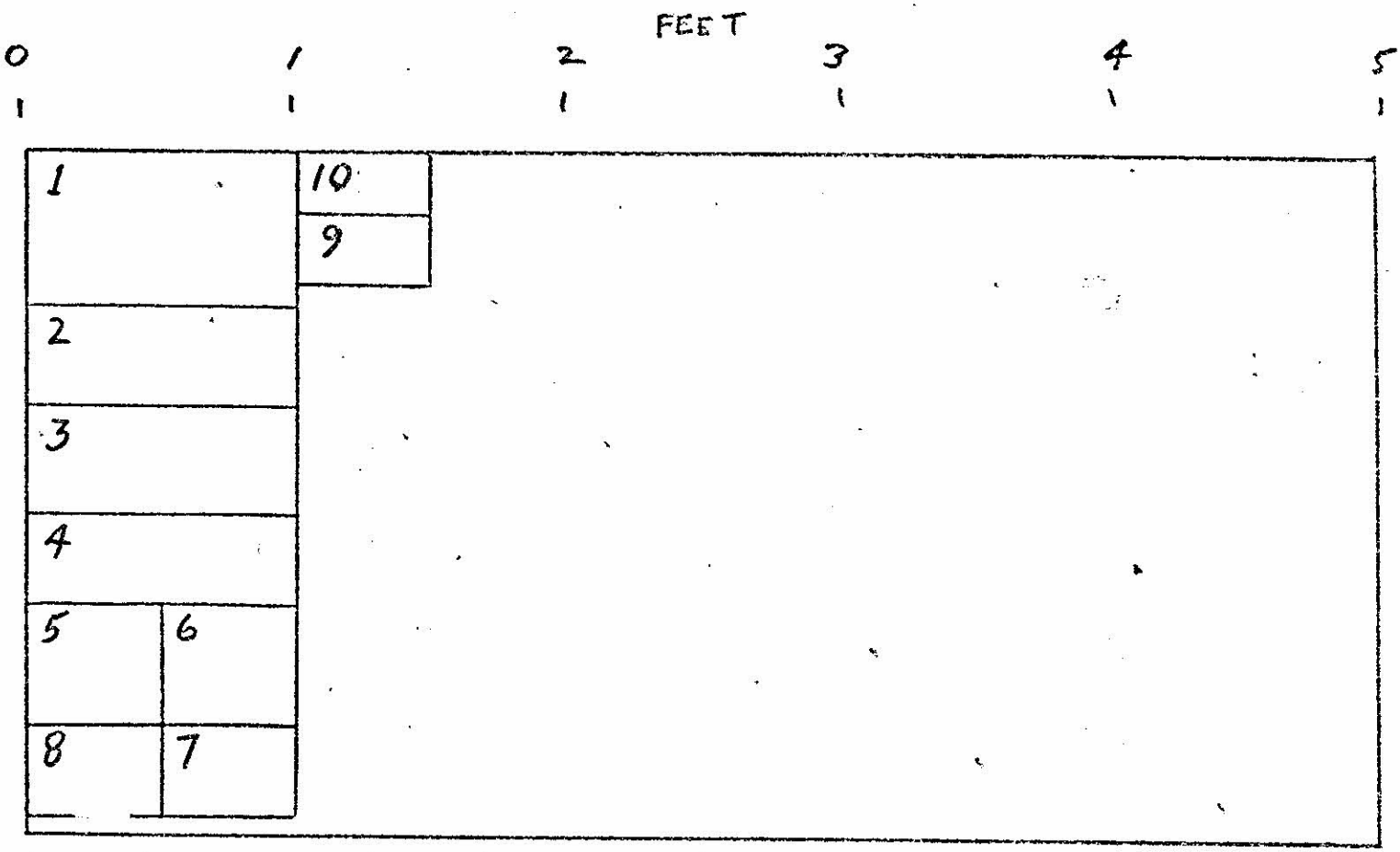

Figure 5 - Allocation of Space Where One Groups Has 70% Of The People, Illustrating How The Formula Provides Proportional Representation To The Smaller Groups.

Table 5: Tabulation of Votes and Calculations for Fig. 5

Group-Name	Number of Votes.	Probability p_i	Weighting $(-\log p_i)$	Rel.Space $(-p_i \log p_i)$	Square 2"x2"
1	210	0.70	0.52	0.364	20.0
2	21	0.07	3.86	0.270	14.8
3	18	0.06	4.08	0.245	13.4
4	15	0.05	4.35	0.218	12.0
5	9	0.03	5.10	0.153	8.4
6	9	0.03	5.10	0.153	8.4
7	6	0.02	5.70	0.114	6.3
8	6	0.02	5.70	0.114	6.3
9	3	0.01	6.66	0.067	3.8
10	3	0.01	6.66	0.067	3.8
	300	1.00		1.765	97.2

NOTICE

The notices submitted this week did not contribute any significantly new information not already known to practically all the employees at this location.

Figure 6 - Illustration of What Happens, If One Group Gets Everyone To Vote For The One Group(# 1).

Table 6: Tabulation of Votes and Calculations for Fig. 6

Group-Name	Number of Votes.	Probability p_i	Weighting $(-\log p_i)$	Rel.Space $(-p_i \log p_i)$	Square 2"x2"
1	300	1.00	0	0	0
Others	0	0.00	∞	0	0
	300	1.00		0	0

The above results come from the properties of:

logarithm of 1 is zero, making $p \log p \rightarrow 1 \times 0 \rightarrow 0$

logarithm of 0 is ∞, making $p \log p \rightarrow 0 \times \infty \rightarrow 0$

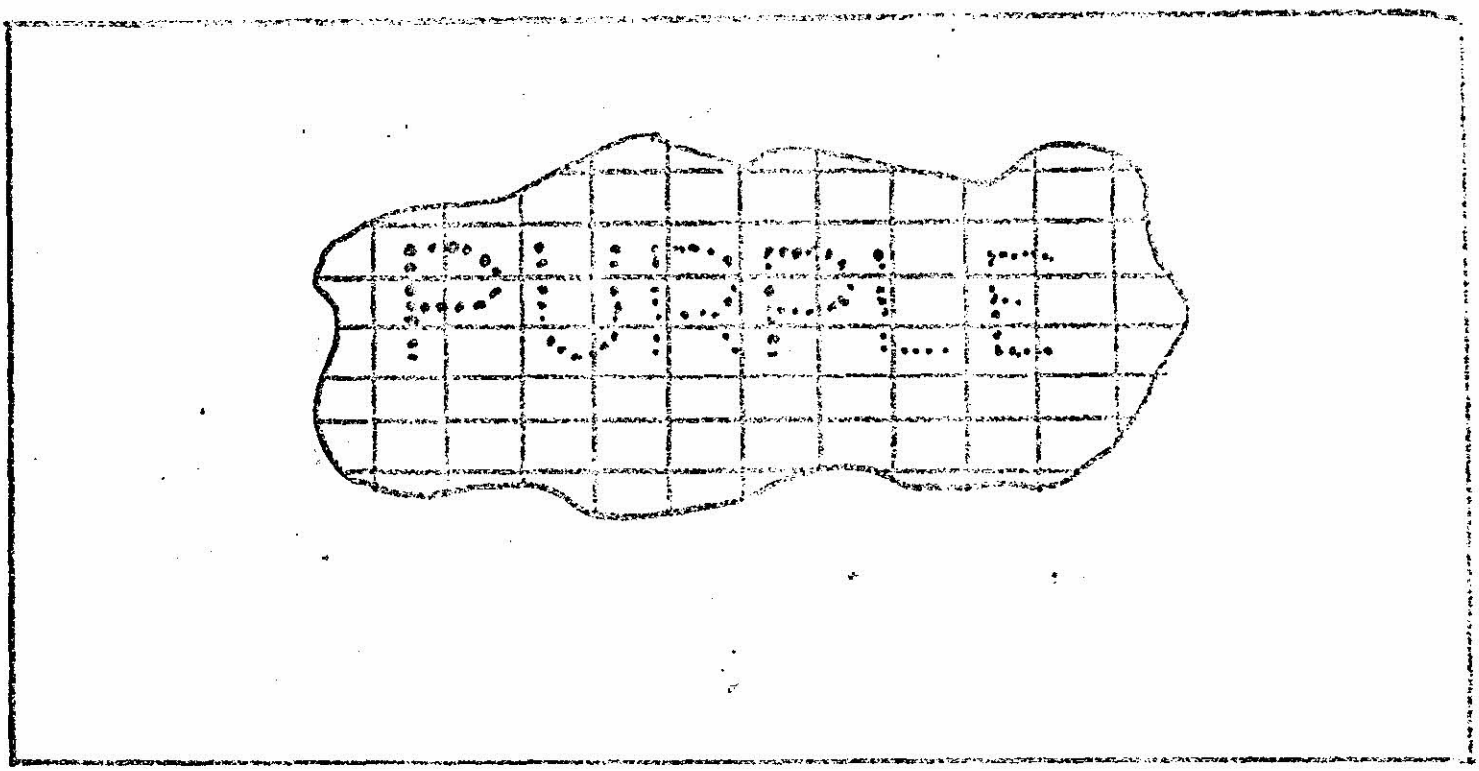

Figure 7A - Illustration Of What Could Happen Without The Randomizing Of Position On Bulletin Board.

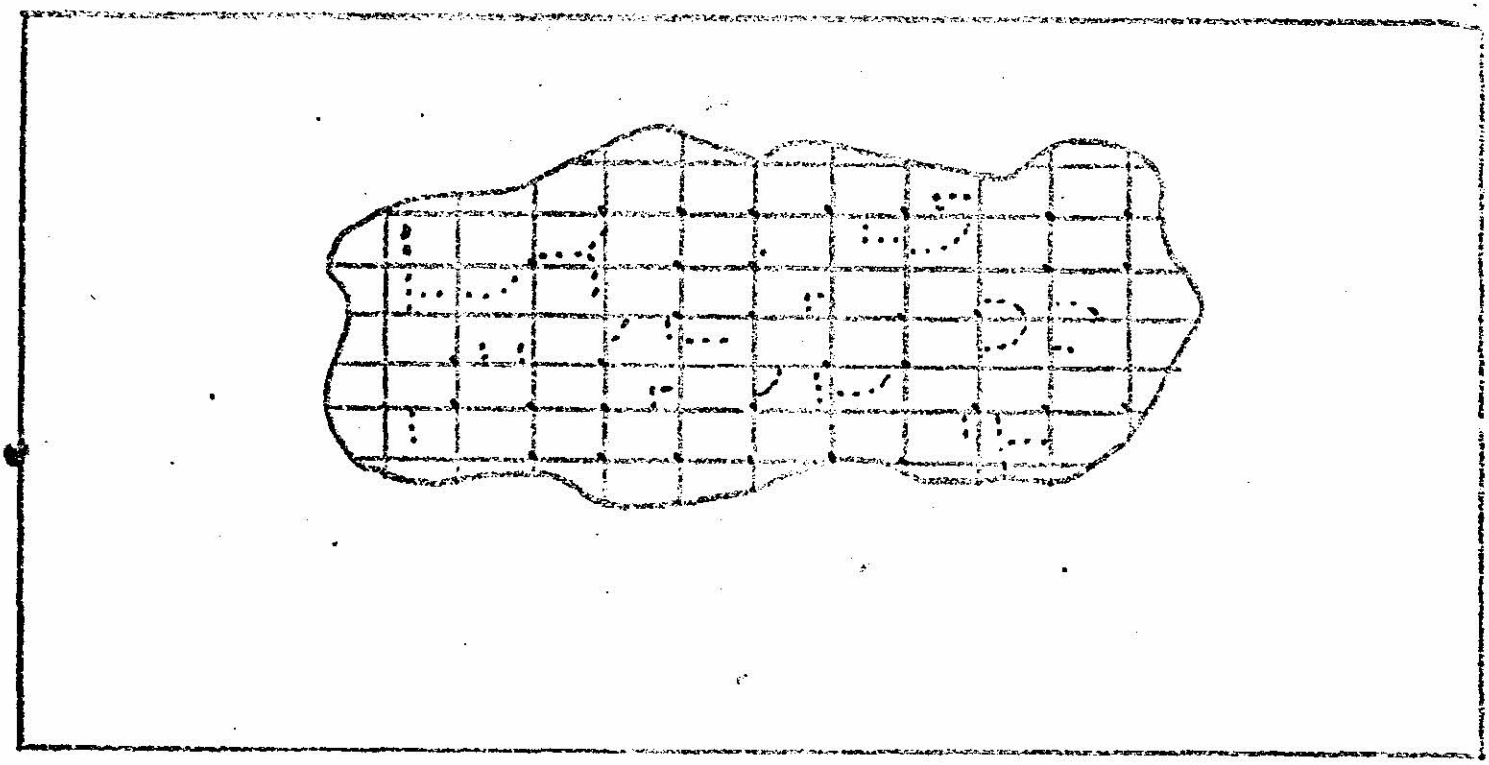

Figure 7B - Illustration Of How The Randomizing Procedure Of This Plan Breaks Up Any Card Trick Plans To Get More Than The Maximum Space Allowed Per Group.

Alternative Approach to Bulletin Board Problems

People who are experts in sociology, political science, and other related behavioral sciences can make allocations of bulletin board space and book and magazine exhibit space for libraries without needing the mathematics of cybernetics. For example at some college YMCAs I have seen exhibits of books and magazines which gave proportional representation to all the different shades of political views of the time.

I remember seeing a literature shelf at the Spartan YMCA-YWCA in 1956 at San Jose State College on which were exhibited a set of magazines and pamphlets which covered the full range of political views from left to right. As I recall the space allocation, it was approximately the same as would be calculated by the formula from cybernetics, namely $(p_i \log p_i)$.

At this stage in the evolution of business organizations it does not appear that we are ready to employ social scientists at each plant, laboratory, or regional office. By using the principles of cybernetics we can from a simple computer logic program obtain equitable distributions of bulletin board space without having to maintain a staff of social scientists. However it is desirable to have a social scientist consultant review the allocation program to make sure that the engineers using cybernetics haven't neglected any important angles.

Conclusions

The possibility of applying concepts from cybernetics and information theory ~~has been discussed for~~ to biological, psychological and sociological problems has been discussed extensively for the last twenty years.

Specfically, with the proposed method of space allocation, no single group can dominate ....

Emphasize how the proposed system is equitable and low risk ....

Maybe something on basic conceptual framework behind cybernetic allocation. I.e. - if everybody already has the information, its' not very efficeint to put it on the board. The cybernetics allocation method does nto judege the merits or demerits of various groups, only the efficeincy f communication. But nn so doinv, it safeguards both the rights fo individuala a nd groups to dommunication, I and protects IBM, idndivduals groups, et.

tien maybe how IBM unique --- estend its competance to application oftechnology, not just production of new tecnology in human areas, etc.

Help implement IBM principles, etc.

IBM be the leadeer in society not just busineess,e prototype for society in general

This application developed in connection with a 10-year study of engineers and social responsibility as a sub-program of a 25 year study possible isomorphics relations between phenomena and their representation in different fields f science.

[illegible] with [illegible].