# SOCIO-ENGINEERING PROBLEMS REPORT NO. 7

A series of manuscripts on the social relations of engineering and related philosophical questions dealing with the interaction of science and society. Distribution is limited to reviewers and discussion groups for criticism prior to consideration for possible publication.

Frederick B. Wood, Ph.D. P. O. Box 85 • Campbell, California

June 3, 1963

Date: 8/11/59 6/3/63
Stage: Stage E Added Table
$p_1 \log_2 p_1$
(SEPR No. 7-A)

"PROBLEMS TO BE REFERRED TO THE SOCIETY FOR GENERAL SYSTEMS RESEARCH"

7.1.1: What should be the aims, goals, activities and services of the Society for General Systems Research for the period 1959-1961?

7.1.1: Should the ultimate objective be to help provide the people of the world a better understanding of themselves and the groups, corporations, associations, governments, and United Nations agencies of which they belong so that each individual can find a rational way to apply the highest ethics available to him in his culture?

7.1.2: Is free parallel thinking important to creative interdisciplinary research?
(a) Stieltjes Integral
(b) The Heine-Borel Theorem
(c) Taylor's Series
(d) How Many Angels Can Stand on the Head of a Pin?
(e) Parallel Logical Operations

7.2: How can generals systems research be defined?

7.3: Does general systems research require the distribution of preliminary hypotheses in preliminary form for discussion by members of the society in different parts of the country without waiting for formal institutional publicational approval?

7.4: How can the Society for General Systems Research impliment the distribution of working hypotheses?

*Stages A through T are defined in SEPR No. 6, page 6 in 'Why A Working Paper Draft?'

SOCIO-ENGINEERING PROBLEMS

A series of working paper drafts on the subject of the social relations of engineering. This series of reports on ideas developed in the pursuit of my hobby of considering the potential analogies of various engineering concepts in the social sciences as a way of establishing a technique for engineers to discharge their responsibility for the social use of their ideas and inventions. The function of this newsletter is to provide a limited distribution of some preliminary ideas for discussion prior to editing for submission to established journals and engineering societies. In some cases no formal publication is planned, since this medium of communication will be used to suggest ideas to universities and research institutes who are better prepared to develop the ideas.

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Engineers' Council for Professional Development:

> "The engineer may be regarded, therefore, as an interpreter of science in terms of human needs and a manager of men, money, and materials in satisfying these needs."

This series deals with the function of the engineer as an"interpreter" on the assumption that other people are dealing with the management functions which many engineers acquire.

SOCIETY FOR GENERAL SYSTEMS RESEARCH

This issue contains problems proposed for discussion at a local meeting of the Society for General Systems Research. The statements given in this issue are my own and do not represent any policy of the Society. These problems may well contain more reference to ethical and philosophical problems than the membership would agree falls within the scope of the society. There is the possibility that some of this material is an unnecessary duplication of questions which have already been resolved by some social scientists, but which have not been communicated to the scientific community in general.

For a description of the activities and function of the Society for General Systems Research, refer to the publications of the Society issued through its editorial and business office: Mental Health Research Institute, University of Michigan, Ann Arbor, Michigan.

The Yearbooks issued to date are as follows:

General Systems, Vol. I(1956)
- Part I. Introduction
- Part II. Exploration of Mathematical Models.
- Part III. In Search of New Foci of Integration.

General Systems, Vol. II(1957)
- Part I. Introduction
- Part II. InSearch of Gross Principles of System Behavior
- Part III. In Search of Gross Principles of Mass Behavior
- Part Iv. In Search of Structual Units of Behavior
- Part v. The Systems Approach in Psychology

General Systems Vol. III(1958) Part I. Introduction
Part II. Concepts of Biology
Part III. Population Dynamics
Part IV. Science and Education

PROBLEMS TO BE REFERRED TO THE SOCIETY FOR GENERAL SYSTEMS RESEARCH:

Problem 7.1: What should be the aims, goals, activities and services of the Society for General Systems Research for the period 1959-1961?

Problem 7.1.1: Should the ultimate objective be to help provide the people of the world a better understanding of themselves and the groups, corporations, associations, governments, and United Nations agencies of which they belong so that each individual can find a rational way to apply the highest ethics available to him in his culture?

I realize that bringing the question of ethics challenges the concept of science as an entity by itself - the search for truth. In considering this problem The thoughts from Rosenstock-Huessy on the stages of Western Civilization (Socio-Engineering Problems No. 5, p. 12B) may be useful. My thought is that it is not necessary for the Society to get involved with the selection of a particular set of ethics. We can list the statements which are representative of the principal religious faiths. This would show a certain amount of common ideas in all the major cultures in the example given in THINK, October 1952 (SEP 1, p. 15).

Another approach would be to describe the different viewpoints on ethics with an amount of space proportional to the negative entropy of the statistical distribution of the different viewpoints. An example of this is as follows: Consider an hypothetical city of 100,000 adults (children not counted in this study). The distribution of adult members of the different religious faiths is as follows:

City D

| Religious Group | N Members | $p_i$ Probability | $-p_i \log_2 p_i$ negentropy |
|---|---|---|---|
| 1. Roman Catholic | 60,000 | 0.600 0 | 0.442 0 |
| 2. Protestant | 20,000 | 0.200 0 | 0.463 0 |
| 3. Lutheran | 15,000 | 0.150 0 | 0.411 0 |
| 4. Protestant Episcopal | 3,000 | 0.030 0 | 0.152 0 |
| 5. No Church | 1,000 | 0.010 0 | 0.066 5 |
| 6. Budhist | 600 | 0.006 0 | 0.044 3 |
| 7. Unitarian | 230 | 0.002 3 | 0.020 2 |
| 8. Jewish | 100 | 0.001 0 | 0.009 96 |
| 9. Eastern Orthodox Catholic | 60 | 0.000 6 | 0.006 4 |
| 10. Ethical Culture | 10 | 0.000 1 | 0.001 33 |
| Totals | 100,000 | 1.000 0 | 1.616 7 |

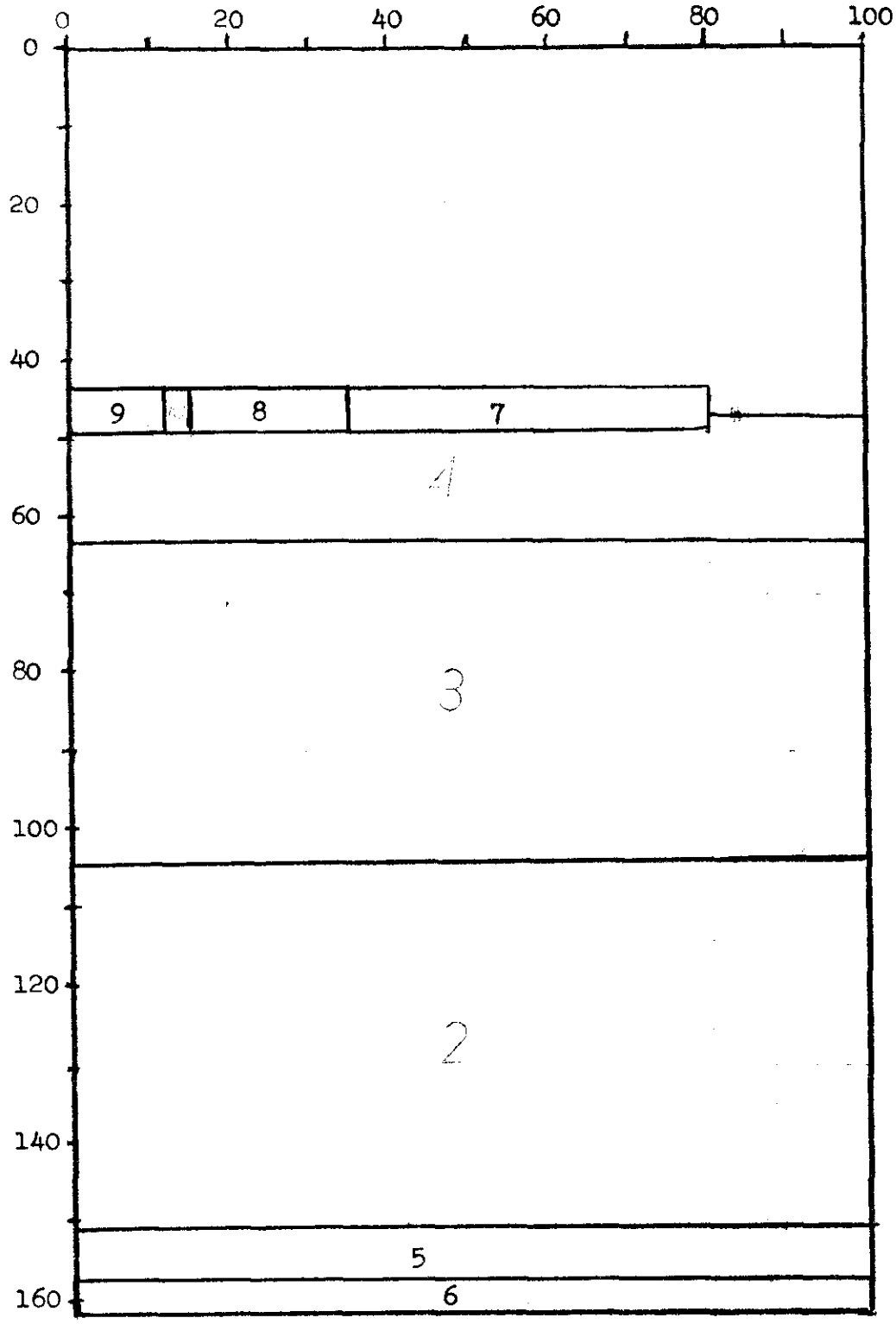


Fig. 1. Sample Distribution of Community Exhibit Space Determined by Negative Entropyof Membership Statistics.

Fig. 1 shows the distribution of space to scale for the above statistical distribution of religious groups. Consider the situation described in "San Jose 2008 A.D.," SEP 2, P. 7, where The First National Bank Building is devoted to an experiment in practical democracy. Suppose that a 100'x30' section of the main lobby is devoted to exhibit space consisting of four feet wide bulletin board around the room. Then 16,167 unit squares of Fig. 1 correspoond to 1040 sq. ft. Each unit on Fig. 1 is 9.4 sq. in. This makes the Group No. 10 (Ethical Culture) space of 13.3 units correspond to 116 sq. in. or one legal size sheet of paper.

Suppose one individual developed some new ideas he wished to advertize in the community exhibit space. on the scale of the sample in Fig. 1, he would be entitled to one third of a page space. On this he could put a brief statement and list his address for inquiries about further information.

A public policy of allocating display space in accordance of the negative entropy of the membership distribution could help prevent the democratic ideal from being distorted to allow the majority group to suppress minority ideas. This proportional representation in the community activities building should help maintain a respect for the right of individuals in a society which emphasizes conformity.

Problem 7.1.2: Is free parallel thinking important to creative interdisciplinary research?

(a) Stieltjes Integral (for description see Chapter XII of L. M. Graves, The Theory of Functions of Real Variables N.Y.: McGraw-Hill(1946).)

When I first studied the Stieltjes Integral in a mathematics course, I gave some thought as to what use I as an engineer would find for this type of integral. Two potential uses occured to me: (1) the representation of the electric voltage or the magnetic flux induced in a coupling loop in an electromagnetic field, and (2) the representation of the "social diffusion" in a human population of an interest in peace and justice (and democracy). The first application was one I could use in my engineering work.

The second posed a problem as to whether it had validity. At the time I couldn't find a social scientist who had enough of a common mathematical background to discuss the idea. The present problem is whether ideas which drop out in parallel with engineering analyses made by engineers and physical scientists are of real value to sociological research. We need some communication between different specialists to determine whether these parallel by-product thoughts should be preserved or discarded.

(b) The Heine-Borel Theorem. (See also Graves, op. cit, p. 50.)

The Heine-Borel Covering Theorem in the analysis of point sets intuitively suggests a covering theorem for the social application of scientific research. If we extend the coneept from point sets to spaces, and then to phases of a three-dimensional space (phenomena, activity phase, and time) we should be able to arrive at an interconnected system which has stabilizing feedback loops built into it.

(c) Taylor's Series.

The Taylor's Series used in mathematics to represent a function in a limited region about a point suggests a series of partial histories of different orders for obtaingin a suitable perspective to deal with the essential historical background of a problem dealing both with engineering and sociology.

(d) How Many Angels Can Stand on the Head of a Pin?

This question was once an important issue to theologians in Europe during the middle ages. Perhaps discussion of this unrealistic problem helped develop the logical tools for the development of concepts of modern mathematics such as infinite point sets. Perhaps this problem can be better answered by some historian of science. As a starting pant, I note that Cassius J. Keyser has a section on "The Infinite Abelian Group of Angel Flights" in his article "The Group Concept," The World of Mathematics(1956), pp. 1538-1557, esp. p. 1543.

(e) Parallel Logical Operations.

John von Neumann in The Computer and the Brain (New Haven: Yale U. Press, 1958) discussed the difference between natural automata (brain) and artificail automata (computers). He points out that large and efficient natural automata are likely to be highly parallel while large and efficient artifical automata will tend to less so, and rather to be serial(see pp. 50-51). Perhaps this indicates that the human brain is specially suited to parallel operation in the process of analysing the usefulness of systems forms in different fields of phenomena.

In a way it is the experience of many physical scientists that thoughts occur to them on analogies of their mathematical abstractions of physical phenomena which might be useful in the social sciences. Normally young scientists are encouraged to discard or suppress such thoughts. In fact I was told that I would get schizophrenia, if I didn't learn how to suppress such thoughts. There seems to be two levels of operation which must be distinguished in order to pursue this question further: (1) logical - analog or digital, and (2) formistic - development of a picture, structure, or symbol.

Problem 7.2: How Can General Systems Research Be Defined?

I feel that the more formal definition will be more easily developed as work progresses. For the present I would make reference to the following articles:

Ludwig von Bertalanffy, "General System Theory" General Systems Vol. I, pp. 1-10 (1956)

W. Ross Ashby, "General Systems Theory as a New Discipline," General Systems, 3, pp. 1-6(1958)

A. D. Hall and R. E. Fagen, "Definition of System" General Systems 1, pp. 18-28(1956)

Problem 7.3: Does general systems research require the distrbution of preliminary hypotheses in preliminary form for discussion by members of the society in different parts of the country without waiting for formal institutional clearance of working paper drafts?

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 competantly 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. Heressome 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.

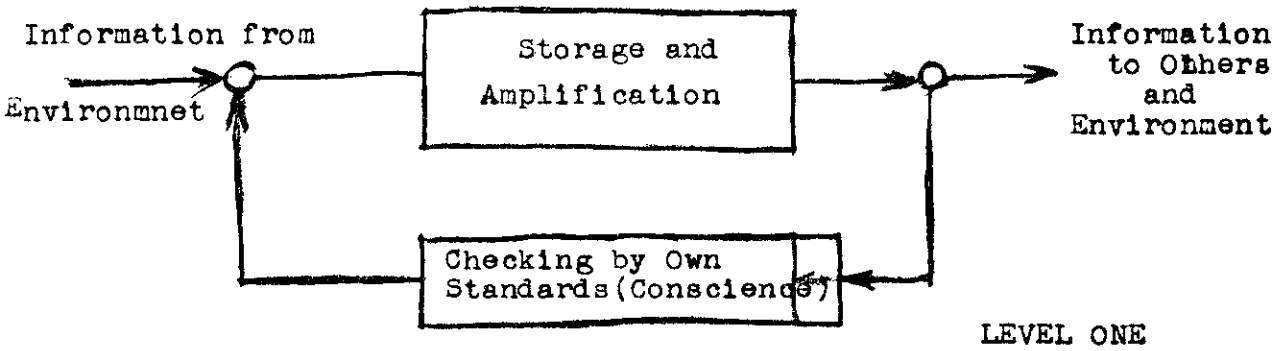


Fig. 2. Negative Feedback Representation of a Human Being.

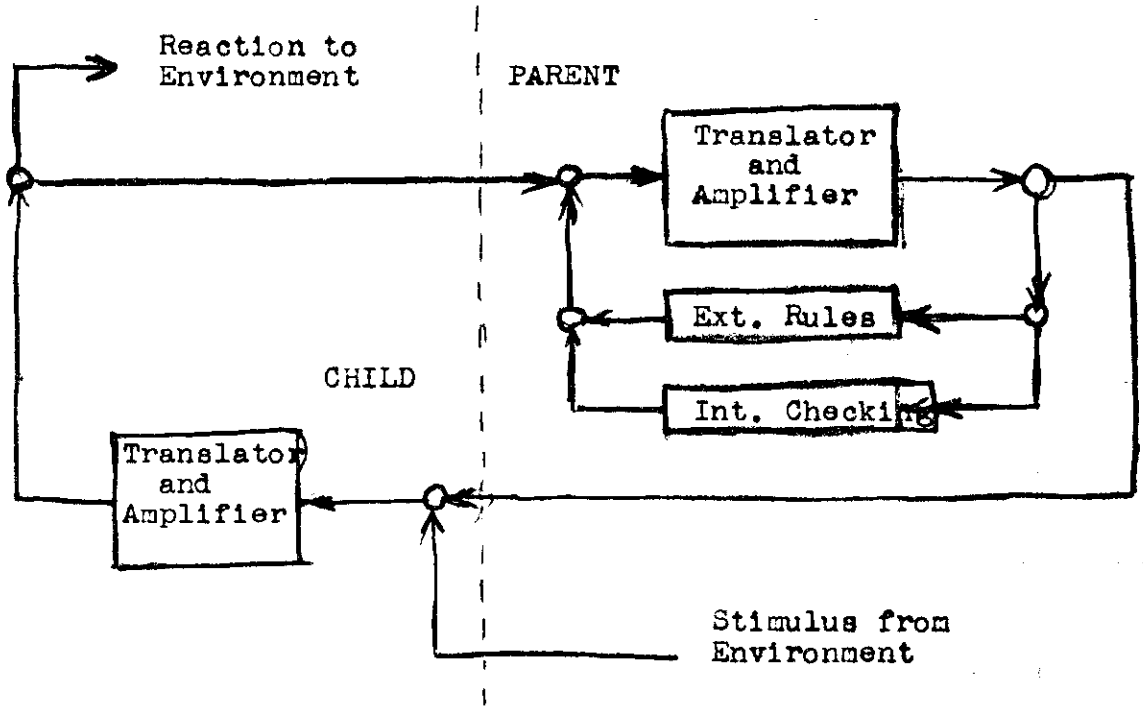


Fig. 3. Early Childhood While Parents Provide Controls.

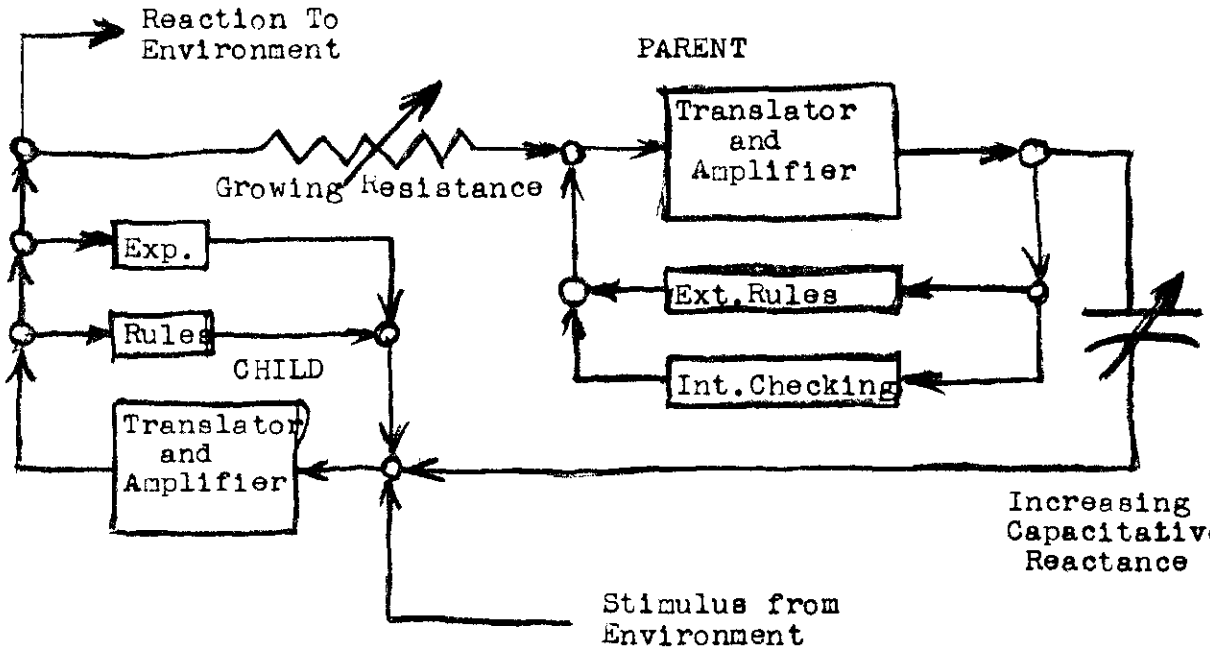


Fig. 4. Transistion of Growing Child.

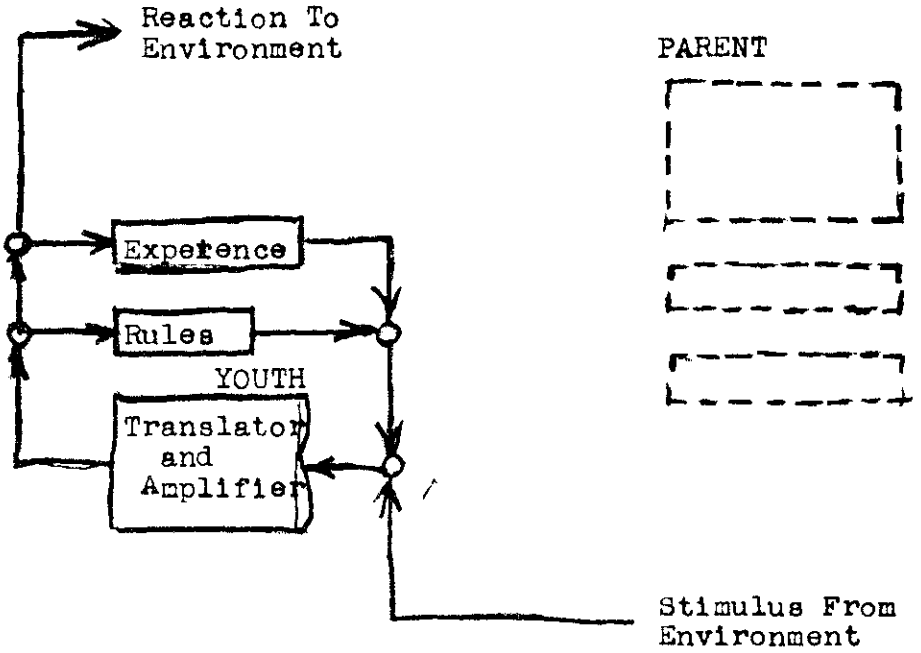


Fig. 5. Maturing Youth Becoming Independent.

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

Fig. 6 illustrates the controls established by Congress and U.S. Supreme Court decisions which stabilize the actinns 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.

Problem 7:4: How can the Society for General Systems Research impliment the distribution of working hypotheses?

I propose that the society establish a "working paper draft" distribution center where xerox or microfilm copies can be obtained, and that a quarterly list containing abstracts of drafts deposited with the secretary be distributed. In this way Dr. Bernal's proposal for the dissemination of scientific information might be tested in a limited way.

Frederick B. Wood
August 11, 1959

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## Supplement on Calculation of Negentropy Terms.

The following table is added for convenience in calculating the negentropy of membership statistics for tables like that on page 3 of this report.* The table is plotted on logarithmic graph paper for convenience in interpolating between calculated points.

* SEPR No. 7

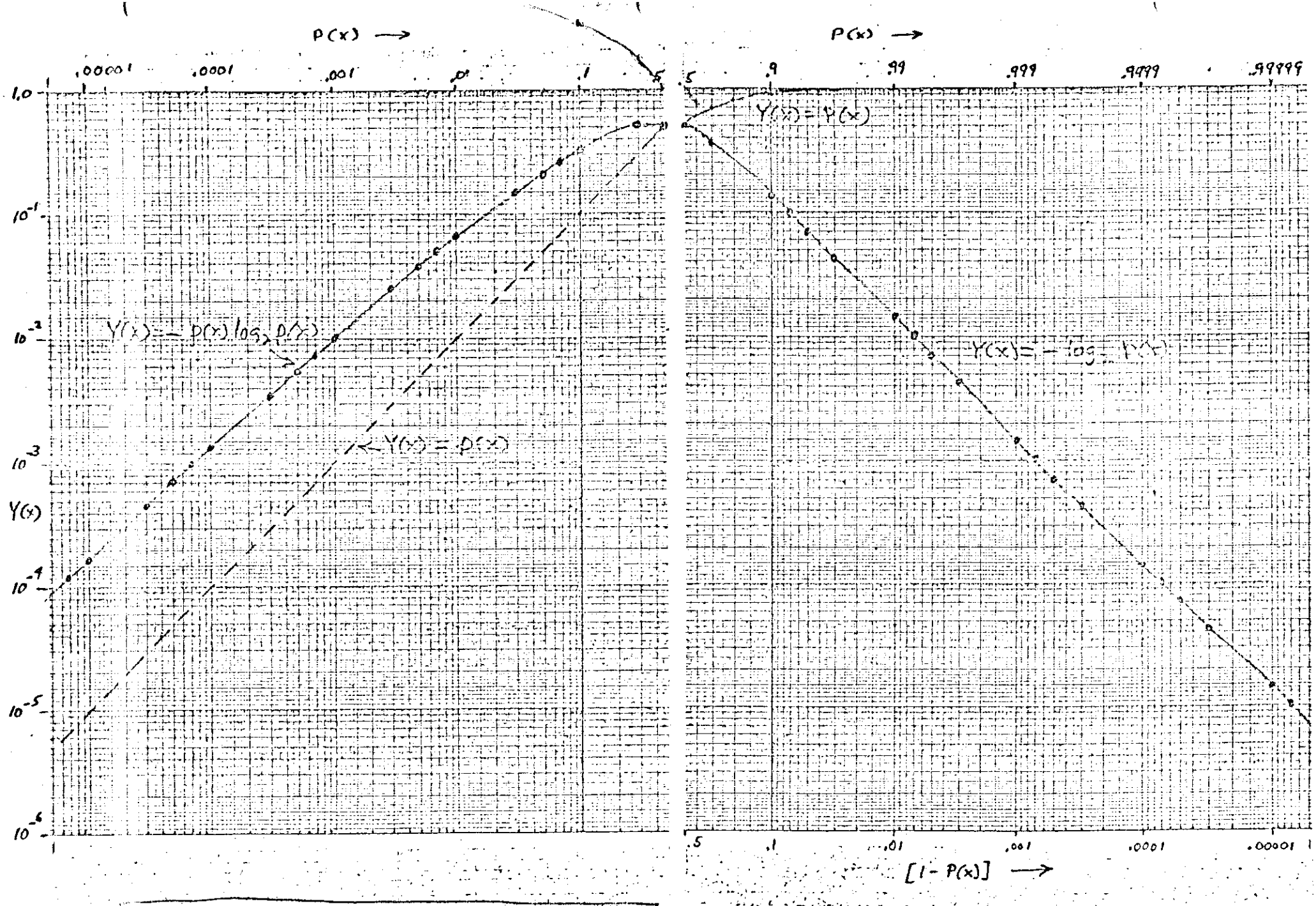
TABLE OF NEGATIVE LOG PROBABILITY VALUES

| L | PROBABILITY P(L) | LOG PROB. PLOG(L) | NEGENTROPY -PTLOG(L) |
|---|---|---|---|
| 1 | 0.9999930 | -0.0000101 | 0.0000101 |
| 2 | 0.9999900 | -0.0000144 | 0.0000144 |
| 3 | 0.9999700 | -0.0000433 | 0.0000433 |
| 4 | 0.9999500 | -0.0000721 | 0.0000721 |
| 5 | 0.9999300 | -0.0001010 | 0.0001010 |
| 6 | 0.9999000 | -0.0001443 | 0.0001443 |
| 7 | 0.9997000 | -0.0004329 | 0.0004328 |
| 8 | 0.9995000 | -0.0007215 | 0.0007212 |
| 9 | 0.9993000 | -0.0010103 | 0.0010095 |
| 10 | 0.9990000 | -0.0014434 | 0.0014420 |
| 11 | 0.9970000 | -0.0043346 | 0.0043216 |
| 12 | 0.9950000 | -0.0072316 | 0.0071954 |
| 13 | 0.9930000 | -0.0101344 | 0.0100634 |
| 14 | 0.9900000 | -0.0144996 | 0.0143546 |
| 15 | 0.9700000 | -0.0439434 | 0.0426251 |
| 16 | 0.9500000 | -0.0740006 | 0.0703006 |
| 17 | 0.9300000 | -0.1046974 | 0.0973686 |
| 18 | 0.9000000 | -0.1520032 | 0.1368028 |
| 19 | 0.7000000 | -0.5145733 | 0.3602013 |
| 20 | 0.5000000 | -1.0000003 | 0.5000001 |
| 21 | 0.3000000 | -1.7369660 | 0.5210898 |
| 22 | 0.1000000 | -3.3219289 | 0.3321929 |
| 23 | 0.0700000 | -3.8365022 | 0.2685551 |
| 24 | 0.0500000 | -4.3219292 | 0.2160965 |
| 25 | 0.0300000 | -5.0538949 | 0.1517668 |
| 26 | 0.0100000 | -6.6438578 | 0.0664386 |
| 27 | 0.0070000 | -7.1584312 | 0.0501090 |
| 28 | 0.0050000 | -7.6438580 | 0.0382193 |
| 29 | 0.0030000 | -8.3808239 | 0.0251425 |
| 30 | 0.0010000 | -9.9657867 | 0.0099658 |
| 31 | 0.0007000 | -10.4803600 | 0.0073363 |
| 32 | 0.0005000 | -10.9657869 | 0.0054829 |
| 33 | 0.0003000 | -11.7027527 | 0.0035108 |
| 34 | 0.0001000 | -13.2877157 | 0.0013288 |
| 35 | 0.0000700 | -13.8022889 | 0.0009662 |
| 36 | 0.0000500 | -14.2877158 | 0.0007144 |
| 37 | 0.0000300 | -15.0246818 | 0.0004507 |
| 38 | 0.0000100 | -16.6096444 | 0.0001661 |
| 39 | 0.0000070 | -17.1242177 | 0.0001199 |

$P(L)$ = Probability

$PLOG(L) = Log_2(P(L))$

$PTLOG(L) = P(L) * Log_2(P(L))$




MORE DETAILS IN SEPR No. 88-B Fig 2.
P.S.B. 12/27/63

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# "ALLOCATION OF SUPPLEMENTARY PUBLIC EXHIBIT SPACE BY NEGENTROPY OF MEMBERSHIP STATISTICS."

## Note

This memorandum is a revision to pages 3-5 of SEPR No. 7, "Problems To Be Referred To The Society For General Systems Research," 8/11/59; and also a revision to pp. 5-7 of SEP No. 65-E, "Abstract of A Research Plan for a Book on 'COMMUNICATION THEORY IN THE CAUSE OF MAN!'," 5/22/63.

My concern over church meeting and exhibit space comes from a series of experiences since World War II principally in California in which churches have been forced out of strategic locations through the state's use of eminent domain for expansion of schools and freeways. Juries and local judges understand financial injustices easily and thus have corrected any unfair awards in regard to the monetary compensation. The location of the principal churches and synagogues in strategic points around central parks, squares, and civic centers used to be a symbol of the role of the religious organizations in helping man develop a conscience and to look forward from the past struggles toward a better more just society. Even though some of the churches may be a generation behind in adjusting to the advances of modern science, discussions of the problems of our civilization in church discussion groups serves an important role in developing understanding of the problems of our civilization.

The economic trends and city planning policies of large American cities result in the 'socialization' of an increasingly larger fraction of the property in the center of our cities. Public buildings and freeways eat up the land area in the centers of our large cities, while skyscrappers shield the remaining central squares from general view. If a new religious group should develop in a typical large American city, it would have a very difficult time acquiring a strategic site for their central temple. We may have a conflict between the principle of separation of church and state and the guarantee of religious liberty when the percentage of publically owned property in the centers of our cities exceed a certain fraction.

When this level of 'socialization' exceeds a certain critical fraction, it may be necessary for the state or city to allocate supplemental space in the form of bulletin board space in a central square or civic center to different religious and philosophical groups. The purpose of this memorandum is to explore a hypothesis that the concept of negentropy from electrical communication theory can be used as a guide in such circumstances for determining the ratios of supplemental space to allocate to each religious group.

The reason for considering "negentropy" rather than some other property for a guide in this allocation of space is that there is a loose relationship between maximizing negentropy and an ethical principle of "reverence for life." The analogy can be seen partially by noting how biological systems preserve or increase order, thereby decreasing entropy ( or increasing negative entropy). This is discussed more fully in SEPR No. 88-B, "Negentropy and the Concepts of Freedom, Democracy and Justice."

Reviewing the situation of a city that has been cut up by freeways and in which the original center formerly holding the central core of principal churches has been shrunk by expansion of a college and by schools and public buildings. The churches which have been eliminated can be found relocated out in the suburbs, with the exception of the largest denominations the diversity of religious belief of the city no longer can be seen at a glance as one stands in the center of the city.

Consider an hypothetical city of 100,000 adults (children not counted inthis study). The assumed distribution of adult members of different religious faiths is as listed in Fig. 1. It is assumed that each religious group has bulletin board space as indicated on its church property, but visible from the public street. For some locations the bulletin board may be in a strategic place, but for other s it may face on a side street in a suburban area and the church may be obscured from view by a freeway and a set of skyscrappers. We shall experiment with a way to allocate supplemental bulletin board space in a public building or public square to guarantee that all religious groups have some prime public bulletin board space for the benefit of their own members, visiting members of their faith from out of town, and to be a symbol of the cooperative existence of differing faiths in a democratic community.

The results of a sample calculation are tabulated in Fig. 1. The supplementary public bulletin board space is taken proportional to the negentropy of the membership statistics. In addition the privately owned bulletin space and the total values are tabulated. These values are drawn graphically to scale on the bottom part of Fig. 1. Suppose that a 100' x 30' section of the main lobby of the civic center building is devoted to exhibit space consisting of a four foot wide section of bulletin board around the lobby. Then 16,167 unit squares of space would correspond to 1040 sq.ft,. making each unit be 9.4 sq.in. This makes the smallest group (No. 10, Ethical Culture) have 13.3 units or 116 sq. in. or one legal size sheet of paper. If one individual developed some new philosophy, by the negentropy formula, he would be entitled to the space of one third of a page space to state in one paragraph his cause and to give his address, phone, etc., for further details.

Frederick B. Wood
March 31, 1964

**Fig. 1 redrawn 5/30/64**

| Religious Group | Members | $p_i$ Prob. | $-p_i \log_2 p_i$ Negentropy | Bulletin Bd. Space Private | Public | Total |
|---|---|---|---|---|---|---|
| 1. Roman Catholic | 60,000 | 0.600 0 | 0.441 0 | 6,000 | 4,420 | 10,420 |
| 2. Protestant | 20,000 | 0.200 0 | 0.463 0 | 2,000 | 4,630 | 6,630 |
| 3. Lutheran | 15,000 | 0.150 0 | 0.411 0 | 1,500 | 4,110 | 5,610 |
| 4. Protestant Episcopal | 3,000 | 0.030 0 | 0.152 0 | 300 | 1,520 | 1,820 |
| 5. No Church | 1,000 | 0/010 0 | 0.066 5 | 100 | 665 | 765 |
| 6. Budhist | 600 | 0.006 0 | 0.044 3 | 60 | 443 | 503 |
| 7. Unitarian | 230 | 0.002 3 | 0.020 2 | 23 | 202 | 225 |
| 8. Jewish | 100 | 0.001 0 | 0.009 96 | 10 | 100 | 110 |
| 9. Eastern Orthodox Catholic | 60 | 0.000 6 | 0.006 4 | 6 | 64 | 70 |
| 10. Ethical Culture | 10 | 0.000 1 | 0.001 33 | 1 | 13 | 14 |
| | 100,000 | 1.000 0 | 1.616 7 | | | |

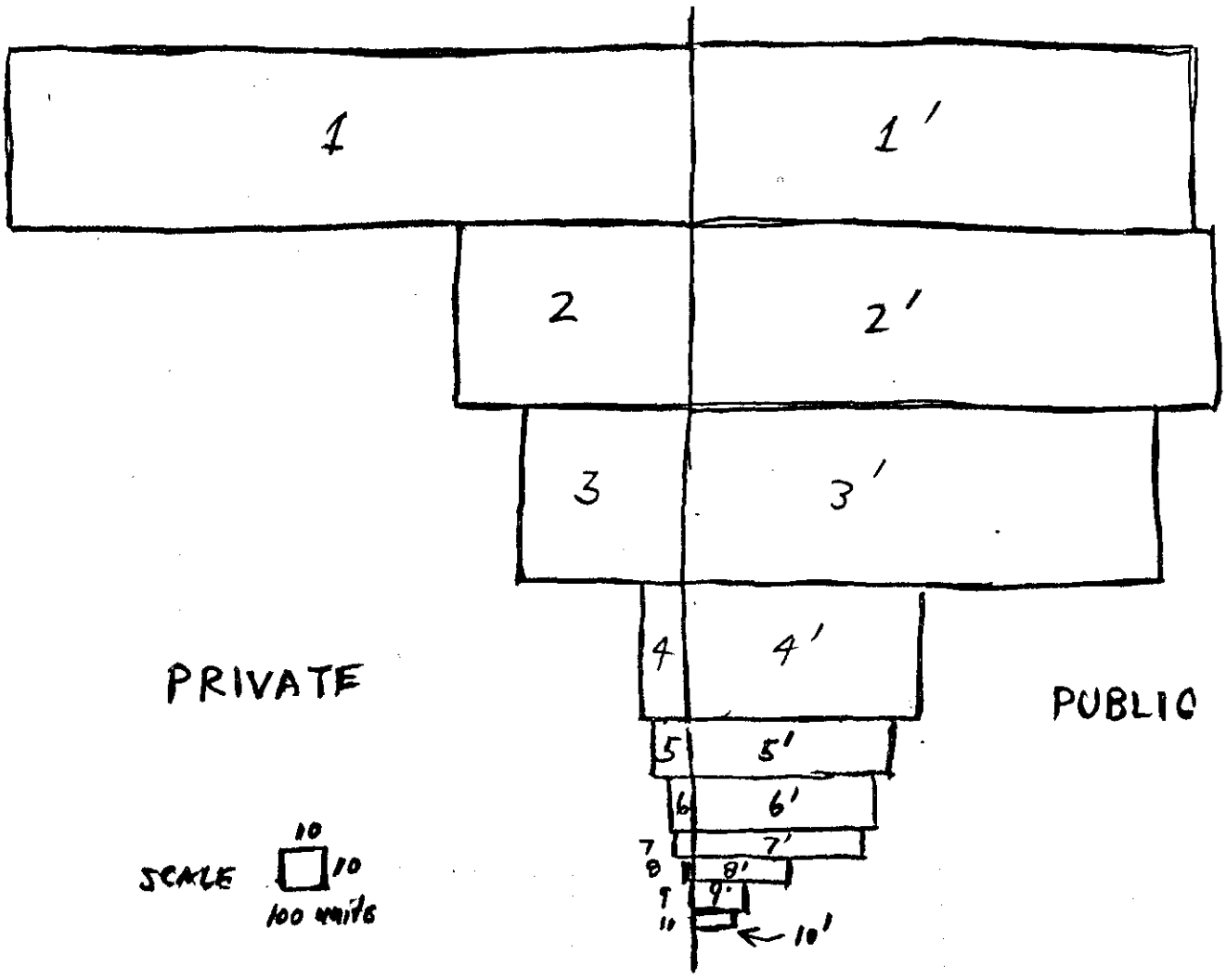


Fig. 1. Sample Distribution of Private and Supplemental Public Exhibit Space Determined by Negentropy of Membership Statistic

Stage E of A to T. A Working Paper Draft SEPR No. 7-C

# "Angels and Infinite Set Theory"

by

Frederick B. Wood, Ph.D.

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In my memo of 8/11/59, I listed a number of problems to be referredt to the Society for General Systems Research. ITem 7.1.2(e) was:

"How Many Angels Can Stand On The Head Of A Pin?"

The above question was brought up on account of the following conjecture which needs to be further investigated: 'Perhaps the period of scholasticism was a necessary prelude to modern mathmeatics. Dis the question of how many angels can stand onthe head of a ~~pppp~~ pin set the background for Cantor's infinite set theory?'

References: World of Mathematics, pp. 1582-1587,
pp. 1602-1605,
pp. 1593-1601,
pp. 2328,
p. 2411.

SOCIO-ENGINEERING PROBLEMS REPORT No. 7-C

Date: 9/13/57 8/11/59 12/18/62

Stage: Draft 7.1.2(e) File 7-C
SEP 7

# "TAYLOR'S SERIES AND PARTIAL DERIVATIVES OF HISTORY"

by

Frederick B. Wood, Ph.D.

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In my 1947 paper "History of Electromagnetic Thoery," I restated Leonard Loeb's stages of the development of electricity and magnetism in terms of "Partial Derivatives of History." This structuring of history into a hierarchy of levels analogous to first, second, third, etc., derivatives in mathematics was discussed in SEP Nos. 9-A, and 10-A. This was also discussed briefly in SEP No. 7 as problem 7.1.2(c).

Illustrations were prepared for this concept of partial derivatives of history as Section 5, Figures 16-21, in SEP No. 82, 5/17/62. A page of tewt on Taylor's Series in included in the rough drft of SEP 65-B in file(not in issued SEPR No. 65-B). A further discussion of use of the concepts is included in SEP No. 65-C and 65-D.

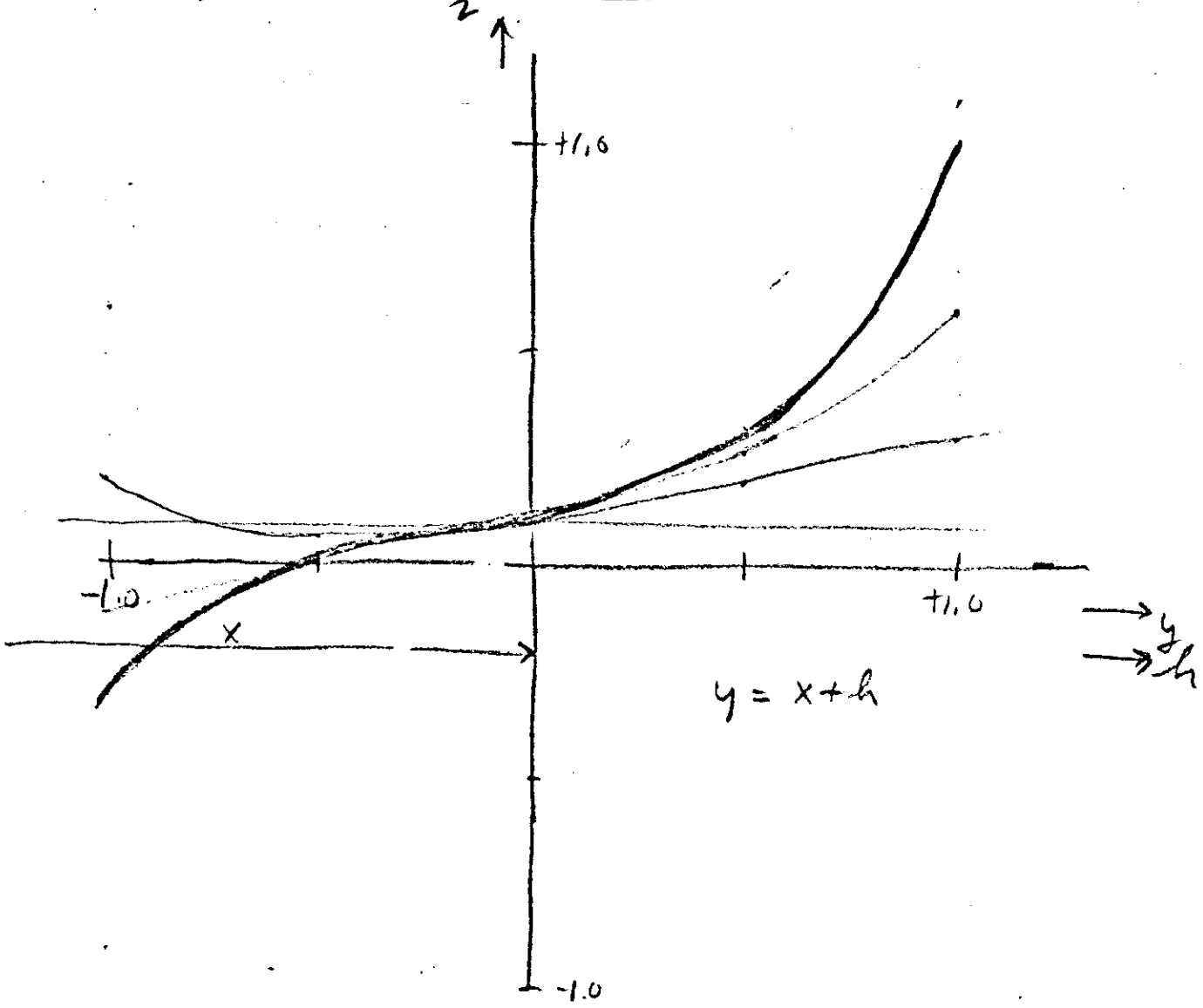
Two examples of curves represented by Taylor's series are shown on the next two pages with equations. On the page after is a short description of Taylor's Series with a set of curves following.

# Taylor Series

$$f(x+h) = f(x) + h \cdot \frac{df(x)}{dx} + \frac{h^2}{2!}\frac{d^2f(x)}{dx^2} + \cdots + \frac{h^n}{n!}\frac{d^nf(x)}{dx^n}$$

For example: $z = f(y) = f(x+h)$

$$\boxed{z = 0.1 + 0.2y + 0.3y^2 + 0.4y^3}$$



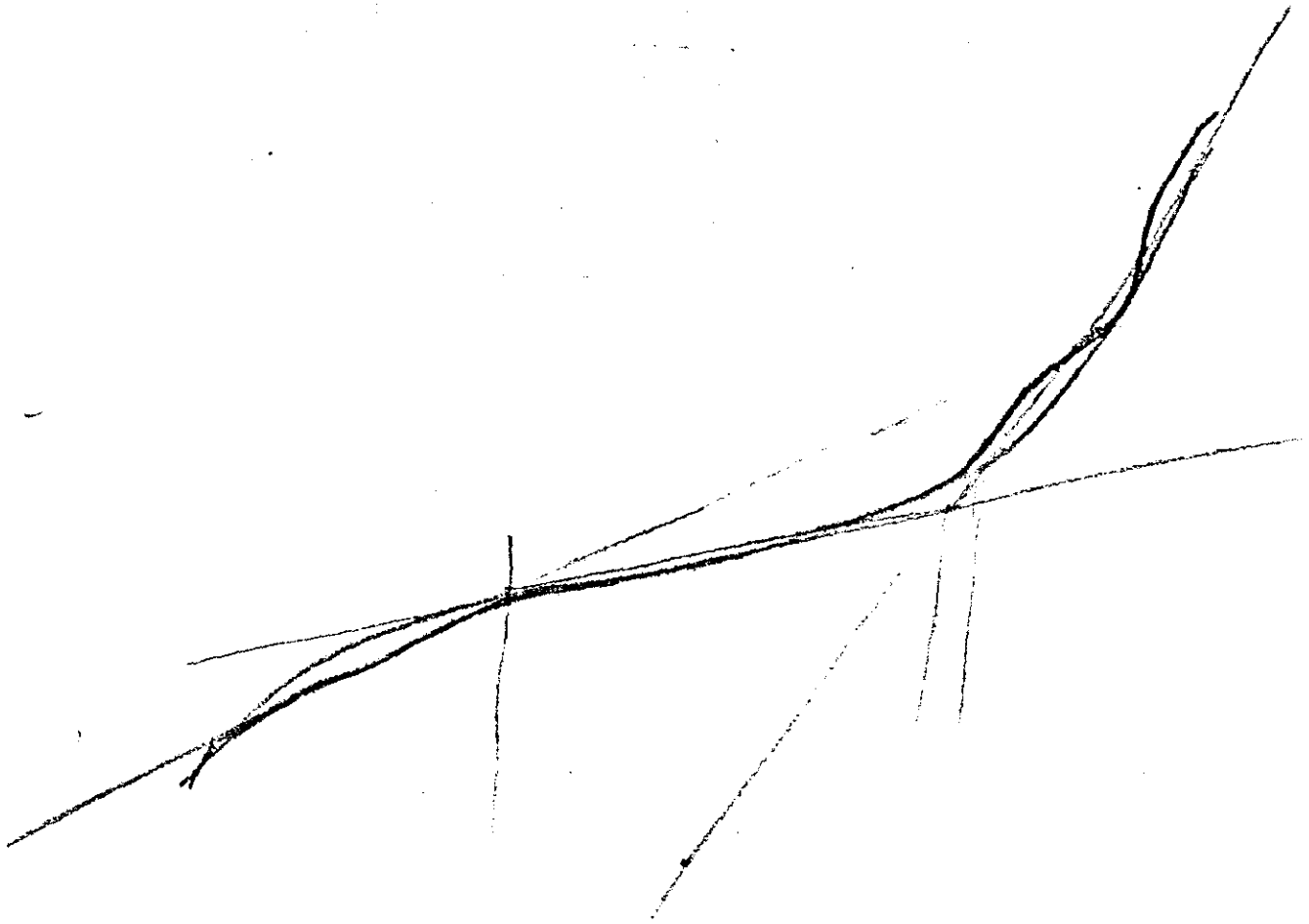

$$\frac{dz}{dy}_{y=0} = 0.2 + 0.6y + 1.2y^2 \rightarrow 0.2 \qquad \frac{d^4z}{dy} = 0$$

$$\frac{d^2z}{dy}_{h=0} = 0.6 + 2.4y \rightarrow 0.6$$

$$\frac{d^3z}{dy^3} = 2.4$$

$$f(x+h) = 0,1 + 0,2\,h + \frac{h^2}{2}\,0.6 + \frac{h^3}{6}\,2,4$$

$$= 0,1 + 0,2\,h + 0.3\,h^2 + 0.4\,h^3$$



B. PARTIAL DERIVATIVES AND SERIES EXPANSIONS (Mathematics and Mathematical Biophysics).

When a mathematician has a problem properly defined on a space, i.e., he has the space defined, the boundary conditions are known, and the basic differential equations governing the phenomena are known, it still may be difficult to find an exact solution. When he cannot find an exact solution in closed form he must choose as to what incomplete answer would be of value.

(1) He may decide it is important to find a complete solution for a region lying within a certain radius of a particular point in the space, or

(2) He may decide that solving for one particular partial derivative may give him the needed information on how the system changes with changes in one particular parameter.

To use the first approach the mathematician must develop a series expansion in terms of functions which satisfy the differential equation and must verify that the whole series is capable of providing a complete solution in the region of interest. For the second part he must take a partial derivative of the exact solution or of the series expansion.

For this section I plan to develop a semi-popular account based on the standard treatment from a textbook like Woods & Bailey(* It would be aimed at helping the layman to be able to perceive better the significance of articles in Bulletin of Mathematical Biophysics and books like Mathematical Biology of Social Behavior(§).

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* Frederick S. Woods and Frederick H. Bailey, Analytic Geometry and Calculus. Boston: Ginn & Co.(1917), pp. 136, 335, 410-412.

§ Nicolas Rashevsky, Mathematical Biology of Social Behavior(1951)

## 4. Partial derivatives and related series expansions.

The Taylor's Series used in mathematics to represent a function in a limited region about a point suggests a series of partial histories of different orders for obtaining a suitable perspective to deal with the essential historical background of a problem dealing both with engineering and sociology. Taylor's series enables us to expand a function in terms of powers of x-a when the value of the function and its derivatives are known for x=a. The function is said to be expanded in the neighborhood of x=a, and the series can be used to compute the value of the function for values of x which are near a. For example, set

$$f(a+h) = f(a) + hf^{1}(a) + \frac{h^2}{2!} f''(a) + \frac{h^3}{3!} f'''(a) + \cdots + \frac{h^n}{n!} f^{(n)}(a) + \cdots\cdots$$

If we take the first derivative of f(a+h) with respect to h, we have

$$f^{1}(a+h) = f^{1}(a) + hf''(a) + \frac{h^2}{2!} f'''(a) + \frac{h^3}{3!} f^{IV}(a) + \frac{h^4}{4!} f^{V}(a)$$

Then the 2nd through 5th derivatives are:

$$f''(a+h) = f''(a) + hf'''(a) + \frac{h^2}{2!} f^{IV}(a) + \frac{h^3}{3!} f^{V}(a)$$

$$f'''(a+h) = f'''(a) + hf^{IV}(a) + \frac{h^2}{2!} f^{V}(a)$$

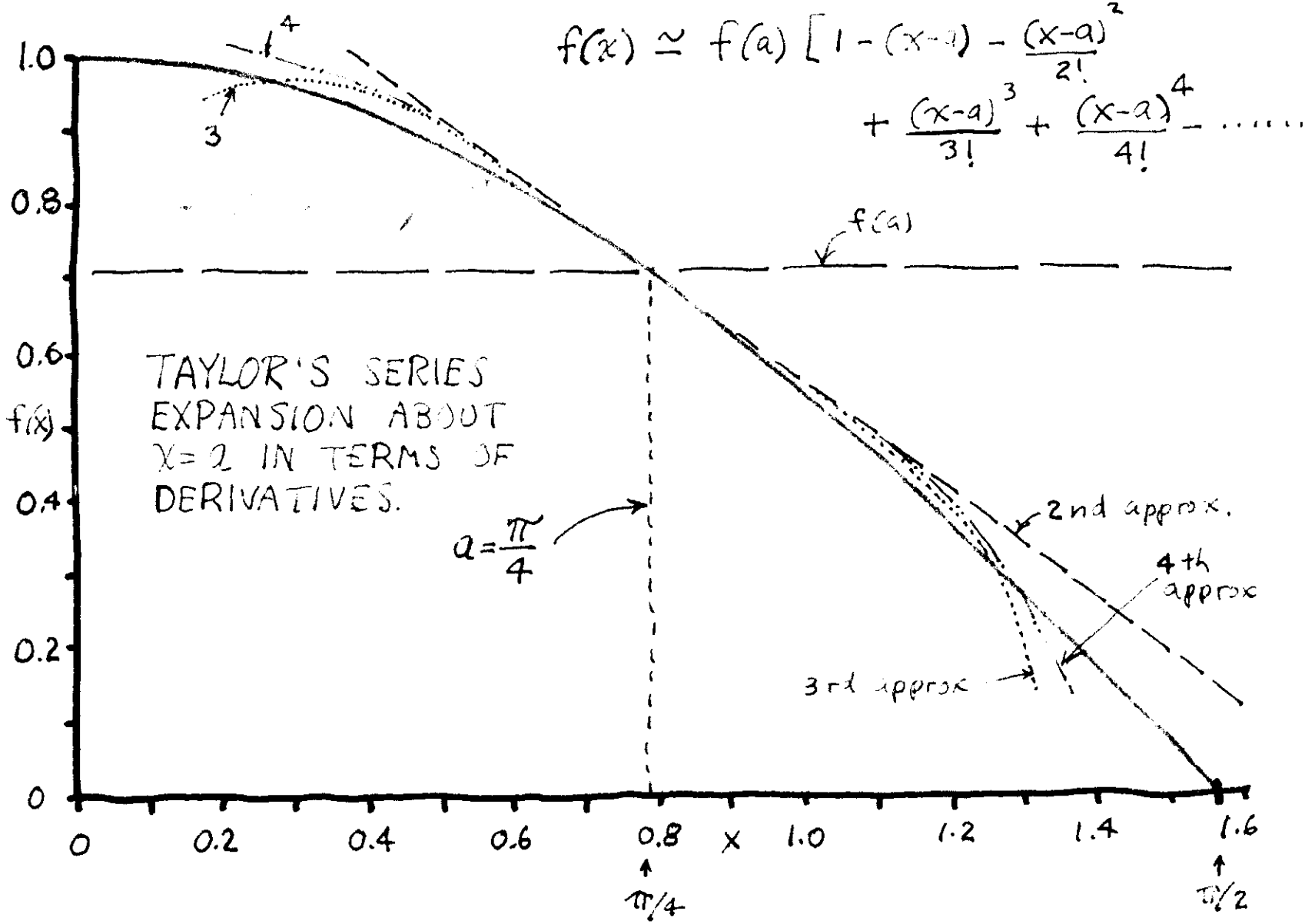
$$f^{IV}(a+h) = f^{IV}(a) + hf^{V}(a)$$

$$f^{V}(a+h) = f^{V}(a)$$

With the taking of each derivative less detail about the function is left. The objective of this note is to collect some reference material for the development of series of partial derivatives of history similar to the Taylor's Series of mathematics.

See Fig 10, 11.

# PARTIAL DERIVATIVES OF HISTORY



β. USE OF "PARTIAL DERIVATIVES OF HISTORY" CONCEPT TO QUALIFY GRAND THEORIES OF HISTORY SIMILARLY TO THE WAY SERIES EXPANSIONS AND PARTIAL DERIVATIVES ARE USED IN MATHEMATICS.

At this stage it is not possible to put Toynbee's A Study Of History (*) into mathematical form, and perhaps such areas of study are not amenable to direct mathematical formulation. The problem here is to determine which of the variables he is dealing with so we can determine the nature of his study as a "partial derivative of history" or is he dealing with particular regions of history such that the individual sections in his series of studies are equivalent to a series approximation in mathematics. The object of this part of the project is to attempt to put some important grand theories of history and sociology in an appropriate perspective by use of the appropriate analogy from mathematics. In addition to Toynbee, the works of Sorokin(#), Friedrich Engels(§), and W.W. Rostow(§) need to be considered. For future projection the work of Teilhard de Chardin(ℓ) requires careful consideration.

---

* Arnold J. Toynbee, A Study of History (Abridgement by D.C. Somervell), N.Y.: Oxford Univ. Press(1947)

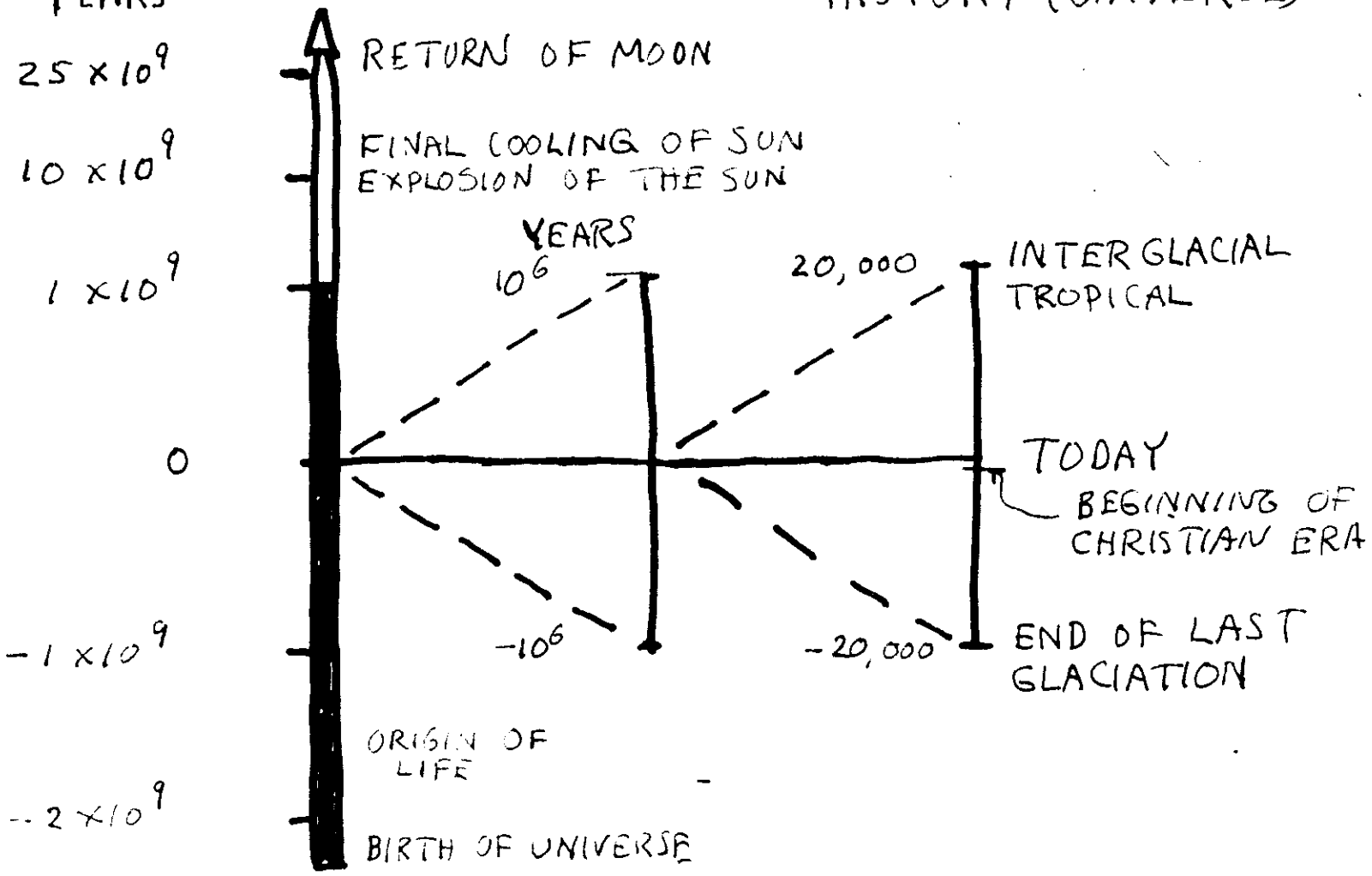
# Pitirim A. Sorokin, Society, Culture, and Personality, N.Y.: Harper and Borthers(1947)

§ Friedrich Engels, Dialectics of Nature, written between 1872 and 1882, publ. in Moscow about 1934, in N.Y., 1940.

§ W..W. Rostow, The Stages of Economic Growth - A Non-Communist Manifesto. Cambridge; The University Press(1960)

ℓ Pierre Teilhard De Chardin, The Phenomenon of Man. In French, Paris: Editions du Seuil(1955); English trans., N.Y.: Harper & Bros.(1959)

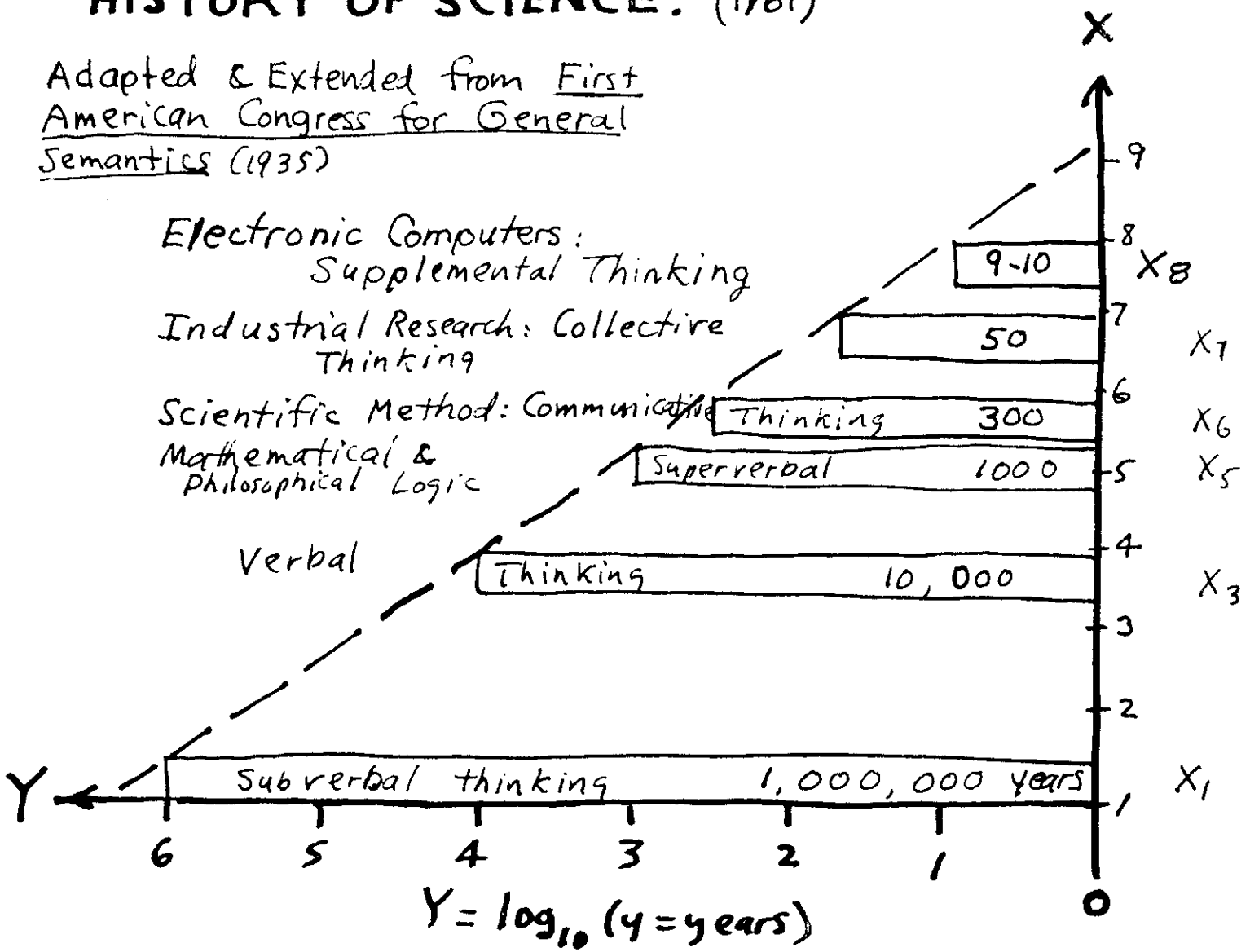
# 5TH ORDER PARTIAL HISTORY (UNIVERSE)

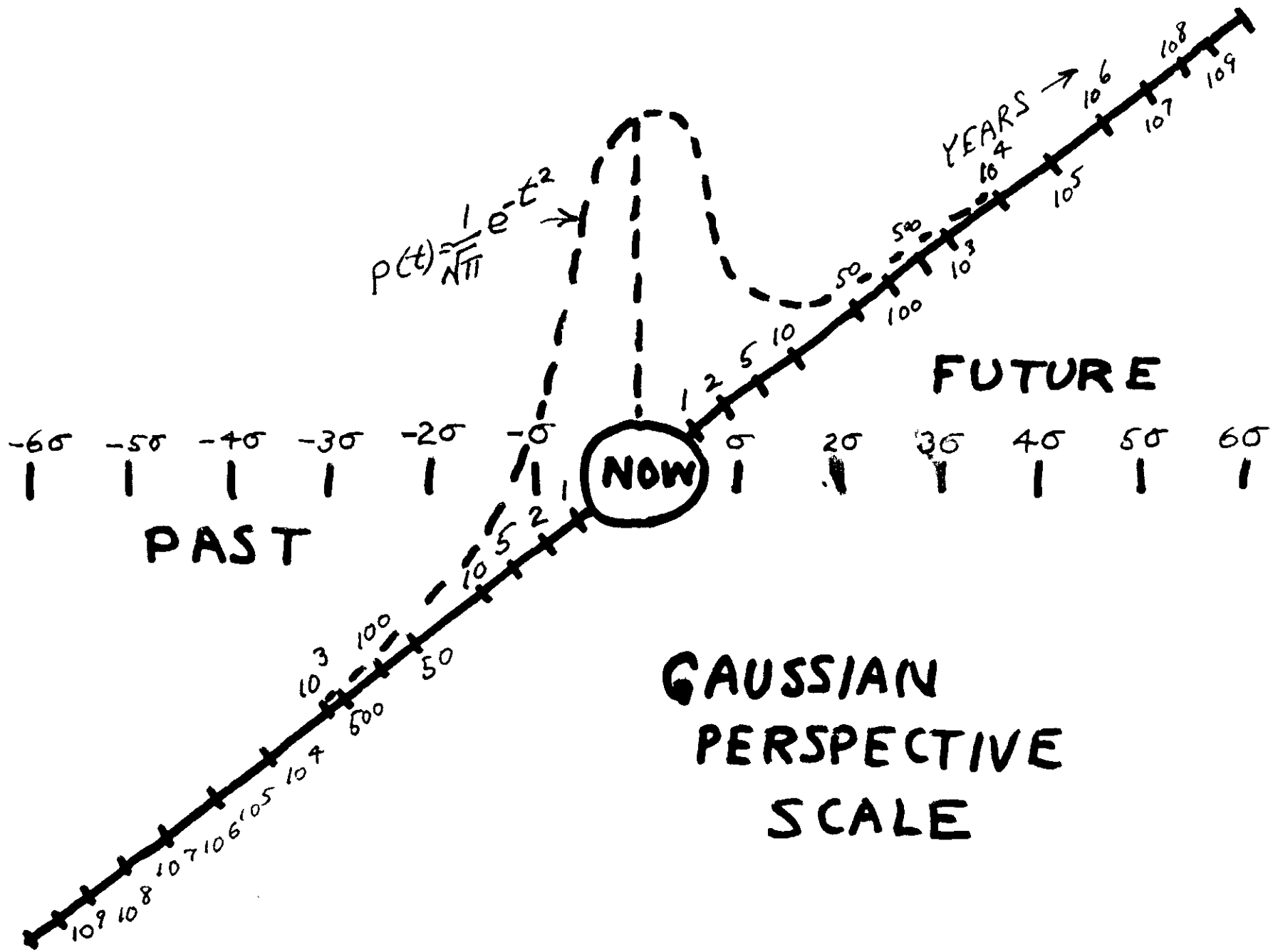


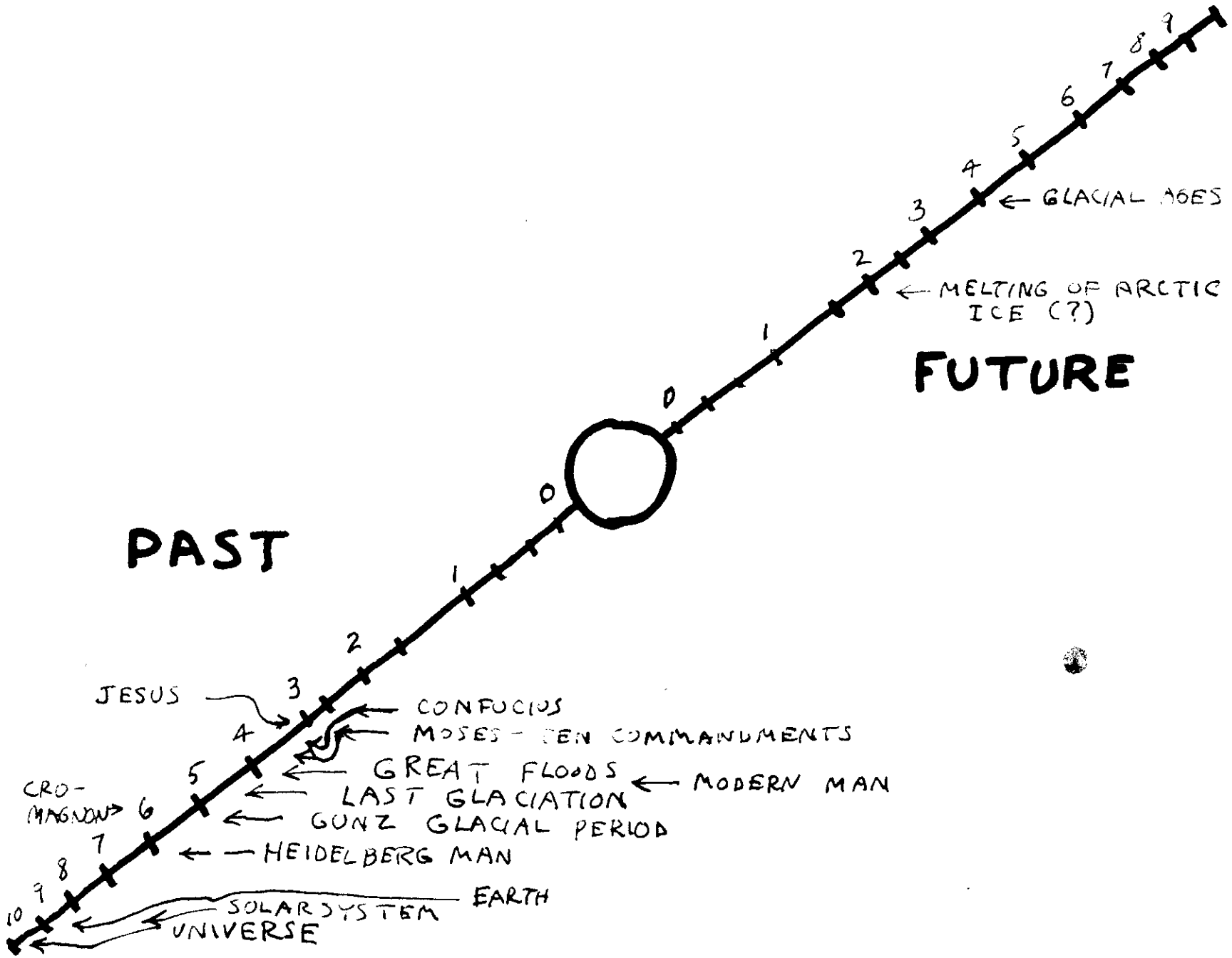

SCALES FROM GAMOW

# 2ND ORDER PARTIAL HISTORY OF SCIENCE. (1961)

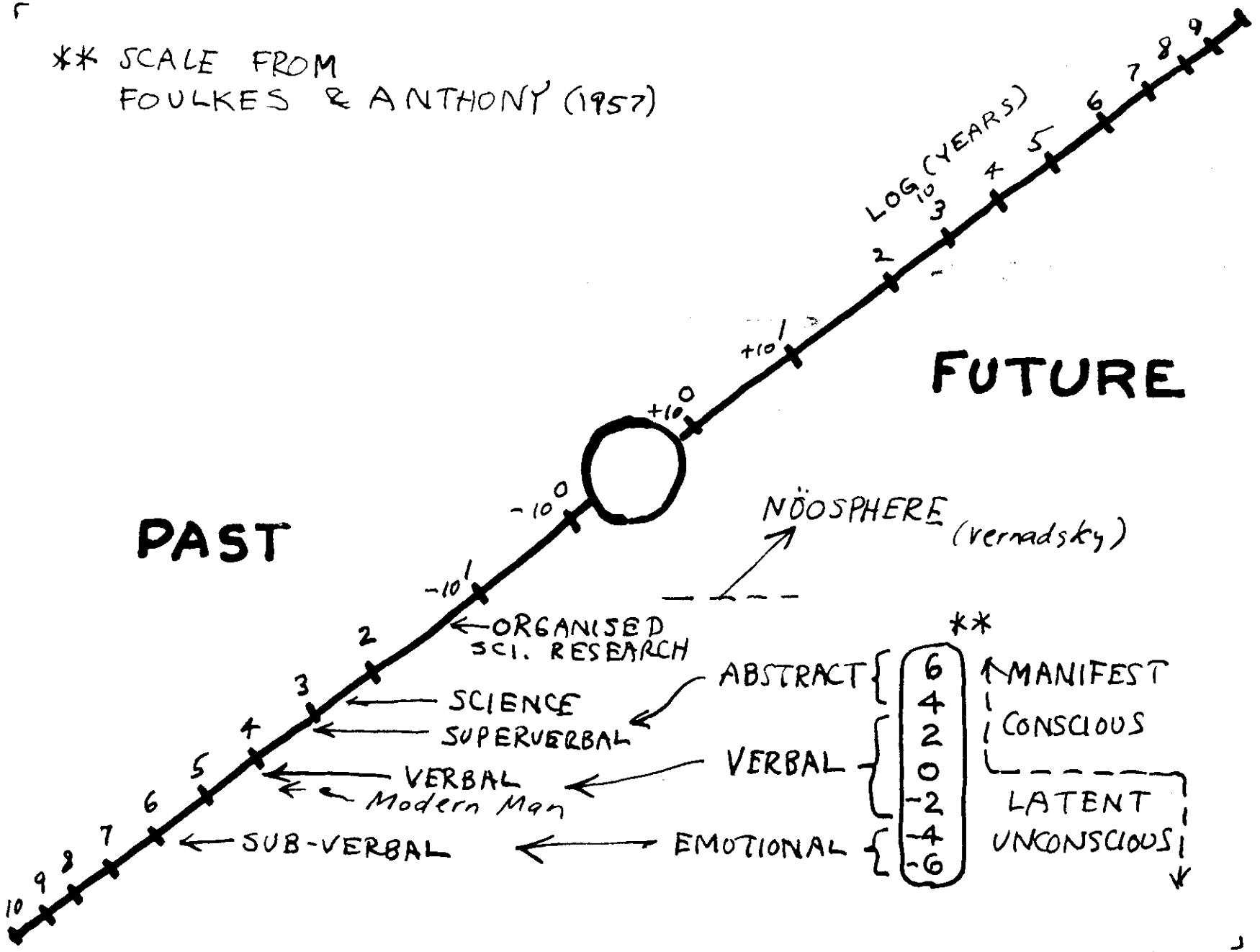
Adapted & Extended from First American Congress for General Semantics (1935)




$p(t) = \frac{1}{\sqrt{\pi}} e^{-t^2}$
YEARS →
$10^9$ $10^8$ $10^7$ $10^6$ $10^5$ $10^4$ $10^3$ 100 50 10 5 2 1
-6σ -5σ -4σ -3σ -2σ -σ NOW σ 2σ 3σ 4σ 5σ 6σ
1 2 5 10 50 100 $10^3$ 500 $10^4$ $10^5$ $10^6$ $10^7$ $10^8$ $10^9$
PAST
FUTURE
GAUSSIAN
PERSPECTIVE
SCALE


FUTURE
9
8
7
6
5
4
← GLACIAL AGES
3
2
← MELTING OF ARCTIC ICE (?)
1
0
0
PAST
1
2
3
JESUS
CONFUCIUS
4
MOSES - TEN COMMANDMENTS
5
GREAT FLOODS
← MODERN MAN
CRO-MAGNON
6
LAST GLACIATION
GUNZ GLACIAL PERIOD
7
HEIDELBERG MAN
8
9
EARTH
10
SOLAR SYSTEM
UNIVERSE

** SCALE FROM
FOULKES & ANTHONY (1957)



A larter more detailed gaussing curve of history is included in SEP No. 34.

SOCIO-ENGINEERING PROBLEMS REPORT No. 7-D

Date: 11/25/46 3/16/61-3/6/62 8/11/59 9/25/62 12/18/65 1/20/67

Stage: Basic Concept | SEP Nos. 9-A and 10-A. | Problem 7.1.2(c) | Draft SEP 65B | Draft SEPR 7D | SEPR 7-D

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