SEPR No. 96-B

"A Comparison Of The Complexity Of Testing Thematic Hypotheses In The Physical Sciences And The Social Sciences"

by

Frederick B. Wood, Ph.D.

Abstract

The relative complexity of the testing of thematic hypotheses in different fields of science is reviewed. The term "thematic hypothesis" refers to a fundamental generalization as defined by philosophers of science such as Dr. Gerald Holton(1).

"Thematic and Phenomenic Hypotheses: Concepts for Re-evaluating Historic Stages in Physical Science," paper delivered at 10th International Congress for the History of Science, Cornell, August 30, 1962. (See also related paper at AAAS Meeting, Philadelphia, Pa., December 1962.)

The increasing complexity of the testing of hypotheses is examined as we procede from physical-chemical phenomena to biological phenomena to psychological and sociological phenomena. The philosophy of general systems theory is used to compare the requirements for testing an example from physical science, namely Einstein's special theory of relativity, with a psychological-sociological hypotheses, namely R. B. Lindsay's "thermodynamic imperative."(2)

The Role of Science in Civilization, N.Y.: Harper & Row(1963). See also Bernard Baumrin, editor, *Philosophy of Science - The Delaware Seminar*, vol. 2(1962-1963). N.Y.: Interscience Publishers(1963), pp. 411-448, "Physics, Ethics and the Thermodynamic Imperative." For a preliminary development see R. B. Lindsay, "Entropy Consumption and Values in Physical Science," *American Scientist*, *47*, 376(1959). Also, S. Polgar, "Evolution and the Thermodynamic Imperative," *Human Biology*, *33*, 99, (1961). Also, William Malamud, "Psychiatric Research: Setting and Motivation," *The American Journal of Psychiatry*, Vol. 117, No. 1, July, 1960.

The review of the experimental evidence of the special theory of relativity is based upon W. K. H. Panofsky's matrix of rows of theories versus columns of experiments(

Classical Electricity and Magnetism, Reading, Mass.: Addison-Wesley Publishing Co.(1955) pp. 230-242.

The structuring of such a table for a "thematic hypothesis" such as the "thermodynamic imperative" is found to be more complex. First moving to biological phenomena increases the complexity in that in addition to the simple

matrix for testing hypotheses, an evolutionary time scale has to be added. Then moving to psychological-sociological phenomena, a third factor increases the complexity, namely the existence of many different human cultures on our planet, so that some cross-cultural test must be applied to prevent the researcher from being blind to some factors which are assumed or screened out by the culture in which the researcher is embedded. There is a further complication in that important national and international decisions are being made on the basis of thematic hypotheses which have not been adequately tested. It is important that tentative ways be developed to test important hypotheses like the "thermodynamic imperative", before it develops into a political ideology, so that rational use can be made of such hypotheses to conserve human values.

THIS IS AN INCOMPLETE PAPER =
= SPACE IS RESERVED HERE FOR
ADDITIONAL NOTES BY READER ....

I. Introduction.

How can we test sociological hypotheses?

Is the problem more complex than in the Biological case?

What thematic hypotheses shall we test?

Immanuel Kant's "Categorical Imperative"

> "So to act as to treat humanity,
> whetherin thine own person
> or in that of another, in
> every case as an end, withal,
> never as a means only."

Albert Schweitzer's

> "Reverence for Life."

R. B. Lindsay's "THERMODYNAMIC IMPERATIVE"

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

IL/4

My objective is to compare the relative complexity of testiing thematic hypotheses in the physical sciences and the social sciencs in order to lay some groundwork for testing the validity of the application of analogies from communication sciences, informtion theory to sociological systems. First we must define what we mean by "thematic hypotheses." Here I am referring the concept as it is used and has been developed by Gerald Holton(1,2).

Professor Holton defines a three-dimensional space in connection with the study of concepts and principles of science. The x-dimension is called the "phenomenic" , the y-axis the "heuristic-analytic," and the z-direction the "thematic."

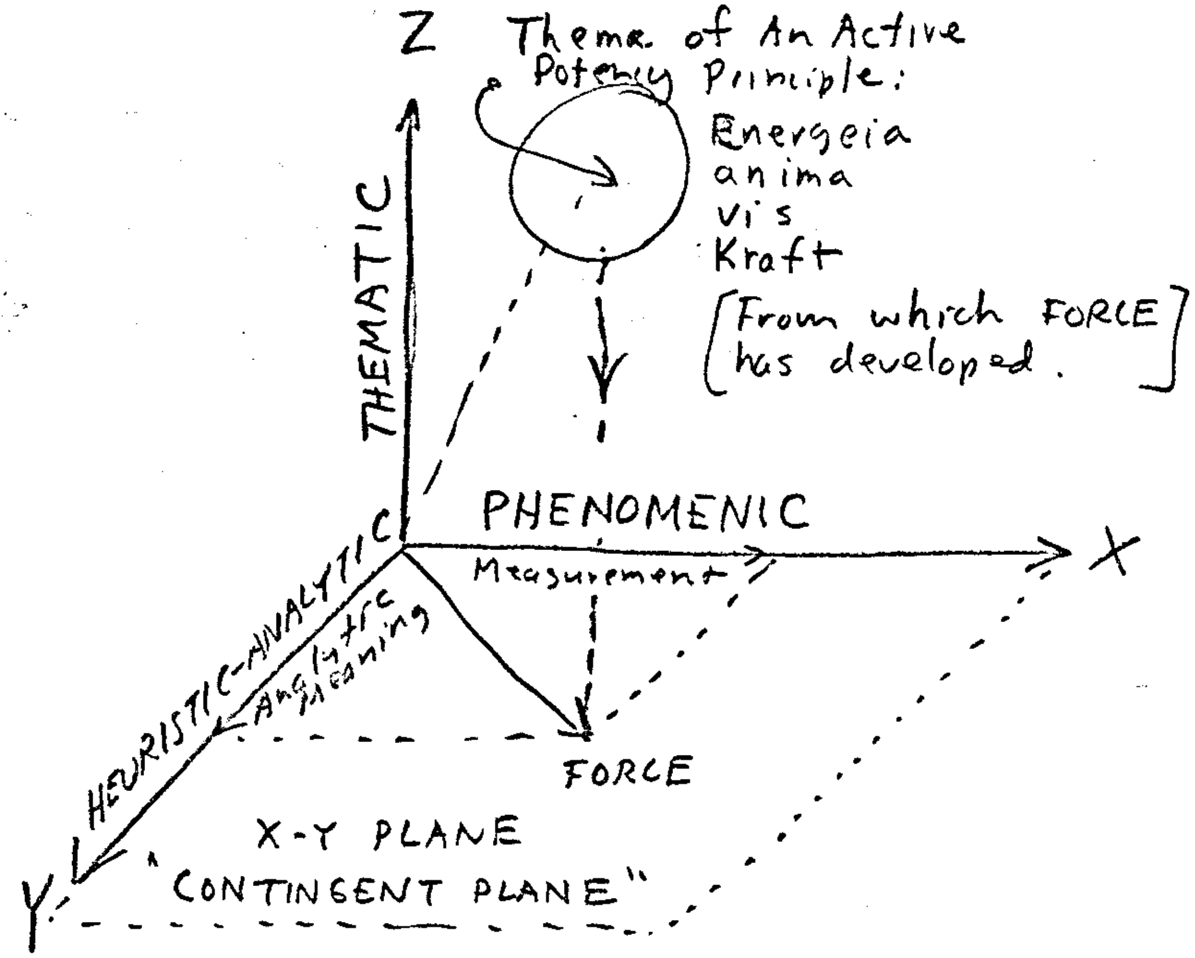
Z
Theme of An Active Potency Principle:
Energeia
anima
vis
Kraft
[From which FORCE has developed.]
THEMATIC
PHENOMENIC
Measurement
X
HEURISTIC-ANALYTIC
Analytic Meaning
FORCE
X-Y PLANE
"CONTINGENT PLANE"
Y

Fig. 1.

2R

I. Introduction -- Thematic Hypotheses.

My objective is to compare the relative complexity of testing thematic hypotheses in the physical sciences and the social science in order to lay some groundwork for testing the validity of the apparent analogies from communication systems, information theory to sociological systems. First we must define what ~~a it~~ we mean by "thematic hypotheses." I am referring to the concept as it has been developed by Gerald Holton (1,2).

Professor Holton defines a three-dimensional space in connection with the study of concepts and principles of science. The x-dimension is called "phenomenic", the y-dimension "heuristic-analytic", and the z-direction "thematic". Quoting Dr Holton.

> "All commentators on science agree that two types of propositions are scientifically not meaningless, namely (1) propositions concerning empirical matters of "fact", and (2) propositions concerning the calculus of logic and mathematics that help us to structure and analyse.

1.

2. Gerald Holton "Thematic Hypotheses" AAAS, Philadelphia, Dec 1962.

as in Fig 7

We can use these 2 coordinates to define an x y plane. It is the plane in which scientific discourse usually proceeds. A concept such as force is considered as a point in the x y plane. The projection on the x or phenomenic dimension corresponds to the empirical meaning of "force", i.e. its detection and measurement by, say, the deflection of standard objects. The projection of "force" on the y dimension is its analytical meaning (vector property, e.g. parallelogram law of composition).

Having shown this for a concept, we analyze a statement, i.e. an hypothesis, or the law of universal gravitational attraction, in terms of its phenomenic and heuristic-analytic components. Such an analysis is a contingency analysis, because the value of a statement in the x y plane is contingent on the possibility of (1) checking the phenomenic component (e.g. whether 2 masses do move closer in a Cavendish experiment) and (2) checking the heuristic analytic component (e.g. whether the analysis in terms of vectors in Euclidean Space is more appropriate than, say, in terms of scalars). The x y plane is thus the "contingent plane", where scientific concepts and propositions have both empirical and analytical relevance.

And it is precisely such non-verifiable, non-falsifiable, and non-arbitrary thematic hypotheses which are most difficult to advance and to accept. It is they which are at the heart of major changes or disputes, and whose growth, domination, and decay are the much-neglected indicators for the course of significant developments in the history of science.

Now it has been the claim of modern positivism and empiricism that statements are scientifically meaningful only insofar as they have components in the contingent plane. This attitude has also been the ruling one in the younger sciences such as psychology, and also history, particularly the history of science. From Bacon, Kepler and Newton on, all who have claimed not to feign hypotheses are concerned with keeping the hypotheses they must use in the contingent plane. And this is one reason why science has grown so rapidly since 1600.

The fact, however, is that this aim is not and never can be fully achieved. The analysis of historic cases in science should therefore also begin to take into account that concepts and hypotheses as used in science are historically meaningful not only in the contingent plane, that the contingent components are merely 2 of 3 components, resulting from the projection of concept from x y z space to the x y plane. A concept such as force has also a thematic component, which is directly coupled not to phenomena or tautological, analytic statements, but to the persisting theme of an active potency principle that stands behind the whole sequence of concepts from which our $\vec{F}$ for force has developed: Energeia, anima, vis, Kraft.

I call a thematic position, or methodological thema, a guiding theme in the pursuit of scientific work, such as the thema of expressing laws of constancy, of extremum, or of impotency, or the method of the return to an earlier classical purity of the state of the science (e.g. Copernicus)* or quantification, or the rules of Reasoning. I call a thematic proposition, or thematic hypothesis one that is directly neither verifiable nor falsifiable, like Einstein's principle of the constancy of light velocity in free space, or for that matter Newton's secretly held hypothesis that, as Koyré expressed it, the cause of gravity is the action of the Spirit of God. //

b

II. An Example from the Physical Sciences.

Einstein Special Theory of Relativity is a prime example of a theoretical hypothesis in the physical sciences.

I. Construction and Testing of Hypotheses in Science.

First we must inquire how the scientist decides to accept a particular hypothesis like the Einstein Special Theory of Relativity. In many fields of science we never have absolute proof of a law, but have to be satisfied with testing hypotheses and using the hypothesis which is most consistent with the known facts. Maxwell's equations haven't been derived from more fundamental laws, without assuming one relationship that comes from knowing Maxwell's equations. The special theory of relativity is an interesting example. It is one of seven competing theories listed in Fig.1 which is based on Panofsky's lectures(1). If one examines the status of agreement of disagreement of each theory with the thirteen experiments, one can easily see that Einstein's special theory of relativity is the only one of the theories that has no contradictions. Therefore scientists accept the special theory of relativity until someone finds some experiment which results in a contradiction. Professor Panofsky considers the validity of the special theory of relativity as follows:

> "This outline(Fig. 1) of the experimental basis shows that experiment contradicts any reasonable alternative to the theory of relativity, rather than any single experiment proving the theory. The experiments outlined above(Fig. 1 on next page) present evidence that:
> (1) The presence of an ether, either stationary or convectively carried, cannot be established.
> (2) Modification of electrodynamics of the emission theory type is untenable. The conclusions then make it plausible to look upon the basic laws of mechanics as in need of modification.
>
> In 1905 Einstein proposed as a solution, compatible with the experimental facts known at that time, the following postulates:
> (1) All laws of electrodynamics (including, of course propagation of light with the velocity c in free space) shall be the same in all inertial frames, as are the laws of mechanics.
> (2) It shall be impossible to devise any experiment defining a state of absolute motion or to determine a preferred inertial frame having special properties for any physical phenomena.
>
> It is clear that if the laws of physics obeyed these postulates all the experimental facts outlined above (Fig 1.) would be in agreement with those postulates." (1)

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1. W. K. H. Panofsky, <u>Classical Electricity and Magnetism</u>, Physics 210B, Univ. of Calif. Syllabus CG, Mar 1949, pp. 249-251.

TABLE 14-3

Theory		Light propagation experiments							Experiments from other fields					
		Aberration	Fresnel convection coefficient	Michelson-Morley	Kennedy-Thorndike	Moving sources and mirrors	De Sitter spectroscopic binaries	Michelson-Morley, using sunlight	Variation of mass with velocity	General mass-energy equivalence	Radiation from moving charges	Meson decay at high velocity	Trouton-Noble	Unipolar induction, using permanent magnet
Ether theories	Stationary ether, no contraction	A	A	D	D	A	A	D	D	N	A	N	D	D
	Stationary ether, Lorentz contraction	A	A	A	D	A	A	A	A	N	A	N	A	D
	Ether attached to ponderable bodies	D	D	A	A	A	A	A	D	N	N	N	A	N
Emission theories	Original source	A	A	A	A	A	D	D	N	N	D	N	N	N
	Ballistic	A	N	A	A	D	D	D	N	N	D	N	N	N
	New source	A	N	A	A	D	D	A	N	N	D	N	N	N
Special theory of relativity		A	A	A	A	A	A	A	A	A	A	A	A	A

Legend: A, the theory agrees with experimental results.
D, the theory disagrees with experimental results.
N, the theory is not applicable to the experiment.

By permission from W. K. H. Panofsky and Melba Phillips, Classical Electricity and Magnetism, Addison-Wesley Pub. Co., Reading, Mass., Copyright 1955.

I have not attempted to update Dr. Cuffey's tables with recent work. I think it would be better to wait until some of the current confusing [illegible]. Wallace Kantor in 1962 reported on an experiment which on the propagation of light from a moving source which yields results apparently in disagreement with the "Einstein's hypothesis" of the constancy of the speed of light (.)

The [illegible] Special Theory of Relativity [illegible] has been questioned by H. Dingle (..,...)

(.) Wallace Kantor, "Direct First Order Experiment on the Propagating Light from a Moving Source", *Journal of the Optical Society of America*, 1962, vol 52, pp 978-984.

(..) H. Dingle, *Nature*, 1962, vol 195, p 985.

(...) [illegible], "Reason and Experiment in Relation to the Special Relativity [illegible]" *British Journal* [illegible].

Fred S. Grodins, "Computer Simulation of Cyb ernetic Systems."
Computers in Biomedical Research, Edited by Ralph Wj. Stacy
and Bruce Waxman, N.Y.: Academic Press(1965), pp. 135-164.

p. 142:

"The value of computer simulation to an engineer designing a new control system is obivious. He knows the variables he wants to control or manipulate, he knows the equations of the components he might use, and he combines these in a computer simulation to determine whether the poroposed syst m will behave as required. It is quicker and cheaper to explore many poroposed dsigns in this way than to actually build a system without prior simulation only to find that it does not work.

But the biologist faces a quite different problem. Before he can even begin to talk about simulation, he has to discover what the important controlled and manipulated variables are in an existing biological system, and to establish whether anything analogous to a negative feedbackloop actually exists. This is no small task. It has kept experimental physiologists busy for many years in the past and will continue to do so for many more in the future.

.... So computer simulation has value for both engineer and biologist. The former usese it to explore possible designs which will meet the arbitrary performance specifications of a system yet to be built. The latter uses it to explore possible hypotheses which might explain observed performance of,and guide furhter experiments upon, a mysterious system alreddy in existence. '

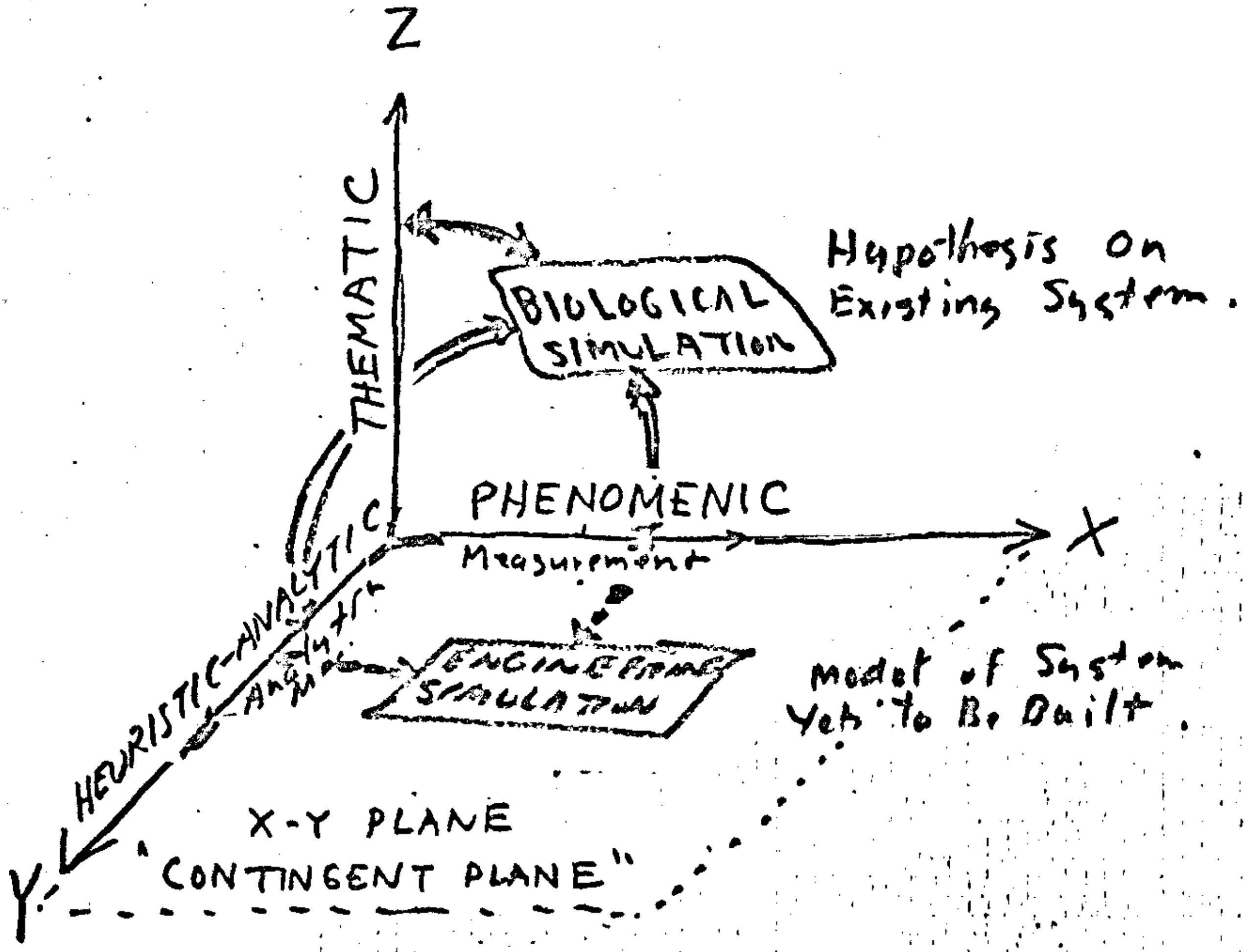

Fig 3. Engineering & Biology : A Comparison of Computer Simulations.

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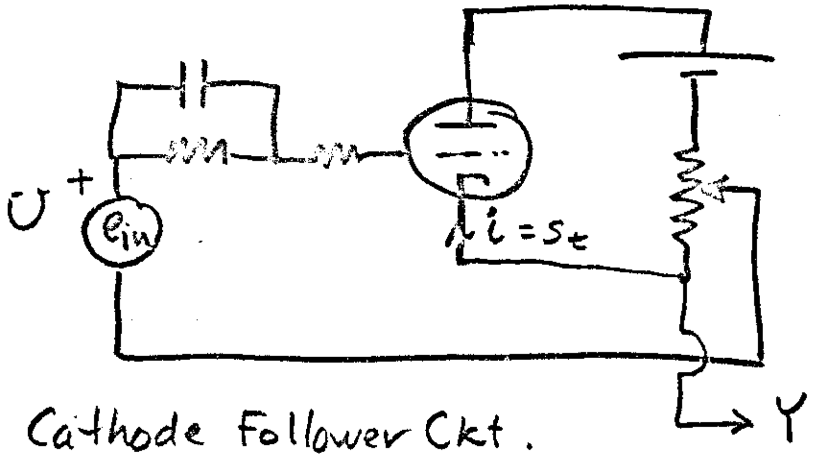
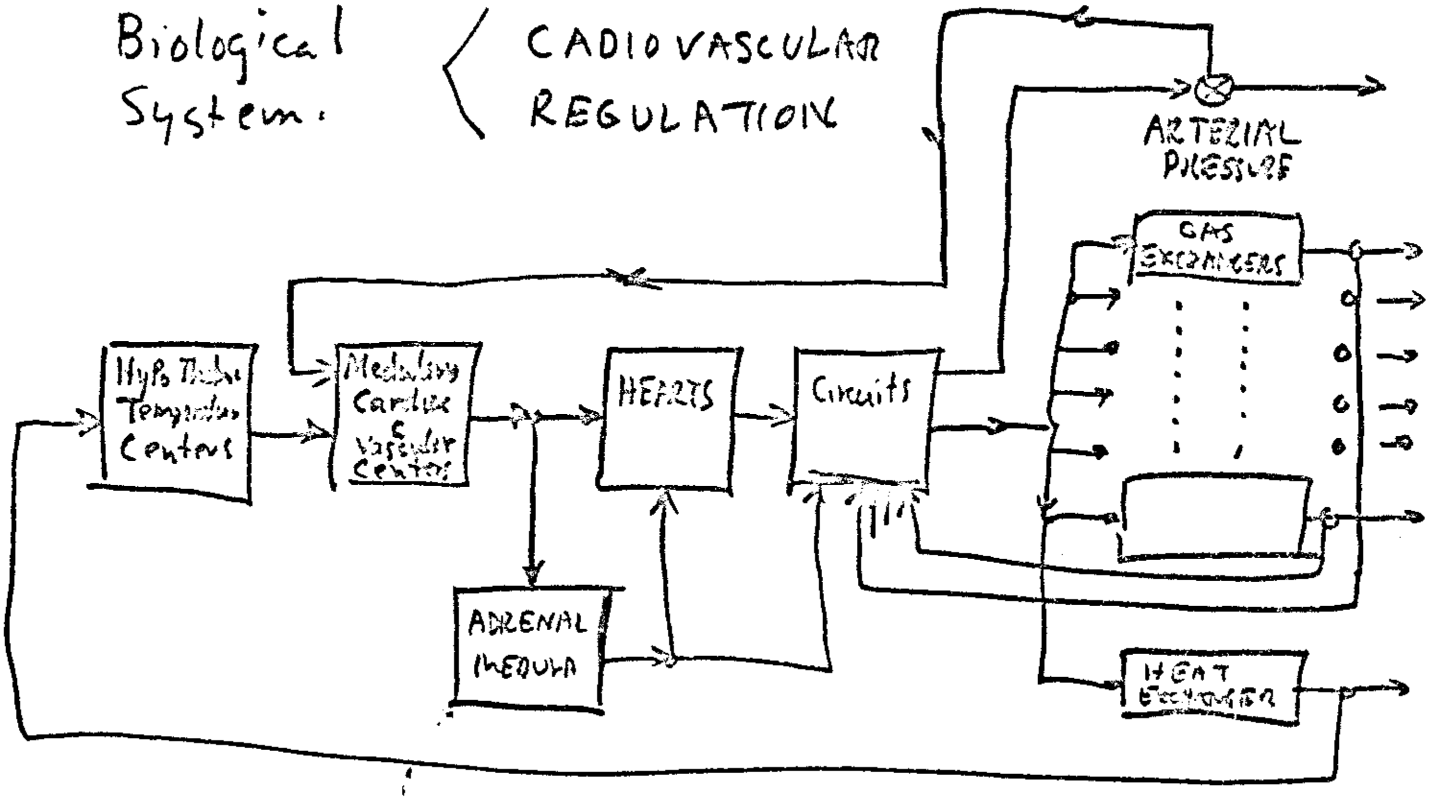
Electrical Circuit

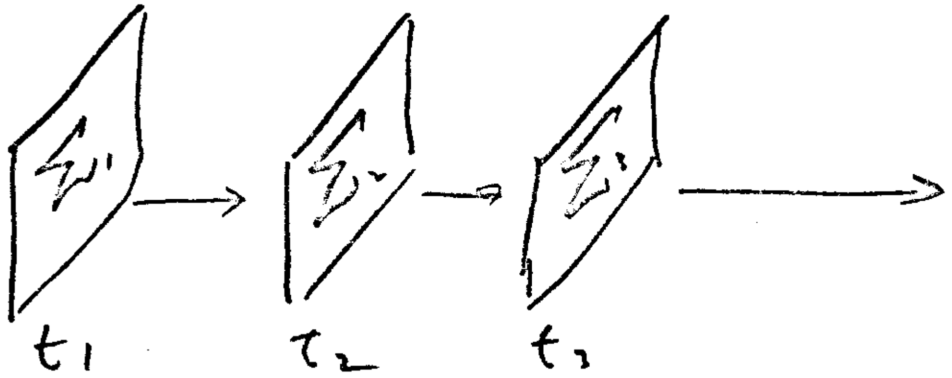


Cathode Follower Ckt.

Biological System. ⟨ CADIOVASCULAR REGULATION



Sociological System. .



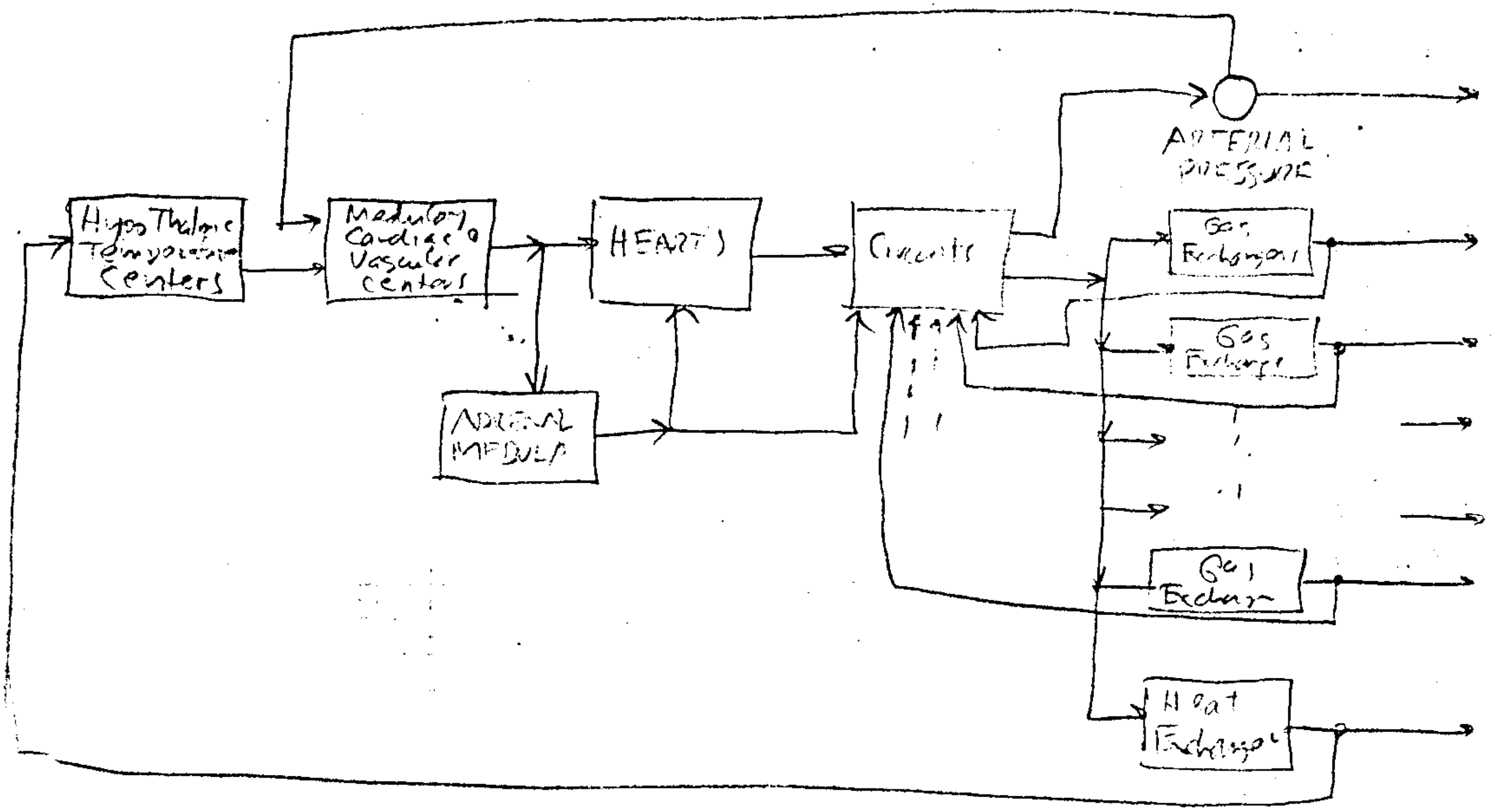
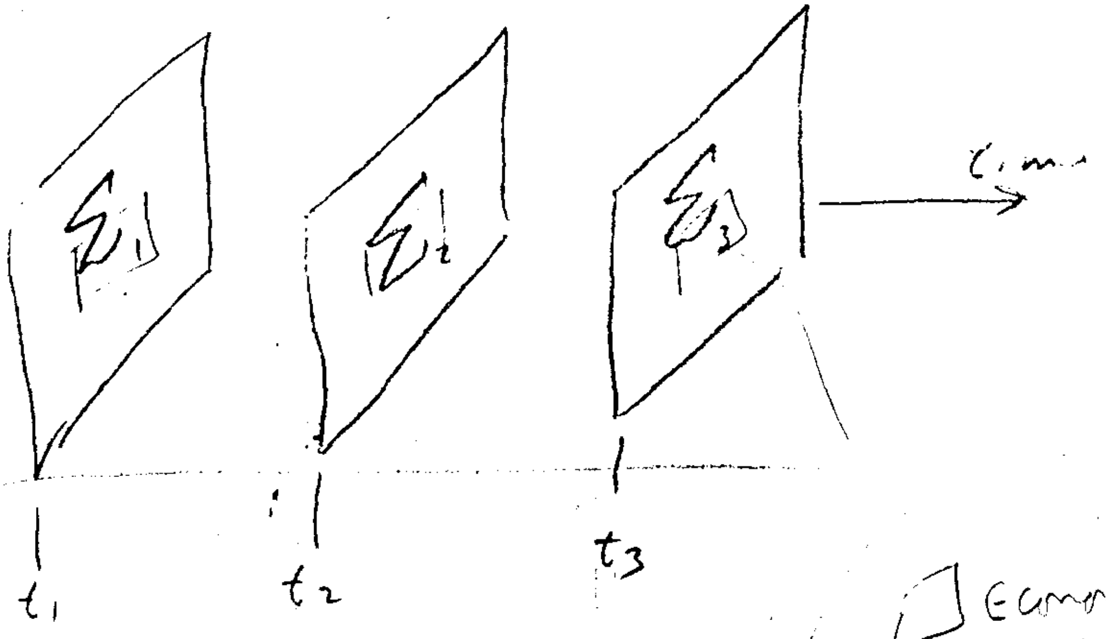


Fig 5. Biological System: Cardiovascular Regulator

$$\Sigma = \begin{bmatrix} s_{1,1,t} & s_{1,2,t} & \cdots & s_{1,k,t} \\ s_{2,1,t} & s_{2,2,t} & \cdots & s_{2,k,t} \\ s_{i,1,t} & & & s_{i,k,t} \\ & & \vdots & \\ s_{e,1,t} & \cdots & & s_{e,k,t} \end{bmatrix}$$

$(s_{i,j,t})$ set of properties of a sociological system

If we do not know the mapping function f or g, but can empirically observe Σ at time t_1, t_2, and t_3, etc. Then we can at least define the states



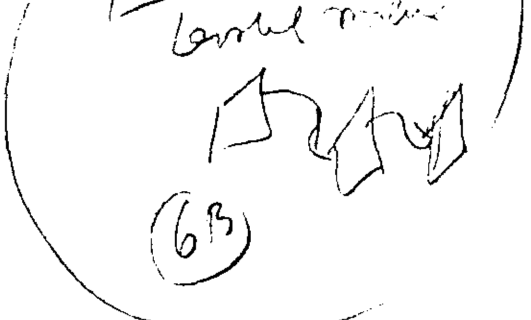


Fig 6A. Sociological System

A Finite State System A is a triple

$$\text{of finite sets} \begin{cases} \Sigma, & \text{elements } \{s_t\} \text{ are states of } A, \\ U, & \text{inputs } \{u_t) \text{ to } A \text{ at time } t, \\ Y, & \text{outputs } \{y_t\} \text{ of } A \end{cases}$$

and a pair of mappings:

$$f : \underset{t=t_i}{\Sigma} \times \underset{t=t_i}{U} \times T \longrightarrow \underset{t=t_i+1}{\Sigma}, \text{ or } \quad s_{t+1} = f(s_t, u_t, t)$$

$$g : \underset{t=t_i}{\Sigma} \times \underset{t=t_i}{U} \times T \longrightarrow \underset{t=t_i}{Y}, \text{ or } \quad y_t = g(s_t, u_t, t)$$

where T is the set of integers, (*)

* L.A. Zadeh, "The Concept of State in System Theory", *Views on General Systems Theory*, ed. by. Mihajlo D. Mesarovic, New York, John Wiley (1964), pp. 39–50.

III. How Do We Proceed to Test Thematic Hypotheses in Social Systems?

A. Is there a way of making a single matrix like that used for the Special Theory of Relativity?

Let us first move from physical systems to biological systems to see if there is any increase in the [illegible] complexity of testing hypotheses. If ask for how many years back into history did the physical and chemical laws we know today hold? We can generally assume the physical and chemical laws existed forever or depending upon what cosmological theory of the origin of the universe one holds, we could at least say that our physical and chemical laws were rigidly specified very shortly after the forming of our universe.

If we take the age of our universe as 10×10^9 years and the start of the Archeozoic Era on our planet as 2×10^9 years ago, we can say that the part of the universe in which our solar system and later our planet developed existed for approximately 8×10^9 years as a purely physical system and that 2×10^9 years ago biological laws became relevant to our planet (system). Then if we consider sociological processes developed when ~~modern~~ sub-human man emerged about one million years ago. Our planet functioned with physical-chemical laws and biological laws for 1.999×10^9 years before sociological laws became significant.

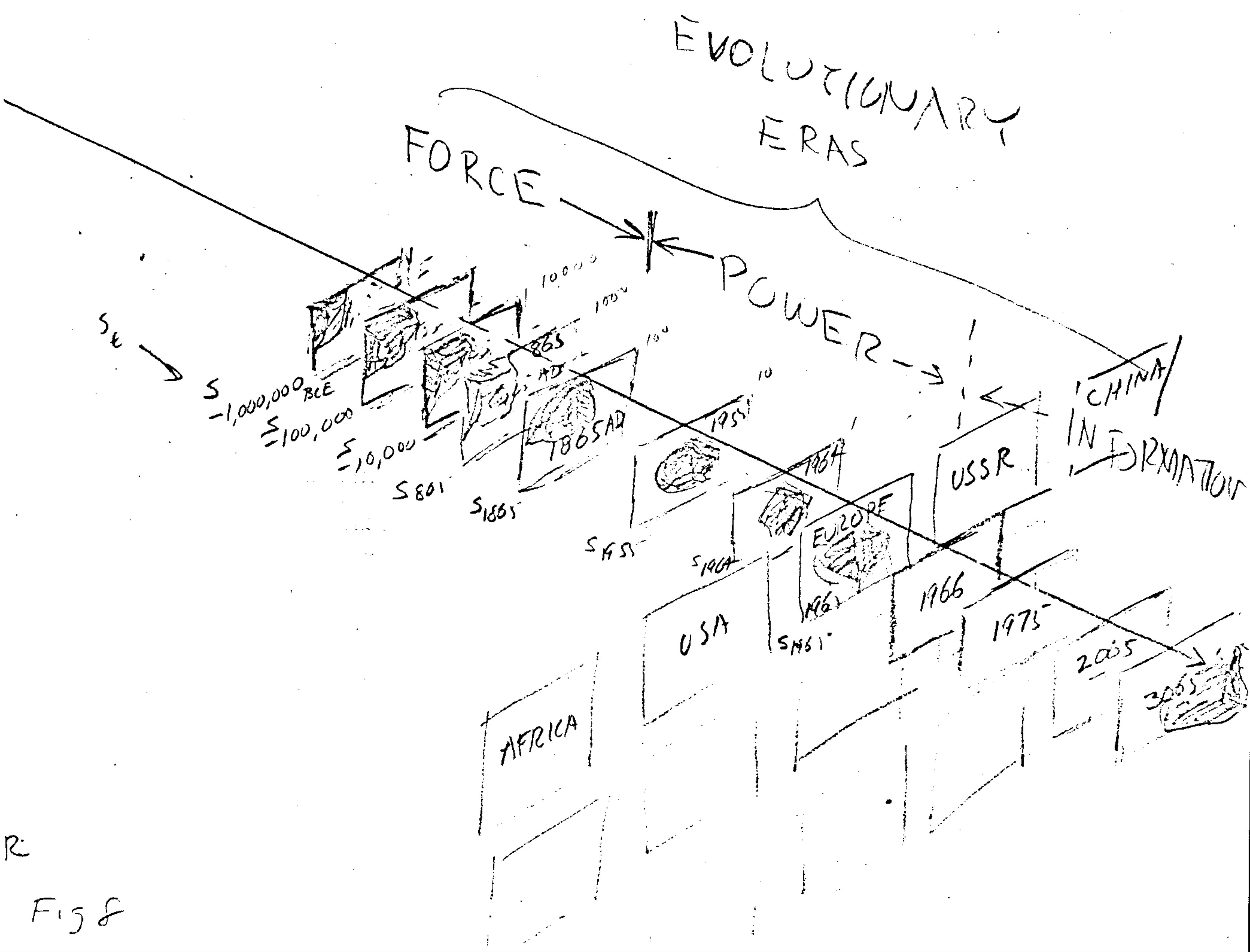

EVOLUTIONARY ERAS
FORCE
POWER
CHINA
INFORMATION
S_E
$S_{-1,000,000\,BCE}$
$S_{100,000}$
$S_{10,000}$
S801
S1865
S1955
S1964
S1961
10,000
1000
100
10
865
AD
1865AD
1955
1964
EUROPE
1961
USSR
USA
AFRICA
1966
1975
2005
3005

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Fig 8

The breaks between Force Era, Power Era, and Information Era)
Communication Era

permits leaders / government to change policies x

Social System A

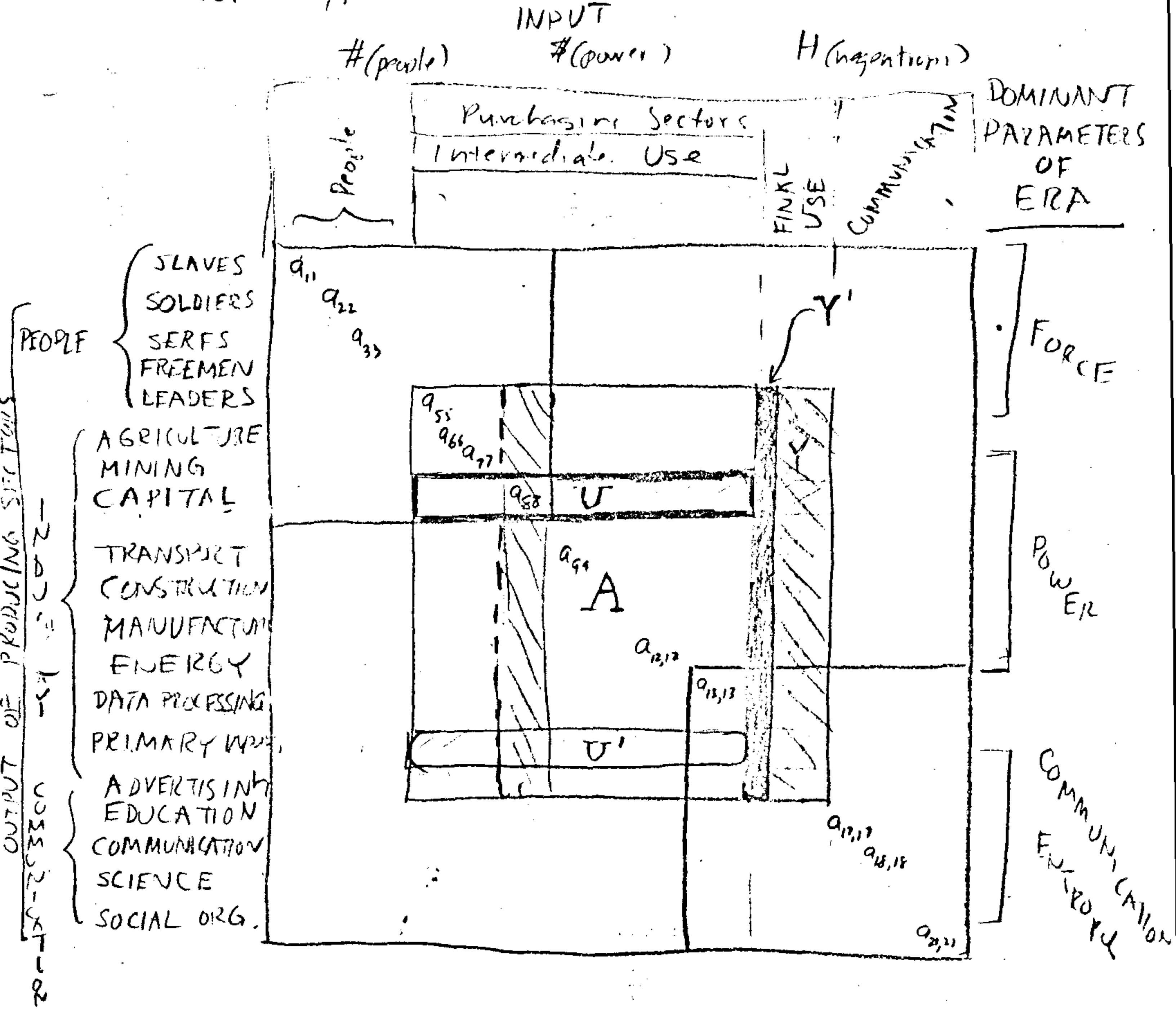

Fig 7

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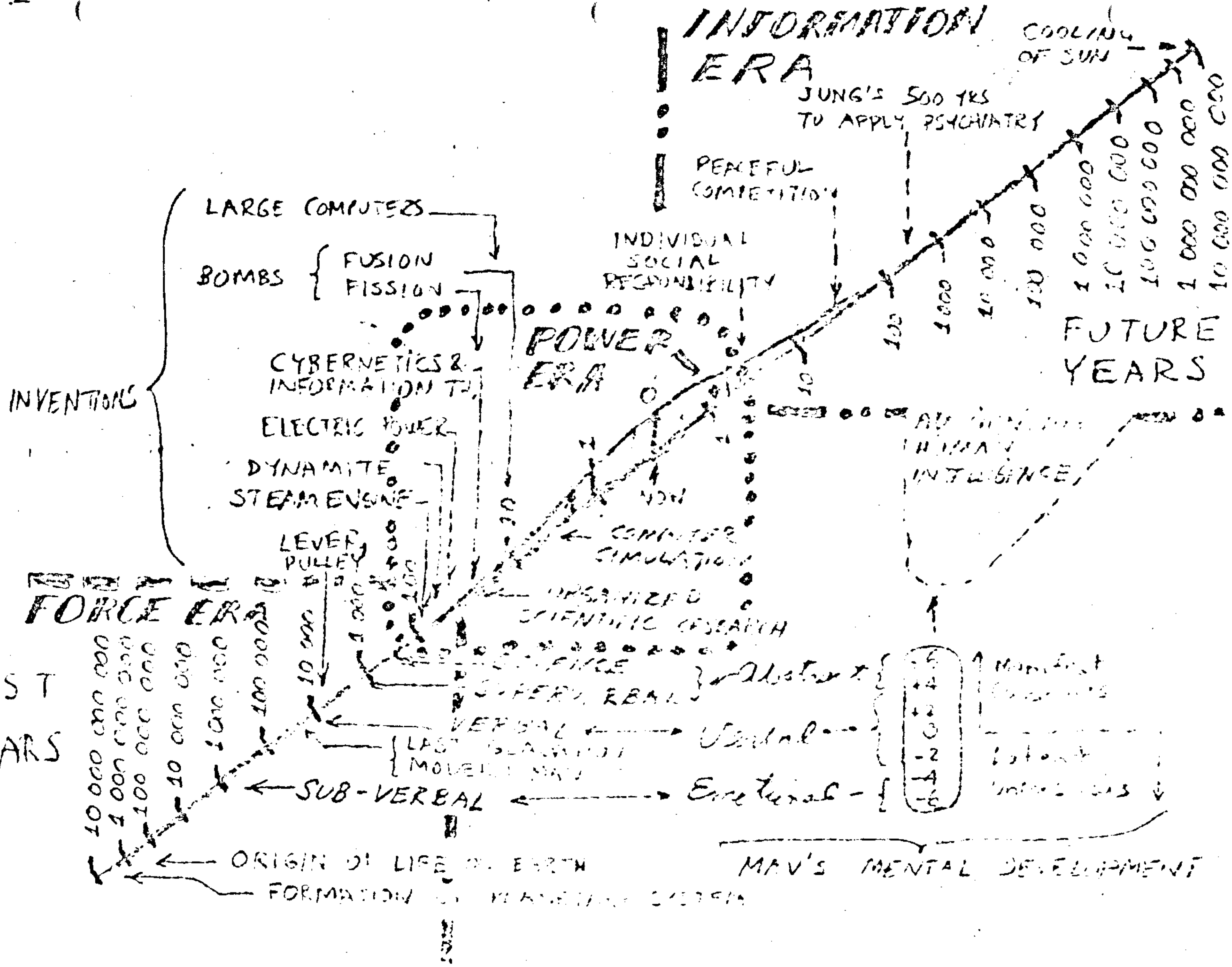
Fig. 2


INFORMATION ERA
COOLING OF SUN
JUNG'S 500 YRS TO APPLY PSYCHIATRY
PEACEFUL COMPETITION
INDIVIDUAL SOCIAL RESPONSIBILITY
10 000 000 000
1 000 000 000
100 000 000
10 000 000
1 000 000
100 000
10 000
1 000
100
10
FUTURE YEARS
LARGE COMPUTERS
BOMBS
FUSION
FISSION
CYBERNETICS & INFORMATION TH.
ELECTRIC POWER
DYNAMITE
STEAM ENGINE
LEVER, PULLEY
INVENTIONS
POWER ERA
0
NOW
AN INCREASING HUMAN INTELLIGENCE
COMPUTER SIMULATION
ORGANIZED SCIENTIFIC RESEARCH
FORCE ERA
10 000 000 000
1 000 000 000
100 000 000
10 000 000
1 000 000
100 000
10 000
1 000
100
10
PAST YEARS
SCIENCE
SUPERVERBAL
VERBAL
LAST GLACIAL MOVEMENT
SUB-VERBAL
Abstract
Verbal
Emotional
+6
+4
+2
0
-2
-4
-6
Manifest Conscious
Latent Unconscious
ORIGIN OF LIFE ON EARTH
FORMATION OF PLANETARY SYSTEM
MAN'S MENTAL DEVELOPMENT

	Allocation of Scarce Public Space:				Measure of Democracy				Conditions of Disarmament	Political Ideology	Ethical Principles	Usefulness in Developing a Strategy	Susceptibility to Democratic Public Understanding & Control
	1. Library Shelf Space	2. Public Bulletin Boards	3. Meeting Space in Center	4. Availability of Computing Service	Monitoring of Economic Development	Evaluation of Alternativ Military Policies	Population Control(=) Birth Control	Dynamic-Justice					
MIGHT MAKES RIGHT													
REVOLUTIONARY GUERILLA WARFARE													
LIFE CYCLE OF CIVILIZATIONS...													
MARXIST EVOLUTION TOWARD SOCIALISM													
STRUGGLE BETWEEN CAPITALISM & COMMUNISM													
ESCALATION OF POWER													
THERMONUCLEAR WAR STRATEGIES													
ECONOMIC GROWTH THEORY & INDUSTRIALISATION..													
TRAGIC DILEMMA THEORY													
WORLD LAW THROUGH LEADING POWER													
WORLD LAW THROUGH COMMUNICATION													
THERMODYNAMIC IMPERATIVE =DISCRETE CHANNEL MODEL													
THERMODYNAMIC IMPERATIVE =CONTINUOUS CHANNEL MODEL													
THERMODYNAMIC IMPERATIVE =CYBERNETIC FEEDBACK													
THERMODYNAMIC IMPERATIVE=NON-PROBABILISTIC & "FUZZY" SETS													
PACIFIST ETHICAL ACTION													

Fig 7

A List of Human Freedoms.

To assign a numerical value to "freedom" is a difficult task. There are many kinds of freedom, some of which are more valued than others. The ideal way to start this section would be to get some social psychologists to determine the relative weights to different types of freedom and the range of values to be expected in different political systems. Since such information is not presently accessible to me, I shall assume the following ten kinds of human freedom to have equal weight in order to obtain some trial calculations. See Table I for the list of freedoms.

I shall assign to each human a unit of "freedom," $F_i = 1.0$. If he is deprived of some of his freedom, his F_i becomes less than one, and the person or persons interfering with his freedom have F_i's greater than one. For example, if a dictator reduces the freedom of his subjects to 0.5 and there are 100,000 people under his control then the dictator's freedom is $F_i = 50,001$.

To obtain a measure of freedom that behaves like a probability function, we define a normalized "freedom" function,

$$a_i = F_i \,/\, n, \qquad [4]$$

where n is the population of the country sub-system. In the above case the normalized freedom for each subject is $a_i = 0.000005$ and that of the dictator is $a_i = 0.5$, i.e. the dictator has 100,000 times the freedom of a subject of his.

TABLE I. [illegible]

[illegible]	[illegible]	[illegible]
(1)	Freedom of speech	0.1
(2)	Freedom of religion	0.1
(3)	Fr[illegible] to print, broadcast, televise and listen	0.1
(4)	Freedom to find sexual partner	0.1
(5)	Freedom to obtain education	0.1
(6)	Freedom from discrimination on account of [illegible] origin .	0.1
(7)	[illegible] to [illegible]	0.1
(8)	[illegible]	0.1
(9)	[illegible]	0.1
(10)	[illegible]	0.1
	Total F =	1.0

[illegible]

This analysis is a test of an hypothesis as to the analogy between "[illegible]" and "[illegible]." At this stage it is [illegible], because of the lack of independent data. Our objective is to [illegible], if [illegible], the [illegible] of a set of [illegible] by the [illegible] of [illegible] of the individuals in a social [illegible] will [illegible] of [illegible] which is [illegible] by [illegible] social [illegible]

[illegible]

[illegible] of democracy [illegible] relative [illegible], [illegible] accordance with the [illegible] analysis of [illegible], [illegible] is found [illegible] with [illegible].

Using equation [2] and replacing H by D and P_i by G_i, we have:

$$-D = G_1 \ln_2 G_1 + G_2 \ln_2 G_2 + \ldots\ldots + G_i \ln_2 G_i + \ldots + G_n \ln_2 G_n . \qquad [5]$$

with the restraint that:

$$G_1 + G_2 + G_3 + \ldots\ldots + G_i + \ldots\ldots + G_n = 1.000 \qquad [5]$$

[illegible] a single individual [illegible] calculated, [illegible] regard to [illegible] result of [illegible] a [illegible] individual. [illegible] "[illegible] democracy" [illegible] and are listed in Table II.

TABLE II. [illegible] OF DEMOCRACY FOR SIX POLITICAL SYSTEMS.

(Calculated from [illegible] entropy of a set of assumed distributions of [illegible].)

	Type of Political System	Entropy [illegible] Democracy
A	[illegible] democracy	13.61
B	Representative democracy with 10% under-[illegible] group based upon individual performance	15.52
C	Partial democracy with upper 2 [illegible]	13.00
[illegible]	[illegible] democracy of 40 [illegible]	0.51
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

[illegible]

[illegible] different types of social organization. This [illegible] that [illegible] can obviously consider using the calculation of negentropy to evaluate social systems where we do not have good common sense references. However we would have to check more rigorously the method of computing the normalized "freedoms" Q_i.

Another feature is that a dictatorial country like country C can [illegible] a considerable portion of its population (the minority [illegible]), provided the restrictions are based on [illegible] rules to individual [illegible] are [illegible] obtained [illegible]. For example [illegible] [illegible] D [illegible] will [illegible] of restrictions [illegible] [illegible] negentropy by [illegible].

Results of Countries E and F indicate that a rigid caste [illegible] or a one man dictatorship knock the negentropy down to [illegible] the [illegible] value. Another feature of interest is that [illegible] rule, a rigid set of rules can be almost as bad as [illegible] dictatorship. This may also have relevance to centralized [illegible] and governmental agency accounting systems.

Another feature is that a substantial increase in negentropy results [illegible] a one-man dictatorship changes to a twelve-man oligarchy. [illegible] the possibility of developing a more detailed measure [illegible]

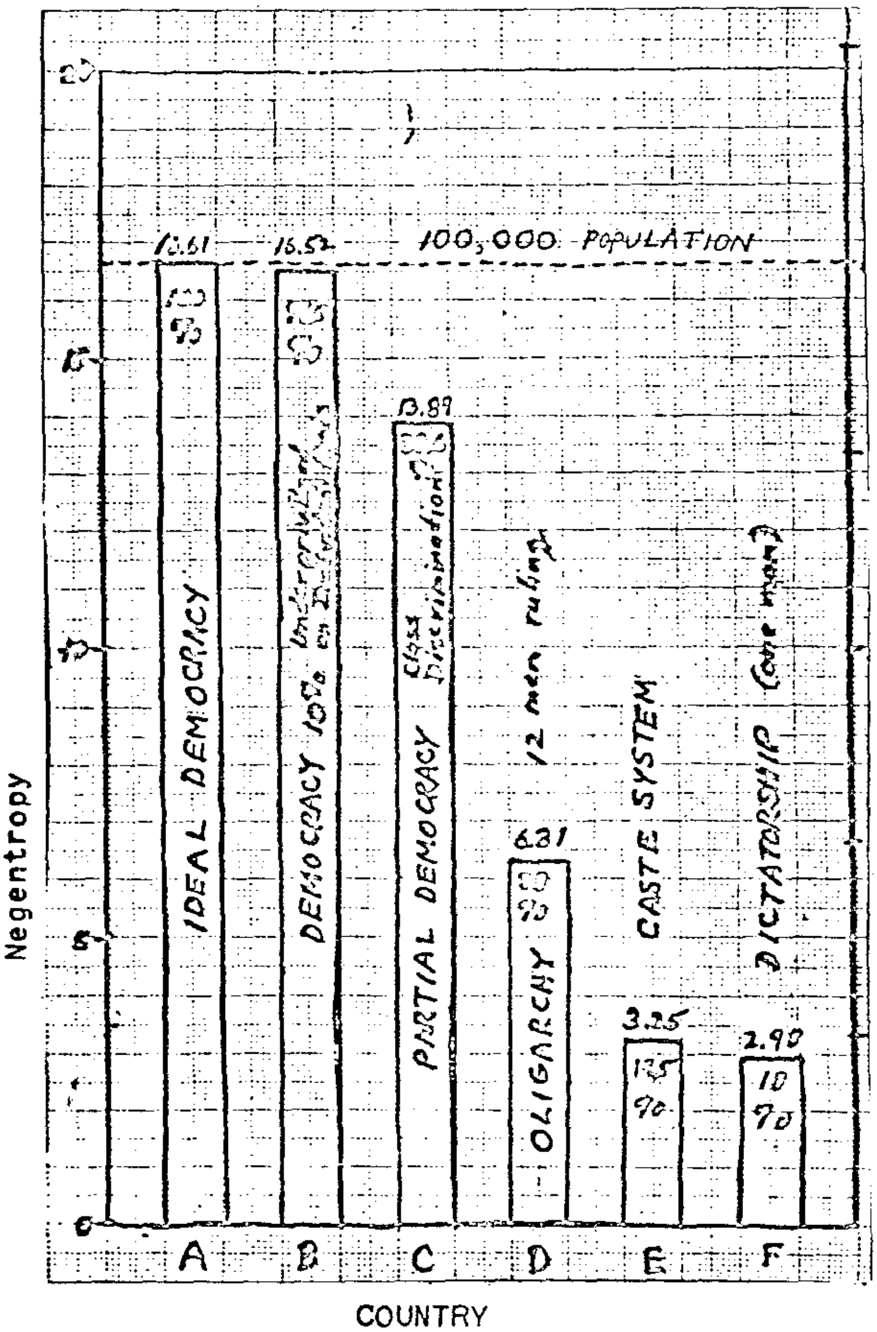


Fig. 11. Comparision of the Negentropy of Six Hypothetical Countries.

a Reprint from
BULLETIN of the BAY AREA SYSTEMS GROUP, No. 26

Dr. Frederick B. Wood: The Philosophy of General Systems Theory

SYNOPSIS OF REMARKS of SEPTEMBER 25, 1965

The objectives of general systems research have been established by the Society for General Systems Research as follows:

1. To investigate the isomorphy of concepts, laws, and models in various fields, and to help in useful transfers from one field to another;

2. To encourage the development of adequate theoretical models in the fields which lack them;

3. To minimize the duplication of theoretical effort in different fields;

4. To promote the unity of science through improving communication among specialists.

It is important to consider what further applications general systems research might have in our civilization. To explore this question, we first examine a somewhat broader range of applications than communication between specialists. There are roughly four major areas to consider:

Multidisciplinary Research: Research being pursued by one scientist, who must learn the concepts of two or more fields of science due to the problems he is concerned with not fitting within the narrow boundaries of traditional special fields. (1)

Inter-Disciplinary Research: Scientific research where specialists work as a team on projects crossing the normal field boundaries.

Managerial Decision Making: General systems theory gives promise of helping decision makers and managers in business and government to develop a better understanding of the systems they are managing.

Citizens' Discussions in a Democracy: General systems research contributions to the unity of science may be of potential help in making it easier for the citizen to acquire a perspective of the interplay of science and government so that he may be better prepared to elect competent representatives.

It appears that different types of organizing perspectives of the status of general systems research are required for these different types of activities. In multidisciplinary research where one scientist is pursuing a problem through several fields, a perspective based upon three coordinates: phenomena, method, and activity appears the most generally useful. The range of these coordinates is:

Phenomena: Physical, Chemical, Biological, Psychological, and Sociological;
Method: Intuitive, Abstract, and Empirical;
Activity: Science, Engineering, Education, and Decision-Making.

When more extensive problems are encountered involving inter-disciplinary cooperation between a number of specialists, the above perspective becomes somewhat cumbersome. Then a tracing of the usage of concepts through different fields and by different scientists becomes more practical. O. R. Young (2) has prepared some excellent tables of the usage of concepts in different fields with the following classes of categories:

1. SYSTEMIC AND DESCRIPTIVE FACTORS: open and closed systems; organismic and non-organismic; subsystems; state determined systems; equifinality;

boundaries; field; isolation and interaction; interdependence; integration and differentiation; centralization and decentralization.

2. REGULATION AND MAINTENANCE: stability; equilibrium, feedback; homeostatsis; control; negative entrophy; repair and reproduction; and communication.

3. DYNAMIC AND CHANGE: adaptation; learning; growth; change; teleology; goal; and dynamics.

4. DECLINE AND BREAKDOWN: stress; disturbance; overload; positive entropy; and decay.

While the above classification provides a convenient perspective for inter-disciplinary research, still another type of perspective appears needed to help the decision-makers and the citizens. It is possible to organize models and technologies on the following coordinate system:

1. Size of System (Small to Medium to Large)
2. Complexity of System (Simple to Complex)
3. Degree of Quantization (Gross Parameters down to Fine Detail)

The degree of quantization is closely related to another possible coordinate -- namely Time Relationship (Static to Slowly Varying to Dynamic).

The Size-Complexity-Quantization coordinate systems can be used to develop a perspective of mathematical models of value to the decision-makers. It can also be used as a reference system for illustrating the physical systems such as control systems, computers, radar systems, and telephone networks for better understanding by the citizen.

Dr. Donald N. Michael (3) has predicted that in 1982:

"There will be a small, almost separate, society of people in rapport with the advanced computers. These cyberneticians will have established a relationship with their machines that cannot be shared with the average man any more than the average man today can understand the problems of molecular biology, nuclear physics, or neuropsychiatry. Indeed, many scholars will not have the capacity to share their knowledge or feeling about this new man-machine relationship."

Now I predict that vigorous general systems research will make possible better communication between multi-disciplinary and inter-disciplinary scientists and decision makers and citizens so that democratic instutions can function, and that Dr. Michael's dire predictions need not come to pass.

References

1. W. Gray - Letter to the Editor on multi-disciplinary and inter-disciplinary studies. Science, 1964, 144, No. 3620, May 15.

2. O. R. Young, "A Survey of General Systems Theory." General Systems, Vol. IX, pp. 61-80 (1964).

3. Donald N. Michael, "Cybernation: The Silent Conquest" A Report to the Center for the Study of Democratic Institutions, Box 4068, Santa Barbara, California, January 1962, pp. 44-45

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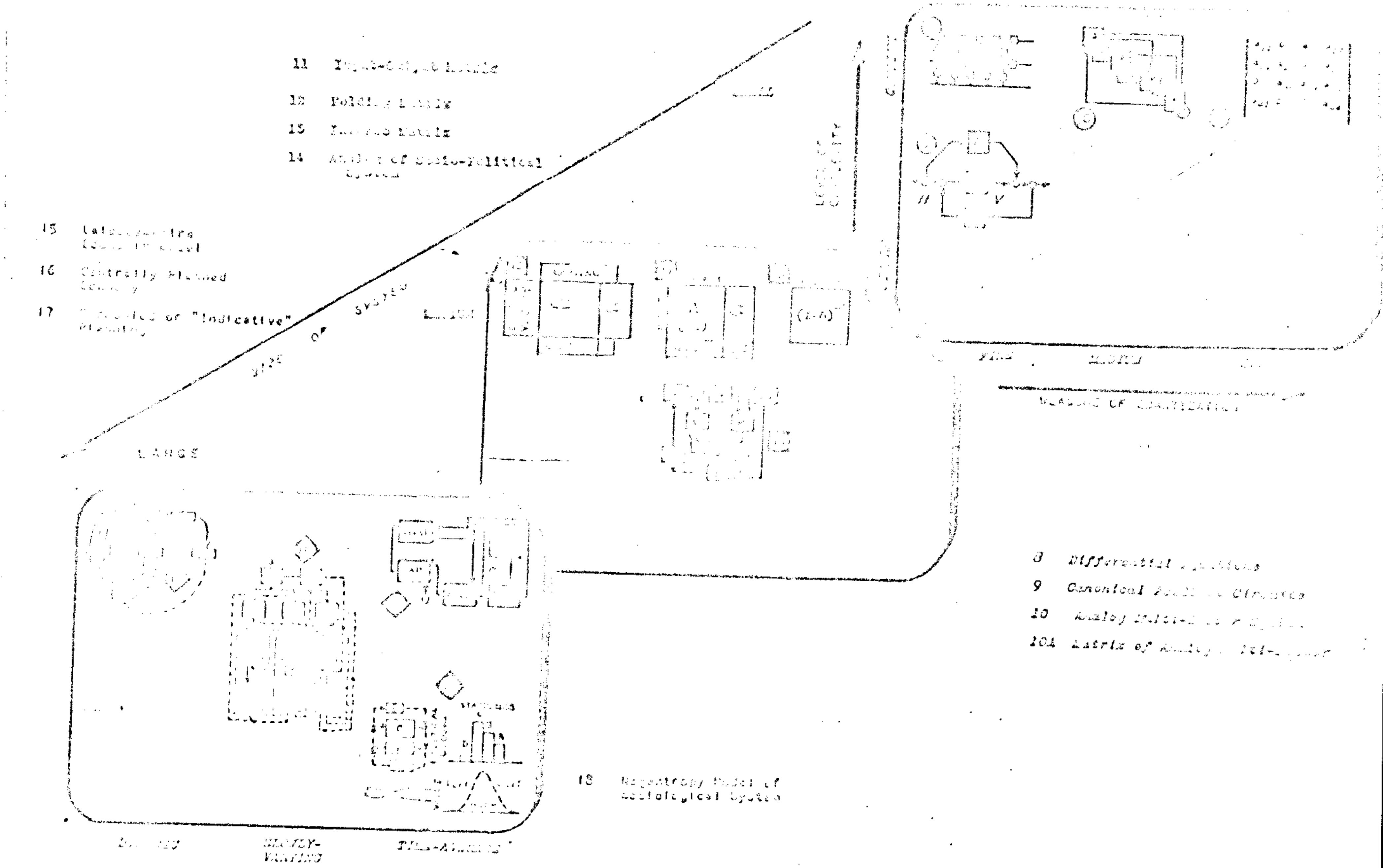
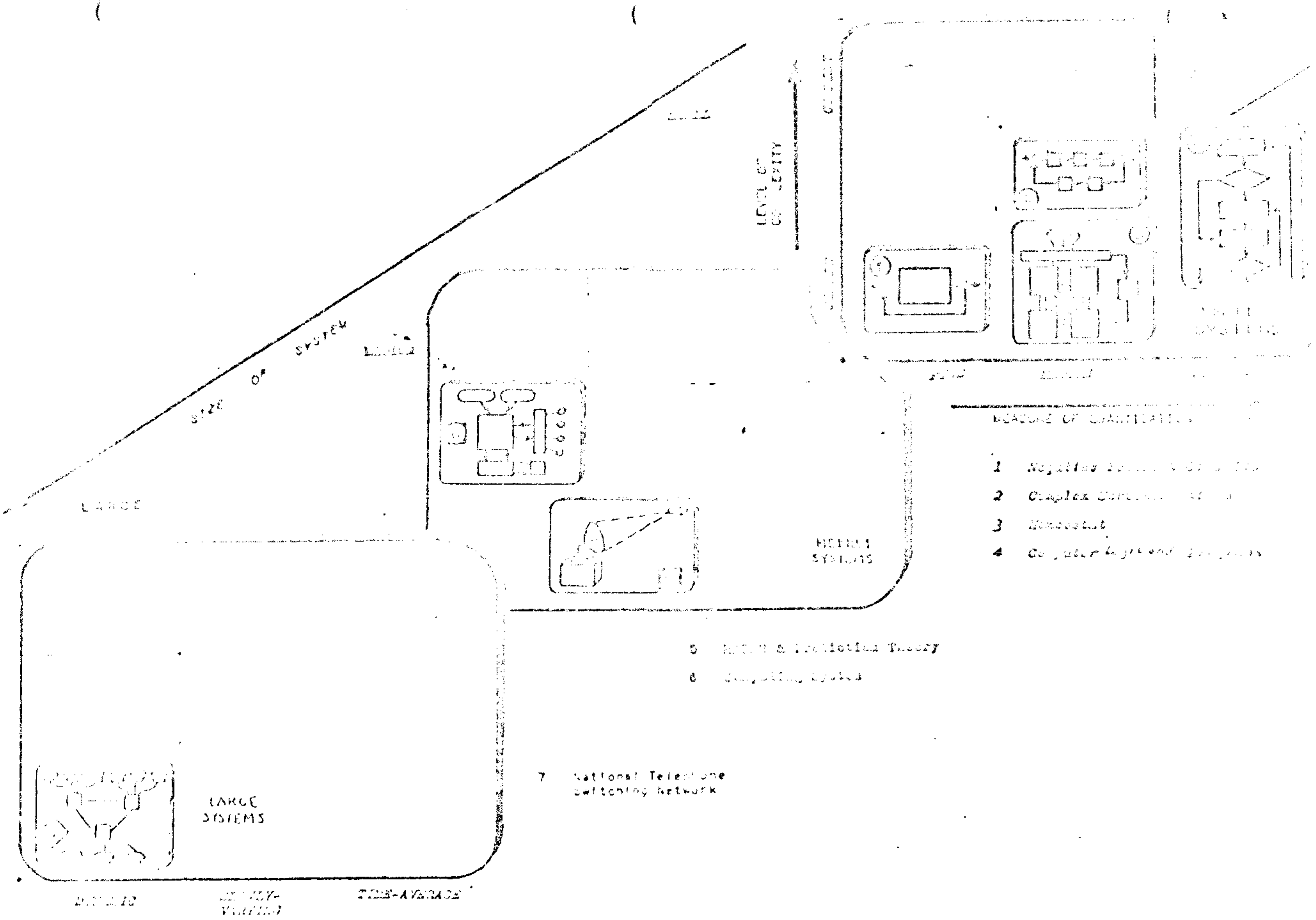
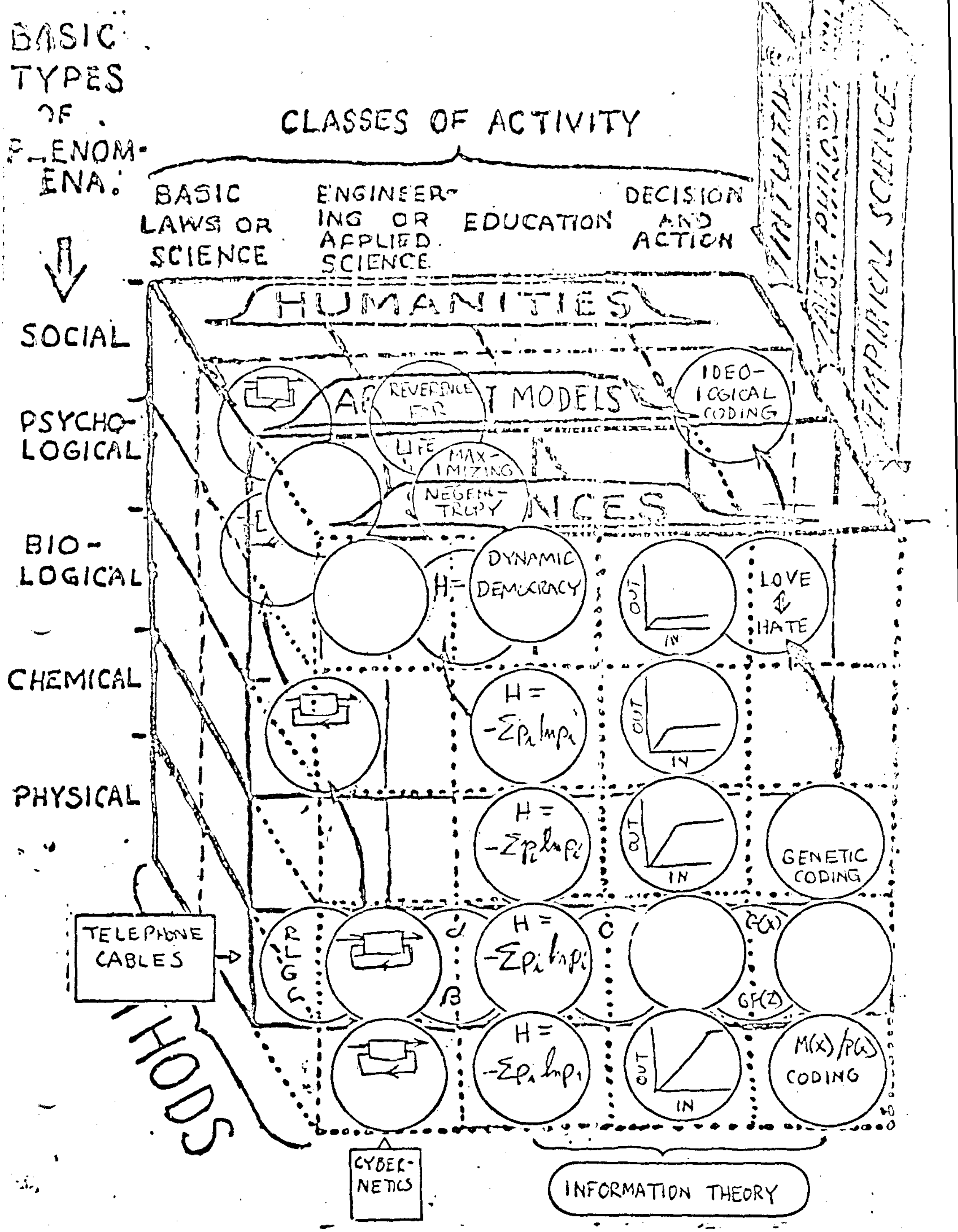

11 Input-Output Matrix
12 Policy Matrix
13 [illegible] Matrix
14 Analysis of Socio-Political System
15 Laboratory [illegible]
16 Centrally Planned Economy
17 [illegible] or "Indicative" Planning
SMALL
SIZE OF SYSTEM
LARGE
8 Differential Equations
9 Canonical [illegible] Circuits
10 Analog [illegible]
10A Matrix of Analog [illegible]
FINE
MEDIUM
[illegible] OF QUANTIFICATION
18 Negentropy Model of Sociological System
SLOWLY-VARYING
TIME-VARYING
(Z-A)
V
H


LEVEL OF COMPLEXITY
SIZE OF SYSTEM
LARGE
MEDIUM SYSTEMS
LARGE SYSTEMS
SMALL SYSTEMS
TIME-AVERAGE
STEADY-STATE
DYNAMIC
1 Negative Feedback
2 Complex Control
3 Homeostat
4 Computer Logic and Programs
5 Information & Prediction Theory
6 Computing Systems
7 National Telephone Switching Network


BASIC TYPES OF PHENOMENA:
CLASSES OF ACTIVITY
BASIC LAWS OR SCIENCE
ENGINEERING OR APPLIED SCIENCE
EDUCATION
DECISION AND ACTION
INTUITION
PAST PHILOSOPHY
EMPIRICAL SCIENCE
SOCIAL
PSYCHOLOGICAL
BIOLOGICAL
CHEMICAL
PHYSICAL
HUMANITIES
A T MODELS
REVERENCE FOR LIFE
MAXIMIZING NEGENTROPY
IDEOLOGICAL CODING
NCES
H=
DYNAMIC DEMOCRACY
OUT
IN
LOVE ⇕ HATE
H = $-\sum p_i \ln p_i$
OUT
IN
H = $-\sum p_i \ln p_i$
OUT
IN
GENETIC CODING
R L G C
α
β
H = $-\sum p_i \ln p_i$
C
G(x)
GF(Z)
TELEPHONE CABLES
H = $-\sum p_i \ln p_i$
OUT
IN
M(x)/P(x) CODING
THODS
CYBERNETICS
INFORMATION THEORY

SOCIO-ENGINEERING PROBLEMS REPORT NO. 96-B

Date:	7/26/65	9/25/65	12/7/65	12/27/65		12/27/65
Stage:	SEPR 58B Abstract	SEPR 55C Philosophy	sepr 96 Abstract	Flip Charts	SEPR 96A Abstract & Philosophy	SEPR 96B Notes [marked SEPR 58C]

Date: 6/2/68

Stage: SEPR 96B
Revised Notes

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