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THE IDEOLOGY OF GROWTH
AND THE UTOPIA
OF EQUILIBRIUM

A Thesis

Presented to the
Department of Sociology
and the
Faculty of the College of Graduate Studies
University of Nebraska at Omaha

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by

John C. Cunningham

December, 1975

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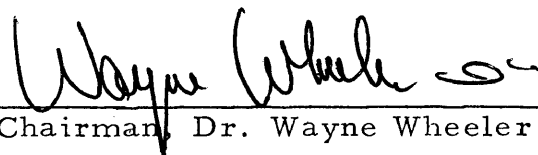
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Chairman, Dr. Wayne Wheeler Sociology

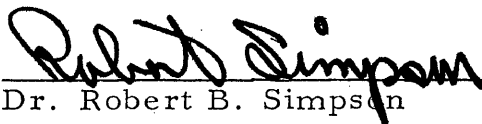
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Since this is a paper about the communal nature of thinking, it is no surprise that I myself am convinced this thesis came into being through my associations with colleagues, family, and friends. My world view changed dramatically over two intense years with the students and teachers in the "soc." department at the University of Nebraska (Omaha). I am particularly indebted to Wayne Wheeler who started me on the theoretical perspective of this paper and encouraged me to believe I would someday complete the work. George Barger and Bob Simpson critiqued my social theory comprehensive and required me to hand in a supplementary paper on Karl Mannheim. This episode gave me a deeper grasp of sociology of knowledge, and convinced me I could write a paper using Mannheim's approach to sociology.

Others of the informal network at U.N.O. who influenced both my outlook on life and what went into this thesis were Mark Rousseau, Gale Miller, John Nye, Nan Britt and Dale Gaeddert. I remember vividly the long discussions between Penny and Carl Nordahl, my wife Pat and myself. These are a part of this paper.

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Ken Britting, Bill Behrens and Mike Goodman. Ron Kirk with Eastman Kodak gave me some special insights into the systems dynamics group and their interface with corporate management people.

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Finally I thank my wife, children and the rest of my family for their patience and understanding. As they all know, this paper has not come easily to me, and sometimes my disposition has been less than cheerful.

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INTRODUCTION

In the spring of 1972 a group of scientists from Massachusetts Institute of Technology led by Dennis and Donella Meadows presented their assessment of the present and future state of global society. Their findings, oriented to the general, informed, public as well as the scientific community, were first published in the book Limits to Growth.

Limits to Growth is unique in several ways. First Limits to Growth has forced an unprecedented debate among scientists, technologists, planners and policymakers by reason of its message and its methodology. In the three years since publication Limits to Growth has sold two million copies world wide.

Second it is more than a public pronouncement by a group of concerned scientists about the state of the world such as Blueprint for Survival (1972) is. Limits to Growth characterizes itself as a summary of findings on the basis of a scientific investigation aided by computer modelling techniques. The study is based on a specific theoretical stance, that of systems dynamics theory, developed largely by Jay Forrester, a professor in Systems Management at the M. I. T. Sloan School of Management. The systems dynamics theory and the M. I. T. systems dynamics group approach is almost

universally perceived by the group itself and its critics to be an inquiry into the nature of social systems using methodology and theories originating from the sciences of technology; that is, it is an engineer's approach to social systems.

Third, the study project was funded and supported by a group of international industrial and government planners interested in the so-called "predicament of mankind" and calling themselves the "Club of Rome". This procedure added to its further aura of scientific endeavor to the undertaking. Limits to Growth became a measured response to a question posed by a client rather than an unsolicited assertion of a group of scientists.

Fourth and most important to the perspective of this paper, the whole research group which refers to itself as the M.I. T. systems dynamics group, their modelling technique, and their social system theory all have a distinct history of development which is closely associated with the development feedback systems or cybernetic systems at M.I. T. starting in the 1940's. The M.I. T. systems dynamics group is a prime example of what Berger and Luckman (1966) refer to as a "concrete social group" or what Holzner (1968) calls an "epistemic community". Kuhn (1970) more specifically refers to such a group as a "particular community of specialists". A long history of group development, social cohesion, and a shared theoretical stance strongly suggests that the M.I. T. systems

dynamics group can be studied from the theoretical perspectives of community studies and/or a sociology of knowledge.

This paper's approach, analogous to an anthropologist's report, is of that strange tribe of "MIT's" who inhabit the Cambridge side of the lower reaches of the Charles River circa 1970. The anthropologist is particularly interested in their beliefs about social systems which are an outgrowth of their skills and techniques acquired in designing and producing various artifacts of commerce and industry.

One might at this point want to know something of the background and credentials of the "anthropologist" that lead him to make this study. The traditional qualifications of a prospective field researcher would allow that he know something about the "MIT's" but not too much lest he be too imbued with their beliefs himself.

My own qualifications are balance of knowledge and ignorance. I attended M. I. T. as an undergraduate student in 1943. I have seen Norbert Wiener who of course was the father of cybernetics, wandering absent-mindedly through the halls and have heard anecdotes of his absent-mindedness. I did not know him personally. I have for years been a fan of his popular books but understood nothing of the basic mathematical theory of feedback systems.

I spent a good many years as a construction engineer and manager, and feel I have experienced something of the particular

"mind set" with which the engineer deals with problems. In addition to studying the writings of the M. I. T. systems dynamics group and its predecessors such as Wiener, I did spend ten days at the Sloan School taking an introductory course in systems dynamics and managed to rub elbows for a short time with some of the members of the Group, including Forrester.

There is a certain hard to define and explain middle class and middle America quality about Norbert Wiener and Jay Forrester and the engineer oriented members of the M. I. T. group. Engineers rarely come from the higher strata of society. They are essentially artisans that "made good". Wiener was born in Columbia, Missouri, and Forrester in Anselmo, Nebraska. Wiener's father achieved some academic acclaim as the translator of Tolstoy and as a Harvard professor. However he farmed in his spare time, and young Norbert tinkered with equipment, and hiked and boated in a rural setting. Forrester's parents lived a Nebraska sandhill cattle rancher's life. Both Wiener and Forrester reveal this down to earth "hands on" attitude in the implications they draw from even their most sophisticated social theories.

Finally I have been a part of the so-called "environmental movement" for the past two years. My specific role was that of chairman of the Sierra Club Ozark Chapter Upper Mississippi Task Force, working primarily on the Locks and Dam #26 issue. There

is a revolution going on every day in this country and in other parts of the world. Limits to Growth is one of a number of theoretical expressions of that revolution. The Locks and Dam #26 issue is one small segment of the skirmish line on which the revolution is fought.

This paper is divided into five chapters. Chapter I briefly describes the Limits to Growth model of world society and defines what Forrester and Meadows mean by the term "economic growth". One of the major premises of sociology of knowledge is then presented. All theories about world systems are basically theories of legitimation of certain values. The historical dialectic raised by the systems dynamics group pits present world ideologies built as they are around the utility and necessity of economic growth, against an emergent value system based on the judgment that economic growth must come to a halt within the next few decades and the sooner the better.

Chapter II deals with the theory and methodology of concrete social groups and the way they define reality. It presents a typology of the "structure of conscious knowledge" adapted from Thomas Kuhn's The Structure of Scientific Revolutions. This typology thus becomes the analytical tool by which the development of the M. I. T. systems dynamics group can be interpreted.

Chapters III and IV consist of the actual interpretation of the

group's historical development first in the Wiener era and then in the Forrester era.

Chapter V shifts to a second analytical tool in sociology of knowledge methodology, that of the "structural analysis of epistemology." This approach develops a way of comparatively interpreting the basic presuppositions of the Limits to Growth thesis to those of its critics. Such an analysis lays bare a number of contradictory assumptions about the nature of social systems and pits those who believe in continuing world economic growth against those who oppose it.

An epilogue both summarizes and speculates on the significance of the kind of sociological interpretation presented in this work of the ideology of growth and the utopia of equilibrium.

It should be noted, in passing, that Meadows et al. (1974) have published a second edition of Limits to Growth, but the changes appear to be minor and the pagination is the same. All references are to the first edition.

CHAPTER I

A SOCIOLOGICAL PERSPECTIVE ON THEORIES OF GROWTH AND EQUILIBRIUM

1. Focus of This Study

A. Social Process of Theory Formation

This study focuses on the ongoing social processes of theory formation. It is a description of how individuals as members of a concrete social group think about social systems, share their world views within their group, explain their ideas to others, and attempt to produce realities corresponding to these ideas. The types of individuals under consideration are "policymakers" or "decision-makers," and the substantive issue is that of theories about global trends of world growth, particularly economic growth. The study depicts the process of social change as a construction arising out of interaction between social groups with conflicting visions of past, present, and future realities as they relate to global problems of economic and population growth versus equilibrium.

B. Social Theories of the M. I. T. Systems Dynamics Group as Contrasted to the World View of World Technological Society

Limits to Growth and the underlying social system theories

of systems dynamics represent the group thinking of a number of scientists associated primarily with the Massachusetts Institute of Technology, Sloan School of Management, beginning with Jay Forrester, founder of systems dynamics theory and developer of the first prototype world systems model (cf. Forrester, 1961, 1968, 1969a, 1971). The group also includes Dennis Meadows, director of the Club of Rome¹ project; his primary collaborators Donella H. Meadows, Jørgen Randers and William H. Behrens, III; and other project researchers.² More generally, it encompasses graduate students and others of the faculty of the M. I. T. Sloan School of Management who have developed various systems dynamics models. Lastly, the group includes the predecessors of these contemporaries such as Norbert Wiener and the developers of Cybernetics at M. I. T. Taken together they are an example of an evolving community of scientific specialists whose thinking exhibits a certain communal structure not found in world views of an historical era or a society as a whole.

The M. I. T. systems dynamics group might be considered a part of the "environmental movement" in that group members express values of concern for the environment above those of economic development. The "environmental movement," however, is more diffuse and has neither a common theoretical viewpoint nor a unified social structure, but is, rather, a coalition of many groups, both

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scientific and social action oriented, with many specific points of view and precise goals.

In like manner, those who believe in economic growth do not necessarily represent a single identifiable group, but rather, an amorphous and ill-defined aggregate which includes policymakers, decisionmakers, legitimators and theoretical advocates who feel and express commitment to action programs built around the fundamental belief in economic growth. With this aggregate there are a number of theories of social systems, each predicated on belief in the desirability of and necessity for economic growth.

The confrontation between the "utopians of equilibrium" and the "ideologists of growth" parallels the nineteenth century struggle between the Engels-Marxist theorists and the capitalist ideological establishment. This confrontation, in its early stages, pitted a small group of social theorists seeking scientific legitimation of their theories against a broad spectrum of societal controllers who had no single theoretical stance but who shared belief structure built out of their activities and experiences in the everyday world of business, manufacturing, and finance. In each instance, utopian theorists stand as surrogate experts and advocates for a depressed and powerless segment of society or class. The utopians perceive a need for an intellectually powerful theory as a rallying point for depressed classes. The contemporary revolutionary movement pits

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a powerful present generation against powerless future generations. There is then a common element of class struggle that links the Marxian capitalist confrontation in the nineteenth century with the confrontation between growth and equilibrium in the later half of the twentieth. Again the question centers around the distribution of capital between classes and masses. Now however representatives of future populations dispute the ongoing irrevocable waste of capital by present producing class, a waste that will deprive future generations of their existence.

C. Substantive Issue of Economic Growth

Limits to Growth (Meadows, et al., 1972:21) points out that the problem of central concern is that of world exponential growth. The Forrester-Meadows world model depicts the causal relationship of five major variables: population, capital, nonrenewable resources, pollution, and food per capita. The model is an attempt mathematically to portray the adverse impact that growth of the two variables first mentioned have on the last three. It is, in fact, a global environmental impact statement based on a computer model of the causal relationships of the major variables described above. These causal relationships are changed by various sets of assumptions. Each set of assumptions generates a different system behavior that can be explained and graphically represented by its own computer print out

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called a "model run."

The Limits to Growth studies indicate that continued world economic and population growth will lead to a world crisis some time in the twenty-first century with an attendant overgrowth and collapse of the "world system" and thus of world social order. However, according to Forrester and Meadows, of the two independent variables, population growth and capital growth, the latter is the master villain. Their commentary and model runs (Meadows et al., 1972:140 & 160; and Forrester, 1961:121) indicate that control of capital growth could in itself effectively inhibit population growth and lead to a state of world equilibrium. Population stabilization alone would not prevent a world crisis situation.

This paper focuses on what is interchangeably called capital growth, economic growth, or accelerating industrialization as the issue of central concern. Critics of Limits to Growth concede that population growth is a world problem (cf. Cole et al., 1973; U.S. Department of Health, Education, and Welfare Publication, 1973; and Knoppers, 1972). It presents world policymakers with an essentially different kind of problem than economic growth. The solution to the population problem is one of convincing "publics" who control the institutions of family formation of the necessity of birth control, or birth delay, either by persuasion or by force. The population problem requires policymakers to influence and interact

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with institutions they do not now completely control. On the other hand, theories of global economic equilibrium confront directly the ingrained belief structures of growth oriented policymakers themselves. These conflicts and contradictions in beliefs and values of policymakers themselves is the central focus of this thesis.

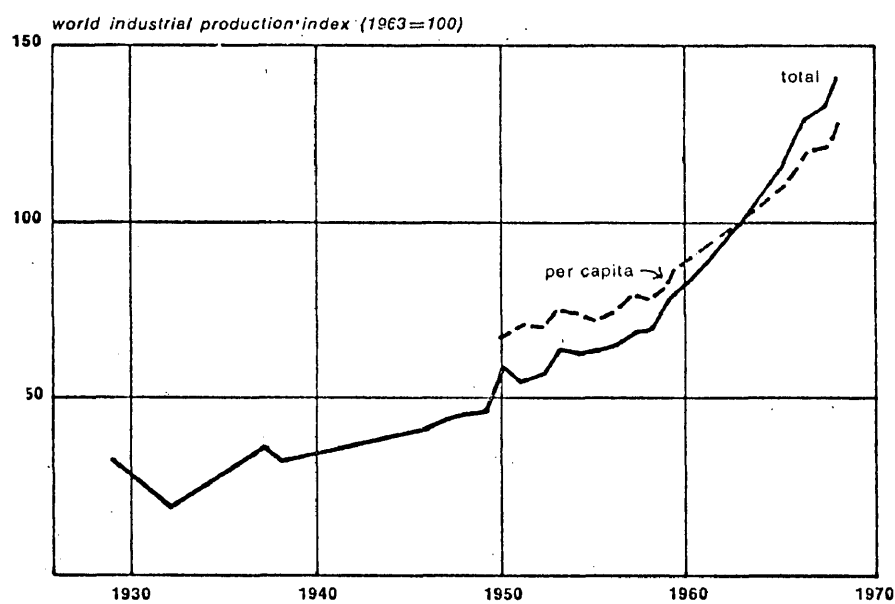
2. Definitions of Economic Growth

What is economic growth, the phenomenon that imperils world order? Meadows et al. (1972:38) introduce the concept by alluding to an ever-increasing world industrial output. They cite the world industrial production index as computed by the United Nations Department of Economic and Social Affairs and note an exponential increase of 7% per year between 1963 and 1968 (see Figure I). The authors next refer to the per capita increase in Gross National Product of a number of countries for the years 1775 to 1969 (Figure II), and finally note the worldwide correlation between GNP and energy consumption per capita (Figure III). Yet these are all social indicators of an "evil" thing rather than the thing itself. (Meadows et al, 1972:40 & 70).

From the standpoint of the systems dynamics model, Meadows et al (1972:39 & 95) define industrial capital as the world pool of all industrially made physical assets, "factories, trucks, tools, machines, etc." increased every year by investment and decreased by

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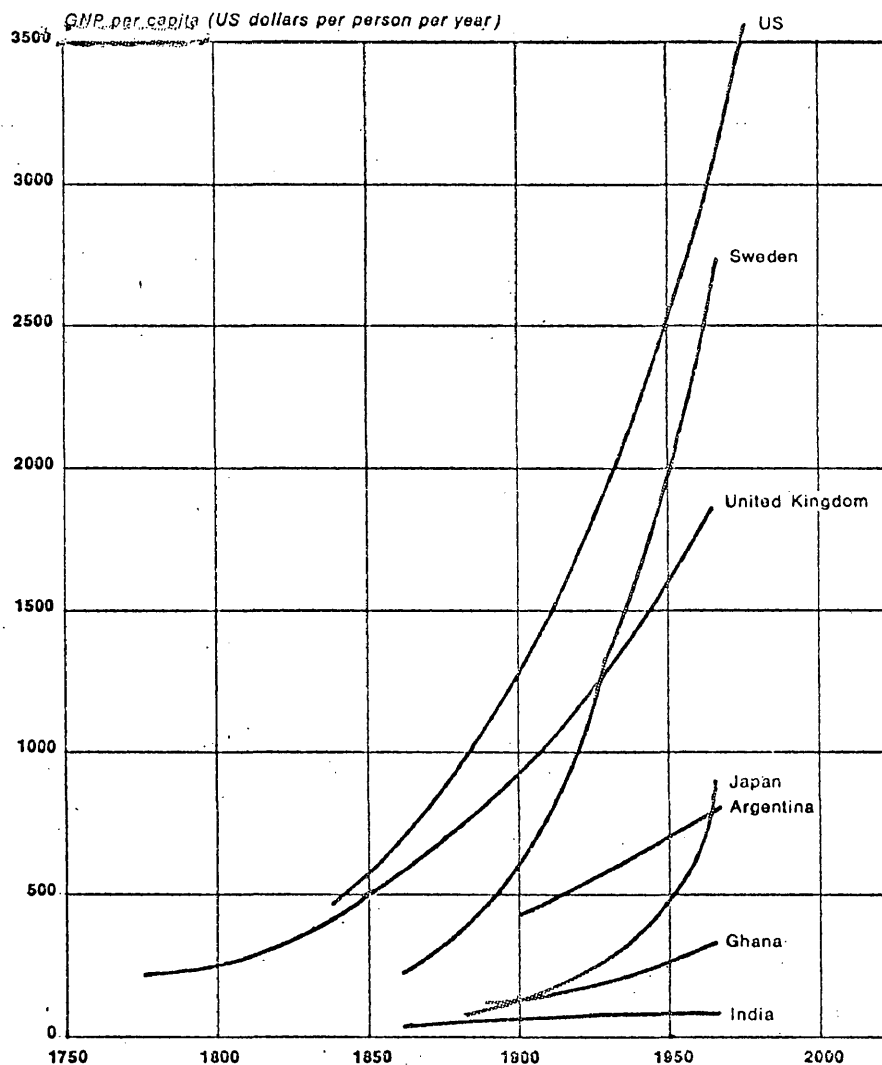
FIGURE I: WORLD INDUSTRIAL PRODUCTION



World industrial production, relative to the base year 1963, also shows a clear exponential increase despite small fluctuations. The 1963-68 average growth rate of total production is 7 percent per year. The per capita growth rate is 5 percent per year.

Reproduced from Meadows et al. (1972:38).

FIGURE II: ECONOMIC GROWTH RATES

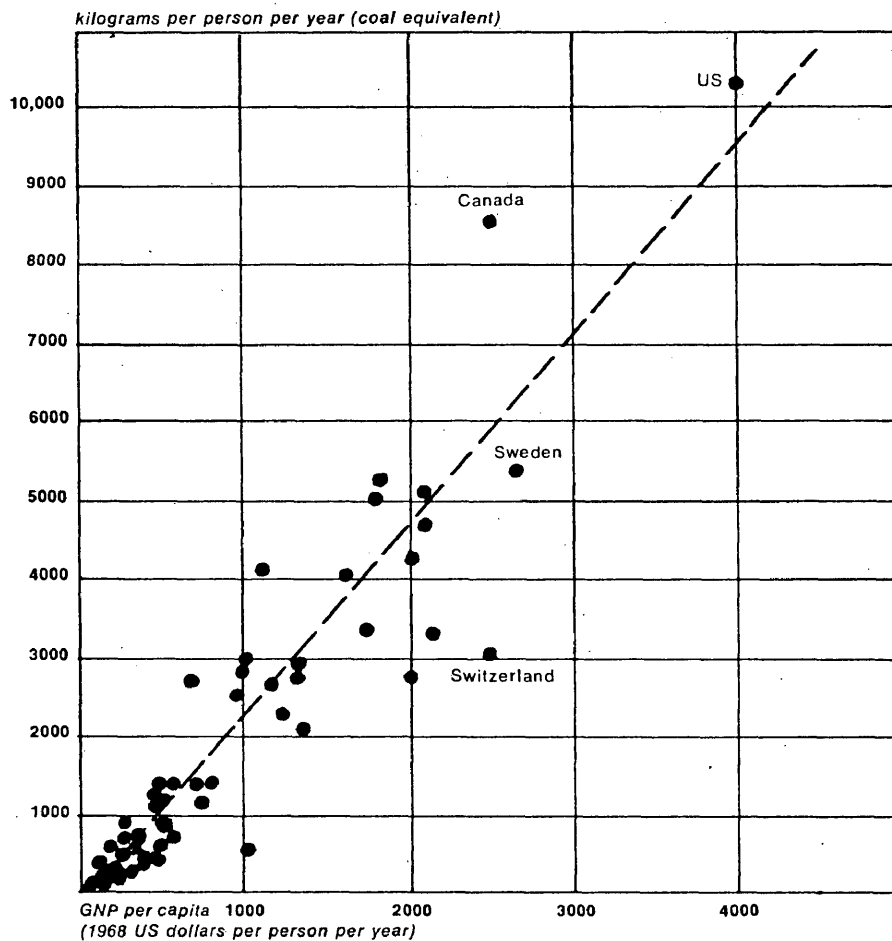


The economic growth of individual nations indicates that differences in exponential growth rates are widening the economic gap between rich and poor countries.

SOURCE: Simon Kuznets, *Economic Growth of Nations* (Cambridge, Mass.: Harvard University Press, 1971).

Reproduced from Meadows et al., 1972:40.

FIGURE III: ENERGY CONSUMPTION AND GNP
PER CAPITA



Although the nations of the world consume greatly varying amounts of energy per capita, energy consumption correlates fairly well with total output per capita (GNP per capita). The relationship is generally linear, with the scattering of points due to differences in climate, local fuel prices, and emphasis on heavy industry.

SOURCES: Energy consumption from UN Department of Economic and Social Affairs, *Statistical Yearbook 1969* (New York: United Nations, 1970). GNP per capita from *World Bank Atlas* (Washington, DC: International Bank for Reconstruction and Development, 1970).

Reproduced from Meadows et al., 1972:70.

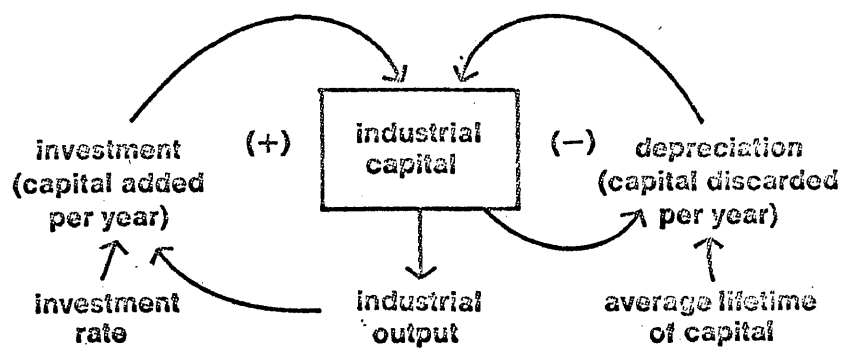
physical depreciation (Figure IV). Meadows et al. are not interested in industrial capital in terms of absolute numbers but rather in its rate of change or growth rate. They thus assume a year 1900 value of one as the beginning industrial capital quantity level. This is an operational definition of industrial growth and explains only how the concept can be quantified and integrated into the model. It singles out industrial capital formation from other elements of the generic term, economic growth.

Not all industrial growth has the same impact on the global environment. For instance the development of some imaginary energy producer that would receive its power from some inexhaustible source and would be completely non-polluting would greatly increase capital formation without depleting or disturbing the environment.

A society that values highly such cultural amenities as education, books, paintings, physical exercise and access to open space might find that their GNP increases even though resource depletion and pollution are at a standstill. According to the Ford Foundation Report (1974:89) the association between increasing energy use and increasing GNP could become uncoupled in the future. Energy consumption could be held and zero growth maintained without concurrently causing GNP to flatten out. Social indicators and operational definitions of economic growth may not hold over long periods of historical time.

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FIGURE IV: A DEFINITION OF INDUSTRIAL
CAPITAL FOR USE IN THE
MODEL



Reproduced from Meadows, et al., 1972:39.

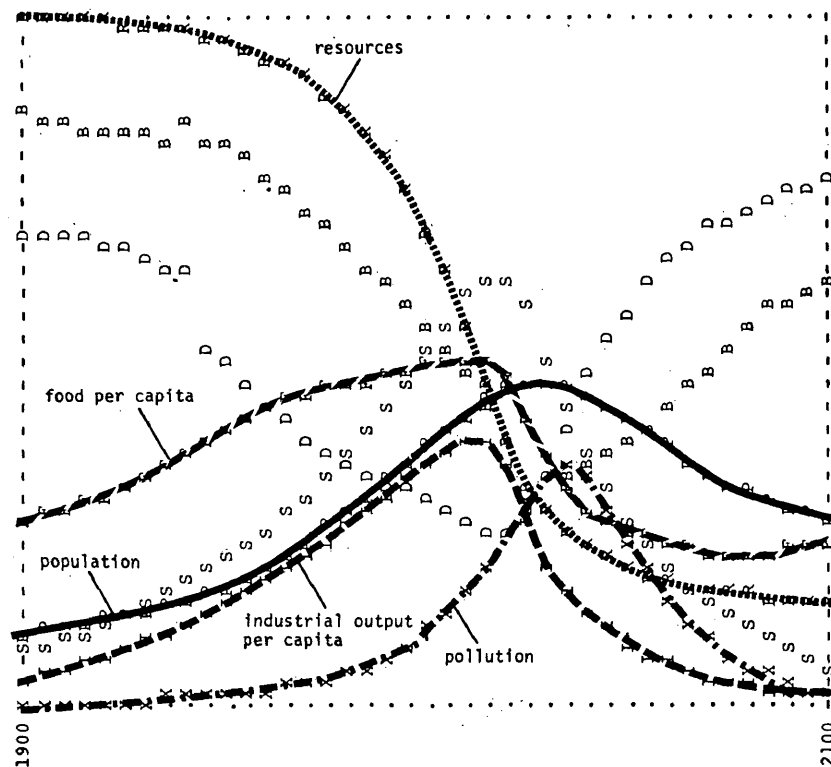
Those segments of economic growth that promote invention, research, and efficiency would be expanded rather than curtailed in an equilibrium society according to Meadows et al. (1972:163).

Behind the social indicators and operational definition of economic growth is the assumption that economic growth is a cultural value of world technological society. On this level of analysis, the value of economic growth is what Mannheim (1953:42) has referred to as the "inner motor or dynamic principle" of any belief structure. A cultural belief structure in turn becomes the nucleus of the social system.³ Meadows et al. (1972:124) represent the present world social system in their "World Model Standard Run" (Figure V), a perspective of world technological society as a social system organized around the core cultural value of economic growth.

Meadows et al. (1972:181) emphasize the cultural nature of economic growth by referring to it as the "growth ethic." The "growth ethic" is the socially shared belief that every member unit of society, individuals and groups alike, can endeavor to optimize its gratification in terms of physical rewards without depleting the physical environment. Meadows sums up his condemnation of the growth ethic and presents his vision of an equilibrium society as follows:

The final, most elusive, and most important information we need deals with human values. As soon as a society recognizes that it cannot maximize everything for every-

FIGURE V: "STANDARD" WORLD MODEL RUN--
 THE GLOBAL SYSTEM ORGANIZED
 AROUND THE CORE CULTURAL VALUE
 OF ECONOMIC GROWTH



The "standard" world model run assumes no major change in the physical, economic, or social relationships that have historically governed the development of the world system. All variables plotted here follow historical values from 1900 to 1970. Food, industrial output, and population grow exponentially until the rapidly diminishing resource base forces a slowdown in industrial growth. Because of natural delays in the system, both population and pollution continue to increase for some time after the peak of industrialization. Population growth is finally halted by a rise in the death rate due to decreased food and medical services.

Reproduced from Meadows et al., 1972:124.

one; it must begin to make choices. Should there be more people or more wealth, more wilderness or more automobiles, more food for the poor or more services for the rich? Establishing the societal answers to questions like these and translating those answers into policy is the essence of the political process. Yet few people in any society even realize that such choices are being made every day, much less ask themselves what their own choices would be. The equilibrium society will have to weigh the trade-offs engendered by a finite earth not only with consideration of present human values but also with consideration of future generations. To do that, society will need better means than exist today for clarifying the realistic alternatives available, for establishing societal goals, and for achieving the alternatives that are most consistent with those goals. But most important of all, long-term goals must be specified and short-term goals made consistent with them. (Meadows et al., 1972:181)

The growth ethic is a shared world value in that it transcends any differences in political and economic ideology between capitalist, communist and socialist countries. The growth ethic is shared alike by developing nations and advanced industrial societies. Yet, according to the M.I.T. systems dynamics group, this ethic is the heart of the problem of world social system order and stability.

Mesarovic and Pestel (1974:5) in their sequel to Limits to Growth, again funded by the Club of Rome and using more complicated systems dynamics computer models as a forecasting tool, call attention to the difference between organic growth and undifferentiated growth. Organic growth in the social context envisions each subunit of the world community growing as a functionally interdependent part of the total world community. Undifferentiated growth

is defined as each subunit attempting to grow without consideration of that growth effect on the other units. Undifferentiated growth represents the growth ethic of present world society.

Enzensberger (1974:4), a neo-Marxist theorist, states the problem in another way by shifting the emphasis from values to societies and by using a terminology that contrasts "political ecology" with "world industrial society". His statement of the central hypothesis is: "Industrial societies of this earth are producing ecological contradictions, which must in the foreseeable future lead to their collapse."

3. Theories About World Systems As Theories of Legitimation

A. Ideal and Pragmatic Theories of Legitimation

Huber (1973) notes that there are two ways in which theories about social systems present themselves to their adherents as worthy of allegiance. Idealistic theory might offer convincing evidence that the values it espouses command support regardless of the consequences. Pragmatic theory, on the other hand, justifies its program of action by prediction of its own success. Such a theory espouses not ultimate values but intermediate values, or action strategies that will lead society to what is "obviously", taken as common knowledge by the members, to be a better end state.

Thus the beneficial direction in which society moves is what motivates the believer. The values of both economic growth and economic equilibrium are intermediate values or indicators of progress within the context of pragmatic theory. This requires that protagonists of each camp must offer a legitimating program which is, in effect, a prediction of the future.

Given the present historical climate, it seems that such legitimating theories must be cloaked in the mantle of "scientific authenticity." Otherwise they would not be convincing to "professionals", nor would they have "the ring of authority" to lay publics. Still if failure or success is to be the relevant criterion, as it is in pragmatic theory, there must be a continuous, ongoing assessment of the probability of future events in the light of the reality of a given present. In this sense, a "science of the future" forms an indispensable part of all pragmatic theory.

Meadows et al. (1972:196) and Forrester (1968:3-4), and in all probability their critics, generally agree with the assumption that futures are not wholly deterministic, that is, that on the most comprehensive level of analysis, world social systems are "open systems"--indeterminate and problematical by their nature. Pragmatic value strategies and world views based on them are always subject to new developments.

Given then, this one assumption that programs' successes

are their own rationale, pragmatic value strategists advocate either economic growth or economic equilibrium, based on "objective" and "cognatively rational" arguments which their adversaries and theoretical critics judge on three different presuppositional criteria. The first criterion requires an ongoing objective assessment of future possibilities in the light of present realities--a "science of predution" or a "science of the future". Systems dynamics is such a "science". The second criterion requires an interpretation of the ultimate or overriding values that lie behind the purely intermediate operational or strategic values of "growth" or "equilibrium". The third criterion requires an assessment of the risk a policy maker is willing to take in order to achieve his overall values in the light of objective reality, a weighing of values against object realities.

Although the first presuppositional criterion can, in theory, be dealt with as a problem in cognitive rationality, the second and third criteria are essentially subjective. Put another way, the shared world view of both believers in economic growth and believers in economic equilibrium stress a pragmatic scientific and cognitive rationality that tends to place the theoretical controversy between the two groups in a presuppositional arena of "scientific theory" rather than social action theories. Each group claims to be the authentic representative of cumulative civilized knowledge. If the opposing group is wrong, this is because its members do not possess

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the right "facts", the correct "model", the "most comprehensive and objective view of empirical reality". Further, there is no empirical rationale for assuming that all policy makers for the global social system (or any other social system for that matter) share the same group perspective. Each one may see the fate of his particular group as quite different from the fate of the aggregate, the total group, in relation to some specific existing social system direction or policy strategy.

B. Basic Hypothesis of Sociology of Knowledge

The line of reasoning which serves as an introduction to what can be called an hypothesis from the sociology of knowledge is for this work, as follows:

Cognatively rational theories about how social systems work are inevitably founded on presuppositions which are value judgments of the theorist as advocate of a social group with whose destiny he identifies and whose ongoing experiences he shares.

This hypothesis has been expressed in different terms by Marx (1847), Mannheim (1936), Friedrichs (1970), and Gouldner (1970).⁴

Berger and Luckman (1966:116) express this hypothesis by pointing out that all theories about how social systems work are theories of legitimation, that is, theories expressing the validity and authenticity of future action. One would be incorrect, however,

to consider social system theories as being irrational or founded in part on irrational presumptions. These theories form a special class of rationality. Theories of legitimation pursue a line of reasoning that falls outside pure reason as laid down by Hume and his logical positivist followers (Ayer, 1959:10).⁵ While theories of social systems are, in a sense, metaphysical, for any one pursuing a course of action they are hardly irrelevant -- as the theories themselves determine in part the future fate of the theorist.

The problem for a discussion from the perspective of sociology of knowledge is not to confirm or deny the hypothesis of theories of legitimation, nor to make a judgment on the substantive issue of economic growth versus equilibrium. Rather, the task of the sociologist of knowledge is to develop a method of interpretation of the two conflicting theories of legitimation.

Two diametrically opposed views of the present state and historical direction of world society can be presented as rational arguments which evidence a social paradox. Quine (1966:1) spoke of paradoxes as follows:

. . . a paradox is just any conclusion that at first sounds absurd but that has an argument to sustain it . . . The argument that sustains a paradox may expose the absurdity of a buried premise or of some preconception previously reckoned as central to physical theory, to mathematics, or to the thinking process. Catastrophe may lurk, therefore, in the most innocent-seeming paradox. More than once in history the discovery of paradox has been the occasion for major reconstruction at the foundations of that thought.

Comparative analysis of basic presuppositions leads one to the final goal; that is, of resolving paradoxes by exposing misconceptions about social systems. That there can be misconceptions about social systems presumes that there is either some natural order or better order of how social systems can be perceived than either side presently possesses. Such a supposition presumes a systematization of social system knowledge moving forward historically in a manner comparable to knowledge systems such as physical theory, mathematics or logic.

C. An Elaboration of the Concepts

According to Mannheim (1936:40) the term "ideology" reflects the social theory of ruling groups -- those who see their interests best served by maintaining the social condition in question. Opposing them are the oppressed groups -- utopians -- "strongly interested in the destruction or transformation of a given condition in society." Ideologies and utopias as contrasting world views are totally opposing belief structures.

Berger and Luckman (1966:92) believe the term world view ("Weltanschauung" from the German historicists) is too broad and instead substitute the notion of "levels of legitimation" of institutional process. To them, one can distinguish roughly four discrete levels of legitimation:

1. Incipient legitimation, rules about language, how things are done, rules of etiquette, routine, social custom;
2. Rudimentary theories, pragmatic schemes, proverbs;
3. Theories of institutional order, rights of cousinhood, laws, economic theories;
4. Symbolic universes, theories which "encompass the institutional order in its totality" (Berger and Luckmann, 1966:94-96).

Controversies between ideologies and utopias have historically produced conflict on the third level of legitimation rather than the fourth.⁶

On a different plane Rokeach (1970:3) analyzes belief structures from the perspective of social psychology. He notes that not all beliefs are equally important but rather vary along a central-peripheral dimension. He proposes that "the more central the belief changed the more widespread the repercussions in the rest of the belief system." While Rokeach studies the individual's beliefs his research seems applicable to shared beliefs of a community or a society.

In effect cultural belief structures present two centrality-peripheral axes which require separate consideration. First one might consider a cultural belief structure as an entity possessed by an individual. Here centrality-peripheral measurements concern how completely internalized is the norm in question - how close to

"the innermost core of the belief system" (Rokeach, 1970:6).

Second, one could consider the belief structure as a cultural externality, that is, as the nucleus of the social system itself. In this latter case, the individual need not believe in the norm itself at all but is simply coerced into conforming action by the outside realities of his social situation.⁷

One can relate Rokeach's central peripheral typology to the growth ethic by thinking of this ethic as central to both the great majority in individuals' cultural belief systems and, in addition, central to a dominant and objectively existing social system.

Lovejoy (1963:1) makes an observation from the perspective of the history of philosophical doctrines. He notes that idea systems can best be understood by relating them to a single proposition or unit-idea. The systematic development of any world view can only be undertaken in relation to some specific problem of focus; but there is no world view which is a commonly held totality of beliefs existing in a vacuum, that is, there is no group "collective consciousness" that has a life of its own and can relate to any and every problem in the world.

In summary, a world view is defined as follows:

(1) An ideology is a world view held by the ruling group who controls the existing social order and whose thought-processes, social perceptions, mental models and theories about the social

order are conditioned to the maintenance of that order. In contradiction, a utopian world view reflects mental commitments of those opposed to the existing social order.

(2) One can consider world views either as internalized norms or beliefs held by the individual or as the nucleus of an extant social system, an objectification of beliefs that coerce the participants of the system into conformity.

(3) Finally, a particular world view is intelligible or capable of systematic analysis only if it is related to a specific proposition, problem, or unit-idea.

4. The M.I.T. Systems Dynamics Group as Social System Theorists

The question of economic growth versus economic equilibrium is an important question, perhaps a fundamental question as far as the future of world society is concerned. Laszlo (1973:3) presents the predicament which every contemporary world system theorist faces:

The argument I am advancing is that no model in existence today is sufficiently complete and free from error to warrant implementation on a global scale. On the other hand, to wait until sufficiently sophisticated models are developed may be lethal; by that time world systematic processes may have shifted to catastrophic pathways. If my argument is correct, it is improper to act now, and it is folly to wait till later.

Thus the problem of economic growth may be the central problem of

the future, but the solution must come in the present.

Aside from the substantive issue of growth versus equilibrium, the M. I. T. systems dynamics group as social system model-builders and theorists merit a full investigation regardless of whether one wishes to define their approach as scientific or action-oriented. Their insights into the structure of social systems with the mathematical models which represent them can not be taken lightly.

Their approach to the following particular social system problem areas requires further study and elaboration:

1. Concepts of open and closed systems;
2. Non-linear versus linear social system models;
3. Social systems as "dynamic objects", objects which have extension in time rather than extension in space;
4. Decisionmakers "mental models" of social systems as the controlling mechanism of the system itself;
5. A social system as a grouping of parts that operate together for a common purpose;
6. The notion of a multiplicity of social systems each one organized around a question asked by the modeller;
7. Definitions of system boundary, system structure and system rationality;
8. The hypothesis that the rational choices and action of the system decisionmakers can, in theory at least, control any social

system.

In summary this paper is both a social history and an epistemic analysis of the M.I. T. systems dynamics group, a concrete social group who has developed a theory of social systems that explains the coming or proposed transformation of world society from one oriented toward economic and population growth to one committed to equilibrium.

This paper focuses not on the substantive issue of growth versus equilibrium itself but rather the question of how did this group come to believe as they do about economic growth, and what basic assumptions do they make that are in opposition to those who believe in present world values of economic growth. The conflict between growth and equilibrium has many elements of social structure that make it parallel to the nineteenth century struggle between the working classes and capitalist elites. The contemporary conflict again centers around the distribution of capital, but this time it pits the present producing class against future generations.

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CHAPTER I ENDNOTES

1. The Club of Rome plays an important role in the development of the theory of world equilibrium. This group was made up originally of thirty world policymakers from ten different countries. They met at the Accademia dei Lincei in Rome in 1968 at the invitation of Dr. Aurelio Peccei, an Italian industrial manager and economist. They seemed to share the conviction that traditional institutions and policies were not coping with the recently emerging set of interconnected world problems which they defined as the "world problematique" or the "predicament of mankind." It was through this group's efforts that the M.I.T. project culminating in Limits to Growth was organized and funded. The connection between the Club of Rome and the M.I.T. systems dynamics group is viewed from a sociological perspective in Chapter IV.

2. These include Dr. Alison A. Anderson, Dr. Jay M. Anderson, Ilyas Bayar, Farhad Hakimzadeh, Dr. Steffen Harbordt, Judith A. Machen, Peter Milling, Nirmala S. Murthy, Roger F. Naill, Stephen Shantzis, John A. Seeger, Marilyn Williams, Dr. Erich K. O. Zahn.

3. Forrester consistently refers to his systems dynamic model as a model of a social system (Forrester, 1969a:120; 1968:1-1; 1971:VII and 1). He defines the generic concept "systems" as "a grouping of parts that operate together for a common purpose" (1968:1-1). In a social system this nucleus of purpose could be defined by the community of actors within the system or it could be defined by the observer who studies the social system as Forrester (1968:1-6) notes. In either case such a definition of purpose supplies the cultural values, intended or unintended, which makes observable action meaningful. Parsons (1951:5) stresses the cultural nature of social system values in the following definition of a social system:

Reduced to the simplest possible terms, then, a social system consists in a plurality of individual actors inter-acting with each other in a situation which has at least a physical or environmental aspect; actors who are motivated in terms of a tendency to the optimization of gratification and whose relation to their situations, including each other, is defined and mediated in terms of a system of culturally structured and shared symbols.

Although Berger and Luckman (1966:82, note 52) shun the term social system as suggestive of a functional integration of a number of unit social systems into one overall social system; they do describe the social process as one of objectification of institutional order. There thus seems to be a consensus among Forrester, Parsons and Berger and Luckman that there is a phenomenon of observable patterned social action organized around specific cultural values. This phenomenon is called a social system.

4. This hypothesis has taken different forms in different contexts. Marx's most important pronouncement on the matter is:

In direct contrast to German philosophy which descends from heaven to earth, here we ascend from earth to heaven. That is to say, we do not set out from what men say, imagine, conceive, nor from men as narrated, thought of, imagined, conceived, in order to arrive at men in the flesh. We set out from real, active men, and on the basis of their real life-process we demonstrate the development of the ideological reflexes and echoes of this life-process. The phantoms formed in the human brain are also, necessarily, sublimates of their material life-process, which is empirically verifiable and bound to material premises. Morality, religion, metaphysics, all the rest of ideology and their corresponding forms of consciousness, thus no longer retain the semblance of independence. They have no history, no development; but men, developing their material production and their material intercourse, alter, along with this their real existence, their thinking and the products of their thinking. Life is not determined by consciousness but consciousness by life. (Marx, 1970:47, originally 1847).

Mannheim states the hypothesis in two different ways:

The principal thesis of the sociology of knowledge is that there are modes of thought which cannot be adequately understood as long as their social origins are obscured. It is indeed true that only the individual is capable of thinking. There is no such metaphysical entity as a group mind which thinks over and above the heads of individuals, or whose ideas the individual merely reproduces. Nevertheless it would be false to deduce from this that all the ideas and sentiments which motivate an individual have their origin in him alone, and can be adequately explained solely on the basis of his own life-experience. (Mannheim, 1936:2).

In actuality it is far from correct to assume that an individual of more or less fixed absolute capacities confronts the world and in striving for the truth constructs a world view out of the data of his experience. Nor can we believe that he then compares his world view with that of other individuals who have gained theirs in a similarly independent fashion, and in a sort of discussion the true world-view is brought to light and accepted by the others. In contrast to this, it is much more correct to say that knowledge is from the very beginning a co-operative process of group life, in which everyone unfolds his knowledge within the framework of a common activity, and the overcoming of common difficulties (in which, however, each has a different share). (Mannheim, 1936:29).

Friedrichs commenting on Kuhn's (1970) Structure of Scientific Revolutions notes that:

Its central thesis is that the communal life of sciences rather than being dictated by the formal logic that justifies its methods of verification, demonstrates considerable affinity to the life-cycle of the political community. (Friedrichs, 1970:1).

Gouldner states the hypothesis as follows:

It is an essential element in my theory about sociology that its articulated theories in part derive from, rest on, and are sustained by the usually tacit assumptions that theorists make about the domains with which they concern themselves. Articulate social theory, I shall hold, is in part an extrusion from, and develops in interaction with, the theorist's tacit domain assumptions. Believing this to be the case for other theorists, I shall be obliged at various points in the discussion to present my own domain assumptions, for reasons of candor as well as of consistency. (Gouldner, 1970:34).

5. Ayer quotes Hume as follows:

When we run over libraries, persuaded of these principles, what havoc must we make? If we take in our hand any volume; of divinity or school metaphysics, for instance, let us ask, Does it contain any abstract reasoning concerning quantity or number? No. Does it contain any experi-

mental reasoning concerning matter of fact and existence?

No. Commit it then to the flames: for it can contain nothing but sophistry and illusion. (Ayer, 1959:10).

6. Conflict of capitalism versus communism is one involving, among other ideologies, the private versus public ownership of production-type capital. The conflict was and is carried on in the epistemic background of a mutually shared belief of all combatants in six basic suppositions: (1) economic development; (2) the continuing rationalization of the means and institutions of production; (3) the ascendancy of economic institutions over all other institutions; (4) the advancement of knowledge of science and technology; and (5) domination of cognitive rationality over all other thought forms. A conflict between two social groups with totally differing world views would more resemble a war between two tribes that do not even speak the same language.

7. One of the distinguishing features of the growth ethic is inescapable externality that forces conforming patterns of behavior on believers and unbelievers alike. Durkheim (1941:2, originally 1895) describes the external pressures of social systems in defining the concept "social fact":

These types of conduct or thought are not only external to the individual, but are, moreover, endowed with coercive power by virtue of which they impose themselves upon him independent of his individual will.

This definition does not begin to describe the external coercion of a technological society. Urban systems, transportation systems, communications systems, agricultural land use systems tend to overpower and control all other social systems on the one hand and "natural" physical systems on the other; so that even the study of such subjects as hydrology or meteorology or oceanography become more and more the study of technological impacts on the once "natural" systems involved. (Berger and Luckman, 1966:89).

CHAPTER II

CONCRETE SOCIAL GROUPS

1. Life History - Group Biography

Berger and Luckman (1966:116) note the importance of the concrete group's social structure in the development of cognitive reality:

Reality is socially defined. But the definitions are always embodied, that is, concrete individuals and groups of individuals serve as definers of reality. To understand the state of the socially constructed universe at any given time, or its change over time, one must understand the social organization that permits the definers to do their defining.

While Berger and Luckman do not follow this dictum by studying concrete social groups, they concentrate on the institutional nature of cognitive structure (cf. Berger and Kellner, 1964; and Berger, 1954). Berger's (1965) Towards a Sociological Understanding of Psychoanalysis approximates a group biography of a specific social group engaged in a scientific enterprise, and who must concomitantly construct a theory of social reality. Other studies which consist of group biographies of concrete social groups engaged in scientific or technological enterprise include Mullins (1966), Crane (1969), and Mitroff (1974). Friedrichs (1970), Gouldner (1970), and Turner (1974), emphasize the group centered

nature of sociological theory formation.

2. The Comparative Importance of History versus Social Organization in a Concrete Social Group

The term world view as conceived by Mannheim was used to represent the cognitive structures or total thought (that mixture of intellectual, social and spiritual phenomena that makes up the cognitive complex), of an historical individual, a concrete group or a "spirit of an era" (Mannheim, 1971:xii). The central organizing motif of a Weltanschauung varies depending on whether one is considering a concrete group or a "spirit of an era". The latter described a sociocultural matrix of thought of all groups in a common cultural space and historical time frame. A world view as a "spirit of an era" can become comprehensible only as an integration of ideas focused around a particular problem, albeit a problem of broad national or global concern. Mannheim reminds the student of world views that the basic methodology for their comprehension is integrative interpretation rather than analytical explanation.

Thus in referring to Reigl's study of the history of art, he states:

And in trying to elucidate in turn the causes of the mutations of the art motive, we must make reference to the even more fundamental factors such as Zeitgeist, "global outlook" and the like. Bring these various strata of cultural life in relation to each other, penetrating to the most fundamental totality in terms of which the interconnectedness of the various branches of cultural studies can be understood -- this is precisely the essence of the procedure of interpretation which has no counterpart in

the natural sciences -- the latter only "explain" things.
(Mannheim, 1971:11).

The structure of the world view of an era seems to hang together on historical connections. Wolff in his introduction of From Karl Mannheim stresses this point in a particularly cogent manner by asking:

. . . what is common to the various interpretations of the same historical period that would account for their mutual understandability . . . [what] elements [are] common to all men, by means of which they identify with one another and make allowance for the relative . . . ? (Mannheim, 1971:xxix).

In contrast the world view of a concrete social group is bonded together by social structure rather than this sense of general historical unity.

The distinction between world views of an era and world views of a concrete social group is important in this paper because the "ideology of growth" is a composite world view of a great number of diverse groups in a particular historical era. The utopia of equilibrium, on the other hand, as solely the product of the M. I. T. systems dynamics group, is presented in this paper.

The history of the M. I. T. systems dynamics group is presented in Chapters III and IV. How does one develop a methodological tool that will expose structure of social organization of that group in the process of recounting their history?

3. Disciplinary Matrix

Kuhn (1970:182) uses the term "disciplinary matrix" to define the total cognitive structure of a specific social group, particularly one engaged in scientific or highly professional enterprise. He reinforces Berger and Luckman's thesis of cognitive structure development as a product of a concrete social group by the following statement:

Having isolated a particular community of specialists by techniques like those just discussed, one may usefully ask: "What do its members share that accounts for the relative fullness of their professional communication and the relative unanimity of their professional judgments." But for this use, unlike the ones we discussed below, the theorem is inappropriate. Scientists themselves would say that they share a theory or set of theories, and I shall be glad if the term can ultimately be recaptured for their use. As currently used in philosophy and science, however, "theory" connotes a structure far more limited in nature and scope than the one required here. Until the term can be freed from its current implications, it will avoid confusion to adopt another. For the present purposes I suggest "disciplinary matrix": "disciplinary" because it refers to the common position of the practitioners of a particular discipline; "matrix" because it is composed of ordered elements of various sorts, each requiring further specification. (underscoring not in original)

The consequent typology of the "disciplinary matrix" of a scientific enterprise, as presented in Table I, is thus preceded by the qualification that the typology refers to "a particular community of specialists".

4. Concrete Social Groups as Epistemic Communities -- The Functions of Social Organization

Holzner's (1968:60) term "epistemic community" is synonymous with Berger and Luckman's "concrete social group", but the former emphasizes the communal nature of the group. He further elaborates the concept by applying it particularly to "a social organization of specialized knowledge" (1968:123). In order to indicate more precisely our referents, we shall sometimes characterize the M. I. T. systems dynamics group as a scientific epistemic community (SEC).

Holzner goes on to note that the organizing principle of a SEC arises out of the unique modelling techniques and paradigms that allow the total cognitive structure developed within the SEC to be considered as an entity unto itself, something distinguishable from the total general integration of scientific knowledge.

One often thinks of scientific knowledge as some sort of single universal entity. As Kuhn (1970:186) points out, if a cognitive structure of a total institutional scientific enterprise were completely homogenous, it would be difficult for colleagues or groups of colleagues to react to anomalies of the developing research situation in novel or "high risk ways". The balance between the universality of the scientific knowledge structure and its continuous balkinization possibly accounts, according to Kuhn, for

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that community's ability to reach consensus, but to distribute the risks of new theories and scientific revolutions.

The social organization, then, of the scientific enterprise, demands that members of that enterprise form into specific recognizable concrete social groups. The history of science is in part one of cooperation between these groups and in part competition (cf. Hagstrom, 1974). As a by-product of this social organization, no one can speak with authority for "science". The conflict between "growth" and "equilibrium", a central concern of this thesis, can be understood as a conflict between competing scientific groups, each acting as legitimators of contrasting world views. This in itself is no rending of the institutional fabric of science, but is natural to the on-going development of science.

Holzner (1968:123) discusses how the social organization of a group of knowledge specialists, an SEC, influences its reality construction which itself develops in the process of social differentiation. The following modification of Holzner's thesis is specifically applicable to scientific groups.

The social organization of SEC is an outgrowth of the interaction between group purpose or group goals and the historical environment in which those goals must be achieved. First the SEC must have a unity of purpose that sets it apart from other scientific communal entities. Second, the group must develop

working relationships with its prospective clients. Consequently the group invents concepts and definitions and analogies which bridge the gap between the specialized reality of the group enterprise and the common sense reality of everyday life. Third, there must be a series of more technical reality bridges between the SEC and the enterprises of the interrelated disciplines. Fourth, whereas it is important for the group to make contributions to the generalized body of scientific knowledge, it is more important to maintain a certain purity, a uniqueness that separates the concepts and origins of the group in that general body of knowledge. The group itself must compete for status within the hierarchy of the meritocracy of scientific achievement, just as internally some form of hierarchy inevitably exists. Parsons and Platt (1973:129) assert that knowledge constructing enterprises are not organized along democratic lines. This stratification of position reinforces the ethnocentric aspect of knowledge-specialized social groups and intellectual separation of any one SEC from its neighbor. Fifth, social organization implies a physical locus of action. Members of the group have a sense of the geographic domain in which they operate.

5. Social Organization and Cognitive Structure

A sharp distinction between the social organization of a SEC and its cognitive structure is now considered. The distinction is one

of the methodology of observation. Parsons (1951:5) refers to the physically observable set of symbols (artifacts) and practices that bind the group together into an understandable action pattern as a social system. It is an exterior phenomenon. Cognitive structure consists of the way the group organizes its communal knowledge and thus its shared perspective of the "real world". There is nothing observable in the physical sense about cognitive structure. As Husserl (1931:92) originally maintained, cognitive structure is a primordially known reality, because each individual can examine his own by his immediate experience of its presence. From this experience one can infer the presence of like structures in other persons. By the process of interpretation or phenomenological reduction, the researcher can build a composite picture of the cognitive structure of a concrete social group (Husserl, 1931:101-110; and Schutz, 1962:104-110).

The research for this thesis has been gathered by both methods, i.e., the objective observation of social structure and the construction of cognitive structure through the process of interpretation. The model that emerges is not that of two different structures, but of the same structure as seen from two different methodological perspectives. For example, in the instance of the fifth in the preceding list of elements of social organization, the element of territoriality, the investigator could make a map showing the spatial

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locations of various individuals important to the development of the M.I. T. systems dynamics group. He could also illustrate through quotations from the group members how they regarded M.I. T. and the general Cambridge milieu. The way a building is organized may give us the same information concerning the purpose of a concrete social group as would a memorandum of the architect. What emerges then is a composite structure with a physically observable social system and an understanding of the cognitive structure of the concrete social group in question.

6. Kuhn's Disciplinary Matrix

The disciplinary matrix is a more specialized term for such concepts as "structure of consciousness", "structure of knowledge", "world view", "cognitive structure", "epistemic structure", "socio-cultural matrix", and sometimes simply "culture". Kuhn's (1970: 182) special contribution was to develop this cognitive structure in a way that was particularly appropriate for specialized knowledge groups (SEC's) within the domain of the larger scientific community.

Kuhn roughs out the elements of the disciplinary matrix in a postscript to his Structure of Scientific Revolution, somewhat as an after thought to the original work (Kuhn, 1970:182-191). It is presented here in tabular form in keeping with the idea of a matrix. (See Table I). Care must be exercised in applying Kuhn's categories

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TABLE I
THE DISCIPLINARY MATRIX (AFTER KUHN)
THE STRUCTURE OF CONSCIOUS KNOWLEDGE FOR AN EPISTEMIC COMMUNITY OF SCIENTIFIC SPECIALISTS

Kuhn's Terminology	Subsystem Components Added	Kuhn's Elaboration	Significance and Comments
1. Symbolic Generalizations	<p>Generalized Empirical Statements</p> <p>A. Law - Schema</p> <p>B. Concepts</p>	<p>" . . . expressions deployed without question or dissent by group members which can be readily cast into logical form. Like (x) (y) (z) \emptyset (x,y,z) or $f = ma$ or $I = V/R$ (Kuhn, 1970:182). Symbolic generalizations are made up of two components:</p> <ol style="list-style-type: none"> 1. Law statements which are "<u>corrigible piecemeal</u>", i.e. can always be modified by further experimental observation. 2. Definitions of the symbols deployed which are by their nature tautologies, that is, objects constituted by group convention so as to form the officially observable "landscape" of group perception where active empirical observation can take place. (Kuhn, 1970:183). 	<p>" . . . the power of a science seems quite generally to increase with the number of symbolic generalizations its practitioners have at their disposal (Kuhn, 1970:183).</p>
2. Metaphysical Paradigms		Shared commitments to beliefs or particular models, "preferred by permissible analogies and metaphors" (Kuhn, 1970:184).	
3. Values	<p>A. Methodological Considerations</p> <p>B. Relating to the social organization of science as a whole</p> <p>C. Relating to the social organization of the particular group</p>	<ol style="list-style-type: none"> 1. To identify crisis or, later, choose between incompatible ways of practicing their discipline (Kuhn, 1970:185). 2. Judgments of accuracy . . . simplicity consistency, plausibility . . . (Kuhn: 1970:185). " . . . to provide a sense of community to natural scientists as a whole" (Kuhn, 1970:184). 	<p>Such values emerge as a <u>programmatic</u> statement of the scientific epistemic community. A unique interpretation of the pursuit of <u>cognitive rationality</u> which is the general goal of science. (cf. Parsons and Platt, 1973).</p> <p>The implication of the functional necessity of social organization values in the disciplinary matrix is that each SEC must internally generate some mental model of a social system for group use as a working model so that this SEC</p>

TABLE I (continued)

Kuhn's Terminology	Subsystem Components Added	Kuhn's Elaboration	Significance and Comments
3. Values (continued)	D. Relating to the social organization of the larger society and particularly to the enterprises of client groups.	"Other sorts of values exist as well - for example, science should (or need not) be socially useful . . . " (Kuhn, 1970:185).	can relate to its own social environment. This orientationally perceived model, however, can not help but form a part of the domain assumptions of the group, if it would later embark on a research endeavor into explicit social system modelling.
4. Paradigm as shared Example - An exemplar		<p>Whereas "symbolic generalizations" are empirical statements generalized from many diverse examples a "paradigm" in Kuhn's terminology represents the embodiment of that statement as perceived by the SEC in the real world. It is a projection of the model into the life world of the SEC. The ability of a member of the SEC to literally "see" his theoretical models in the real world sets him apart from non-members.</p> <p>"In the absence of such exemplars the laws and theories he has previously learned would have little empirical content (Kuhn, 1970:188).</p> <p>"The student discovers, with or without the assistance of his instructor, a way to see his problem as <u>like</u> a problem he has already encountered. Having seen the resemblance, grasped the analogy between two or more distinct problems he can interrelate symbols and attach them to nature in ways that have proved effective before. The law sketch say $f = ma$, has functioned as a tool, informing the student what similarities to look for, signaling the gestalt in which the situation is to be seen." (Kuhn, 1970:189).</p>	<p>"The paradigm as shared example is the central element of what I now take to be the most novel and least understood aspect of this book." (Kuhn:1970:187).</p> <p>An historically developed shared paradigm is the concrete scientific achievement . . . which becomes a "locus of professional commitment," (Kuhn, 1970: 11), for a concrete social group of specialists within the larger scientific community.</p>

too literally to the interpretation of the development of a particular scientific enterprise.

The methodological procedure of using some schemes like Kuhn's disciplinary matrix is much the same as in any community study. Somewhere in any community study, be it a community of scientists who deal in ideas, or a simple peasant community, there is a notion of a culture developing in a coherent if not logical fashion through time. In this vein, Arensberg defines a community as "a unit minimum population aggregate colony. The community is a structured social field of inter-individual relationships unfolding through time." (Arensberg, 1961:12). Perhaps Redfield (1960:102) best captured the unifying element of purpose in any unfolding community study as follows:

This is a small history with a central theme: a purpose of a people and its outcome. I do not know if this theme was chosen by me from others possible, or if it forced itself on me as the only possible or acceptable theme. I incline to the latter opinion.

Kuhn, to this writer's knowledge, never himself deployed his own matrix to elucidate the development of any particular concrete social group. Had he done so he might well have re-ordered elements within the matrix to facilitate research.

7. Qualifications of a Concrete Social Group

In summary one might ask what qualifications an aggregation

of scientists must meet in order to merit the designation "concrete social group" or "epistemic community"? These qualifications are summed up as follows:

Purpose

- (1) A perception of a common fate or group goals -- a unity of purpose;

Social Organization

- (2) Territoriality, a physical locus of social action;
- (3) Collective history, particularly a vision of the common origin of members of the community;
- (4) A presently operating and on-going network of communications;
- (5) A common set of general values;
- (6) An internally developed status system;
- (7) A sense of individual commitment to the group that transcends the general commitment to science, perhaps competes with it;

Pure Cognitive Elements of Structure

- (8) A common specialized reality. That is, a special language and special emphasis and elevation of certain paradigms at the expense of others, a uniqueness that sets the particular epistemic community apart from the broader scientific enterprise;
- (9) Language's concepts and analogies that tie the group to interconnected disciplines and to everyday reality.

This sort of analysis simply asserts the uniqueness of every SEC.

In this thesis, Kuhn's disciplinary matrix is used as a typology of analysis of the M. I. T. systems dynamics group. The first

period (Chapter III) describes the development of cybernetics at M. I. T. by Norbert Wiener and others. The second period (Chapter IV) carries on with the history of Jay Forrester and the systems dynamics group at the M. I. T. Sloan School of Management. The sub-chapter headings form the topological divisions of the modified matrix. Table II relates these divisions to Kuhn's Matrix for the Wiener era of development, and Table III performs a similar function for the Forrester era. It deals primarily with the period from the school's founding in 1956 to the publication of Limits to Growth in 1972.

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TABLE II

WIENER'S CYBERNETICS

Developmental Sequence	Place in Kuhn's Disciplinary Matrix
<ol style="list-style-type: none"> 1. <u>Territoriality</u> 2. <u>Collective History</u> <ol style="list-style-type: none"> 1. Forrester Looking Back 2. Wiener Looking Forward 3. <u>Scientification of Technical Enterprises</u> 4. <u>The Gun Control Problem</u> 5. <u>Wiener as a Social Philosopher</u> <ol style="list-style-type: none"> 1. His concept of social systems 2. Wiener's insights as they relate to growth 	<ol style="list-style-type: none"> 3. <u>Values</u> - Physical locus of social action 3. <u>Values</u> - A sense of common origin 3. <u>Values</u> - The concrete social group's special interpretation of cognitive rationality 4. <u>The Basic Paradigm or Shared Example</u> - Positive and Negative feedback systems 2. Metaphysical Paradigms

TABLE III

THE SYSTEMS DYNAMICS GROUP TAKES ON THE WORLD
MODEL

Developmental Sequence	Place in Kuhn's Disciplinary Matrix
<ol style="list-style-type: none"> 1. Forrester's Departure from Weiner - Reconceptualization of a Social System 2. Towards a Science of Social Systems - The evaluation of systems 3. Enter the Club of Rome 4. The Strategy of Social Change 5. The World Model and the Thesis of <u>Limits to Growth</u> 	<ol style="list-style-type: none"> 1. Symbolic Generalizations - Concepts 3. Values - Cognitive Rationality 3. Values - The relationship of the Scientific Epistemic Community to its clients 3. Values - Acceptable strategies of influencing interfacing institutions 4. & 2. The Basic Paradigm and its relationship to the Meta-physical Paradigms of the Systems Dynamics Group

CHAPTER III

SOCIAL AND HISTORICAL FOUNDATIONS OF THE

M. I. T. SYSTEMS DYNAMICS GROUP:

WIENER'S CYBERNETICS

1. Territoriality

Members of every community have a sense of place. This is no less true for a community of scholars whose theoretical interests concern the study of social systems than of other communities. Thus, a mental map will help locate the foundations of the M. I. T. systems dynamics group in both space and time. Physical space exerts social pressures that affect the development of a SEC; and therefore, the physical descriptions are interlaced with their social connotations.

Since M. I. T. is at heart an engineering school, the geographic layout could be conceptualized as a plot on a piece of graph paper. (See Graph I). Massachusetts Avenue is the ordinate, except that it doglegs to the left after about three city blocks, heading straight toward Harvard Square about two miles away. Memorial Drive is the abscissa and the zero-zero point is located at the intersection of Massachusetts Avenue and Memorial Drive, just after one has

crossed the Charles River on the Harvard Bridge. Most of the history of the M. I. T. systems dynamics group takes place within a triangle beginning at the Memorial Drive and Massachusetts Avenue zero-zero point. Sloan School of Management holds down the right hand terminal of the triangle on Memorial Drive. Here Jay Forrester developed the idea of a systems dynamics model as applying to all social systems. Harvard Square fixes the left hand terminal of the triangle, the leg that runs along Massachusetts Avenue.

The Rogers building is the first point of interest on our triangle. It is about one city block northeast of the zero-zero point. This is the entrance to M. I. T., and particularly to the core structure of the entire campus. This core structure consists of some twenty-four separate buildings, all inter-connected with each other to form a single unit of immense spatial and architectural complexity and diversity. Looking at the Rogers building and interconnected buildings say, from the air, it is a hodge-podge of squate "1930's modern" architecture attached here and there to Meis Vanderhos type high rise buildings. A huge Grecian classical dome straddles the core structure just east of the Rogers building entrance. The entire campus sits in the middle of the grimy, early twentieth-century-vintage, manufacturing town of Cambridge.

If one would pass through the Rogers building entrance and into the interconnected core buildings, he would have the feeling he

Mechanic Square



CHARLES RIVER

Sailing Pavilion 51

had stumbled onto a rat's maze of corridors leading off in different directions at irregular intervals. One can lose one's bearings easily in such a configuration of hallways.

This maze represents symbolically the structure of scientific knowledge as it appeared to Norbert Wiener when he taught at M.I.T. and walked in these same corridors in the early 1940's, the beginning of our time reference point of the growth and development of the M.I.T. systems dynamics group. Wiener (1965:2) described the "Map of Science" as follows:

Today there are few scholars who can call themselves mathematicians or physicists or biologists without restriction. A man may be a topologist or an accoustician or a coleopterist. He will be filled with the jargon of his field and will know all its literature and its ramifications, but, more frequently than not, he will regard the next subject as something belonging to his colleagues three doors down the corridor, and will consider any interest in it on his own part as an unwarrantable breach of privacy.

These specialized fields are continually growing and invading new territory. The result is like what occurred when the Oregon country was being invaded simultaneously by the United States settlers, the British, the Mexicans, and the Russians--an inextricable tangle of exploration, nomenclature, and laws.

It was always Wiener's purpose to explore "the boundary regions of science," and to make some sense out of the "Oregon country" of science in order to build it into an intelligible integrated entity. Wiener was not the founder or originator of systems dynamics. Only Forrester could make that claim. However, the historical

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thrust of systems dynamics can hardly be understood without an examination of the precedent history of the development of cybernetics, or, as Wiener called it, "the control and communication in the animal and the machine." Systems dynamics is an outgrowth of cybernetics, an extension of a more general program of unification of the sciences, but that particular extension which concerns itself with the study of the behavior of social systems.

Between M. I. T. and Harvard Square along Massachusetts Avenue is Avon Street where Norbert Wiener lived as a boy at the turn of the century. When he was a child some people still called Massachusetts Avenue by its older name, North Avenue. It was then still lined with comfortable mansions of well-to-do businessmen as Wiener (1964:60) described it. Cambridge then had more of the look and feel of a country college town rather than its later appearance of a dirty commercial city.

Vanderbilt Hall lies geographically outside of the M. I. T. Harvard Triangle, the focal area of the territoriality of the M. I. T. systems dynamics group. It is a part of the Harvard Medical School campus and lies about one mile southwest of the coordinate zero point of our mental map. In Vanderbilt Hall, Arturo Rosenblueth and a number of young scientists mostly from the Harvard Medical School gathered for dinner at a round table. Afterwards one of the group members, or perhaps an invited guest, would pre-

sent a research paper. The ensuing discussion would usually be on questions of methodology and the connections between the speaker's scientific discipline and those of his colleagues. Manuel Sandoval Vallarta, a professor of physics, used to bring some of his students. Wiener was a regular member of the group.

This Vanderbilt Hall group was particularly interested in bringing the "sciences of social need", as Kuhn called them (1970: 19) more into unison with the natural sciences through the investigation of and application of the scientific method to their respective works.

If the map of science was a jumble of narrow disciplines each invading each other's territory, then Rosenblueth, Wiener and others in the group reasoned that the overlapping boundary areas offered the richest opportunities for investigation. The group dream was one of a team of scientists working together on a specific project. Each one would possess a specialized competence. Over and above this, each would have a sound acquaintance with the fields of their colleagues.

As Wiener (1964:3) explains it:

We had dreamed for years of an institution of independent scientists, working together in one of the backwoods of science, not as subordinates of some great executive officer, but joined by the desire, indeed by the spiritual necessity, to understand the region as a whole, and to lend one another the strength of that understanding.

This dream was not of the Apollo-type operation wherein the systems team is locked into some mission conceived of by non-scientists as being socially worthy of pursuit. It was a dream predicated on a communal organization more resembling the artisans who gathered about the foundation of the Cathedral at Chartres and imparted to that structure their own "unity and a spirit of devotion." (Clark, 1969:59).

M. I. T. was established in 1861. One might get a summary view of how the physical configuration of the university has changed over the last 100 years by referring to the founder's original statement of purpose as quoted in the M. I. T. Bulletin (1974:2):

Where students would learn exactly and thoroughly the fundamental principles of positive science with their leading applications to the industrial arts . . . [and] in those of the humanities and social sciences most closely related by method or content to modern developments in engineering, science and mathematics.

The history of M. I. T. from its beginnings in 1861 to the early 1930's was largely dominated by developments in the various disciplines of applied science -- electrical engineering, mechanical engineering, civil engineering, and so forth. By the early 1930's M. I. T. had developed into an applied science school of some fifteen different departments, each with buildings and laboratories of their own. From the point of view of physical space, probably the heart of any one of these disciplinary buildings was its laboratory.

Here the engineer or other applied scientist could gain a "hands-on" relationship with the materials of his field. For instance, in the civil engineering laboratory, the scene was dominated by large material testing machines, compression testers, tensile strength testers, and perhaps the ultimate, a large beam testing machine where a real concrete or steel beam could be tested by bending until it ruptured.

The servo-mechanisms laboratory set up in the early 1930's under the Department of Electrical Engineering seemed perhaps at that time only a slight departure from the traditional format, its purpose being to study the behavior of mechanical and electrical control devices and their application to engineering problems. Forrester (in M.I.T. 1972:10) however sees industrial dynamics as an outgrowth of research instituted in this laboratory.

About that time Dr. Vannevar Bush and his associates were engaged in the building of the Bush differential analyzer, a prototype of the modern computer. The computer in itself is a control device, an apparatus which can be interphased with mechanical or electrical mechanisms in order to achieve more sophisticated forms of behavior autonomous from the manual manipulation. The computer, however, was also a vehicle for simulating the behavior of machines, thus substituting a mathematical model for study of manipulation as contrasted to the physical model as traditionally handled in the dis-

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ciplinary laboratory. Such a laboratory, with its capability of mathematical simulation of physical problems can, nevertheless, be structured along traditional lines. At M.I. T. it was the progression from the traditional disciplinary laboratory to the computer laboratory, coupled with Wiener's vision of the inter-disciplinary research teams, that began to dominate the physical landscape of M.I. T. in the 60's and early 70's. One can thus summarize the progression of the M.I. T. landscape as one of transition from disciplinary laboratories to computer laboratories to systems centers, that is, inter-disciplinary group-oriented research conceived of as computer simulation models of "real life" problems.

When one walks into the Sloan School of Management at the extreme right end of the M.I. T. triangle on Memorial Drive one can visualize the significance of this milieu by thinking of it as one of the many systems centers for the inter-disciplinary study of larger and more complex systems problems -- in this particular case, perhaps one originally narrowly focused on corporate management and government bureaucratic management problems. In the basement of the Sloan School of Management building is an IBM 360 computer. Most of the rooms are of a large seminar-type with U-shaped tables that seat twenty or thirty and chalkboards about them for rough sketching of models. An important feature is the computer terminal that interconnects the teaching and research within

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the room with the computer and its multitude of programs in the basement.

The Alfred P. Sloan School of Management Master's Program Brochure (M. I. T., 1972:10) paraphrases this more general historical development at M. I. T. from disciplinary laboratory to computer laboratory to systems center as follows:

Industrial dynamics is the outgrowth of a series of developments pioneered at M. I. T. dating from the 1930's. The initial developments were in the dynamics of feedback processes engineering (servo-mechanisms). Early work included the development of mechanical and laser electronic differential analyzers. Then, during World War II, Servo-Mechanisms Laboratory organized the theory of feedback systems, and applied that theory to the design of remote control devices for radar antennas and gunmounts. This work expanded rapidly in the post-war period and was applied to chemical plants, aircraft, astronautical guidance, and many other engineering systems. In 1956, J. W. Forrester, who had directed the development of digital computers at M. I. T. and pioneered their application to military control systems and the simulation of complex machine interactive systems, moved to the Sloan School of Management and began to extend feedback system theory and system stimulation to corporate policy systems, later broadened to include more general types of social systems. This work has continued and expanded, and has been applied by many organizations and groups all over the world.

One block behind the Sloan School of Management, a modern six-story building, is a circa 1930 concrete warehouse, one of many like it that sprung up in commercial Cambridge during the upsurge in industrial development following World War I. This building is called E-40. It is also referred to as the Urban Systems Laboratory. It was here that the M. I. T. systems dynamics group developed

their world systems model. Neither the Sloan School of Management nor the E-40 building which houses the Urban Systems Laboratory dominate either the physical or intellectual landscape of M. I. T. According to the M. I. T. Bulletin (1974:105-124) there are some 37 programs or centers for advanced study or laboratories devoted to inter-disciplinary projects. Although the division is somewhat arbitrary, 12 of these inter-disciplinary units may be considered to be specializations of some branch of a traditional discipline such as the Bates Linear Accelerator Group or the Center for Cancer Research or the Center for Space Research. The remaining 25, however, reflect very much the "spirit of the thought of the time" (Wiener, 1965:4) of the early 1940's and Wiener's dream of teams of scientists bound together into interdisciplinary team research. This spirit can perhaps be best illustrated by Table IV which lists 14 of the 25 inter-disciplinary centers or laboratories with an excerpt expressive of the M. I. T. multidisciplinary spirit.

The last laboratory is the territorial domain of the M. I. T. systems dynamics group which actually operates as part of the Sloan School of Management. It is dominated by the unique thrust of M. I. T. as a total institution, and by Norbert Wiener and Jay Forrester who are only part of the cast of educators, scientists, engineers and technologists of the larger educational institution.

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TABLE IV

A PARTIAL LIST OF M.I.T. COMPUTER LABORATORIES
REFLECTING THEIR "SPIRIT OF THOUGHT OF
THE TIME"

Center	Quotations
1. Center for Advanced Engineering Study	The Center adds a new dimension to the activities of M. I. T. by offering educational programs which are designed to enable experienced men and women from industry, government, and educational institutions to acquire the understanding and skills needed to open technical frontiers.
2. Center for Transportation Studies	The Center has developed a sense of community that promotes cooperation, exchange of ideas, a wider perception of the opportunities of a common purpose.
3. Operations Research Center	Operations Research deals with traffic control systems rather than the design of cars, with the management, organization, and scheduling of production rather than the technology of machines;
4. Arterio-Sclerosis Center	It is unique in that it is run by physicians from M. I. T. and the Massachusetts General Hospital, and engineers from both institutions and physical sites on both sides of the Charles River.

TABLE IV (Continued)

5. Artificial Intelligence Laboratory	Cognitive engineering suggests a fundamental respect in which the Laboratory's approach to such problems differ from that of philosophers and psychologists: the cognitive engineer tries to produce intelligence (in the laboratory).
6. Center for Advanced Visual Studies	Collaboration through a working dialogue between artists and scientists and engineers is of primary importance in the exploration of new creative objectives.
7. Center for Policy Alternatives	The Center also seeks to find new ways to beneficially connect a technology and social and economic welfare . . .
8. Clinical Research Center	Many research projects are in progress, including those in nutrition, psychology, cardiology, endocrinology, gastroenterology, mechanical, chemical, and electrical engineering.
9. Commodity, Transportation and Economic Development Laboratory	This inter-departmental laboratory . . . interlocks strongly with many of the dispersed activities related to "social, political, economic and legal" aspects of commodity transportation in an effort to develop integrated approaches to the solutions of transportation problems.
10. Division for Study and Research in Education	Current research foci involves relating the following areas to developing new theoretical perspectives of learning; problem solving, modelling representations and transformations of information and knowledge; group process theory, organ-

TABLE IV (Continued)

	izational learning and reliable processes for change; information processing, theories of perception and new technologies.
11. Energy Laboratory	The Energy Laboratory enables M. I. T. to concentrate its diverse intellectual resources on the complex societal issues and technological problems involved in supply, demand and consumption of energy.
12. Information Processing Services	. . . the computer serves increasingly as a tool that opens up totally new ways to process information and presents an opportunity to formulate and think through both old and current problems in wholly different ways.
13. Research Laboratory of Electronics	Established at the end of World War II as the Institute's first inter-departmental laboratory.
14. Urban Systems Laboratory	The Urban Systems Laboratory, as inter-departmental laboratory, provides a framework and facility for conducting research projects in the various disciplines of engineering, management, architecture, planning, and the social sciences. While the principal focus is on urban problems, the work of the Laboratory encompasses a wide range of societal problems.

2. Collective History

Jay Forrester gives three separate accounts of the origins of systems dynamics. The first account from his book, World Dynamics (1971:13) stresses the group nature of the history:

At the Massachusetts Institute of Technology, over the last 40 years there has developed a powerful approach to understanding the dynamics of complex systems. The foundation was laid in the 1930's when Vannevar Bush built his differential analyzer to solve the equations of certain simple engineering problems. Such a set of equations is a model of the system they represent. Such a model describes the rules that govern the system behavior. The differential analyzer, set up in accordance with the equations that are the instructions, becomes a simulator to trace the dynamic behavior of the system being studied. In that same period, Norbert Wiener developed his concept of feedback systems that were later given the name "Cybernetics". Harold L. Hagen wrote some of the first introductory papers in the field of feedback control that was to be known as "servo-mechanisms." In the 1940's Gordon S. Brown created the Servo-Mechanisms Laboratory in which the theory of feedback systems was expanded, recorded, taught, and radiated. In the 1950's J. W. Forrester, author of this book, was director of the Digital Computer Laboratory and Division 6 of the Lincoln Laboratory where digital computers were first used for systems simulators; and since 1956 he and a group of associates at the M. I. T. Alfred P. Sloan School of Management have extended the preceding developments to cope with the greater complexity of social systems.

Forrester's preface to Industrial Dynamics (1961:v-vii) contains an autobiographical account of the history of systems dynamics:

The research represented in this book has evolved directly from my own experiences. The cattle ranch operated by my parents, M. M. and Ethel W. Forrester, at Anselmo, Nebraska, provided my first exposure to business and to the nature of commodity markets. The study of electrical

engineering at the University of Nebraska laid the foundation for graduate research. My graduate study at M. I. T. was under Professor Gordon S. Brown who was then starting the servo-mechanisms laboratory in developing the concepts of information-feedback systems in a research project atmosphere that gave leadership experience to graduate students and junior staff. In the late 1940's, the challenging environment of the M. I. T. Division of Industrial cooperation under Mr. Nathaniel McL. Sage, Sr., gave me an opportunity to plan and direct with broad managerial responsibility, the construction of Whirlwind I, which was one of the first high speed electronic digital computers. As head of the digital computer division of the Lincoln Laboratory, I had the opportunity to manage a growing technical organization, to coordinate the early planning of the Air-Force's Semi-automatic Ground Environment (SAGE) system for air defense and to guide the early stages of company industrial manufacturing to build the needed equipment. Together, these experiences provided the view of management problems at all levels as well as the foundation and the methodology of which the book is based.

Forrester's third historical rendering dwells on the development of a more general model structure of systems dynamics from their more particular and restricted structure application in engineering and industry (Forrester, 1969(a):1):

This book examines the life cycle of an urban area, using the methods of industrial dynamics that have been developed at the M. I. T. Alfred P. Sloan School of Management since 1956. The term "industrial dynamics" has become too restrictive because the methods are applicable to many fields other than industrial management. The concepts of structure and dynamics behavior apply to all systems that change through time. Such dynamic systems include the processes of engineering systems, biology, social systems, psychology, ecology, and all those where positive and negative feedback processes manifest themselves in growth and regulatory actions.

Each of these historical accounts emphasize the M. I. T. origin of

the theoretical approach of systems dynamics. Proper acknowledgment is given to the founders, but these accounts are notable in their lack of some particular founding father or charismatic figure of systems dynamics theory. There is no Marx "or Moses" "or Christ" or "Mohammed" in the "in-house" version of M. I. T. group history. The emphasis is entirely methodological. Perhaps most revealing is the autobiographical sketch of Forrester's own background but which in a larger sense indicates the background of every systems dynamicist who must pass through his apprenticeship within the group. The common elements of background are as follows:

- (1) Undergraduate experience in engineering or the hard sciences.
- (2) A high degree of mathematical training, particularly the mathematics of applied technology.
- (3) An apprenticeship period in a computer laboratory working on information feedback systems.
- (4) Membership in a research and development team engaged in some facet of systems research.
- (5) A growing confidence that all systems, natural, biological, technological and social exhibit the same elements of structure.
- (6) An emphasis on the perspective that social systems are

to be studied as a problem of management by technologically oriented policy makers.

The common history presented to the prospective member of the systems dynamics team, the student entering the Sloan School of Management, particularly the graduate school, is in effect a description of the socialization process into full-fledged group membership. It is a description of passage into the group. One sees also the collective history of the group revealed in the descriptions of the graduate courses for the Sloan School of Management (M.I.T., 1974:295-299). The program emphasizes such courses as advanced computer systems, operations planning and control systems, principles of systems dynamics, mathematical elements of planning and control, and management and administration. The only two graduate courses listed under the section entitled History and Environment are those in crises in contemporary American society and readings in power and responsibility. There are no courses in the conventional, contemporary social sciences but there are courses in organization theory, theories of planned change, and seminars in social psychology. In summary, the study of social systems is a special case of the more generalized studies of mathematical systems models from a methodological point of view and of management systems from a standpoint of application. To the member of the systems dynamics group, a way of looking at life is the study of social

systems or a study of applied management technology, just as the study of physical systems would be a study of applied engineering technology. Systems dynamics, like cybernetics, is a matter of control of man and machine.

Further evidence of the technological background of prospective members of the systems dynamics group can be seen in the profile of entering graduate students in the 1970 class of the Sloan School of Management. (Table V)

TABLE V
PROFILE OF ENTERING GRADUATE STUDENTS
M. I. T. SLOAN SCHOOL OF MANAGEMENT

Undergraduate Major	Percent
Engineering	38%
Science	21%
Management	17%
Economics & Political Science	10%
Business	7%
Other	7%
Total	100%

(M. I. T., 1972:24)

Forrester apparently perceives the history of systems dy-

namics as synonymous with the history of social systems. In fact, history itself is an unimportant study for one attempting to obtain a clear, concise view of social systems. One is reminded of Merton's discussion of history and systematics of sociological theory, and particularly of Kessler's provocative quotation (Merton, 1968: 28) which seems so much in the spirit of the systems dynamics treatment of history:

Even the masterpieces of scientific literature will in time become worthless except for historical reasons. This is a basic difference between the scientific and the belletristic literature. It is inconceivable for a serious student of English literature, for example, not to have read Shakespeare, Milton and Scott. A serious student of physics on the other hand, can safely ignore the original writings of Newton, Faraday and Maxwell.

The student of systems dynamics must be satisfied with the vignettes presented by Forrester. They are probably assigned as a part of the first assignments in the beginning of some elementary course and are relegated to coffee-break conversations. The result of this approach to the collective history of systems dynamics tends to preclude history itself as a proper subject of study.

The fact that social systems can only be grasped through mathematical analysis and modelling techniques becomes an underlying presupposition of the systems dynamics group that can be taken without question by all members of the group. Wiener, then, from the point of view of Forrester looking back, is worthy of citation as

one of the predecessors of systems dynamics, but Wiener's own views on social systems are too far in the past to be of relevance to the student of systems dynamics. The collective history of systems dynamics is a triumph of methodology and theory over history itself. Because of this trifling commitment to history, the notions of the systems dynamics approach as the only approach to the social systems is more likely to be accepted as given by the group initiate.

There are other and opposing historical perspectives of the history of what Wiener terms "cybernetics" and Bertalanffy calls "general systems theory". This conflict of histories is indicative of the inherent competition of closely related scientific epistemic communities, each trying to preserve and enhance their own identities. Bertalanffy (1968) does not mention Forrester's systems dynamics in his review of the foundations, development and applications of general systems theory. He discusses, however, the development of Wiener's cybernetics and considers it as one of twelve developments in general systems theory (Bertalanffy, 1968: 22). According to Bertalanffy, general systems theory pre-dates cybernetics and cybernetics is merely a part of the later intellectual movement.

Systems theory also is frequently identified with cybernetics control theory. This again is incorrect. Cybernetics, as the theory of control mechanisms and technology in nature, and founded on the concepts of information feedback, is not a part of a general theory of systems;

cybernetics systems are a special case, however important, of systems showing self-regulation (Bertalanffy, 1968:17).

In another paragraph Bertalanffy (1968:10) states:

So far as can be ascertained, the idea of a "general systems theory" was first introduced by the present author prior to cybernetics, systems engineering, and the emergence of related fields.

Probably one of the more succinct statements of the beginnings of general systems theory is given by Bertalanffy (1968:90) in the following:

The idea goes back some considerable time: I presented it first in 1937 in Charles Morris' philosophy seminar at the University of Chicago. However, at that time, theory was in bad repute in biology, and I was afraid of what Gauss, the mathematician, called, "Clamor of the boeotians", so I left my drafts in the drawer, and it was only after the war that my first publications on the subject appeared.

Without going into greater detail it is apparent that each scientific epistemic community writes its own collective history to the exclusion of its nearest rivals. (Wiener, 1965:11).

3. Scientification of Technical Enterprises

The fundamental element of cohesion for any social group is group purpose or group goals. The fact that a group can exhibit some common purpose is the central element distinguishing a group from an aggregate of individuals. Thus a clear definition of that purpose is a prerequisite to interpreting the meaningful behavior of

the group.

Groups in actuality exhibit hierarchies of purpose in a scientific epistemic community. The highest purpose centers around the construction of knowledge structures, cohesive entities of abstract symbols that represent the accumulated knowledge of the scientific enterprise. Mannheim referred to these knowledge structures as "systematizations" (1953:15). Parsons and Platt (1973:vi) discussing the purpose of higher education in contemporary United States in terms of the pursuit of the cultural values of "the cognitive complex" -- knowledge, rationality, learning, competence, intelligence -- further note that this cultural component of higher education represents "the most critical single feature of the developing structure of modern society." The core value of higher education, also referred to as "cognitive rationality," can also be considered at the apex of the hierarchy of purpose of a scientific epistemic community such as the M.I.T. systems dynamics group. Institutionalization of higher education, therefore, centers around a specific set of core cultural values represented by the central concept of cognitive rationality.

The question now is how would those at M.I.T., particularly in the line of succession from Norbert Wiener to Jay Forrester and beyond define cognitive rationality. If we look at Wiener (1965:9) we get a glimpse of the type of historical progression that best

expresses the M. I. T. view of cognitive rationality.

Once we had done this, at least one problem of engineering design took on a completely new aspect. In general, engineering design had been held to be an art rather than a science. By reducing a problem of this sort to a minimization principle, we had established the subject on a far more scientific basis. It occurred to us that this was not an isolated case, but that there was a whole region of engineering work in which similar design problems could be solved by the methods of calculus variations. . . . We thus have replaced the design of wave filters processes which were formally of an empirical and rather haphazard nature by processes with a thorough scientific justification.

In doing this, we have made of communication engineering design a statistical science, a branch of statistical mechanics (Wiener, 1969:9-10).

The research group moves an engineering problem from an "empirical and rather haphazard" solution to one based on a mathematical model. The process is one of rationalization of technology. Becker (1970:9) used the term "scientization" to describe such a process. We suggest "scientification of technique" as a phrase most descriptive of what Wiener and his associates were attempting.

Such a cultural goal is quite different from, say, the development of science itself, which implies an evolutionary belief in a vein somewhat similar to the Comptean notion of knowledge development from religion through philosophy to science.

Wiener recounts the thrust of the group's research experience as follows:

Thus, as far back as four years ago, (1943) the group of scientists about Dr. Rosenbluth and myself had already become aware of the essential unity of a set of problems about communications, control, and statistical mechanics, whether in the machine or in living tissue. On the other hand, we were seriously hampered by the lack of unity of the literature concerning these problems, and by the absence of any common terminology, or even a single name for the field. After much consideration, we have come to the conclusion that all of the existing terminology has too heavy a bias to one side or another to serve the future development of the field as well as it should; and as happens so often to scientists, we have been forced to coin at least one artificial neo-Greek expression to fill the gap. We have decided to call the entire field of control and communication theory, whether in the machine or in the animal, by the name of cybernetics, which we form from the Greek *κυβερνησις*, or steersman. (Wiener, 1965:11).

The quotation emphasizes not so much the transition of an art to a science as the unification of a number of problems into a basic set of problems about communication control and statistical mechanics, in other words, the detection of a single structure underlying a diverse set of problems. This type of scientific accomplishment is precisely what Kuhn (1970:19) had in mind in his concept "paradigm". It happens that in the development of cybernetics, the programmatic cultural evolution of the scientification of technique and the development of the basic paradigm of cybernetics, the feedback model, apparently coincided in the same event (in historical time). Kuhn (1970:19) states:

In the sciences (though not in fields like medicine, technology, and law of which the principle raison d'être is an external social need), the formation of specialized jour-

nals, the foundation of specialist societies, and the claim for a special place in the curriculum have usually been associated with a group's first reception of a single paradigm. At least this was the case between the time a century and a half ago when the institutional pattern of scientific specialization first developed, and of a recent time when the paraphenelia of a specialization required a prestige of their own.

It was in these very "sciences of social need" that the paradigm of the feedback mechanism arose and concurrently became both the center of the nucleus of program of the specialized groups involved and the model paradigm of those same groups. The purpose of the group, as with the collective history of the group, is often thought of as a historical tale. It may be one experienced by the member himself or it may be a recitation of the antecedents of the group history itself. Wiener's (1965:38) view of the latter is paraphrased as follows:

The thought of every age is reflected in its technique. The first engineers to draw their nourishment from science rather than the collective experiences of common sense were the land surveyors, astronomers, and navigators of the 15th and 16th centuries. These were followed by the clock makers and grinders of lenses in the 17th and early 18th centuries. The precision watch in particular, coupled with the telescope, made possible the age of navigation after the model of Hygens and Newton. This was the period of commerce on the great ocean, a result of the engineering of the mercantilist. It set the stage for the industrial revolution when the manufacturer succeeded the merchant and the steam engine succeeded the chronometer. The central field of engineering here is the study of prime movers, that is, steam engines, steam turbines, and water turbines. Later on in the 18th century the science of thermo-dynamics was paralleled by the science of electric currents and the

dynamo was added to the steam engine in an ever-expanding repertoire of prime movers.²

The basic unit of this progression of physical sciences is now and has always been energy. But Wiener now states:

There is in electrical engineering a split which is known in Germany as the split between the technique of strong currents and the technique of weak currents, and which we know as the distinction between power and communication engineering. (Wiener, 1965:39).

The new engineering required a new science for its underpinning, a science based on a completely different unit of measure, that is, information rather than energy.

Cybernetics is the programmatic development of the scientification of techniques based on information as the basic unit of analysis. The M.I.T. systems dynamics group is a continuation of this same historical development, using information as the unit of analysis and the basic feedback loop as the element of structure in their models. The M.I.T. systems dynamics group takes its point of departure from cybernetics, at least as Wiener conceived it, when it focuses its scientification program and information feedback paradigm on the concept of "social system".

4. The Gun Control Problem

The paradigm or "shared exemplar", to use Kuhn's terminology, places the gestalt of a particular model into the eye of the

observer. By its very nature it must precede perception itself. It may be built up in the course of numerous preceding perceptions, that is, a continually evolving gestalt. But the point is, it is a condition precedent to perception rather than a consonant with it, although it is experienced as an immediate outside reality. The experience is analogous to "projection" in the Freudian sense; that is, it relates to a transferral of an inner experience into outside reality. This paper is not concerned with just how these gestalts are formed, but rather with the particular gestalts, mental models, or paradigms that underlie cybernetics and systems dynamics.

The particular application of the basic paradigm of cybernetics foremost in Wiener's (1965:7) mind is the gun control problem. He mentions it first in the introduction to cybernetics. Again he makes reference to it in his accounts of cybernetics development (Wiener, 1965:35 & 61; 1967:245). This particular application of cybernetics to fire control problems is also appropriate inasmuch as Forrester played a leading role in coordinating and managing the technical organization that developed the Air Force's Semi-automatic Ground Environment (SAGE) System for air defense in the 1950's. The SAGE System was an historical continuation of Wiener's prototype model of the fire control problem.

As Wiener explains the historical precedents that led to this

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model at the beginning of World War II, the German superiority in aviation and problems of Britain's defense made the improvement of anti-aircraft artillery a vital technological concern in the United States.

Over the preceding few years the speed of airplanes had improved to the extent that they were at least in the same range and magnitude as the speed of the anti-aircraft fire itself. The problem of predicting the future location of an airplane which had originally been a problem of simple extrapolation required a new approach. The old approach of prediction of the future through extrapolation could treat the system as a simple linear system; the motion of the plane itself could be considered as progressing in a fixed straight line pattern. The problem of fire control, then, became one in Newtonian physics. The variables are the muzzle velocity of the gun, transectory behavior, shellburst characteristics, and such factors as atmospheric pressure, wind velocity, air temperature, and the like.

Wiener and his electrical engineering associate, Julian H. Bigelow, discarded the former model and substituted a feedback model, one that controlled the firing of the gun on the basis of information received as to the relative position of the airplane to the last perceived shellburst, plus a computer model that took into account the pilot's most probably evasive action. The physical environment

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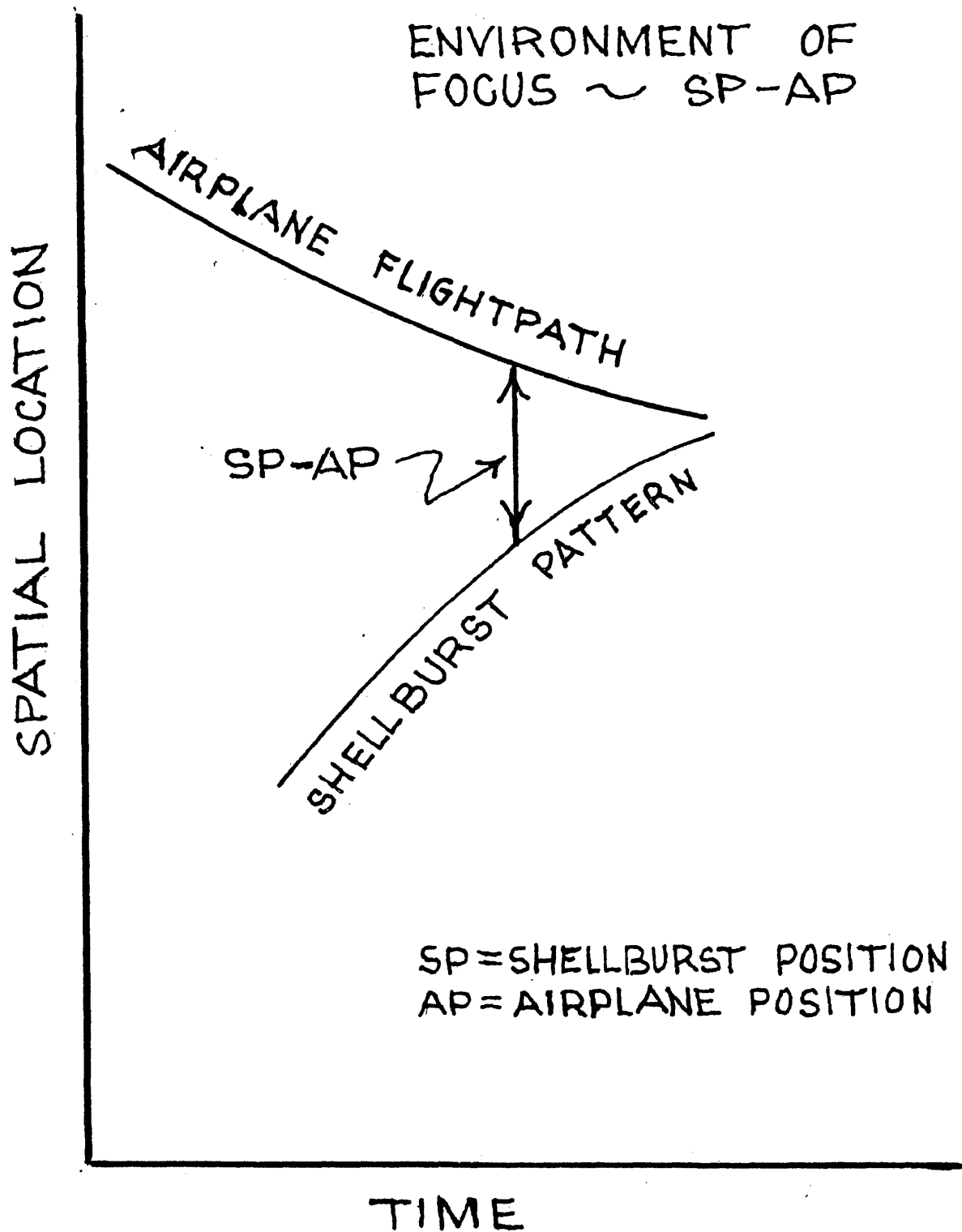
that counted in this type of model was the environment that measured the distance between the perceived shellburst and the position of the plane (see Figure VI). The actions of the gun controller were governed by a series of bits of information as to the perceived condition of this specialized environment. In this type of model, the type of fire that would eventually prove most successful in bringing down the target would be a series of shellbursts that would move progressively closer to the target until closure was achieved, except that the closing time for this achievement could not be too great or the plane would move out of range. A computer program that first undershot the mark and then overshot the mark would simply swing the shellburst back and forth across the target in wild gyrations or oscillations. MacColl (1946) had already done a paper on the problem of rudder overshoot of steering mechanisms relevant to the problem Wiener and Bigelow faced.

Some twenty-five years later, Forrester (1961 & 1968) reconceptualized the "gun control problem" into the textbook language of the basic feedback loop. In that twenty-five years, the mathematical language, the symbolic generalizations required to grapple with the problem of feedback systems, had been tremendously simplified. The concepts had been refined, but the basic paradigm that the student of application of feedback control mechanisms is required to grasp, remained stable.

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FIGURE VI

WIENER'S GUN CONTROL PROBLEM

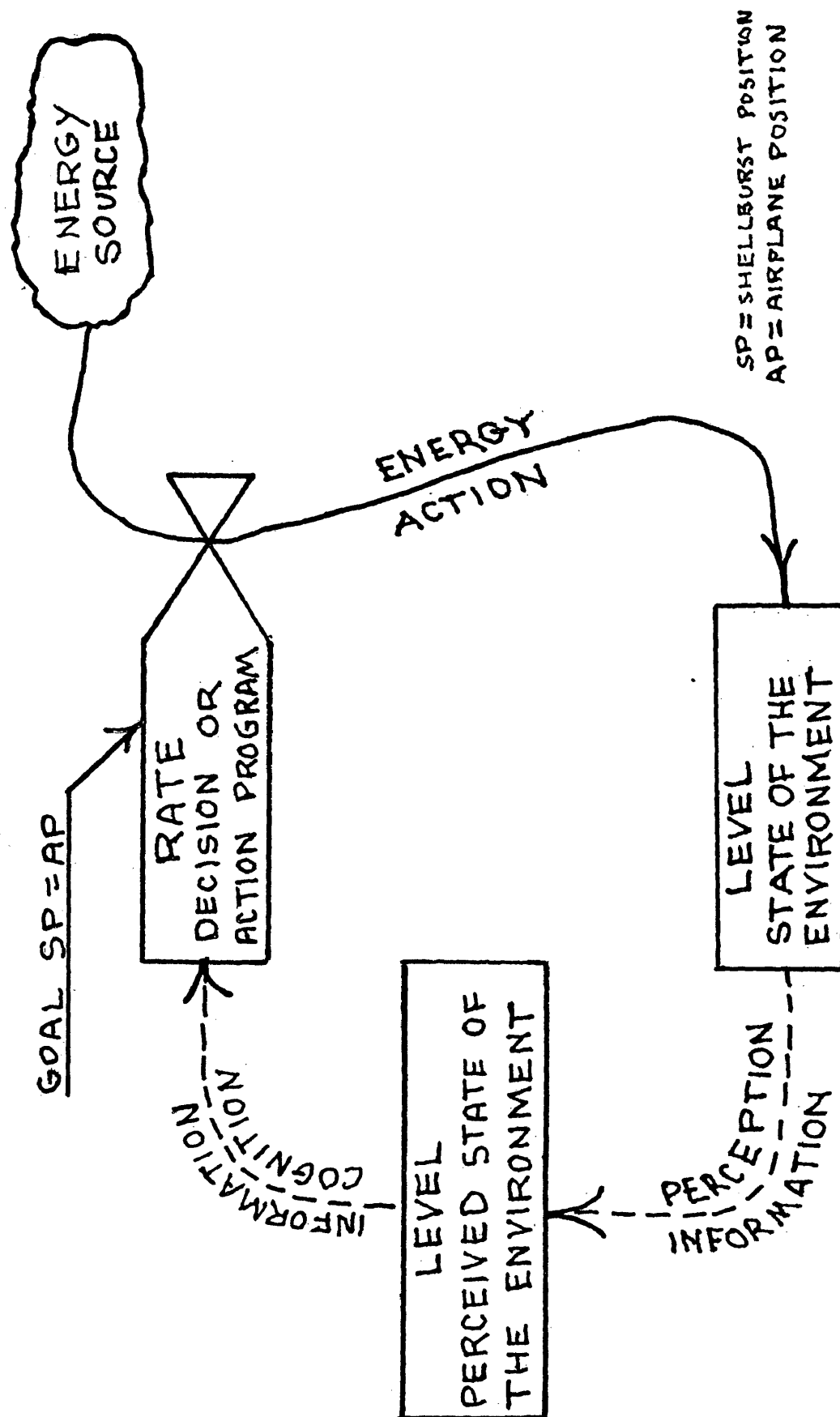


The gun control problem could be explained in terms of Forrester's (1968:4-1) feedback loop by referring to Figure VII. As Forrester (1968:4-1) notes, "The feedback loop is the basic element from which all systems are assembled." In understanding the science of systems, the first problem to be encountered is what information passes in this loop of the feedback system and what information is blocked out of the system. The only information that the system acts upon is information regarding the state of what is considered the environment, or, as Forrester calls it, the "level" within the system.

In the gun control problem, this system level or environment has already been described as the difference in the distance between the plane and the shellburst. All other types of information are irrelevant. The way this is described in the language of systems is that the system has a closed boundary; that is, it is influenced by its own past behavior (Forrester, 1968:1-5). On the other hand, it is not influenced by any exogenous variable. Put another way, the systems modeller explicitly assumes that the system behavior is always predictable through time. This explicit assumption is of paramount importance as one proceeds to the problem of social systems. To continue a description of a feedback loop, the loop itself is made up of two fundamental elements: levels and rates. The level denotes quantitative state of the environment within the system, and

FIGURE VII

THE BASIC PARADIGM OF CYBERNETICS AND SYSTEMS DYNAMICS
THE INFORMATION-FEEDBACK LOOP



the rate denotes the reaction or resultant behavior of the system to changes in levels. In language more appropriate to conventional descriptions of social systems, rates are the policies of the decisionmakers within a feedback system. These rates or policies have four separate components.

The first component is the goal of the policymaker. In the example of the gun control problem, the goal is to make the airplane position and the shellburst position coincide or, mathematically speaking, the goal is $SP = AP$. The second component is the apparent condition or the perceived condition of the level. As Forrester (1968:1-8) notes the true state of the system may differ from its perceived state, but it is the perceived state and not the true level state of the system that is the basis for the decision process. This perceived state is the only information the actor possesses. In the example of the gun control problem, there is always a time lag between the perception of the relative position of the firebursts and the plane at the time action is taken to fire the next shot and the true condition of the plane's shellburst environment. In fact, in feedback systems, the difference between perceived levels and actual levels can always be explained in terms of time. The underlying assumption of feedback systems is, given enough time, the decisionmaker will eventually understand the true condition of the system, but there are slow and fast learners.

The third component of rate is the discrepancy between the goal and the apparent condition of the level within the system. To put this more in the sociological language of social systems, this discrepancy is the normative orientation of the policymaker or actor towards the system. In feedback systems, the emphasis is not on a typology of normative orientation, but rather on a quantitative description of possible magnitudes of action. The fourth component of rate is the action itself resulting from the discrepancy between the goal and the condition or the level of the system.

One notes, looking at the basic feedback loop figure, page 84, that the loop is broken into three discrete symbols: (1) the basic variable of the level or the environment of the system itself; (2) the apparent condition of the system, and (3) the decision made by the decisionmaker or actor in the system. Each of these is connected by a process. The process that connects decision and level is action, a process requiring the transfer of energy. As noted in the diagram, energy comes from outside sources. There is always the assumption of an unlimited energy supply to accomplish the action required. This fits in with Ashby's (1964:4) observation that: "Cybernetics might, in fact, be defined as the study of systems that are open to energy but closed to information control -- systems that are information-tight."

The process that connects the level to the apparent condition

or information about the level involves the passage of information. One might describe this as the perception process in the feedback loop. The process that connects the apparent condition of the system to the decision unit is also an information passage process. Again, placing this more in the language of social systems, the actor has some mental picture or computer program which enables him to converge perceived reality and continuing action.

This action program involves the transference of information back into energy to complete the cycle of the feedback loop. Thus, the feedback loop is a constant transference of information to energy and back into information. What the feedback loop does, then, is describe behavior of the decisionmaker toward the environment upon which he is focusing. The basic feedback loop is a simple or linear system. Forrester always refers to this kind of loop as a first order feedback system. A second order feedback system involves decisions based on the observation by actors of two or more levels. Second order feedback systems are nonlinear, and as Forrester (1973:8) notes social systems of any complexity at all are nonlinear systems. These might be illustrated by systems of interaction of a plurality of decisionmakers, each one making decisions in response to his own perception of a particular environment.

In such a model of a social system each level is changed physically, but the model is inherently constructed so that amounts

of energy necessary to make these changes are irrelevant to the model behavior. What counts is information. Quantified units of information "drive" the model, so to speak. The information must be acted upon by a goal seeking convertor of information to energy -- that is, an actor in sociological language, rate and goal assembly in systems dynamics language, or an 'operator' in Wiener's terminology.

The discrete unit of information is called a message. Wiener defines "message" and its relationship to "actor" or "operator" as follows:

The message is a discreet or continuous sequence of measurable events distributed in time -- precisely what is called a time series by the statisticians. The prediction of the future of a message is done by some sort of operator on its past, whether this operator is realized by a scheme of mathematical computation or by a mechanical or electrical apparatus. (Wiener, 1965:9).

Information driven, goal seeking systems can also be defined as purposive systems. Forrester defines "system" as a "grouping of parts that operate together for a common purpose." (Forrester, 1968:1-1; cf. Hall and Fagen, 1956).

If, as Kuhn proposes, a basic paradigm gives the practitioner of science some new perception of certain problems in the physical world, then one might ponder on the type of perception which the practitioner of cybernetics and systems dynamics has that distinguishes him from members of other scientific communities. If one

thinks of a contrasting scientific community of physical scientists conditioned to a mechanistic concept of physics, then the difference can be stated as that which exists between those who see mechanistic systems in nature and those who see purposive systems. Some review of the historical development of the problem of purposiveness of objects might better contrast the difference in perspectives.

Philip Frank (1957:23) gives an account of the change of thinking concerning the purposiveness of objects when he discusses what he calls the shift from "organismic to mechanistic philosophy", which occurred at the time of the rise of Newtonian physics. He states that in ancient and medieval science, what were considered "intelligible principles" that laid the foundation for scientific observation, involved the belief that everything had a certain nature and acted according to that nature: birds flew, frogs jumped, stones rolled downhill, smoke went up chimneys, and celestial bodies moved in permanent circular motion. The general notion was that the way an object acted was intelligible according to the intrinsic nature or purpose of that object. The motion or dynamic characteristics of an animal were easier to understand than that of a stone, and animals seemed to behave in accordance with some unifying principle whereas stones tended to behave in a random and, therefore, unintelligible fashion.

As Frank (1959:24) reports, Galileo and Newton developed

the basic principles of the laws of motion in order to explain the behavior of inanimate objects such as stones. Once these laws were grasped, the dynamic characteristics of all inanimate objects became intelligible and plausible. Behavior of inanimate objects could then be thought of as arising out of forces acting upon these objects, which caused such behavioral characteristics as inertia, acceleration, velocity, and the like. In short, the principles that explain the behavioral characteristics and thus the purpose of an object are all those forces acting externally on the object itself. Historically, then, the behavior of a rolling stone became intelligible and the behavior of an animal became more mystifying. Mechanistic theories of behavior crept from Newtonian mechanics to explanations of behavior in biology and the organismic sciences.

Buckley (1967:37), in tracing the history of the general systems perspective, notes that d'LaMettrie was one of the seminal thinkers who opposed the drift of scientific thinking toward a universal mechanistic paradigm as the basis for all systems. d'LaMettrie asserted that purposiveness can not be accounted for in terms of whether the object is animate or inanimate, sensible or insensible, conscious or unconscious, but, rather, the way the materials which go to make up the object "were organized".³ d'LaMettrie and his followers at least contested the proponents of a universal mechanistic paradigm in such disciplines as biology, physiology and psy-

chology.

The mechanistic paradigm, however, remained unchallenged in terms of inanimate material and thus in regard to physical laws. The mechanistic paradigm can be thought of in terms of physical systems theories as follows: the nucleus of a system is a set of relationships that exist in objective reality governed by eternal and universal laws that are valid anywhere and everywhere that the system exists. The system is independent of the observer spatially and temporally. The forces that cause dynamic behavior in the system act outside the system and on the system itself. Those forces are algebraically cumulative both in terms of magnitudinal quantities and directional vectors. The total resultant force is an entity of causation and completely describes the object's dynamic behavior. The principles of mechanistic theory represented by Newtonian theory dominated the hard sciences of physics, chemistry, and others. As Buckley (1967:8) notes, the social scientist of the 17th century often interpreted social systems in terms of "social physics".⁴ By the late 19th century, however, mechanistic theory was being challenged in its own citadel, that of the physical sciences.

Wiener (1967:30) notes:

. . . a shift in the point of view of physics in which the world as it actually exists is replaced in some sense or other by the world as it happens to be observed, and the

old naive realism of physics gives way to something on which Bishop Berkeley might have smiled with pleasure.

He comments that Einstein made abundant use of the observer in his theory of relativity, and Gibbs' statistical approach to entropy departed from Newton's deterministic conception. Wiener states:

In Gibbs' view, we have a physical quality which belongs not to the outside world as such, but to certain sets of possible worlds, and therefore to the answers of certain specific questions which we can ask concerning the outside world. Physics now becomes not the discussion of an outside universe which may be regarded as the total answer to all questions concerning it, but an account of answers to much more limited questions. (Wiener, 1967:31).

Bertalanffy (1968:92) makes the same point concerning Newtonian mechanics when he states:

A classical science was essentially concerned with two-variable problems, linear causal trains, one cause and one effect, or with two variables at the most. The classical example is mechanics. It gives perfect solutions for the attraction between two celestial bodies, a sun and a planet, and hence permits exact predictions of future constellations and even the existence of still undetected planets' power. However, already the three-body problem of mechanics is insoluble in principle and can only be approached by approximation.

It follows, then, that if there is not one universal world system governed by universal law, but an infinitude of special systems, still physical and measurable; a continuous sequence of events describes the behavior of each system of focus. The organizing principle of the system must be the question asked by the model maker. He must ask how a certain set of variables behaves under

such and such circumstances. Thus having defined the boundaries of the system, he can analyze the behavior in relation to the specific question he has asked about the system. Such a paradigm drives research in the direction of constructing either mathematical or mechanical models and charting the behavior of these models. In this approach there is no such thing as observing "the" preexisting condition in nature (cf. Bruner, Goodnow and Austin, 1956).

Another way of conceptualizing the system as structured by the transmission of a continuous sequence of messages, is to compare the notion of a static object with that of a dynamic object. Husserl (1931:119) notes that the perception of a static object is pre-conditioned by intentionality of the observer; that is, the object must somehow fit into the frame of reference of the observer's activity so as to be meaningful to those activities, or else it is excluded at least from the focal perception of the observer. Thus the static object is also defined in some manner by the purpose of the observer. It is his paradigms that give it functionality and meaning rather than any intrinsic characteristic of the object itself (Heap and Roth, 1973:355).

Dynamic objects are objects that must be literally seen through time by the observer. This results in quite a different sensation than, say, seeing an object in motion. For example, one can stand by a river and watch it flow past as it emanates from its

headwaters and flows into some far-off ocean. But the perception of a river flowing through time is one of change in the characteristics as defined by time continuum questions asked by the observer. For instance, one might ask, if navigation expands four-fold on a river over fifty years, what will be the characteristics of the river in terms of water quality, surface area, changes in velocity, and changes in turbidity in a like period of time? The perception of the river in terms of these variables over time would be the perception of a river as a dynamic object. It is this type of gestalt that is one of the goals of perceptual attainment of the practitioner of cybernetics and systems dynamics. This is also true when one looks at the physical behavior of variables in one of Meadow's model runs of the world system: the computer printout itself becomes a graphic presentation of a dynamic object.⁵

Referring back to the gun control problem, the entire grouping of objects, including the plane and its evasive maneuvers; the shell burst; the gun and its fire control mechanism; and the motives of the gun controller, as actor, make up the system. The dynamic object of the system is the relationship between shell burst and target; because this objectification is expressive of the motives of the gunner. A systems dynamics modeller will focus immediately on this intentional object, since his perception is paradigm-conditioned to single out this object.

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A final way of approaching the idea of a shared paradigm or a basic underlying gestalt of cybernetics and systems dynamics is to visualize the structure of the basic feedback loop in terms of an everyday life situation social system. The situation presented here can be called "the case of the prudent showering person". Imagine a person taking a shower. He is standing in a very small shower so that he does not have the option of stepping back out of the way of the flowing water, but must endure either cold water or overheated water as it emerges from the shower head. On the other hand, he may enjoy the pleasure of flowing water at a certain desired temperature. One further constraint is that he must turn on the shower after he has entered the shower stall. He cannot simply adjust the temperature of the water to a pleasing one by sticking his hand through the shower curtain. As he turns the shower faucet on, the water feels icy cold. The dynamic problem is to attain desired temperature at the shower head. There are two intermediate problems, however, of differing orders of importance. First, is the problem of overprudence. A too-cautious approach to the goal would mean staying under the cold shower for a relatively long period of time. The other problem is much more serious. The person might make overbold adjustments that would bring down upon his head scalding water within the narrow confines of the small shower stall, in which case he would have to take strong correctional

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measures in the other direction which would probably bring him back to icy water or out onto the floor, still dirty. The first course of action, while subjecting the shower person to a longer period of discomfort, does not produce the crisis situation of the latter course.

Turning now to a more formal description of the situation in terms of feedback loop terminology, the structural components of the feedback loop are as follows: (1) The system level -- the actual ratio of cold to hot water as it exists at the faucet valve point in the system; (2) The perceived state of the system -- the temperature of water leaving the shower head as it is experienced by the shower person; (3) The shower person himself -- as actor, and decision-maker in the system -- which may be divided into two components, his goal or normative orientation and his mental model of the mechanics of operation in the system or cognitive orientation; and, (4) The resources of the actor or the source of action -- in this case, the shower faucet itself. The basic feedback loop of such a system would be much the same as that shown in Figure VII, page 85. Again, the prudent showerer needs to know nothing about hydraulics, whereas knowledge about the delay time between turning the shower faucet and experiencing the resultant change in temperature at the shower head would be most helpful. Furthermore, some knowledge of the magnitude of change in the temperature compared to the mag-

nitude of faucet turning would be helpful. However, as in most social systems, this can be learned experientially by trial and error. In this example, the ability of the prudent showerer to reach his goal of comfortable and safe water temperature is a measure of the favorable solution of the problem and thus a measure of his organization of the system.

If the example is expanded to two or more shower persons in as many stalls, to say nothing of the flushing of toilets, on the same water system, then such a model is representative of a non-linear situation and is the kind of model that is of most interest in systems dynamics and cybernetics theory. The system is a closed system and an expressed precondition of systems dynamics model (Forrester, 1961:51). Such a model exhibits admirably the contrasting concepts of functional rationality and substantial rationality as varying perspectives in social systems (Mannheim, 1940:51). The rationality of the various persons using water from the same system of plumbing reflects their individual understandings of the situation from the point of view of their own perceptions, experiences and goals. A substantial rationality represents the rationality of the system model builder himself who foresees the entire system as a whole. As Mannheim states:

We understand as substantially rational an act of thought which reveals intelligent insight into the interrelations of events in a given situation. (Mannheim, 1940:53).

In this case each shower person may have varying degrees of functional rationality; that is, varying degrees of competence in being able to bring the shower head temperature asymptotically to the desired temperature. Each learns this functional rationality by his own experiences in trying to achieve a personal goal but can understand substantial rationality only with an overview of the entire system. Mannheim defines functional rationality not in terms of thinking and knowing, but rather as:

A series of actions [that] is organized in such a way that it leads to a previously defined goal, every element in this series of actions receiving a functional position and role.

In applying the paradigm to social systems, Forrester is not clear in defining what distinguishes the social system from a non-social system. The implications of conceptual structure would suggest that social systems need not necessarily have human actors as rate controllers or control mechanisms within the system. System levels must change, however, in response to societal goals. Thus, the world model is a social system because it depicts the physical change in the system in response to cultural values of economic and population growth. Even the world model, however, can be visualized in terms of dominant human interest groups within a society responding to specific level states of primary societal values within the system and less powerful groups responding to

other system levels. Thus, industrial planners and corporate executives are primarily interested in capital formation within their own organizations of responsibility; workers and consumers are interested in material quality of life; and environmentalists are concerned with pollution levels.

Boguslaw (1973:181) has examined the differences between social and nonsocial systems with considerable insight. To him the essential difference does not center on whether the subsystem parts are human actors or control mechanisms, these being often interchangeable, as it might be in the case of the prudent showerers. Nor does the difference have to do with the reliability or unreliability of the subsystem parts or human actors. The question to Boguslaw is one of system objectives, a question of how deeply and pervasively the system is geared to respond to the needs of the persons within the system "su generis" -- as a community. Systems which are predominantly preoccupied with some goal that strays from this essential human element are nonsocial in nature -- technologically oriented rather than social. As Boguslaw (1973:182) puts it, ". . . if you are ethnocentric about the race of mankind . . . then you are somewhat prepared to enter into the activity of social system design"; such an interpretation gives "substantive rationality" a moral dimension in addition to the cognitive.

5. Wiener as a Social Philosopher

If the M.I.T. systems dynamics group is an historical extension of a more general M.I.T. group which has its roots in cybernetics, and if Wiener was the spokesman for the group in its developmental stages, then it can be instructive to scrutinize Wiener's sociological perspective so that in the next chapter one will have an historical reference point against which to measure both the changes and the constancies over time in group perspective. It would be naive to think that the overall thesis of Limits to Growth sprang full-blown from the research on the Club of Rome project and the systems dynamics world models.

Wiener differed from Forrester in one major respect. Wiener did not believe the basic information-feedback paradigm could be used directly to model social systems; whereas Forrester built his career on the basis that it could be so used. Wiener was however, intensely interested in what he considered to be the major problem facing world society, the problem of the unintended consequences of scientification of technology. Cybernetics and the development of the computer were a part of this second industrial revolution, as he called it. Most of his later writings stressed this theme.

Although Wiener did not directly deploy the information-feed-

back paradigm in his social analysis, he relied on it as an analogy. His *modus operandi* was similar to that of most social philosophers of previous and present eras. He simply used the totality of his education experiences and speculations as a background referent to judgments about the contemporary world. Whatever his technique, Wiener's conclusions, particularly regarding the questions later raised in the Limits to Growth problematique, are strikingly close to those of Forrester, Meadows, and the rest of the contemporary systems dynamics group. Wiener's personal biography illuminates his particular world view.

First, what are Wiener's qualifications as a social philosopher? Wiener ranks as first-rate as compared with any personage who lived during the 1940's and 1950's and who commented on the major problems facing world society. He had attained intellectual credentials as a mathematician and a logician in the manner of a Leibnitz, Des Cartes, Whitehead, and Russell. But world viewing philosophers are not fashionable in the middle 20th century -- at least within scientific communities. His own intellectual inheritors were scientists who respected him for his scientific contributions but rejected his grand pronouncements.

The Marxian notion that philosophers and other ideologists did not run the real world -- the world of economics and material production -- had become the "irrefutable truth" of communist and

capitalist alike. No serious critique of Wiener as a social philosopher from an historical perspective has yet been published; yet there are a number of books on cybernetics, as such. They, almost universally, address themselves to the problem of what cybernetics is as a science. These books do generally recognize Norbert Wiener as the founder of cybernetics.⁶

In discussing Wiener's qualifications as a social philosopher, there are certain facts that are unquestioned. He was a child prodigy. His own autobiography (Wiener, 1964) chronicles his younger life. He graduated from high school at age 11, attained a bachelor's degree from the University of Tufts at age 14, and received his doctorate from Harvard University at age 18. In his early childhood he was drilled incessantly by a father who was an intellectually gifted and renowned person in his own right, the translator of the entire twenty-four volume works of Tolstoy from Russian to English. Wiener described one of the tutoring sessions with his father as follows:

Algebra was never hard for me, although my father's way of teaching it was scarcely conducive to peace of mind. Every mistake had to be corrected as it was made. He would begin the discussion in an easy, conversational tone. This lasted exactly until I made the first mathematical mistake. Then the gentle loving father was replaced by the avenger of the blood (Wiener, 1964:67).

Wiener's special gift and his later professional emphasis were on mathematics, but his interests were wide-ranging. Wiener's

father, Leo Wiener, was a professor of languages and philology at Harvard University, and it was natural that Wiener's education embraced the study of many different languages, including Latin and Greek. Wiener first intended to take his advanced study in biology, but poor eyesight and lack of coordination made him unfit for the exactitudes of biological lab work. Wiener studied the history and philosophy of sciences under the great names of the era at Harvard: Josiah Royce, Lawrence Henderson, E. V. Huntington, Ralph Barton Perry, Palmer, Munsterberg and Santayana.

After graduating from Harvard, and just prior to World War I, he spent a half year at Cambridge under the tutelage of Bertrand Russell, G. H. Hardy, the mathematician, and G. E. Moore. He was 19 at that time, and he wrote his first mathematical paper on the reduction of the theory of relations to the theory of classes. The paper was published in the Proceedings of the Cambridge Philosophical Society. After Cambridge his education continued in Göttingen, Germany, where he rubbed mathematical shoulders with men such as Felix Klein, Felix Bernstein, Otto Szasz, and others. Besides the mathematical courses he sat in on some of Professor Husserl's lectures on Kant and phenomenology. His appraisal of his German experience is as follows:

The philosophical courses left very little impression on me, as my German was inadequate for the subtleties of the philosophical language. I got something at the time

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from the mathematics courses, but much more that sort of intellectual doubletake that allows one to realize at a later date the importance of what one has already heard, but not understood (1964:210).

After his doctorate Wiener drifted somewhat to let his social maturity catch up with his intellectual capacity. By 1920, at the age of 25, he had finally found his niche as an instructor in mathematics at M. I. T., a happy association with that institution that lasted uninterruptedly until his death some 45 years later. By age 29 he had already achieved an international reputation as a mathematician, particularly after he published his work on potential theory in Comptes Rendus, Professor Henri Lebesgue's mathematical publication for the French Academy of Sciences. That was in 1923. From then until World War II, he worked for some twenty years as one of the leading mathematical pioneers in what he described as "theoretical and practical advances in the theory of communication." (1964:275).

Besides these experiences, there are several themes that run through Wiener's autobiography that he himself emphasizes as important factors in the makeup of his world perspective. There is a vein of Tolstoyian socialism that both Leo Wiener and Norbert shared. Leo Wiener was born a Russian Jew and received his advanced education in the German Gymnasium in Berlin, specializing particularly in the classical languages of Greek and

Latin. As his son reports (1964a:15):

Father did join up with a student colleague in a wild undertaking to found a vegetarian-humanitarian-socialist community in Central America. His companion reneged, and Father found himself alone on board a ship bound for Hartelpool, after showing a bewildered official his school certificate in lieu of the German military papers which he should have possessed (Wiener, 1964:15).

Leo landed in New Orleans in 1880 at the age of 18, with fifty cents in his pocket. He worked in a cotton baling factory, as a waterboy on a railroad being built across Lake Pontchartrain, and tramped through the South and Midwest working as a farmhand. Later, after he became a successful professor of philology at Harvard University, he moved his family to a place called Old Mill Farm, and Norbert spent about three years of his life in this rural setting. Perhaps the paragraph that best explains both Norbert's and his father's feelings towards Tolstoyian socialism is the following concerning Leo's career as an itinerant farmer when he first came to the United States:

At one point in his farming career, father ran into the remains of an old Fourierist community in Missouri. It had gone to seed and all the efficient people had left it, while all the low and footless, incompetent idealists remained. Father soon had his fill of this and while he continued to be a Tolstoyian all his life, he never afterward had much use for those whose idealism was not mixed with a certain practical sense. (Wiener, 1964:19).

In another place in Wiener's autobiography (1964:72) he makes observations of his father's religious orientation, which is probably

also expressive of Wiener's own sentiments:

. . . while my father was a man of strong moral sense, it cannot be said that he had any great interest in theology. The source of his humanitarianism was Tolstoy, and even though Tolstoy embellishes his propagandist text with many quotations from the Bible, he is at home with that side of Christianity which preaches humility and charity and extolls the virtue of the oppressed and undervalued. (Wiener, 1964:72)

Still, Norbert's socialist perspectives probably pointed more towards Jacksonian populism ideals than a feeling for the urban poor and government ownership of private capital. Wiener in recollecting his experiences with the countryfolk around Old Mill Farm had this to say:

My individuality and my privacy were respected by my teachers, my playmates, and my older schoolmates. I was treated with particular affection and understanding by Miss Leavitt. I had a chance to see the democracy of my country at its best in a form in which it is embodied in the small New England town. I was prepared and ripened for the outer world, and for my college experiences. (Wiener, 1964:101)

The small town next to the Old Mill Farm was named Ayer, and another quotation reinforces the image:

I have the impression that my friends in this small industrial town represent a sort of stability without snobbishness which is universal rather than provincial, and that the structure of their society compares well with the best that a similar place in Europe would have to offer. When I go back among them it is expected of me, and rightly expected of me, that I revert in some measure to my status as a boy among elders of the family. And I do so gratefully, with a sense of roots and security which is beyond price for me. (Wiener, 1964:101)

Norbert Wiener, between the completion of his service at the

end of World War I and the continuance of his mathematical career, did a short tour of duty as a journalist for the Boston Herald. As part of this experience he covered one of the periodic strikes of the textile industry of Lawrence, Massachusetts. He saw first hand the deepening conflict between the new immigrant labor -- the French Canadians, Belgians, Italians and Greeks -- that had supplanted the early English weavers. The impersonal absentee ownership of the emerging textile manufacturing corporations had to a great extent supplanted the more philanthropic native New England manufacturers. His historical perspective was in a great sense one of an older liberalism that perceived an erosion of the broader based values of the 19th century by a more self-seeking, single-minded profit-oriented value structure of the industrial era. The following is evidence of this sentiment:

Be that as it may, the beginning of the 20th century saw the blunting of our national resistance to anti-semitism as it saw the blunting of New England's traditional friendship for the Negro and of many other broader attitudes of the earlier days. The gilded age had already come to an end and had left as its heir the varnished age. (Wiener, 1964: 156).

The telltale signs of history did not reveal to Wiener the ever-unfolding advancement of civilization, but rather the foretidings of future crises. One of his observations was:

Among other things, this was the year of the Titanic. It represented a shock to our emotional security which was a fitting introduction to the shocks to follow. It was per-

haps this event rather than the beginning of the First World War two years later that awakened us children of the long peace that had so long protected Europe and America to the fact that we were not the favored darlings of a beneficent universe. (Wiener, 1964:169).

The other complementary strand in Wiener's own personal life experience was his love of the outdoors and of conservation of the wilderness. He first calls attention to this in his autobiography in the following:

The Sunday school had a good library, and there were two books which I remember impressed me particularly. One was Ruskin's King of the Golden River. Many years afterward, when I read his Modern Painters, I recognized the same sense for mountain scenery and the same strong ethical attitude which I already knew in his story for children. The other book was an English version of a French story of the seventies entitled The Adventures of a Young Naturalist in Mexico. (Wiener, 1964:83).

Wiener's reminiscences of his childhood at Old Mill Farm (1964:95) during the years 1903 through 1906, are filled with visions of punting boats on ponds, exploring dark tunnels in the bushes and poking sticks in old sloughs to watch the marsh gas bubbles rise and burst.

In 1911 when Norbert Wiener was 17 years old, his family rented, then later bought, Tamarack Cottage at Sandwich, New Hampshire, near Bridgewater. From that time on, Norbert spent every summer or at least part of the summer there. He joined the Appalachian Mountain Club in 1912 (1964:168).

His autobiography also mentions his tramps in the woods

south of Göttingen in Hanover-Munden during the summer he spent in Germany (Wiener, 1964:214). He also talks about his summer Appalachian mountain climb (Wiener, 1964:227) in 1915 with the philosopher Raphael Demos and two other young Greeks, following his studies at Columbia. Probably one of his best descriptions of the mountain region near his cottage at Tamarack is as follows:

The mountains were an eternal delight to me. They are beautiful even now, but in those days before the war and the threat of war, before the extensive lumbering which the two world wars called into being, before the motorcar and its reduction of distances to nothing and much of the roadside to a rural slum, the country was beautiful indeed. As one whose physical activity is somewhat limited by his increasing years and the vicissitudes of an active life, I look back with a certain sadness to a time when the mountainsides were as nothing to my efforts, and when twenty minutes of rapid striding would carry me to a bank of lacy wood sorrel. From this bank I could look up to the boles of mighty trees, each fit to be a mast of a king's ship. I felt a sense of romantic union with the hills and the forests. (1964:180).

One can only infer that his direct experiences with nature would reinforce his more theoretical deliberations.

The analogy between information systems and social systems fascinated Wiener. He states:

It is certainly true that the social system is an organization like the individual, that it is bound together by a system of communication, and that it has a dynamics in which circular processes of a feedback nature play an important part. (Wiener, 1965:24).

He contrasted the individual as a communications system with a community as a communication system and noted that the former

had a "fixed nervous system, with permanent topographic relations between the elements," whereas the latter, a community, "consists of individuals with shifting relations in space and time and no permanent, unbreakable physical connections." He asked how a community, whether it be a community of insects like a beehive or ants or a community of humans, acts "in organized unison." Wiener noted, "Obviously, the secret is in the intercommunication of its members" (1965:156).

Wiener shied away from the direct application of feedback systems to the study of anthropology and sociology. Wiener (1965:24) describes how Gregory Bateson and Margaret Mead urged him to devote a large part of his energies to the study of cybernetics and its possible scientific applications to problems of society. His feelings were:

Much as I sympathize with their sense of the urgency of the situation, and much as I hope that they and other competent workers will take up the problems of this sort, . . . I can share neither their feeling that this field has the first claim on my attention, nor their hopefulness that sufficient progress can be registered in this direction to have an appreciable therapeutic effect on the present diseases of society. (Wiener, 1965:24).

Wiener observed that whereas astronomical phenomena can be predicted for many centuries, the prediction of tomorrow's weather is not an easy matter. Wiener's (1965:30) explanation was: "A star is a definite object, eminently suitable for counting

and cataloguing; . . . ". But he observed that in all the language of meteorology, "there is no such thing as a cloud, defined as an object with a quasi-permanent identity; . . . " (Wiener, 1965:31).

Thus while any observer, even a lay observer, can see a cloud as a perceptive entity, a scientist cannot define a cloud in any coherent changeless way. It is a mass of changing, varying, short-term statistical runs that eludes description of continuity over time:

The terms 'cloud,' 'temperature,' 'turbulence,' etc., are all terms referring not to one physical situation, but to a distribution of possible situations of which only one actual case is realized. If all the readings of all the meteorological stations on earth were simultaneously taken, they would not give a billionth part of the data necessary to characterize the actual state of the atmosphere from a Newtonian point of view. (Wiener, 1965:33).

To Wiener's way of thinking of such notions of evolution as developed in the theories of Charles Darwin and Alfred Wallace, give a picture, looking back, of a "definite, long time trend, interrupted and complicated though it might be from the simple to the complex" (Wiener, 1965:36). However, he felt that:

This step was the realization that a mere fortuitous variation of the individuals of a species might be carved into a form of a more or less one-directional or few-directional progress for each line by the varying degrees of viability of the several variations, either from the point of view of individual or the race.

He states:

Darwinian evolution is thus a mechanism by which a more or less fortuitous variability is combined into a rather definite pattern. (Wiener, 1965:36).

Wiener (1965:37) commented on the coincidence that Charles Darwin's son, Sir George Darwin, as a physicist, interested himself in the random motions of the waves in a tidal sea. His research in this area of physics led to a "theory of tidal evolution (which) is quite definitely an astronomical application of the elder Darwin." These kinds of long term statistical runs, Wiener felt, would not be useful in the prediction of the future course of history or the behavior of a social system.

At this point in the argument, Wiener (1967:18) returns to his perspective of the history of science to note the fundamental change of scientific attitude on the problem of determinism between the universal world of Newtonian physics and the more statistically oriented physicists such as Gibbs, Borrell, Legesgue, Heisenberg. He says:

This revolution has had the effect that physics now no longer claims to deal with what will always happen, but rather with what will happen with an overwhelming probability. At the beginning of Gibbs' own work, this contingent attitude was superimposed on a Newtonian base in which the elements whose probability was to be discussed were systems obeying all Newton's laws.

He notes:

It is true that the books are not yet quite closed on this issue and that Einstein, and in some places DeBroglie still contend that a rigid deterministic world is more acceptable than a contingent one; but these great scientists are fighting a rearguard action against the overwhelming force of a younger generation. (Wiener, 1967:18).

Using perhaps his most famous metaphor, Wiener stated that scientists are always fighting against the Augustinian devil, the recognition that the universe contains a fundamental element of chance which changes the texture of the universe itself. This is a random element, an element of organic incompleteness.

We may consider evil; the negative evil which St. Augustine characterizes as incompleteness, rather than the positive, malicious evil of the Manacheans. (Wiener, 1967:19).

The Augustinian Devil, which is not a power in itself, but the measure of our own weakness, may require our full resources to uncover, but when we have uncovered it, we have in a certain sense exorcised it, and it will not alter its policy on a matter already decided with the mere intention of confounding us further. (Wiener, 1967:50).

"The scientist is always working to discover the order and organization of the universe, and is thus playing a game against the archenemy, disorganization." (Wiener, 1967:50). If a social system such as a world system were organized together in some unity of purpose, then it would exhibit some kind of order that could be detected by the scientist trying to make order out of disorganization. Wiener looks upon world society and laments:

There is no homeostasis whatever. We are involved in the business cycles of boom and failure, in the successions of dictatorship and revolution, in the wars which everyone loses, which are so real a feature of modern times.⁷ (Wiener, 1965:159). (underlining not in original)

In Wiener's view, social systems from time to time historically degenerate into opposing groups whose very goals are to destroy

the organization of the other. The pattern of this conflict presents a type of social disorganization completely different to that which could be understood by the methods of science. Each change of policy in one group can be countered by changing strategy of an opposing group: He calls this type of disorganization, that of the Manechaeon Devil (Wiener, 1967:50), which creates opponents who are each determined on victory and who will use any trick of craftiness or dissimulation to obtain victory. Wiener concludes (1967:50; 1964:24) that the only kind of theory that can cope with the Manechaeon Devil was something on the order of von Neumann and Morgenstern's game theory. In Wiener's view any society dominated by "open market" values, whether expressed in world political competition or western industrial economic competition, is bound to degenerate into open warfare sooner or later. Such a society, emphasizing competition between groups as the major force for progress and, therefore, for good, is working on a short statistical run.

Shifting to a perspective of the technological impact of the second revolution of communications on such a society dominated by these values, Wiener believes that the second industrial revolution in communications and communications machinery is "bound to devalue the human brain, at least in its simpler and more routine decisions." Just as the first industrial revolution was bound to

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devalue work of the human arm in competition to machinery. He states:

However, taking the second revolution as accomplished, the average human being of mediocre attainments or less has nothing to sell that is worth anyone's money to buy. (Wiener, 1965:28).

Wiener, perhaps as much as any other scientist, felt the frustration of a scientist who has contributed to a great breakthrough only to see the scientific results prostituted by the uses it would be put to in a society controlled by other values. Perhaps the following quote best characterizes his mood:

Those of us who have contributed to the new science of cybernetics thus stand in a moral position which is, to say the least, not very comfortable. We have contributed to the initiation of a new science which, as I have said, embraces technical developments with great possibilities for good and evil. We can only hand it over to the world that exists about us and this is the world of Belsen and Hiroshima. We do not even have the choice of suppressing these new technical developments. They belong to the age and the most any of us can do by suppression is to put the development of the subject into the hands of the most irresponsible and venal of our engineers. The best we can do is to see that a large public understands the trend and the bearing of the present work, and to confine our personal efforts to those fields, such as physiology and psychology, most remote from war and exploitation. As we have seen, there are those who hope that the good of a better understanding of man and society which is offered by this new field of work may anticipate and outweigh the incidental contributions we are making to the concentration of power (which is always concentrated, by its very conditions of existence, in the hands of the most unscrupulous). I write, in 1947, and I am compelled to say that it is a very slight hope. (Wiener, 1965:29).

Wiener believes that competition leads to progress

as the underlying myth of his era. As he states:

This Heaven on Earth consists for him in an eternal progress and a continual assent to Bigger and Better Things. (Wiener, 1967:59).

He discusses this worship of progress from two points of view, first as an ethical principle. To him, no traditional religion can offer to pay for virtue in the coin of the earth but only as a "promissory note on Heaven." (Wiener, 1967:60). The ethic of progress as material welfare results in covetousness and results in the destruction of any kind of rational society based on submission to order. From the second point of view, the perspective of scientific history and scientific sociology (Wiener, 1967:64) suggests the present world view is based on an historical perspective of society starting from the 1500's when the physical world was one full of unexplored resources and geographic areas. The prospect of unlimited physical resources encouraged an attitude:

. . . not unlike that of Alice's Mad Tea Party. When the tea and cakes were exhausted at one seat, the natural thing for the Mad Hatter and the March Hare was to move on and occupy the next seat. When Alice inquired what would happen when they came around to their original positions again, the March Hare changed the subject. (Wiener, 1967:65). . . . As time passed, the tea table of the Americas has proved not to be inexhaustible; and as a matter of fact, the rate at which one seat has been abandoned for the next has been increasing at what is probably a still increasing pace.

What many of us fail to realize is that the last 400 years are a highly special period in the history of the world. The pace at which changes during these years

have taken place is unexampled in earlier history, as is the very nature of these changes. This is partly the result of increased communication, but also an increased mastery over nature which on a limited planet like the earth may prove in the long run to be an increased slavery to nature, for the more we get out of the world, the less we leave, and in the long run we shall have to pay our debts at a time that may be very inconvenient for our own survival: (Wiener, 1967:65).

His sentiments are almost precisely those voiced by Weber (in Gerth and Mills, 1958:71) some forty-four years previously:

For the development of material interests points, as distinctly as possible, in the opposite direction: in the American 'benevolent feudalism', in the so-called 'welfare institutions' of Germany, in the Russian factory constitutions. . . . everywhere the house is ready made for a new servitude. It only waits for the tempo of technical economic 'progress' to slow down and for rent to triumph over profit. The latter victory, joined with the exhaustion of the remaining free soil and free market, will make the masses 'docile'. Then man will move into the house of servitude.

Thus Wiener was a sound critic of the ideology of growth but as a social philosopher using cybernetic concepts rather than as a systems theorist.

CHAPTER III ENDNOTES

1. In my 10 days in attendance at the Systems Dynamics Conference in June, 1972, the history of systems dynamics was never discussed.

2. Although Wiener doesn't mention it, nuclear power based on Einsteinian theory, is a linear expansion of the same technology of prime movers, a continuation of the Industrial Revolution of the 17th and 18th centuries.

3. Stephan Toulmin and June Goodfield (1962:315-334) give a detailed account of d'LaMettrie's argument.

4. Cf. Pitirim Sorokin, Contemporary Sociological Theories (New York: Harper & Row, 1928).

5. Mannheim (1971:18-20) gives an account of three presentations of meaning of an object which he classifies as natural, given in the physical world; expressive or psychic, given in the world of an individual's own personal motivations as he sees objects in relation to those motives; and documentary or cultural, given in a world of group meaning. In each case the object has a spatial-temporal dimension to which the particular mode is attached and becomes the third dimension.

In each of the three cases the object could be and is usually considered as space constant and as moving through time. A variation of this traditional perception would be that of an object which is time constant moving through space.

An object perceived in this last mode would be a dynamic object. A social system perceived in this mode would be defined as the documentary interpretation of a dynamic object. Meadows et al (1972:19) do not use this terminology, but they do introduce Limits to Growth with a discussion of human perspectives of space and time.

6. Some examples of overviews of cybernetics are: Young (1973); Ackoff and Emery (1972); Fuchs (1971; Rose (1968); Foerster (1968); Dechert (1966); and, Frank (1960).

7. Wiener (1967:69) was one of the first writers to use the term "social feedback" as an expression of a society's ability to

adapt to new environments and survive environmental change. Social feedback is by Wiener's definition a measure of societal homeostasis. Apparently what Wiener means is societies could conceivably be described by information-feedback models, but contemporary world society displays no characteristics that would lead one to believe present societies' behavior would fit that of a feedback model.

CHAPTER IV

THE SYSTEMS DYNAMICS GROUP TAKES ON THE WORLD MODEL

1. The Genesis of the Feedback Model

There seems to be no question that Forrester's goal consisted of carrying on the development of the basic feedback loop, the basic paradigm as described by Wiener, to the point at which it would be an effective tool in understanding the dynamics of social systems. The Sloan School of Management was founded in 1952, and by 1956 Forrester had joined the faculty with the clear intention of the application of feedback models to the solution of decision problems and the management of complex organizations. Forrester (1961:viii) in his first major work on the deployment of feedback models to problems of social systems, set out the following program:

Our most challenging intellectual frontier of the next three decades probably lies in the dynamics of social organizations, ranging from growth of the small corporation to development of national economies. As organizations grow more complex, the need for skilled leadership becomes greater. Labor turmoil, bankruptcy, inflation, economic collapse, political unrest, revolution, and war testify that we are not yet expert enough in the design and management of social systems.

The first question one might ask is how did Forrester solve the paradox of constituting the social system as a definitive object in apparent defiance of Wiener's pronouncement that social systems are too cloud-like, too ephemeral to produce scientifically definable dynamic behavior? Several major lines of development can be distinguished that establish the conditions precedent in making social systems a proper subject for scientific investigation via the feedback loop approach.

First, over the period of the 50's and early 60's Bennett, Roberts, Fox and Pugh (1970) developed the computer programming techniques which led to the simulation of the model. This was under the guidance of Forrester. The original development of applications of feedback models was done by mathematicians such as Wiener. The simulation process, as Forrester (1968:3-5) notes, tremendously simplifies the model application. This frees dynamic modelers from the rigors of years of mathematical background and allows them to focus their attention on the specific empirical problems of the social systems with which they investigate.

Second, it was almost entirely the work of Forrester (1961, 1968), the pioneering work which led to the reconceptualization and simplification of systems dynamics and industrial dynamics language. In other words, feedback model conceptualization passed from the highly theoretical mathematical language of Wiener and its develop-

ers in the 1940's to the "textbook language", as Kuhn (1970) would put it, of Forrester in the late '50's and '60's. Again this enhanced the opportunity of systems modellers to concentrate their attention on model application rather than theoretical development.

Third and most important, however, Forrester seized upon a presuppositional change in theory which Wiener had overlooked. To Forrester the way to approach social systems was to define them as closed systems (Forrester, 1968:1-5; 1961:52). As Forrester expressed this assumption:

Information-feedback systems are essentially closed systems. They are self-regulating, and the characteristics of principal interest are those that arise from the internal structures and interactions rather than those responses that reflect merely the externally supplied inputs.

Closed systems tend to be systems of social organization where the goals of the organization are set, that is, without the possibility of deviation. Thus management analysis was a fortuitous choice for a closed system model. In this field organizations inherently operate on the basis of well-defined goals. Lines of authority are hierarchically structured. Organization decision-makers are carefully screened to appropriately reflect the role model of integrated individual and group goals.

The ideally run business organization would follow a planned course of development, or using Wiener's (1965:31) astronomical

analogy it would have its unique Durchmusterung that assures its future as a discrete object moving toward a known destiny in social space and time.

The problem of goal-fixed organizations that are information-tight has always been one of how systems' behaviors are interpreted and transformed into action by the decisionmakers. How does the behavior of the system in question compare with the expectations of the controller? The controller's knowledge of system structure is decisive in this type of problem. There is presuppositionally no question about his power to control the system.

In contrast a social system representing a conflict between opposing groups presents a different problem and model. The relative physical power of the two groups is of prime importance. Information becomes a weapon in the hands of the adversaries. Since the pay off is domination of one group by the other, conflict is heightened by information. For example, twenty persons in a sinking lifeboat will tend to fight sooner and harder after they know for certain that there are only ten lifejackets aboard.

A third type of problem and model is employed, in the case of a social system controlled by exogenous variables beyond the power of the decisionmaker to change in any way. (Forrester, 1961:52). The decisionmaker's strategy is simply to discover these assumed changeless relationships usually by sampl-

ing data and developing statistical correlations between variables. Econometric and sociometric models investigate social systems from this perspective (Willer, 1967:4; and Naill, 1972:14).

The types of questions best suited for systems dynamics modelling can be described by noting Forrester's¹ definition between "decision" and "policy". A decision is a directive for action based on information received relative to the discrepancy between observed performance and a pre-established goal. Decisions are the action governing commands within a closed system. Policy, on the other hand, is the goal itself. Thus establishing policy is a process of setting the conditions under which the closed system will operate. The policymaker is not the social actor within the system, but the system creator. Establishing policy is essentially an open system process, an act of judgment not governed by any preconceived rules.

In the context of world systems, systems-dynamics-trained policymakers have the benefit of studying them under a number of different model runs and thus would presumably have superior insight into the behavior of the system of focus. Returning to the original definition of world view in Chapter II, page 37, particularly Wolff's statement that it describes 'what is common to the various interpretations of the same historical period that would

account for their mutual understandability"; world systems contain certain statements of policy that are so universally acceptable that they are taken without question by those who are supposed to be the designers of policy. These universally acceptable policy statements which are woven into the underlying paradigms of conventional policymakers are perceived as part and parcel of their invariant landscape.

Systems dynamics is therefore an analytical tool suitable for questioning the "unquestionable" in world systems. It has the potentiality to open social systems to inspection and reanalysis which have been empirically closed because the particular policy in question has been unanimously set outside the domain of consideration by policymakers who actually control the creation of the system. Forrester (1973:3) asserts that social systems are counterintuitive. Perhaps a more accurate way to phrase the notion of counterintuity is to observe that systems dynamics modellers are interested in problems that challenge the conventional wisdom of policymakers. It is not the problem in which, as Simmons (1973:195) suggests, policymakers are beleaguered by poor information, incorrect reasoning, or poor problem formulation, but rather the problem which policymakers have abandoned formulation of new policy and instead try to deal with the problem at the decisionmaking level rather than the policy level.

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A learned college professor might find backing a twenty-five ton trailer truck a counterintuitive experience. The professor's problem is not so much the knowledge he lacks, but rather the knowledge he already possesses which he must now somehow throw away.

2. Towards a Science of Social Systems

Forrester is the acknowledged leader of the M. I. T. systems dynamics group and its foremost contemporary theoretician. Therefore, a short biographical note would be helpful in understanding the historical development of this scientific epistemic community.

Forrester was born in 1918. He spent his early years on a cattle ranch operated by his parents at Anselmo, Nebraska. Unlike Wiener, his background was business rather than academics. Forrester remarks that, "My first exposure to business and to the nature of commodity markets was provided in my early youth at my mother and father's cattle ranch." (Forrester, 1961:viii). He obtained his bachelor's degree at the University of Nebraska in electrical engineering and went immediately on to graduate studies at M. I. T. under Professor Gordon S. Brown, who was then director of the Servo-mechanisms Laboratory. His professional career paralleled that of Wiener's in many ways. They were both primarily concerned with the development of mathematical models and computer simulations as applied to communications engineering

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problems. Forrester's background was more narrowly technologically oriented than Wiener's, and in each case neither individual approached the problem of social systems theory from either a scientific or a social philosophic perspective until later in life.

Forrester's early contributions to engineering and mathematics, however, were impressive, as were Wiener's. Forrester is credited with the development of the magnetic memory cell presently used in high-speed digital computers. Incidentally, after much wrangling, Forrester purportedly arranged with M. I. T., his employer at the time of the development of this memory system, a settlement which established Forrester's share of the patent rights at in excess of \$1,000,000. Forrester, as head of the M. I. T. Lincoln Laboratory from 1951 to 1955, directed the technical organization that planned and developed the Air Force's Semi-Automatic Ground Environment (SAGE) system for air defense. He thus, as pointed out previously, by coincidence worked on a specific application of the information feedback system that was a continuation of Wiener's prototype gun control problem.²

He received honorary doctorates from his alma mater, the University of Nebraska, and Boston University. In 1968 he received the Inventor of the Year award from George Washington University and the Valdemer Paulsen Gold Medal from the Danish Academy of Technical Sciences. Urban Dynamics, his application

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of systems dynamics to cities, received the best publication award in 1970 by the Organization Development Council (Simmons, 1973:194). Even critics of his world model acknowledge his "impeccable academic credentials" (Simmons, 1973:193).

Forrester, then, and the M.I. T. systems dynamics group, must be considered a part of the large numbers of engineers, systems analysts and others who have moved in the direction of social systems study by way of their knowledge of mathematics, computer simulation techniques, the physical sciences, management control, and in general, the control of the technological process in world technological society. In the sense that Boguslaw (1965:v) uses the term, he is one of the "new utopians". The number of these "new utopians" entering social system study and design is considerable, but Forrester has not exactly slipped into the army as a soldier in the ranks. A case can easily be made that Forrester is perhaps one of the most prestigious, if not the most prestigious of the engineers as social theorists.

The dust jacket blurb on Industrial Dynamics reads as follows:

Cited by Professor John R. Platt of the University of Chicago as "one of the seminal books of the last 20 years . . . books that as far as we can now guess might be comparable in ultimate importance to say, Galileo, or Morpheus or Rousseau or Mill. (The New York Times).

As historians of greater scholarship may establish at some future time, Forrester could very well be credited with providing the missing link between the grand conceptions of Classical continental economists and the imaginative inventions of modern electronic wizards. At the press of a computer button, Forrester listens to the heartbeat, checks the respiration rate, and measures the reflexes of a firm as well as any fully outfitted medic does his ailing patient.

In addition to Forrester's own background and recalling that the Sloan School of Management is at M.I. T., the fountainhead of technological development, it seems natural that the faculty and graduate student personnel would be recruited largely from cohort groups with strong technical backgrounds and with little acquaintance in the social sciences and humanities. Donald R. Mack (Systems Dynamics Newsletter, 1972:6) expressed the elan of the group during the height of controversy occasioned by the review of Limits to Growth in the popular press and the academic community:

. . . Why does a straightforward procedure like systems dynamics make people so emotional? I think it is a threat to the professionals in every field it touches. Economists, sociologists, and politicians are appalled to see simplifying assumptions and numerical results in their field of competence . . .

A few months ago I felt that perhaps . . . engineers should stay away from social problems. But the ferocity of the criticism of mathematical models is an interesting new piece of evidence . . . let's keep up the fight.

Systems dynamics has no historical links with sociology. The

systems dynamics group does not even reference their writings to sociologists. Rarely has systems dynamics studies been reviewed or referenced in sociological journals. On the other hand, the engineering journals have contained extensive reviews, references, and critiques of systems dynamics models.³

Freeman (1973:6) is careful to refer to the M.I. T. systems dynamics group as "systems analysts and natural scientists" and while he criticizes the notion that only social scientists may enter the domain of social system modelling, he faults the group membership as not being "interdisciplinary" enough. This is an example of the fact that much of the criticism of the M.I. T. systems dynamics group is evidence of the competitive struggle between different scientific epistemic communities each using competing paradigms; in this case, engineers and systems analysts versus social scientists.

The first application of the mathematical model to what would be an obvious social application was in Forrester's Urban Dynamics (1969), followed closely by Meadows Dynamics of Commodities Production Cycles (1970). Along this line would also be Forrester's (1972) Economic Development Systems. The culmination of this movement toward the analysis of more general social systems was the introduction of the world social system by Forrester in his book World Dynamics (1971), the World 2 model as it is commonly

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called by the M. I. T. systems dynamics group. This model was further developed and extended by Meadows et al (1972) into the World 3 model, which was the basic model presented and interpreted in Limits to Growth.

Consonant with this development of systems dynamics as a closed system, and the development of systems dynamics from industrial dynamics, the group moved from technological and natural systems to larger social systems.

It would be false to consider larger social systems, such as urban and global systems, as more complex forms of lower technological and physical systems. In reality, the complexity of the system is largely determined by the question asked by the systems modeller and by the kind of system he has to construct to answer that question. In operational terms, the complexity of a system's model is established by the number of levels and rates necessary to depict the dynamic behavior of that system.⁴ Each model is built around questions asked by the model builder. Thus, the question asked in a world model is: What is the relationship between the world or global system, considering that its organizing purpose is economic growth, and the effect of this economic growth on the finite physical environment.

Forrester's first formal construction of a world model (1971) answers this question. It is a relatively simple model.

That of Meadows et al. (1972) is more elaborate and sophisticated, but does not compare in complexity in terms of the numbers of levels and rates with Forrester's (1969) urban model.

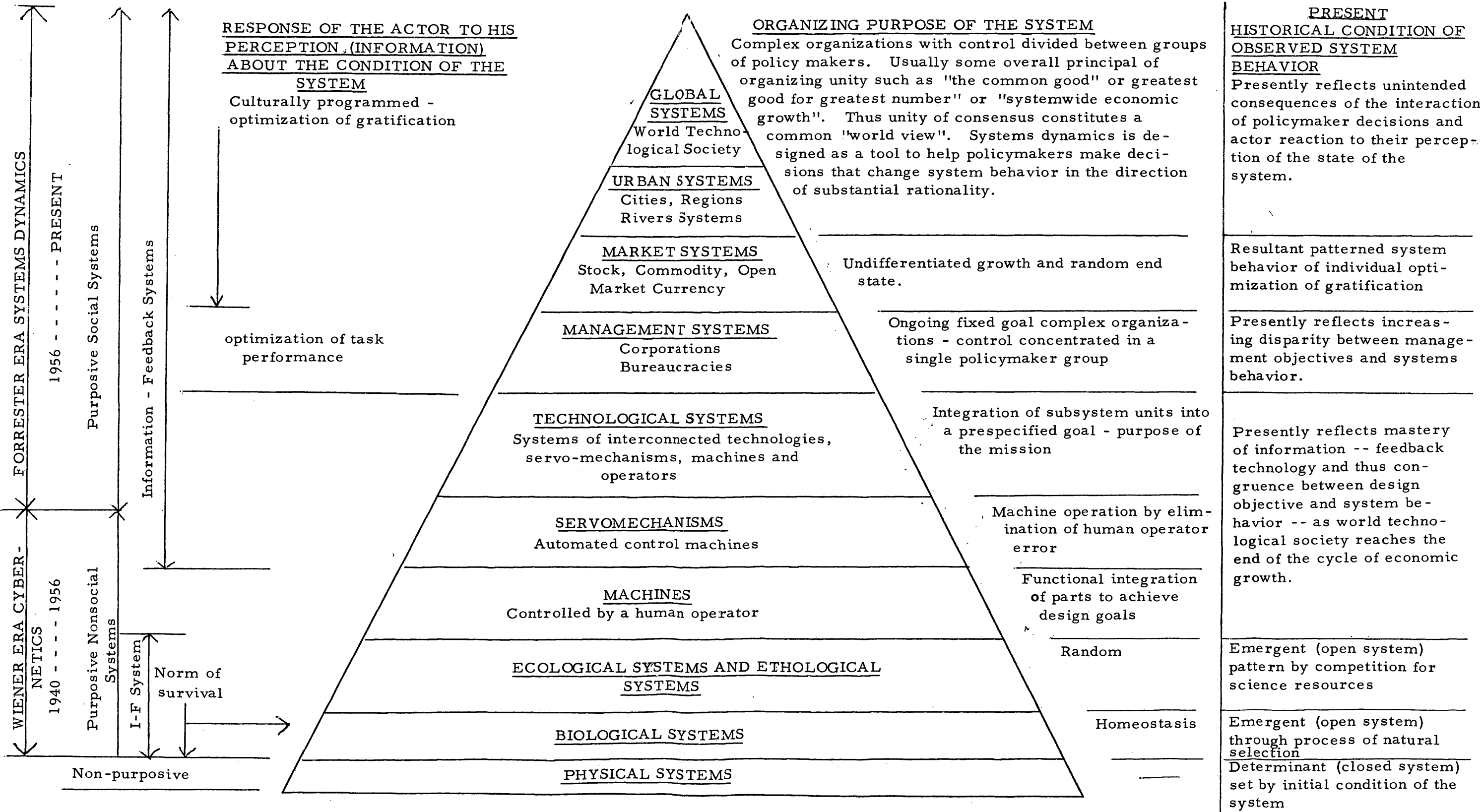
It is an empirical fact that the M. I. T. systems dynamics group has moved historically from the investigation of such systems problems as servomechanisms, biological systems, and the nervous systems in an animal, to the exploration of larger technological systems; and from these to management systems, market systems, urban systems and finally to global systems. Forrester describes the historical process as it applies to social systems in the following statement:

I am speaking of what was earlier called 'industrial dynamics'. The name was a misnomer because the methods apply to complex systems regardless of the field in which they are located. A more appropriate name is systems dynamics. In our work, applications have been made to corporate policy, to the dynamics of diabetes as a medical system, to the growth and stagnation of the urban area, and most recently to world dynamics represented by the interactions of population, pollution, industrialization, natural resources and food. System dynamics, as an extension of the earlier design of physical systems, has been under development at M. I. T. since 1956. (Forrester, 1973:6).

Figure VIII represents a typology of systems showing the historical development of the information-feedback model and its application to specific problems. This development starts with Wiener's cybernetics and continues in the Forrester era with systems dynamics. Still, the basic paradigm of the information-

FIGURE VIII

A TYPOLOGY OF SYSTEMS SHOWING THE HISTORICAL DEPLOYMENT OF THE INFORMATION-FEEDBACK MODEL AND ITS APPLICATION TO SPECIFIC PROBLEMS



feedback system has remained stable over this period of time. In addition the original notion of cognitive rationality as developed at M.I.T.; that is, the scientification of technologies, or the development of the sciences of social need, continues as the governing programmatic statement of development from the Wiener era to the Forrester era. Looking back it seems almost inevitable that sooner or later, members of the M.I.T. systems dynamics group would tackle the problem of applying the information-feedback paradigm to world social systems.

3. Enter the Club of Rome

If there is a World 2 and World 3 model then whatever happened to World 1? The story goes that Forrester sketched it on the back of an envelope during the flight back from Berne, Switzerland in June of 1970, after his first meeting with members of the Club of Rome. (Simmons, 1973:195). The fact to consider here is that all of the world models post-date the meeting between Forrester and the Club members, and therefore, arise out of the interaction between the Group and the Club.

Evidently neither group had considered formally the problems of economic growth as it related to world systems. The official or standard bibliographies containing the systems dynamics books and articles do not show such references prior to 1970. Aurelio Peccei,

who is cited as the "prime moving force" (Meadows, 1972:10) within the Club of Rome, had already written a book The Chasm Ahead (1969) concerning what was to him the mounting list of universal world problems, but these writings do not allude to economic growth as the heart of the matter. The chasm which Peccei suggests is not Forrester's overgrowth and collapse of world industrial society, but, rather, the widening technological disparity between American society and western European society. One of Peccei's central assertions is that problems are becoming more global in scope and can not be solved by national policymaking groups but only by international groups.

As Simmons (1973:205) notes, Peccei sounds a theme that has been the keynote of technocratic utopian philosophy since the 1930's. This is that a more rational approach could be made to the design of world society than that developed historically in the socio-political process. The politicians should give ground to the scientists and rational planners who would then blossom forth with the new methods of societal control. The value system of such a society would be very much the same as present technological society: increased industrial development, more rational planning, larger bureaucratic entities more global in scale and authority, increased efficiency, more control over the environment through technological intervention, and finally, a more homogenous set of world cultural values. Peccei's vision of the future

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simply brings present world technological society to its logical conclusion.

Still, something must have been troubling Peccei. He pushed for a more formal study of the global situation. He dubbed this intended inquiry "Project 1969". In April, 1968, a group of "economists, planners, geneticists, sociologists, and managers" (Simmons, 1973:205) assembled to discuss the project but results were not particularly encouraging.

Nevertheless, Peccei persevered and established the Club of Rome to promote research on global problems and studies would be made by members of the scientific community with "solutions" to world problems following as a non-political and objective format.

The Club of Rome as a group can best be understood by considering who the key members are and what they represent.

Meadows et al. (1972:10) reviews this as follows:

The members of the Club of Rome have backgrounds as varied as their nationalities. Dr. Peccei, still the prime moving force within the group, is affiliated with Fiat and Olivetti, and manages a consulting firm for economic and engineering development, Italconsult, one of the largest of its kind in Europe. The other leaders of the Club of Rome include Hugo Thiemann, head of the Battele Institute of Geneva; Alexander King, scientific director of the Organization for Economic Cooperation and Developments; Saburo Okita, head of the Japan Economic Research Center in Tokyo; Eduard Pestel of the Technical University of Hanover, Germany; and Carroll Wilson of the University of Massachusetts Institute of Technology.

It is clear that this group is representative of the types of

individuals that presently accomplish the rational planning of world technological society. Carroll Wilson was the connecting link between the Club of Rome and the M. I. T. systems dynamics group. At his suggestion a meeting was arranged between Forrester and members of the Club at Berne, Switzerland on June 29th and 30th, 1970.

Evidently Forrester was persuasive as evidenced by a shift in the Club's and presumably Peccei's, outlook toward the problem of global society.⁵ The emphasis shifted from the conventional technocratic solution of global organizations, increased efficiency and the rest, and focused instead on the search for a new methodology to apply to world problems and perhaps new world values to act as the world system's driving force.

Meadows et al. (1972:10) expresses the new mood or feeling of the group in the following paragraph:

The intent of the project is to examine the complex of problems troubling men of all nations: poverty in the midst of plenty; degradation of the environment; loss of faith in institutions; uncontrolled urban spread; insecurity of employment; alienation of youth; rejection of traditional values; and inflation and other monetary and economic disruptions. These seemingly divergent parts of the "world problematique" as the Club of Rome calls it, have three characteristics in common: they occur in some degree in all societies; they contain technical, social, economic, and political elements; and most important of all, they interact.

It is the predicament of mankind that man can perceive the problematique, yet, despite his considerable know-

ledge and skills, he does not understand the origins, significance, and interrelationships of its many components and thus is unable to devise effective responses. This failure occurs in large part because we continue to examine single items in the problematique without understanding the whole, that the whole is more than the sum of its parts, that change in one element means change in the others.

The feeling is one of pessimism and frustration. It could be characterized as "anomie of the managerial classes", a feeling of normlessness and powerlessness by those who are supposed both to support and to control the system.

The implication is clear. The Limits to Growth thesis is not a revolutionary theory arising out of a class consciousness perspective and dealing with the issue of mass discontent, but is rather a revolutionary theory of disenchanted elites themselves. Neither is the thesis one of scientific institutions dominating the social system policy making role and thus displacing the present political institutions as Simmons (1973:196) suggests; it is a call for a "new science" to better understand the nature of social systems and a "new politician" who better understands the interconnection between this "new science" and the world of political realities.

4. Strategy of Social Change

As might be expected, the M.I.T. systems dynamics group's action program of social change is not one of revolution in the

streets but instead appears to be a coup d'etat of the palace guard.

The fact that the Limits to Growth strategy of social change is more than purely scientific and an objective analysis of a problem and is, in fact, a social program is stated explicitly (Meadows, et al., 1972:23):

We have used a computer as a tool to aid our own understanding of the causes and consequences of the accelerating trends that characterize the modern world, but familiarity with computers is by no means necessary to comprehend or to discuss our conclusions. The implications of those accelerating trends raise issues that go far beyond the proper domain of purely scientific document. They must be debated by a wider community than that of scientists alone. Our purpose here is to open that debate.

Notwithstanding the fact that the M. I. T. systems dynamics group considers the computer as merely a "tool to aid our own understanding," it appears from the general thrust of the program that it considers a thorough understanding of the model and a technical capability of being able to run it on a computer to be the shortest, most direct, route to convincing others of the Limits to Growth thesis itself. Thus the widest possible dissemination of systems dynamics group members, computer programs, and the computer language in which these programs are written is in order.⁶

The most direct route of diffusion of the assumptions and the consequent models, then, is to place one of the group's members in

other corporations educational institutions or government planning agencies. This person's main efforts would in turn be directed to the problems that are considered vital to the particular agency. But the group member would, as a matter of course, have a chance to program the computer with the world model and other models of peripheral interest to the agency in question. Other agency personnel, particularly second-line, younger, but technically-oriented, management people, would have a chance to experiment directly with the world model and urban models. This would give these people a practical socialization into the cluster of ideas, techniques, beliefs, and methodologies that makes up systems dynamics.

Even without a specific member of the M. I. T. systems dynamics group, the agency, perhaps through interested agency members who have come into contact with the literature, could get the necessary computer programs and, on its own, adapt some of their agency's problems to the systems dynamics view and technique. This strategy then of systems dynamics penetration into the computer centers of target agencies certainly represents a bold and innovative contemporary approach to social change, or to use Kuhn's (1970) terminology, to aid in the displacement of "the normal paradigm" with the "radical paradigm".

Furthermore, not only does the social class composition of the systems dynamics group and its supporters influence the type of

social action, but it also influences the form, methodology, and manner of presentation, so to speak, of theory and thesis. It is of paramount importance that the theory present itself as scientifically grounded, objective and rational. Couched in the language of a computer program the all inclusive theory and thesis of Limits to Growth can reach its ultimate goal through the medium of the agency data bank. The psychological effect is unobtrusive. The unquestioned assumption that the systems dynamics models are the objective prediction of future realities strongly heightens the legitimacy of those programs.

5. The World 3 Model Versus the Thesis of "Limits to Growth"

In order to understand what Limits to Growth is as an action program one must make a distinction between the "world model" itself and the "thesis" of Limits to Growth. The world model is the simulated computer model. Such a model can be expressed as follows:

- (1) As the totality of the level and rate equations that serve to activate the computer. In Limits to Growth the level and rate equations are not given, but are shown in the follow-up Technical Report. In Forrester's prototype World 2 model, as expressed in World Dynamics, the

level and rate equations are contained in Appendix B (1971:132-134).

- (2) As a level and rate diagram (Forrester, 1971:20-21; Meadows et al., 1972:102-103).
- (3) As a causal loop diagram or series of causal loop diagrams. These are best illustrated in Models of Doom (Cole et al., 1973:26, 57, 67, 81).
- (4) As a flow chart or series of flow charts (Cole et al., 1973:48).
- (5) As a computer print out of the model run itself.

Technically speaking, when one refers to the World 3 model one is implicitly referring to the total model which includes the basic equations that make a general statement about the model. Additionally, the model includes all modifications of the basic statement and thus all model runs which are variations of the basic model in Limits to Growth. In logical terms, the model can only be considered as a formal statement of the modeller's own perception of possible, causal relationships between variables although in physical models these relationships might express fundamental physical laws. In the social systems models, they can only reflect inferential relationships which the modeller perceives to be empirically grounded without, however, being able to explain the exact nature of the causal relationship. Thus, to say that the total world

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population is a cumulative reflection of the state of the world system at any one time, and that this reflects the cumulation of birth rates minus death rates, is simply an analytical statement of definition. But to state the hypothesis that the world death rate increases proportionately with the world pollution rate is a synthetic statement based on an inference -- a causal inference -- drawn by the model maker. Empirical validation of the model would thus consist of examining each causal inference separately to determine if there are empirical data to support that inference.

The model itself, therefore, can be defined as a statement in formal logic of the condition of the system of interest: (1) as a "standard run" with all policies as perceived by the modeller to be considered to be fixed and unchanging throughout the entire model run time frame, and (2) as expressed in all modifications of the standard run made by the modeller with all policy decision alterations that the modeller deems relevant for the study.

Every model is designed around an original question asked by its builder. Stated another way, the modeller might say that he has tried to determine the purpose or goal of the on-going social system as it presently exists. In the case of the world models (that is, the World 2 and World 3 models) the organizing question of purpose is, "What is the relationship between world society and its physical environment?" To define that relationship five system levels

are considered relevant: capital, non-renewable resources, pollution, population, and areable land. Connecting these major levels that define the state of the system are numerous causal links or rates expressed mathematically as rate equations.

To use a physical analogy, each level can be considered to be the storage capacity of a water reservoir. Because all reservoirs are connected by a series of pipes and flow controlling valves, the computer printout would express the non-linear and dynamic relationships of the various reservoir levels for a particular strategy of valve settings. Valve settings or rates are not changed during the computer printout. Thus, once the system is totally defined in terms of levels and rates, the dynamic behavior of the system becomes completely predictable, or in the terminology of systems dynamics, all models are run on the presumption of a closed system (Forrester, 1968:1-5). Such a presumption does not mean that the model builder himself thinks that social systems are by nature closed systems. It is simply a presumptive imperative that he must make in order that the model run itself be mathematically determinate. In Limits to Growth ten different policy alternatives and thus model runs are described. The total model thus could be considered to be the "standard run" plus the nine policy modification runs.

The "thesis" of Limits to Growth includes, in addition to the

model itself, the modeller's presuppositions plus his final interpretation of the models. It is his summary expression and provisional conclusions based on all of the evidence and all that is known to date about the system of interest. The thesis expresses not only what the model is like, but also what the model is like in relation to the larger world of knowledge. On the other hand, the model expresses what the modeller considers to be objective observations of the system expressed in logical and mathematical terms. The thesis tells the story in the language of everyday life. The thesis of Limits to Growth can be summarized as follows:

- (1) Human perspectives. Most people live and act in social systems of small area and short time horizon (1973:18). A few decisionmakers who have successfully solved small area problems move to larger social systems problems set in larger geographic areas and time frames.
- (2) Small area social systems versus world systems. Personal and national social systems problems and objectives may ultimately be frustrated by overriding problems of world social systems (1973:19).
- (3) World system. The first problem in systems dynamics is to establish the fact that there is such a thing as a world social system (1973:21, 44).
- (4) Mental Models. The dynamic behavior of any social system is determined in part by the mental models that decisionmakers have of that system. Thus, the social system in the larger sense represents not only the precipitate objectification of the social action of actors within the system itself but also the relationship of the mental models (world views) of decisionmakers to social system objectification.

- (5) Contemporary world system mental models. The present world social system is dominated by mental models which have deficiencies in that they are:
- (a) Oriented to past experiences of policymakers, i. e., (experientially oriented).
 - (b) Oriented to cultural proscriptions of policymakers (the reification of historically derived social system paradigms).
 - (c) Oriented toward linear versus non-linear thinking, the latter being the true nature of any complex social system. This linear thinking leads policymakers into the classic mistake of visualizing a good system as one of maximum optimization of all sub-systems (1973:181).
 - (d) Oriented to short-term time frames, i. e., thirty years or more, at the most, instead of long term time frames such as 200 years.

Because of these factors, real social systems tend to exhibit dynamic behavior which is counterintuitive to contemporary mental models.

- (6) Present world policy and growth. Because world policymakers think in terms of counterintuitive mental models, the present world social system is organized around theories of national economic development which emphasize exponential increase of industrial growth, of capital, and exponential increase of standards of living for world populations, and which allow exponential increase of world population itself. This de facto policy of exponential growth fails to recognize the ultimate limits of the physical environment of the world social system.
- (7) Social change. The first problem is to convince policymakers to change their perspective from one of promotion of growth to that of equilibrium (1972:23, 188).
- (8) Problem limitation of the world model and limits of growth. The Limits to Growth thesis does not propose to solve all of the problems of the world, but is re-

stricted to an in-depth assessment of one particular problem -- the phase #1 problem, or the problem of the relationship of society to its physical environment (1973:46).

(9) The conclusions of the modellers:

- (a) If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next hundred years. The probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity.
- (b) It is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future. The state of global equilibrium could be designed so that the basic material needs of each person on earth are satisfied, and each person has an equal opportunity to realize his individual human potential.
- (c) If the world's people decide to strive for this second outcome rather than the first, the sooner they will begin working to attain it, the greater will be their chances of success.

The thesis of Limits to Growth represents the totality of the disciplinary matrix of the M.I.T. systems dynamics group as a scientific epistemic community. It is in itself more than the mathematical model or "scientific theory" to those who hold it. In the Limits to Growth world view, the supporting data are embedded everywhere in the course of events of the everyday life world of the global community. The Arab oil embargo, enemy crises, disagreements over safety in nuclear power plants, water quality, water

resources development, urbanization of the countryside, air quality, ocean pollution, worldwide rise in commodity prices, world food supply, and world-experienced phenomenon of inflation and recession in combination all reveal the structure of the world model and substantiate its general predictive thrust. To those of contrasting world views none of these events confirm in the least way the Limits to Growth world model.

Scientific programs which are designed to gather more precise data, improve reliability of data, provide more elaborate models, segment the model into regional areas, or offer more in-depth and penetrating analysis of specific world problem areas all fail to resolve the contrasting and competing world views of growth and equilibrium. To use Kuhn's expression, the two views are incommensurable (Kuhn, 1970:148; Phillips, 1975:38); that is, one cannot hold both views simultaneously any more than one can see both perspectives of a gestalt picture in the same light. For example one view places the dark objects as subject and the light objects as background, and the next view reverses the procedure.

CHAPTER IV ENDNOTES

1. Professor Forrester made the distinction between "policy" and "decision" in a forum session titled "Econometrics and the Forging of Public Policy." World Future Society, Second General Assembly, June 2, 1975.

2. Some of Forrester's other accomplishments are listed in in the 1974 issue of Who's Who in America.

3. Some examples of these articles are: Kadanoff (1971); Babcock (1972); Belkin (1972); Burdekin and Marshall (1972); Garn and Wilson (1972); Gibson (1972); Gray et al. (1972); Graham (1972); Kadanoff and Wimblatt (1972); Pack (1972); Porter and Henley (1972); Richardson et al. (1972); Sagner (1972); Schroeder (1972); Whithed (1972); and, White et al. (1974).

4. Forrester (1975b:325) explains that his World Dynamics (1971) model contains five level variables. His Urban Dynamics (1969) model contains 22 level variables. His present project financed by the Rockefeller Brothers Fund is a study of the life cycle of the economy of the United States. When fully developed, it will contain some 2,000 level variables. A good rule of thumb according to Forrester, would be a ratio of five rate or multiplier variables to every one level variable.

5. Peccei in an interview with Oltmans (1974:741-483) updates his views of the M.I.T. systems dynamics group's work and of the world problematique.

6. Forrester's last section of his epilogue in World Dynamics (1971:127) sets out this strategy. A later version of this strategy is contained in Forrester (1975b:328).

CHAPTER V

THE STRUCTURAL ANALYSIS OF EPISTEMOLOGY: PHYSICAL STRUCTURE AND NORMATIVE STRUCTURE

1. Physical Structure and Normative Structure

A. The Methodology of Epistemic Analysis

Thus far, the approach of this thesis has been to describe the M.I. T. systems dynamics group as a community of scientific practitioners, developing historically a certain perspective of their concept of the social system. As Wilson (1973:130) notes:

The basic components of an epistemology are a community of experiencers, a set of ways of experiencing, and an aggregate of experiences of things experienced.

The theoretical focus now shifts to the study of presuppositions themselves, that is, from an historical methodology to what Mannheim calls "the structural analysis of epistemology" (Mannheim, 1953:15-73).¹

Laszlo (1973) and the contributors to his edited collection of essays critiquing both Limits to Growth and Forrester's systems dynamics theories have raised and examined the epistemology of systems dynamics from a number of perspectives. This chapter

will seek to analyze in depth one particular issue that is fundamental to the understanding of the Forrester-Meadows systems dynamic theory and modelling techniques. Using Quine's terminology, it is a social² "paradox" that some theorists understand social systems as normative systems and others as physical systems.

The epistemological question is that of the difference between normative structure and physical structure. What is the difference between the normative perspective and the physical perspective of a social reality? Wilson (1973:127) noted three perspectives, physical, normative, and probabilistic,³ but this chapter contrasts the first two. Because Forrester emphasizes the term "structure" to denote that which gives understandability to a system, this chapter uses the concepts of physical structure and normative structure as the preferred ones.

By definition, epistemic structures are productions of ongoing social enterprises, that is, historical achievements of epistemic communities. How, then, can one describe or map that structure under the conditions of a particular epistemology? More specifically, in what possible ways can any particular epistemology account for the difference between social and physical structure? The question is a crucial one for comparing the M.I.T. group's world view of equilibrium with the world view of growth.

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B. The Twilight of Physical Systems

Skolimowski in his essay "The Twilight of Physical Description and the Ascent of Normative Models"⁴ (1973:99) is one critic that specifically challenges the study of world systems as physical systems. Skolimowski's (1973:109-110) argument proceeds as follows:

The norms of survival and well-being of organisms cannot be deduced from the descriptions of these organisms in terms of physics and chemistry. Just the opposite, the arrangement of lower organs and ultimately of the cells and their chemistry is subordinated to these norms of survival. This is not to say that some nonmaterial entities called "norms of survival" arrange the chemistry of the cells. But rather that the telenomic character of organisms, as seen through the norms of survival, is a defining characteristic of living organisms as living (1973:109-110).

To Skolimowski, the methodological program of science is one of physical reductionism, that is, the description of the casual structure of a higher level situation in terms of the properties of the smaller elements within the problem area, for example, in terms of molecular structure or atomic structure, force patterns or other purely physical concepts. Furthermore physical structure, he asserts, tends to be deterministic or closed system structure.

Skolimowski depicts what he calls the "brittleness of physical descriptions", particularly when applied to human situations and present world views, in the following passage:

To describe the world is not only to describe its most apparent physical furniture. We have so refined the language of our descriptions that it handles physical descriptions masterfully and sometimes even superbly.

Man's existence is sustained by physical knowledge, but not exhausted by it. We have made a mistake, sometime in the seventeenth century, by assuming that all descriptions can be reduced to physical descriptions. Physical descriptions impress us because they are easy to make and easy to test. In its excessive preoccupation with physical descriptions, Western civilization betrays its shallowness, its inability to probe the deeper aspects of man's universe, its smug satisfaction with appearances. We are a facile civilization, sparkling on the surface, shallow inside. It is imperative to break the spurious dichotomy between the descriptive and the normative, established by prophets of shallow empiricism, in order to bring back to man his due depth, in order to bring back to knowledge the ignored aspects of reality, in order to bring back to descriptions the wealth and depth of which they have been robbed as the result of the mindless pursuit of empiricism and positivism (Skolimowski, 1973:103-104).

Skolimowski ties his argument in with Forrester's systems dynamics theory in the following way:

From Forrester to Skinner a great many efforts to find effective solutions to our global problems are hopelessly bogged down in their inception because of the limitations of physical descriptions which are still recognized as the criterion of validity in our descriptions (Skolimowski, 1973:105).

In his final summation, he says:

Forrester appears to be yet another technocrat juggling with formulas and mesmerizing us with the display of computers which, for the present, can do precious little (Skolimowski, 1973:118).

One way to examine Skolimowski's critique of Forrester's physically descriptive models is to construct a brief summary of an epistemic paradigm as a conceptual tool in order to compare one epistemology to another.

2. Investigation of Epistemic Structure as it Relates to Social Systems

Epistemology is the study of the origin, structure, methods, and validity of knowledge (Runes, 1956:94). The specific question of focus for this chapter is, how do the two opposing world views of growth and equilibrium organize their contrasting epistemologies? How do these organizations influence their theories about social systems? In particular how does each group discriminate between physical structure and social structure? Using primarily Mannheim's (1953) analysis, the elements of epistemic structure are briefly summarized. (Laszlo, 1966:15).

A. Presumption of Objective Reality

This set of presumptions describes that which is to be known.

1. The first presumption of knowledge is that of intelligible order in the field or domain under investigation.

2. A correlary is that of objective reality, a "something out there" beyond the investigator himself, an unknown territory to be mapped. Such a territory is beyond the volition of the investigator.

Berger and Luckmann (1966:1) sum up these presumptions as follows:

It will be enough, for our purposes, to define "reality" as a quality appertaining to phenomena that we recognize as having a being independent of our own volition. (We cannot "wish them away"), and to define "knowledge" as

the certainty that phenomena are real and that they possess specific characteristics.

B. Presumption of a Systematization of Knowledge

This set of presumptions describes the ordering of the knowledge itself.

1. In order for there to be knowledge of an unknown territory, there must be symbols or language which can interpret or translate what structure there is in the unknown territory into a structure of knowledge.

2. There must be some presumption of understanding of those symbols by the investigator so that the investigator at least under certain conditions "knows" beyond a doubt the meaning of these symbols. This would indicate that there is always some element of knowledge structure that must be "taken for granted", using Schutz's (1962) terminology, before the investigation of any unknown territory in objective reality can proceed.

3. Any investigation of an unknown territory must have some specific origin in time. This historical point is rarely known by a present investigator, but investigations themselves are on-going historical events (Mannheim, 1953:21).

4. An investigation must have some originating question. Mannheim (1953:23) uses a concept originally introduced by Reikert called "heterothesis" to describe the beginnings of a knowledge sys-

tem. Heterothesis means that knowledge begins with two concepts that are somehow rooted in each other. Thus epistemology itself is the investigation of the relationship between subject and object. Logic is the investigation of the relationship between form and content. Social psychology is the investigation of the relationship between individual and society, and so forth. Both Schutz (1962:104) and Farber (1962:143) note and use the term "origin" or "genesis" as elaborated by Husserl, to indicate the beginning place of any investigation as centered around some starting point or particular problem.

5. Once some origin of knowledge is established, knowledge is usually considered to be accumulative; that is, there is always more knowledge about the territory at time $T + 1$, than there was at time T . The question of accumulation of knowledge can always be doubted under certain epistemological orientations; or when considering a special knowledge system, for instance, painting or creative writing. Still the question of accumulation of knowledge will almost always be raised in any epistemological perspective. (Freese, 1972:472; Willer and Willer, 1972:473).

6. If knowledge has an origin and a presumption of growth, it must have some ultimate form or end or goal. Mannheim (1953: 26) states this notion as follows:

Although "systematizations", as they are formulated in actual fact, always contain erroneous and tentative elements -- nevertheless, we have to take it for granted that an ultimate, true and complete form of any systematization exists objectively, independently of our own contributions.⁵

This presupposition also indicates an integration of specific questions into more general or theoretical formulations, so that the total knowledge structure evidences a pyramidal or hierarchal form, starting with the specific and concrete at the base and ending with more abstract formulations at the peak (Zetterburg, 1965:18; Husserl, 1931:77; Willer, 1967:9).

Another way of looking at this ultimate form of knowledge is expressed by Wilson (1973:124), who states that "[a] presupposition of systems philosophy is that the world is intelligibly ordered as a whole." He then points out that if this is true, there must be some way of ordering knowledge systems into a unity.

C. Presumption of a Knower as Subject

This set of presumptions describes the subject.

1. Knowledge systems are not objects in the real world. They must locate themselves somewhere. A library or depository for records or a computer does not constitute a location of knowledge unless there is some additional ingredient of intelligibility. This third element of the triad of epistemic structure⁶ has its focus in the mind of the subject.

2. As a correlary this locus could be considered a psychological space or a social space depending on the problem of knowledge at hand.

3. Knowledge systems imply a community of experiencers and thus a social locus of subject.

4. Subject-shared knowledge could be considered as the proprietary property of some special group or could be considered as universally distributed, for instance, scientific knowledge or knowledge in everyday life.⁷ It is the epistemology itself, the "rules of the knowledge game" which is so distributed in each case rather than the bits of data.

5. Knowledge systems based on the presupposition of universality, programmatically de-subjectify knowledge, that is, make it appear as if the subject is a redundant element in the epistemic structure.⁸

D. Presumption of Experience

1. There must be some method of accumulating knowledge about an unknown region. The experiences must be able to develop a contact point with that region, a grasp through the senses so that the knower can know the objects in the region. This requires a definition of what the terms "experience" and "perception" mean.

2. Apart from this problem, there must be an explanation

of a way by which the investigator or knower can generalize from the particular. In other words, how does one transfer from concrete representations in his experience to more general symbols in his knowledge system?

E. Presumption of Non-Meaning Factors

Epistemologies must account for ways to discriminate knowledge from non-knowledge, such as descriptions of how false knowledge arises, as in Plato's parable of the cave or Bacon's discussion of idols.

It also might contain explanations of how knowledge arises from or is affected by non-meaning factors. Thus any knowledge system can be influenced by independent variables such as environment, geography, climate or Marx's notion of the "material life process" (Marx, 1970:47). Along the same lines, behaviorist theory proposes physical stimuli which directly elicit a behavioral response. Such a paradigm develops a direct causal link between some physical phenomenon and action. Another example along these lines is Freud's concept of the libido as the causal factor of action in a specific set of circumstances. Genetic programming or instinctual actualization is a way of describing non-meaning factors. All such non-meaning factors in effect short circuit knowledge as a condition precedent for social action.

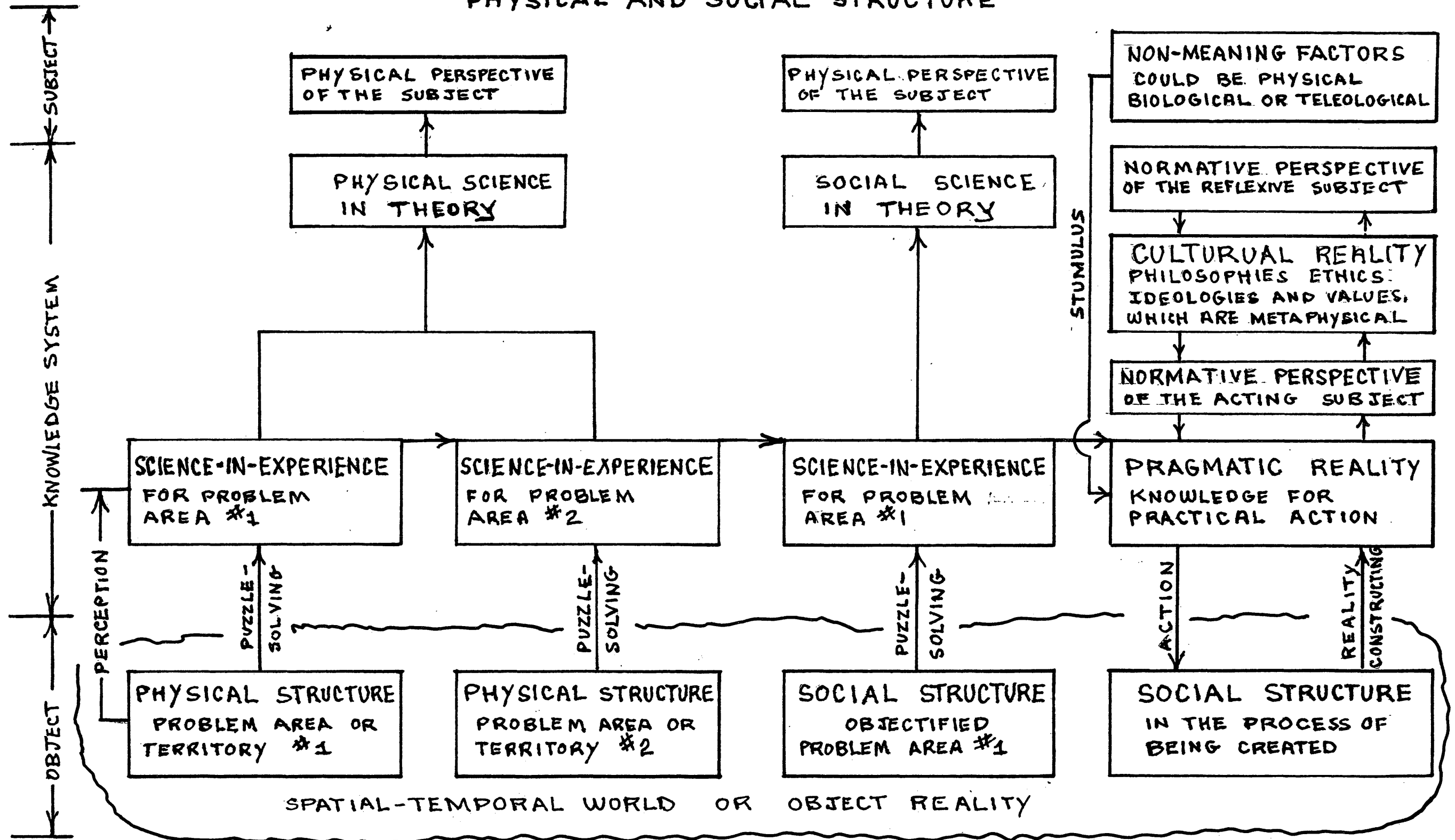
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3. The Epistemic Diagram

Using this brief synopsis of the general conditions of knowledge for any knowledge system as related to a social system, and considering the major elements of these conditions as the structural elements of an analysis of epistemology Figure IX, The Epistemic Diagram, is a heuristic device to explain how a particular epistemology behaves as a total structural system. The epistemic diagram is designed specifically to describe epistemologies of scientific epistemic communities who theorize on both physical theories and social theories and in addition try to influence social policy, such as the M. I. T. systems dynamics group. The diagram can also be used to trace the epistemologies of scientific epistemic communities, who resolutely remain puzzle solvers, but who implicitly work in coalition with action-oriented groups of reality constructors.

Looking again at Figure IX, The Epistemic Diagram, the knowledge system is divided into two levels, science in experience reflecting that portion of the system that forms the link between the knowledge system and observation of objects in the real world. In this level is located the paradigm of the knowledge systems (see Table II, page 50). The second level of scientific knowledge designates the system of interrelated propositions, that is, abstractions

FIGURE IX
EPISTEMIC DIAGRAM
PHYSICAL AND SOCIAL STRUCTURE



of observations into formal statements and mathematical language. This level coincides with Kuhn's concept of symbolic generalizations (see Table I, page 45).

Cultural reality expresses the knowledge system of reality constructors expressing values, metaphysical theories and the like. The total knowledge system constitutes the entire disciplinary matrix of a particular epistemic community or coalition of epistemic communities, if there is a social distribution of knowledge between the coalition groups.

In constructing this diagram, one additional presupposition is required, the origin of which reflects the perspective of the sociology of knowledge more than any presupposition involving epistemology itself. There are essentially two different orientations of the actor towards the object, normative and physical.

Normative orientation arises when the subject as actor is interacting in and imposing his will upon the objective territory in which he acts. It is the orientation of any organism towards its environment. Thought itself is subordinate to the goal of the actor. In this sense, then, the subject is a "reality constructor". Berger and Luckman (1966) discuss how social structure is created by actors and objectified into a "real world" setting. Objectification transforms social action into concrete physical objects or artifacts, or at a deeper level of analysis creates structure in the "real world." A

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social structure rather than a physical structure in the sense of physical laws emerges.⁹

For example, a person standing at a busy intersection, probably will be restrained from crossing the street against a red light. Whether his attitude reflects a social restriction, that the light is red, or a physical restraint, that there is heavy traffic which could subject him to bodily harm, is difficult to determine. In any case some combination of both physical and normative restraints prevents him from crossing the street.

Physical orientation arises when the observer takes a passive or non-manipulative perspective of the objective territory under investigation. The observer's motivation is one of knowledge seeking. He is therefore a "puzzle solver" (Kuhn, 1970:35) rather than a "reality constructor". Kuhn asserts the dichotomy of puzzle solving versus reality constructing not only distinguishes the scientist from the social actor. It also distinguishes the "normal scientist," one practicing within the confines of an established paradigm, from a "radical scientist," one seeking new paradigms because of anomalies uncovered in the established paradigm.

Three perspectives are open to the social scientist who wishes to remain non-manipulative in his territory of observation. These are the physical perspective of the object, normative perspective of the acting subject and normative perspective of the reflexive subject,

as shown in Figure IX.¹⁰

The next question is under what conditions are physical structure deterministic, that is, in a closed system state. Bertalanffy (1968:40) defines a closed system as follows:

In any closed system, the final state is unequivocally determined by the initial condition: e.g., the motion in a planetary system where the positions of the planets at a time T are unequivocally determined by their positions at time T-O.

Conventional macrophysics has historically modelled physical systems as closed systems. Stochastic models of macro-physical systems introduce an element of chance or randomness to the system. Still even this randomness does not change the final end state of the systems as in the case of the end entropic state of a physical system (Bertalanffy, 1967:40; and Wilson, 1973:127).

Normative systems are essentially considered to be open systems. Perhaps the best way to express this "openness" is to say that the future of interest is short range and indeterminant. The future state of an open system, being goal oriented, is finalistic -- future influencing the present (Wilson, 1973:127). An open system is always seeking closure. That is, it is trying to optimize the certainty of its future rather than its randomness. In effect an open system seeks security as opposed to novelty. This security seeking is a necessary condition of the system being goal oriented.

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Turning to empirical cases of open systems which contain these properties, Bertalanffy (1968:39) notes that every living organism is an open system. Berger and Luckman (1966:51) refer to the social nature of systems as follows:

One may say that the biologically intrinsic world-openness of human existence is always, and indeed must be, transformed by social order into a relative world-closedness.

Thus Forrester's (1968:1-5) explicit presupposition of social systems as closed systems is not an attempt to mirror physical structure. He expresses the nature of social systems as normative systems as long as he treats the closedness of social systems as an attempt of an intrinsically open system to achieve closure rather than a fait accompli. The Forrester-Meadows models are closed system models of normative systems placed in the conditional mode of logical expression. They answer the question, "If the world views of society manifest themselves in the achievement of the express goals of that society what will be the objectification of that social order?"

4. Physicalism

A. Physicalism and Physical Structure

The first epistemology, which is analyzed in terms of the Epistemic Diagram is Physicalism. Such an epistemology asserts

that there is only one real world, that is the spatial-temporal world, the physical world. All knowledge, that is all structure of knowledge systems, must find its root or base in this spatial-temporal world.

There are three corollary doctrines associated with physicalism, the first being the doctrine of primitive protocol sentences, the second being that of empirical validation, and the third that of the unity of the sciences. (1) The doctrine of primitive protocol sentences states that the observer is capable of objective or universally shared perception of raw data in the spatial-temporal world. That is, a person properly trained as an objective observer, will see the same thing as any other person so trained. (2) All scientific knowledge being validated by experience gained through perception of the spatial-temporal world indicates that only knowledge so validated can receive the imprimatur of "science" and become real knowledge as contrasted to metaphysics, conjecture, speculation, intuition and the like. (3) Neurath (1959:284) sets out the doctrine of the unity of the sciences:

. . . all types of laws must under given conditions, be capable of being connected with one another. All laws, whether chemical, climatological or sociological, must therefore be conceived as constituents of a system, viz., of unified science.

Carnap (1959:165-198) gives a classic elaboration of the epistemology of physicalism. Carnap's analysis is based on a

discussion of language systems as knowledge systems. Carnap (1959:166) asserts that "physical language is universal and intersubjective." Language systems that say anything meaningful about the spatial-temporal world can ultimately be tied into the universal physical language or a total structure of knowledge based on the universality of objective structure in the spatial-temporal world. Carnap contrasts the two basic modes of speech. The material mode of speech treats objects as immediately "given", i.e., objects in the presence of consciousness and experience. The second or formal mode of speech considers objects as part of a language system. The meaning of language objects is confirmed by specifying its relation to other language objects.

For example, if one is in the material mode of speech and states, "This is a cat," he is implying that there is an object which he experiences to be a cat immediately before his senses. However, if this same person states, "This is a cat," in the formal mode, he is asserting unequivocally that the symbol "this" is equal in every way to the symbol "cat".

What Carnap calls "primitive protocol sentences" are sentences in the material mode of speech about objects immediately given. The system language of a science (the structure of knowledge) is constructed in the formal mode of speech. As Carnap states, "To every sentence of the system language there corresponds

some sentence of the physical language, such that the two sentences are inter-translatable." (Carnap, 1959:156).

Suppose, for example, that to demonstrate more explicitly the doctrines of primitive protocol sentences and empirical validation, ten people with no common language whatsoever are introduced to a room of objects. Suppose, further, that one of the members of this community utters a word and repeats that word while pointing to other objects in the room. The members of this community, assuming reasonable intelligence, might then be able to understand their first unit in the structure of knowledge, that is, there is one word that represents one specific object in the room. All objects then in the room could be enumerated as physical because they are there as opposed to not there. In the next step in the procedure, the leader then by other gestures manages to convey the idea of size of the objects, perhaps by carrying some standard of size in his hand and arranging a few objects on one side of it as larger and a few on the other side of it as smaller. Suppose that this standard which he carries is a breadbox. Cumulative knowledge of the group advances and all objects are classified as bigger than a breadbox or smaller than a breadbox. In this case, the standard of definition imposed by the leader of the group, i.e., the size of the breadbox, is a normative standard. It is a standard which can be operationalized -- expressed in physical terms -- so that a

statement about size as being bigger or smaller than a breadbox can be verified through empirical validation , or an object subsequently being encountered by a member of the group can be perceived as large or small in reference to the standard. The point Carnap is making is not that knowledge is created out of physical structure but rather that knowledge, once having been established by some act of creation, can assume a reliability and validity, and the group can feel confidence in experience as a test of what is in the physical world in relation to their shared paradigms.

The physicalist requirement that science be based on raw experience is now changed to that of a science based on paradigm preconditioned experience. Ayer, in reviewing the work of Carnap and other physicalists, concludes that in the end primitive protocol statements became, not replicas of object reality, but a "verification principal as a convention." He notes that:

They were propounding a definition of meaning which accorded with common usage in the sense that it set out the conditions that are in fact satisfied by statements that are regarded as empirically informative. (Ayer, 1959:15).

Kuhn comments along similar lines as follows:

But is sensory experience fixed and neutral? Are theories simply man-made interpretations of given data? The epistemological viewpoint that has most often guided Western philosophy for three centuries dictates an immediate and unequivocal, Yes! In the absence of a developed alternative, I find it impossible to relinquish entirely that viewpoint. Yet it no longer functions effectively, and the attempts to make it do so through the introduction of

a neutral language of observations now seem to me hopeless.

The operations and measurements that a scientist undertakes in the laboratory are not "the given" of experience but rather "the collected with difficulty." (Kuhn, 1970:126).

Kuhn himself is wary of the universal validity of raw sensory experience, but not to the point of rejecting completely a scientifically based experience link between knowledge systems and objective reality. (Cf. Bruner et al., 1956).

5. Physicalism and Social Structure

Now let us return to the area of the social scientist and paralleling our course of investigation into the physical sciences, let us construct a parable of the origin of the social sciences. Again imagine a group of practitioners of science assembled in a room populated with social objects -- let us say, a tribal group. These practitioners must create a knowledge system based on their observations of objective reality. Their first task would be to develop a measure of first ordering of their phenomena under investigation. Here again the process of organizing can't start unless the beginning practitioners have some idea of what they are looking for. Assume that they stumble onto a rudimentary notion of social class as the first ordering parameter. In this case the leader of the investigators could not start the process by simple first order measure-

ment. He would have to determine what the natives thought about class. Perhaps he could ask them. Perhaps further observation and comparison of studies taken independently would lead the practitioner members to agree that the number beads around each native's neck is a measure of class rank, as determined by the native members themselves. In this case, the practitioner members are dealing with observables that are objectifications created by the native members. The classificatory experiences of the practitioners of science would be valid only for the particular cultural population under study, and only for the historical time frame in which the natives agreed amongst themselves either implicitly or explicitly to recognize class differences in terms of numbers of beads. But what is interesting for the social science practitioner is the same thing that is interesting for the physical science practitioner, and that is to develop more complex relationships between social objects in the observational field of the practitioner.

Social scientist practitioners have a problem in trying to initiate their studies of social phenomena that physical scientists don't have. They cannot simply decide amongst themselves upon their first ordering measure, such as the breadbasket. They must instead first break the code of cultural meaning. Such a strategy interprets one language into another.

The difficulty with the epistemology of physicalism when

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applied to social structure, lies not in its physical descriptions of social objects, that is, not on its insistence on observation of events in objective reality. The basic problem lies at the periphery of social science investigations. It is the problem of how physicalist oriented science practitioners relate to larger social worlds in which they practice. The programmatic development of the social sciences particularly normal sociology, normal economics, and normal political science is based on the physicalist premise that real knowledge as contrasted to metaphysics can only be validated by experience gained through perception of the spatial-temporal world. The physicalist science practitioner has programmatically avoided treating contemporary cultural reality as anything but a given. This assumption of cultural reality invariably allows the physicalist practitioner to treat macro-social structure in the same deterministic way as the physicist treats macro-physics. Garfinkel (1967:7-8) refers to this premise as the "assumption of reflexivity" -- members of the group assume that each one "knows" at the outset what it takes to provide a relevant account of the situation under investigation.¹¹

Systems dynamics theory does focus on the physical description of the objectifications of socially created social structure. The theory however is designed to uncover the irrationality or dysfunction of systems behavior, which can then serve as a basis for a critique of contemporary cultural reality itself. The theory does

not provide any special way for the system modelmaker to propose a superior solution to social system rationality except for his own intuitive judgment or, perhaps more significantly, the particular value orientations of the systems dynamics group. Systems dynamics theory is diagnosis-oriented rather than treatment-oriented, but policy analysis can allow for fundamental social change.

The Limits to Growth thesis does in fact argue for fundamental social change

6. An Epistemic Analysis of the Physicalist Critique of Limits to Growth

Many critics of Limits to Growth, particularly those of the larger scientific community, base their critiques largely on underlying physicalist biases. These critiques taken as a whole reveal a presuppositional pattern which can be demonstrated with the aid of the Epistemic Diagram, Figure IX, page 161. The conflict is one of the proper role of the scientist as subject and the proper methodology of a truly "scientific" analysis of the world social system.

First, a physicalist scientist is not apt to think about world social systems at all. Second, if he does study social systems, he is more prone to study smaller social systems than world systems. Third, he is not likely to model world systems that challenge basic

world values such as economic growth.

The following physicalist presuppositions define an appropriate response to the thesis of Limits to Growth.

1. Bureaucratic Research. Members of the scientific community must play the role of servants to society, and their research must reflect this role.
2. Value Free Social Science. The scientist does not make value judgments as such a stance destroys his objectivity.
3. Functionalism. Societal values are obvious; the problem is to find how the social system works.
4. Manifest Destiny. The world system is evolving in the direction of increasing rationality.
5. Empirical Complexity of World Systems. The empirical world is far too complex to be mathematically modelled given the present state of the art.
6. Behaviorism. Happiness can be operationally defined.

1. Bureaucratic Research

The vast majority of members of the scientific and technological community are engaged in research and development projects, the overall objectives of which are determined by cultural realities of institutions outside that community. The epistemology of physical-

ism makes these cultural realities beyond the reach of scientific inquiry. Mannheim's ideal-type "bureaucratic conservatism" (1936:118) closely parallels the consciousness of bureaucratic researcher. The context of the term "law" changes from "legal" to "social", but, otherwise, Mannheim's description fits completely:

The attempt to hide all problems of politics under the cover of administration may be explained by the fact that the sphere of activity of the official exists only within the limits of laws already formulated. Hence the genesis or development of law falls outside the scope of his activity. As a result of his socially limited horizon, the functionary fails to see that behind every law that has been made there lie the socially fashioned interests and the Weltanschauungen of a specific social group. He takes for granted that the specific order prescribed by the concrete law is equivalent to order in general

In terms of economic growth it is just such a value precept that cannot be questioned by, say, a Federal Economic Administration economist, a Federal Power Commission analyst, a geologist working for the Corps of Engineers, or the Chief of Research and Development for Standard Oil of Indiana.

These functionaries tend to consider their approach to problems as "objective" by reifying the cultural reality of economic growth and thus placing it outside the possibility or probability of social change.

2. Value-Free Social Science

The social scientist conditioned by the physicalist epistemology approaches the subject of conflicting values in contemporary society with a set of presuppositional restraints that block off certain avenues of scientific investigation (Rosenau, 1975:30).

Goode and Hatt (1952:25) set out a typical textbook approach to the problem in terms of value-free sociology:

Since the social scientist who studies the values of his own culture is also involved in those values, it goes without saying that it is difficult for him to keep those values from interfering with his scientific work. This may be especially true when the subject of investigation is not merely the description of value systems, but the analysis of conflicting values. In such a case the temptation to be biased by one of the conflicting systems is surely great.

This particular problem is a significant element in Gunnar Myrdal's analysis of the American race problem, An American Dilemma. Here he shows that the "American Creed," embracing such ideals as equality of opportunity, the freedom of the individual without respect to race, color or creed, is in direct conflict with the actual treatment of the Negro. The description of this value conflict is a scientific operation. An evaluation of the situation is not. The exposure of logical contradictions in value systems is a legitimate scientific activity, even though special pleading for one system or the other is not.

Goode and Hatt's suggestion seems to prohibit studies which view social systems within the context of sciences of social need.¹² The programmatic development of the scientification of technologies as applied to social systems, which is a part of the M. I. T. systems

dynamics disciplinary matrix, lies outside these methodological constraints.

3. Functionalism

The functionalism approach bypasses cultural reality as a problem of rational analysis by proposing that a hierarchy of unquestioned values are produced in the process of historical social development. At the apex of the hierarchy the values are unquestionably good -- values such as societal survival, the common good, cultural sanctions for societally beneficial individual endeavors, maintenance of social order, and the like.

Dysfunction creeps into the system at the level of goal implementation. Policy analysis and action strategies stress the efficient achievement of predetermined and unquestioned societal goals, a strategy commonly associated with the "systems approach" of modern technology.

The strategy simply requires some leader to assemble the "mission impossible" team that can solve any existing problem. Ramo (1973:13) succinctly describes the technique and relates it to large complex systems which he calls "civil systems", a system in scale not unlike Forrester's urban model or the Forrester-Meadows world models:

The systems approach is a technique for the application of a scientific approach to complex problems. It

concentrates on the analysis and design of the whole, as distinct from the components or the parts. It insists upon looking at a problem in its entirety, taking into account all the facets and all the variables, and relating the social to the technological aspects.

When solutions are envisaged, they are expressed in the form of a detailed system, combining men and machines, assigning functions to each, specifying the use of material and the pattern of information flow, so that the whole system represents an optimum ensemble for achieving a particular set of goals.

The key assumption is that the goal pursued is invariant and always lies outside the "systems approach" itself. As Gouldner (1970:104); Horowitz (1968:159); and Friedrichs (1970:89) note, much sociological research is organized around this type of plan. Research in economics is also a case in point in that much of it is designed with the goal of economic growth as explicit or implicit and with the research problem conceptualized so as to attain this growth. (Cf. Meier and Baldwin, 1966; Hozelitz, ed., 1960).

The common epistemic characteristic of all of these perspectives, i.e., systems analysis and sociological and economic functionalism -- is that they are normative orientations to the problem areas under consideration. They deal in creating social structure under preexisting societal values rather than examining the consequences of the creations themselves by using variables which lie outside their respective paradigm constructs.

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4. Manifest Destiny

Cole et al., (1973); Oerlemans et al., (1972) and Boyd (1972) have constructed their own computer models to demonstrate the logical possibility that models can be constructed which project a continuation of economic growth far beyond the end of the twenty-first century. These critics tend to consider that technology -- technological innovations -- will, at the least, keep pace with and may even outstrip any depletion of natural resources as an aggregate totality.¹³ As a parallel presumption, pollution problems are thought to be technologically manageable well beyond the time frames of the Forrester-Meadows models.

The case for the transmutability of all resources may prove to be more empirically correct than the resource finiteness conclusion of the M.I.T. systems dynamics group. The World 3 prediction may, indeed, follow the fate of Malthus. Both Malthus and Meadows may fail to properly account for advancing technology.

Technological optimists also make a leap of faith that goes beyond available data. This stance draws epistemic support from a notion first proposed by Parsons (1949:751) a "doctrine of manifest destiny," which holds that society cherishes rationality as a fundamental value. The long term historical development is one of increasing rationality (exponential growth of knowledge).

Parson's early position is a deliberate program of theoretical analysis to demonstrate how contemporary society could develop out of the trap of unplanned randomness of the utilitarian world view and still escape the rigidity of the world view of positivism (physicalism).¹⁴ His solution proposes an emergent development of society largely governed by the voluntaristic actions of its participants but in the final analysis directed by a super-rational law of societal development that insures movement towards increasing rationality. Such a law depicts the best of all possible worlds, freedom of action of the individual, coupled with increasing functional organization of society as a whole. He states his position as follows:

In order not to leave the reader feeling that the formulation of analytical laws on the basis of the system here worked out is in the structural context impossible, it may be useful to suggest tentatively that there already exists the basis for the formulation of such a law of wide scope and high significance. The law may be tentatively formulated as follows: "In any concrete system of action a process of change so far as it is at all explicable in terms of those elements of action formulated in terms of the intrinsic means-end relationship can proceed only in the direction of approach toward the realization of the rational norms conceived as binding on the actors in the system." That is, more briefly, such a process of action can proceed only in the direction of increase in the value of the property rationality.

Stated in this way this brings immediately to mind a striking analogy to the second law of thermodynamics. That also is a statement of the directionality of change in a system, this time a physical system; it must be in the direction of increasing entropy. Potential energy is con-

verted into kinetic energy, into action, in the physical sense. Rationality occupies a logical position in respect to action systems analogous to that of entropy in physical systems (at least on the basis of classical physical theory). Effort energy is, in the processes of action, converted into realization of ends, or conformity with norms. Rationality is one, at least, of the properties in terms of which the extent of this change is to be measured for any given system at any given point in the process of change.

In such a societal perspective, homeostasis is a mechanism inherently built into social structure.

Parsons' later work (1966:21) and Parsons and Platt (1973: 303-310) reinforce this notion of manifest destiny.¹⁵ In contemporary futurist literature Kahn (1967) and Kahn and Briggs (1972) are representative of those who exude optimism about the structure of world society.

The Oerlemans, Telling and DeVries (1972) critique of the Forrester-Meadows world model shows evidence of the manifest destiny argument:

The model structure does not leave sufficient scope for mankind to intervene when the world system develops in an undesirable direction. (Oerlemans et al., 1972: 252).

They further note that:

At the moment such extra [social] feedback is already clearly noticeable in legislative action, particularly in the U.S.A., but also in North-West Europe political and social pressures are building up. (Oerlemans et al., 1972:252).

Boyd (1972:516) includes a brief scenario in his critique of

Limits to Growth that again illustrates the built-in "social feedback" of the world system:

The technological-optimist view. The adherents of this view argue that there are no foreseeable limits on production of goods. Any particular scarcity will be eliminated by substitution technology. Further, the increasing stock of technology is seen to increase productivity and thus increase the standard of living. Increasing the standard of living is then supposed to produce lower birth rates. Eventually society is seen to reach an equilibrium between a low birth rate and a low death rate.

Laszlo (1973:10), makes a similar point. Cole (1973:30) attacks the same problem in the following statement:

A major problem in modelling dynamic systems as it affects world models is that of instability, which arises when one or more positive (or negative) feedback loops dominate the behavior of the model. Usually in a dynamic system some kind of equilibrium is maintained by the compensating action of negative (or positive) feedback mechanisms.

Cole goes on to demonstrate how the M. I. T. systems dynamics modellers have built in equations that lead to system instability -- overgrowth and collapse behavior -- under a great many assumptions of model run behavior. Without himself overtly displaying bias in favor of innate social system stability, he chides the model builders for biases towards instability:

The features of the models' structure which appear to be unrealistic in a way likely to affect the results are the absence of technical, economic, and social feedback processes and the use of world averages for all variables. (Cole, 1973:32; Cole and Curnow, 1973:132; and Sinclair, 1973:190).

The question raised here is whether social systems inherently

respond to world crisis? Do they reflect a social process that achieves the means-end relationship conceived by the system controllers? Such an achievement is evidence of increasing system rationality. Clearly there is a technological-optimist consciousness that perceives this rationalizing mechanism in contemporary social systems and clearly this perception stands opposed to that of the M. I. T. systems dynamics group. Forrester (1972(a):2) states his side of the argument in his keynote address to the American Public Works Association:

Is it possible that our social system has changed since the days when improved technology did lead to improved living? Can a social system undergo changes so that yesterday's solutions to problems become the causes of tomorrow's problems? I suggest that indeed such changes in the behavior of our social system are possible, and that they are occurring Under the new conditions, remedies that worked in the past are apt to be disappointing in the future.

According to Forrester, then, the advance of technology and science, which became the undergirding force of increasing rationality of social systems in the nineteenth and early twentieth centuries, has now become the inner social system irrationality in the late twentieth century. Mead (1973:27) makes the historical observation:

We have nothing in the history of human societies that suggests that any system can be depended upon to correct itself rather than perish

Ellul (1964:119) is one of the severest critics of the innate optimism of world technological society. He states:

Herein lies the inversion we are witnessing. Without exception in the course of history, technique belonged to a civilization and was merely a single element among a host of non-technical activities. Today technique has taken over the whole of civilization. Certainly, technique is no longer the simple machine substitute for human labor. It has come to be "intervention into the very substance not only of the inorganic but also of the organic".

To him the failure of technological society does not stem from some future faltering in its drive to overcome all physical resistance that it might encounter in the environment. The failure occurs as a result of the process of the technological mind-set invading and finally dominating all other forms of cultural reality.

Ellul's critique of world technological society appears at first glance to be theoretically different from Forrester's statement. Ellul criticizes on moral grounds and Forrester criticizes the lack of an integrated management of technique. However, Ellul's perspective is that of cultural reality; whereas Forrester's perspective is of the physical manifestation of the resultant social construction.

5. The Empirical Complexity of World Systems

According to the physicalist view of the world, all meaningful data come from experience of the spatial temporal world. The edifice of scientific knowledge develops from experiential

data, which is then integrated into a unitary logical system of science in theory. The spatial-temporal world represents the sum total of all available data. It can hardly be doubted that any such entity as a "world system" must be based on a large portion of that data. Consequently, any representation of the world system-in-theory must indeed be a sophisticated set of interrelated variables derived from an exhaustive investigation of a mass of such empirical evidence. The physicalist perspective, then, tends to view any attempt to construct a model of a world system as ambitious, to say the least, if not outright presumptuous.

Freeman (1973:7) writing in Models of Doom follows this "empirical complexity" strategy by setting out the proper format of investigation as follows:

They [the M.I.T. systems dynamics group] rightly believe that ideally each relationship in the model should be an accurate representation of a real world phenomenon and that model behavior must be in reasonable agreement with real world behavior. This implies the need to assemble time series data on the variables in the real world from 1900 to 1970.

Our examination suggests that the M.I.T. models do not on the whole satisfy these requirements. . . . The M.I.T. team cannot be blamed for the lack of data, although they may be criticized for trying to erect such an elaborate theoretical structure and such sweeping conclusions on so precarious a data base.

The Models of Doom team then examines the database, subsystem by subsystem, in laborious and meticulous fashion. What this extensive search uncovers is that not sufficient data exist to build the model in the first place (Cole, et al., 1973: 42, 61, 70, 107, 109, 190, and 203).

Probably the more nearly all-encompassing statement of this insufficiency of empirical data for world models is made in a footnote (Cole, et al., 1973:107) as follows:

Sam Schurr, "Energy", Scientific American, September, 1963: "There is no true measure of the world's endowment of energy resources, nor, in the nature of things is there ever likely to be one. Cost alone would prohibit a comprehensive probing of the earth's crust to provide anything approaching a true measure of the resources. More to the point, society's interest is confined to resources that are exploitable now or seem likely to be in the future. As time passes, the standards of exploitability keep changing, mainly as a result of advances in technology and changes in the economic circumstances. Consequently resource supply estimates are subject to at least as much uncertainty as energy demand estimates."

Other critics of Limits to Growth, calling attention to the model's lack of proper "quantification" or "empirical content", are: Heilbroner (1972:146); Knoppers (1972:2); Bell (1972:49); Kaysen (1972); and Oerlemans, et al. (1972: 251).

The empirical content of a world system model is beyond the scope of this paper. The important point here is that the

empirical content required is dependent in part on the particular epistemological orientation of the modeller. Beyond this, if each particular scientific community has its own unique paradigm-based perception, then empirical data will be perceived differently.

6. Behaviorism

According to Neurath (1959:302)¹⁶ a sociology of behaviorism presumes that the only correct mode of observation of social systems is as physical systems. Such an orientation does not however advocate a simple transfer of the "laws of physics to living things and the groups they form." (Neurath, 1959:301). Referring once more to the epistemic diagram, behaviorism short circuits cultural reality by observing social action and attributing its behavior as energized by non-meaning factors which can be physically described -- factors which can be operationalized. Thus a social actor does not take action because of this or that motive or belief structure or world view, but rather he acts in response to physical stimuli. (Neurath, 1959:289). Belief structures do not influence the creation of social structure but rather the other way around; the former is always the dependent variable and the latter the independent variable.

Marx was right and Weber was wrong, according to Neurath

(1959:302, 310). A study of the development of modes of production can lead a behaviorist to make correct predictions about the religious behavior of social actors. But a study of the similarities between the "spirit of Calvinism" and the "spirit of capitalism" can be nothing but a "metaphysical formulation." The epithet "metaphysical" is, of course, the "kiss of death" bestowed by physicalists on speculative thinkers.

If ideas do not provide the inner motor of social systems in the process of being created by social action, there must be some way to express beliefs, ideas, philosophies and the like in physicalist terms. This leads Neurath to "imagine a thoroughly empirical 'felicitology' (Felicitologie), on a behavioristic foundation, which could take the place of traditional ethics" (Neurath, 1959:306).

Neurath (1959:306) expresses his clinching argument as follows:

Thus it is permissible to ask whether a certain manner of living yields more or less happiness, since "happiness" can be described wholly behavioristically; it is valid to ask on what depend the demands which masses of men make of one another, what new demands are set, what modes of behavior will emerge in such a situation.

This line of reasoning returns the physicalist full circle to the utilitarian philosophy of Bentham "the greatest good [happiness] for the greatest number". Neurath, however, has a new twist to the formula. In place of the ethical philosopher or politi-

cian as the arbiter and apportioner of this "good" among competing groups and individuals there is a new legitimator. As one might have guessed, he is the behavioral social scientist himself, not because of his superior moral judgment, but because of his scientific ability to define "happiness" operationally. (Baier, 1969:33).

Neurath's imaginings of a behaviorist sociology that is in essence a scientification of utilitarian thought, originally entitled "Soziologie in Physikalismus" first appeared in Erkenntnis in 1931. If Gouldner's (1970, Chapters 2, 3, 4) historical interpretations are correct, sociology has indeed developed in this direction in the past thirty to forty years in both the Western industrial countries and Soviet Russia although their respective definitions of "good" are quite different.

A utilitarian cultural reality was not originally scientifically based in theory. It was rather an historical development that featured an alliance of middle class social groups. Utilitarian values are historically associated with the rise of the middle classes as the practical inventors of technology as art rather than a science and as creators of capital deploying that technology in a never-before-realized system of material goods producing enterprises. In the beginning, the cultural reality of utilitarian ideology was not bypassed as in physicalism, but exalted. Such institutional systems as the economic sector, the political sector, and the legal sector

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were structured by the utilitarian ethic and developed quite independently from the progression of the scientific enterprise.

A utilitarian behavioristic social science in effect consummated the marriage of scientific institutions with other institutional structures in modern technological society. Gouldner (1970:91) sums up this historical phenomenon in the following paragraph:

From its beginnings in nineteenth-century Positivism, sociology was a counterbalance to the requirements of an individualistic utilitarian culture. It emphasized the importance of "social" needs neglected by, and required to resolve the tensions generated by, a society that focused on individual utility. It was a theory to cover what had been left out. The residual had to be added; as some sociologists once said, sociology is an $N + I$ science. In other words, it was a theory of the complementary structures needed to make whole the new utilitarian society. While critical of the deficiencies of the new culture, the aim of Positivist Sociology was thus not to overthrow it but rather to complete it. What was seen to be wrong with society was the defective structure of the totality.

In terms of industrial growth, the scientific institution united with other existing utilitarian-dominated institutions to form a two-tiered structure for operationalizing the notion of the "greatest good for the greatest number." On the first level, scientists in the sense of "rational objective" technologists in both the private and the public sectors can measure and order this "greatest good" using "rigorous models" and other "logical trappings" to confirm their findings.

Gouldner (1970:100) expressed this strategy as follows:

Positivism affirmed the propriety of an amoral response to the social world. It stressed the value of knowledge about society and universalized this moral escape by transforming its amoral method for making social maps into a moral rule.

The social maps or models thus often take the concrete form of benefit-cost analyses, engineering projections, econometric models, technological forecasts, management objective strategies, standard operating procedures, or, simply, government regulations to implement more general directives of the second tier of utilitarian order which are dominated by the less scientific, more traditional centers of utilitarian decision making, e.g., political bodies, boards of directors, executive management, committees, and the like.

It was, historically, the utilitarian connection that brought the scientific community into the fold of the larger utilitarian society and by implication made it a part of the all embracing world view of growth, that commonality of belief which became the unifying force of a world technological society.

If things go wrong as they often do within the total entity, there are enough institutional divisions to enable one special interest group to lay the blame on another: labor on management; private sector enterprises on public sector regulators; consumers on producers; practical policy operationalizers on rational planners; lawmakers on executives; and raw material resource owners on pro-

duction controllers. But all can agree that a more rational, comprehensive, efficient approach will in the end solve the problem.

The benefit-cost analysis paradigm is a classic example of physicalist operationalization of "happiness". It is Neurath's dream come true, although perhaps not as he intended.

First it can be stated in mathematical terms:

$$\frac{\text{Benefit}}{\text{Cost}} = \text{Benefit Cost Ratio}$$

(Cf. Niskahan, 1972; and Layard, 1972).

There is happiness (benefit) but there is also sadness (cost). The greatest good is served if the benefit cost ratio is greater than one. It is true that some groups gain and other groups lose, but a benefit-cost ratio of greater than one signifies societal gain. The basic unit of measure is capital, and capital formation or economic growth is the name of the game. Any project that exhibits a favorable ratio is worthy of construction, and any program or service thus endowed is worthy of delivery. Since capital at hand is more valued than future capital, a discount rate or interest rate is usually introduced to reflect this condition.

As Linstone (1974) notes, this conceptualization of value raises the importance of present events and discounts the importance of future events. Such a conceptualization concentrates consciousness on immediate experience -- i. e., on objects in the present --

in contrast to the information-feedback loop paradigm which focuses attention on dynamic objects. Like the systems dynamics model of a social system, it is a physically oriented perspective of a normative system. The normative system, however, centers around the problem of capital formation as a "how to" problem rather than on capital formation as a phenomenon with possible unintended consequences in a finite physical environment. (Ellul, 1964:226).

The paradigm itself can handle almost any quantity of factual data but its model structure is essentially linear. (Forrester, 1975(b):313). The modeller can manipulate results easily by including or externalizing costs and benefits as he sees fit. The model, therefore, succumbs easily to the value idiosyncracies of the modeller or, more important, the value orientation of his epistemic community or general cultural reality; while simultaneously it is being displayed as an accomplishment of objective and rational analysis. The flaw in this epistemology is illustrated by the fact that environmental concerns are often eliminated from the model as being either too subjective on the one hand or too difficult to measure on the other.

In practice and in response to the Cartesian biases of physicalist scientific communities, it is usually applied to fragments or pieces of systems, to individual projects rather than to systems

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as a whole. Thus larger social systems are often aggregations of projects, each based on benefit-cost analyses that optimize some formulation of capital formation although this formulation need not be exclusively thought of as a private enterprise endeavor. The enterprise may be geared to delivery of social services or the development of weapons systems. The result is a utilitarian social system; except that, the individual competition of Spencer's days has been replaced by a laissez-faire competition by large bureaucratic organizations, public and private, for scarce resources. Open market competition is largely replaced by competition at the planning table.

The present social organization of contemporary technological society based on the duality of control of a utilitarian science and technology in league with utilitarian economic and political institutions can be characterized as a laissez-faire bureaucratic society.

7. The Priority Contest Between World Views of Growth and Equilibrium

Table VI, page 195, summarizes the contrasting disciplinary matrices of growth and equilibrium. The two world views compete on three different levels of institutional reality, (1) within the scientific and technological community, (2) in the economic and

TABLE VI
A DISCIPLINARY MATRIX OF THE IDEOLOGY OF
GROWTH AND THE UTOPIA OF EQUILIBRIUM

<u>PRESUPPOSITIONAL CATEGORY</u>	<u>IDEOLOGY OF GROWTH</u>	<u>UTOPIA OF EQUILIBRIUM</u>
1. BASIC PARADIGM OF WORLD MODELS	<p>The scientific community has not yet achieved a formal world model.</p> <p>a) The "real world" is too complex for such an ambitious undertaking.</p> <p>b) A "data base" for a world model must be assembled, and this would take years.</p> <p>c) More research must first be done on the relationships between subassemblies of such a system.</p> <p>d) The Forrester-Meadows models, challenge fundamental values of world society, and therefore exceed the proper area of investigation of a "value free" science.</p> <p>e) Since the highest societal value is utilitarian, a world model would reflect the increase in total world utility -- which is capital formation. It would be a model with capital as the basic unit of analysis -- an economic or cost-benefit model.</p>	<p>Models of social systems are basically models of societal questions asked by the model maker. There is no such thing as a model of the "real world" unless it would be a model as complex and incomprehensible as the "real world" itself.</p> <p>The information-feedback model is the basic paradigm. It can be used to measure all variables in the system without converting them into a standard unit of analysis such as capital.</p> <p>Since all systems exist within a finite physical environment, the end state of long lasting systems is to achieve homeostasis, that is, adaptive behavior allowing steady state maintenance of critical measures of societal stability.</p>
2. CENTRAL QUESTION OF FOCUS ASKED BY THE MODEL MAKER	<p>The basic world problem is one of economic and political realities -- achieving the "greatest good for the greatest number". Thus the solution lies in completing the functional integration of present economic and political order -- imposing normative order on a physical world.</p>	<p>Since all normative order must be objectified in a physical world, the problem of focus is one of determining the compatability of that normative order with the physical environment. The question of focus, is what is the relationship of man (and his normative order) to his environment.</p>
3. PERCEPTION OF ECONOMIC GROWTH	<p>Economic growth is a societal value and beyond the critique of science.</p>	<p>Growth in any system follows a pattern of development which is the system's life cycle. In the formulative stage growth can be exponential, as positive feedback</p>

TABLE VI (Continued)

PRESUPPOSITIONAL CATEGORY	IDEOLOGY OF GROWTH	UTOPIA OF EQUILIBRIUM
3. PERCEPTION OF ECONOMIC GROWTH (Continued)	Economic growth is a measure of felicity or happiness within a society. The role of science is to measure societal goals objectively and operationally so that the larger societal community can understand how to achieve the goals they determine more efficiently.	<p>loops dominate the system. In a mature system negative feedback loops level out growth tendencies. If these negative loop pressures are restrained by delay mechanisms the system will overgrow and collapse.</p> <p>Present societal values stress the introduction of a number of delays into a mature world in an industrial expansion life cycle. Such delays artificially stimulate growth, and will eventually result in the overgrowth and collapse of the world system.</p>
4. PERCEPTION OF PROGRESS	World society is moving toward increasing functional integration and greater rationality in terms of social systems control.	World societal goals emphasize optimization of all societal subunits to achieve total world system optimization. Such goals are inherently unachievable and will eventually produce an overgrowth and collapse of world society.
5. THE ROLE OF THE POLICY-MAKER AS RATIONAL PLANNER	The science of management is one of developing programs to implement goals set out by "the people". These goals are reflected in laws or other statements of policy determined by political representatives.	<p>The management criteria is that of overall system rationality or substantial rationality as opposed to operational rationality.</p> <p>Systems model makers must critique goal decisions of political representatives, if such goals result in irrational system behavior.</p>
6. THE ROLE OF TECHNOLOGY IN THE WORLD SYSTEM	Technological innovation is a response to economic demand. If the problem is economically important enough, resources will be allocated in sufficient measure to resolve the problem. Technological development, therefore, keeps pace with an industrially expanding society.	A technological solution to a problem involves two elements -- innovation and natural resources. In a young world technological society with its profusion of expendable resources, technological solutions come easily. In a mature technological society with a strained pollution carrying capacity and diminishing easily exploitable resources, the cost of innovation itself will become more and more difficult to justify.
7. TIME PERCEPTION OF REALITY	Those who think in terms of economic models must concentrate on present reality where capital is at its highest premium. Future capital and future events must be discounted. If capital becomes more scarce	Information feedback models focus on the "dynamic object", that is, the change in physical objects effected by a continuous series of messages. The systems dynamics modeller perceives the object-through-time as an entity. A group

TABLE VI (Continued)

<u>PRESUPPOSITIONAL CATEGORY</u>	<u>IDEOLOGY OF GROWTH</u>	<u>UTOPIA OF EQUILIBRIUM</u>
7. TIME PERCEPTION OF REALITY (Continued)	in relation to present needs, then consciousness of the present becomes more intense. Long range planning becomes less important	of these interrelated objects around a nucleus of common purpose represents his gestalt of a social system.
8. HUMANISTIC VALUES	The paradigm structure of economic theories of growth support action that places a higher value on present individual human life as opposed to community survival. Human rewards tend to be perceived in terms of the distribution of material comforts and services.	<p>Group survival or system maintenance supercedes individual survival in terms of human values. The claims of future generations on material resources is at least as valid as those of present generations.</p> <p>Human rewards tend to be perceived in terms of more abstract concepts, such as, group respect, a feeling of solidarity and the like.</p>

political world, and (3) within the communications world where consensus of publics is formed.

This paper is concerned primarily with the clash in ideas, the conflict of "radical" and "normal" groups of the larger scientific and technological community each fighting for the legitimation of his own paradigm. The two contrasting world views seem to fill Kuhn's (1970) notion of incommensurability,¹⁷ theories without a measure or standard of comparison. As already noted in Chapter I, world technological society requires scientific legitimation of its cultural reality.

The second arena of conflict, that of economic and political reality, is that of the world of power. The group with the most resources imposes its will, in the end, on the opposing group. Thus the problem of predicting the outcome of social conflict turns out to be an analysis of the relative resource strengths of the groups in combat.¹⁸

The popular perception of social conflict is one of conflict between specific groups or between classes within a society. Much of the real conflict between growth and equilibrium is thus distorted by public interpretation of reality to this power level. The media portrays and the public perceives conflicts between industrialists and environmentalists, governmental regulators and "open market" producer entities, OPEC oil producing countries and industrial oil

consuming countries.

The third arena is that of public knowledge. The problem here is one of convincing publics of the "correct" set of beliefs in the particular circumstances at hand. The conflict between growth and equilibrium takes place in an additional fourth area of conflict. Since all social systems are objectifications of normative systems, that is objectifications of a particular cultural reality (Berger and Luckman, 1966:18; Parsons, 1949:V), social systems impose their will on the social actors in proportion to the dominant group's success in projecting its normative system into object reality via a physical law like form.

Technologically formed social systems impinge drastically on a natural environment. Such social systems tend to completely externalize the norms of social compliance. This objectification process induces social actors to believe that the cultural values driving the system are immutable in proportion to the perceived immutability of the social system itself. In this situation only technological changes appear to be feasible as opposed to changes in cultural reality.¹⁹

There are limits to the ability of social reality constructions to alter underlying physical structure. The success of technology is based on the technologist's ability to rationalize the social system constructed. Simple linear impacts on an environment can be made

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without too many unintended consequences. As the technological changes become more complex, the chances that decisions made are based on ignorance increases. In the present predominant world view of growth, the highest decisions and value judgments are dictated by economic and political realities, not technological and scientific realities. Thus those of the scientific community charged with carrying out the dictates of the economic and political community are induced, and finally required to take ever larger risks. In this technological climate the scientific and technological community will eventually fail in their assignments, according to the systems dynamics group.

The Forrester-Meadows thesis has continually stressed the probability that the most industrialized countries would be first to feel the effects of the collapse of the "world system". Forrester's (1975) most recent statements call attention to Japan as being in the most precarious position of all the world powers, the United States being a close second.

Denis Goulet (1971) discusses the dilemma less developed countries face in whether to adopt the materialist expansion policies of the more advanced technological societies. In his analysis, advanced technological society is moving from a position of less to more vulnerability as it lives out its development cycle without adaptive changes in its value structure. Less developed countries

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would be well advised to consider different development strategies than those of historical growth.

8. The Systems Dynamics Group and the Problem of Social Values

Some commentators in assessing the M.I. T. group's approach to social systems, have sharply criticized the group's lack of feeling for the urban poor and those in underdeveloped countries. These critics claim the systems dynamics group proposes solutions to problems which are more inhumane than the conditions they set out to correct. Laszlo (1973:17) states, for example:

Since current models tend to concentrate on basic biologic, economic, and ecological factors, disregarding moral, psychological, and cultural dimensions, global reform blueprinted by existing models may turn out to be highly coercive.

Mead (1973:25) notes that:

When Forrester suggests to the World Council of Churches that Christians should abandon any efforts to save the dying, the starving, the victims of earthquakes, and concentrate on long-term effects, this alienates all those who know that any Christian willingness to protect the future must be founded upon Christian precepts to relieve suffering now, and they join those who attack the M.I. T. model, the Club of Rome, and the use of all models, as intrinsically destructive of human values.

Simmons (1973:197) notes the rather chilling inhumanity of Forrester's (1969) urban model:

The implication of that model is that the problem lies with the relative attractiveness of the city to the migrant-

ing poor in need of low rent housing and social services and the relative unattractiveness of the city to prospective immigrating advanced technology industries who do not require untrained labor but instead require cheap land and a healthy industrial climate. The solution is to discontinue social services and tear down slum housing for future industrial use. Some have found Forrester's quantified model parameters of "attractiveness" simply a euphanism for "kick the blacks, Puerto Ricans and Chicanos out . . ."

With eighty percent of the world population represented by poor-rural-nonwhites, one wonders what would happen to them as a consequence of their being locked in the value structure of the urban model expanded to a world model and being faced with an advancing agricultural technology too. Where does a rural poor person go in a totally urban world?

The M. I. T. systems dynamics group tends to avoid discussion of the crucial linkage between solutions to social systems problems and their impact on concrete social groups outside of the critical production group that maintains technological society. This leads them to three profound fallacies in their own world view:

1. enforcing a new solution
2. defining social system deficiencies as problems of rational analysis
3. the multiplicity of social systems and the unity of cultural reality.

In the first case, that of enforcement, once the M. I. T. group has

defined the problem as one of "breaking the cognitive code" to how a social system works, then they become the scientific physicalist elite who can establish morality by reason of being able to measure felicity. Historically this had led to various forms of authoritarian social order.

Hardin (1968:261) explains:

Coercion is a dirty word to most liberals now, but it need not forever be so. As with the four-letter words, its dirtiness can be cleansed away by exposure to the light; by saying it over and over without apology or embarrassment. To many, the word coercion implies arbitrary demands of distant and irresponsible bureaucrats; but this is not a necessary part of its meaning. The only kind of coercion I recommend is mutual coercion, mutually agreed upon by the majority of the people affected.
(Italics added)

The difficulty arises in that world technological society is not controlled by "the majority of people affected". It is controlled by coalitions of producer-managers and skilled-worker elites intent on preserving the existing value structure. It is not that coercion in itself is a dirty word but that the present "coercers" are not likely to coerce society into a new value structure that will work to the detriment of those in power and to the benefit of those out of power.

More likely, present in-power coercers will select the population overgrowth theory of the Forrester-Meadows model as valid and reject their theories of economic equilibrium. In such a world, overpopulation can best be explained as the useless overcapacity in

the human sector caused by an evermore advancing automated technology. The central societal problem then becomes "the disposal and control of 'useless' men and useless traits." (Gouldner, 1970:76).

Advancing technological society has always described itself as "humanistic". Hardin's (1971:296) definition of humans as "fortunate civilized minorities" appeals to present power elite:

Every day we [Americans] are a smaller minority. We are increasing at only one per cent a year; the rest of the world increases twice as fast. By the year 2000, one person in twenty-four will be an American: in one hundred years only one in forty-six. . . . If the world is one great commons, in which all food is shared equally, then we are lost. Those who breed faster will replace the rest. . . . In the absence of breeding control a policy of "one mouth one meal" ultimately produces one totally miserable world. In a less than perfect world, the allocation of rights based on territory must be defended if a ruinous breeding race is to be avoided. It is unlikely that civilization and dignity can survive everywhere; but better in a few places than in none. Fortunate minorities must act as the trustees of a civilization that is threatened by uninformed good intentions.

The second fallacy of the M. I. T. group theory is that of assuming the solution to social system problems is one of rational analysis -- better understanding and communication between social actors. Laue and Cormack (1975) cite the difference between two approaches to group conflict and its mediation. The communication model assumes that the root of the dispute between social groups lies in the misunderstanding of each one's point of view. The

mediator's problem, then, is to interpret and integrate each perspective to the other and thus reach a common rationality. Such a model visualizes a rational technological solution to the specific problem at hand. The belief is that the greater the communication, the quicker the solution. The conflict model presupposes some basic understanding of each position by the other. The question of conflict is the distribution of scarce resources (material resources, capital, power, status) among competing groups. It is the problem of triage in battlefield surgery. In this case, the greater the communication and understanding between competing groups, the greater the conflict.

Forrester's (1968:1-2) program of systems dynamics research, from the beginning, was a search for social system structure that would bring understanding and, therefore, order to social systems. The Forrester-Meadows models continue that thrust for final order in an otherwise irrational world. To surmise precisely what Forrester's or Meadow's or the systems dynamics group's thinking is at the present on this point is difficult. The models, however, clearly indicate some survivors of a world population overgrowth and collapse. The survivors, whoever they are, will look back at their "heroic ordeal" and view it as a triumph of "progress".

The third and final fallacy in the Forrester-Meadows approach

to world systems regards the multiplicity of social systems and the essential unity of world cultural reality. The relationship of world technological society to its physical environment may indeed be an overriding contemporary problem, but it is far from the only one. For centuries, world scale social problems have erupted in some corner of the world and moved slowly across its geographical and historical surface. Most of these world problems have as their central theme the conflict over some aspect of the concept of "capital". Moore (1966) for example, chronicles the beginning of the industrialization of agriculture in seventeenth-century England and the evolution of this industrialization process from country to country over the succeeding centuries. This industrialization process "drove off" or "liberated from" the land, the peasants that were to become the actors in the next process, the urban industrial revolution. In the agricultural revolution, land as an eternal finite physical entity and responsibility of the landed aristocracy became simply one of the factors in the production equation that resulted in ever expanding capital formation. The urban, industrial revolution provided a mechanism through which the surplus, landed populations found either freedom (Simmel, 1969:55) as members of the middle class, or slavery to the newly invented technologies of the first capital-intensive industries that had nothing to do with land as part of the production equation. This gave

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rise to the Marxian question of public versus private ownership of capital.

In the early twentieth-century revolution came automated machinery, Wiener's cybernetic revolution. The laborer who had once been a slave to the machine became superfluous, but skilled workers who remained to tend and maintain it, became even more powerful. Whereas machinery was once at the center of power in the urban-industrial revolution, now knowledge, technological knowledge, is the key to control. Capital is now identified with technological ideas, their ownership and control. Each of these revolutions is like a play that comes onto the world stage but somehow remains unfinished before the next one starts.

The most recent world problem, that of economic growth, must first gain its rightful place front stage center. In the eyes of the scientific community, it is fast achieving that position. With all the Forrester-Meadows model's faults and resulting critiques, Forrester and Meadows and the M.I.T. systems dynamics group have done much to involve the scientific community in the overriding problem of economic growth. The solution they may ultimately achieve will more than likely go beyond the narrow bounds of what Kuhn referred to as "scientific theory". It will more than likely involve the disciplinary matrix of science practitioners as a total entity.

The physicalist position of a unity of the sciences with a capital "S" has faded into Kuhn's multiplicity of paradigmatic realities, but the basic program of science based on the experience of object reality has remained intact. If a universal science recedes as a theoretical possibility, a universal scientific community emerges more as an empirical social necessity. The thesis of Limits to Growth and the vision of the model builders themselves is that world society must somehow work as an ordered whole in a finite physical world.

Wiener believed that Leibnitz was more than any of the older philosophers the father of the contemporary scientific philosophy of a multiplicity of possible realities. He was the inventor of the doctrine of many possible worlds (Russell, 1945:589). But as Wiener (1965:109) also noted, Leibnitz was a moral coward, and for the Queen of Prussia he invented the doctrine of the "best of all possible worlds". Voltaire in Candide was compelled to counter the Panglossian utopia with a depiction of the world as the worst of all possible worlds. It may be that Leibnitz, the coward, in his private memoirs which he was afraid to publish, (Russell, 1945:591), hit on the true nature of the case. God is neither entirely good nor entirely evil; instead he is a humorist. Rather than create the best possible world or the worst, he created all possible worlds and left man to fit them together into some meaningful order.

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CHAPTER V ENDNOTES

1. Mannheim's doctoral thesis, Structural Analysis of Epistemology, was first published in Kantstudien, supplementary volume 57, Berlin, 1922. In it he treats the knowledge structures themselves as systems of specialized knowledge developed over historical time. Epistemology and the history of the knowledge developers who produce a particular epistemology are in his approach inextricably bound together. His doctoral thesis focuses on the knowledge systems themselves and not the thinkers. This chapter draws extensively on Mannheim's structural analysis methodology.

His more renown Ideology and Utopia, first published in 1929, concentrates on the historical groups themselves, but the epistemic methodology of his earlier work still permeates the later work.

2. As quoted in Chapter I, Quine (1966:1) explains a paradox as ". . . the absurdity of a buried premise or of some preconception previously reckoned as central to physical theory, to mathematics or to the thinking process." A social paradox would then be such a previously reckoned preconception of social theory.

3. Wilson (1973:127) goes on to state: "Today we are finding it more useful to postulate the coexistence of all three, and forego the futility of trying to reduce any two to the third." This postulate of coexistence is in harmony with the notion of a multiplicity of realities, a position fundamental to sociology of knowledge.

Wilson implies in his typology that physical systems and normative systems are deterministic rather than probabilistic. Systems theorists such as Bertalanffy, Wiener and Forrester have instead considered all systems as either open (probabilistic) or closed (deterministic) depending primarily on the system model-makers' explicit assumptions rather than any inherent "nature" of the system itself.

4. Skolimowski does not define "normative model" but one can infer that it is a system of action whereby the actors are governed by a common set of rules of conduct. Sociological definitions such as those of Kolb (1964:473) and Wickman (1974:199) emphasize the external nature of social norms. Thus the actor perceives the norms as realities which every person of "normal mind" (Black, 1968:1208) would follow. The actor could also be genetically programmed, as Skolimowski suggests, by relating

the normative model to norms of survival, a characteristic of every living organism.

The notion of a normative system goes beyond the class of models that would be defined as social or genetic and includes the general case. Ethical systems are also normative systems.

Farber (1962:108) in discussing Husserl's logical explanations, notes:

The totality of all norms constitutes a closed group that is determined by the fundamental value. A normative proposition which requires of a class of objects that they satisfy as much as possible the characters that constitute the positive predicate of value is called a basic norm. The categorical imperative is the basic norm in the group of normative propositions which makes up Kant's ethics: the same is true of the principle of the greatest good of the greatest number in the ethics of the Utilitarians.

It must be concluded that any structure which is organized from the top down -- that is, starts from a categorical imperative or basic norm and proceeds down the hierarchy -- to programmatic strategies and themes to action.

Parsons (1966:18) draws a distinction between values which are the primary connecting element between social and cultural systems, and norms, which are rules, procedures, customs and laws that determine action within a social system.

5. Mannheim (1953:26) distinguishes between categorical imperatives, which are epistemic rules that must exist or the natural order of the system would be destroyed; and necessary presuppositions, which are conventions agreed upon by the systems formers in order to make the knowledge system explicit. He prefers to think of epistemic structure as of this later "taken for granted" form.

6. Mannheim (1953:58) notes:

Every epistemological systematization is based upon this triad (object, knowledge system and subject), and every conceivable formulation of the problem of knowledge is given by these three terms in some combination (provided it is logically meaningful).

7. Both Berger and Luckman (1966:117) and Holzner (1968:86) discuss the social distribution of knowledge.

8. Mannheim (1953:55) borrows the term de-subjectifica-

tion from Herman Lotze.

9. Berger and Luckman (1965:60) stated:

The process by which the externalized products of human activity attain the character of objectivity is objectification. The institutional world is objectivated human activity, and so is every single institution. In other words, despite the objectivity that marks the social world in human experience, it does not thereby acquire an ontological status apart from the human activity that produced it.

10. Holzner's (1968:72-73) concepts of "orientational structure" and "situational structure" are identical to the concepts of "normative structure" and "physical structure" used in this paper. In each conceptual pair the perspective of the observer determines the form of the structure. In both cases there is a presumption of changelessness in cultural structure. The term "normative structure" of reality constructors is intended to fit Wilson's (1970:60) definition of "normative paradigm". The final perspective, that of the "reflexive subject," is comparable to Wilson's (1970:66) concept "interpretive paradigm," the situation where cultural reality itself is open to change.

11. Garfinkel does not relate this assumption of reflexivity specifically to physicalism, but rather considers it a general everyday life approach to social action. The concept undoubtedly has roots in Husserl's (1931) critique of the "naive conception of the world", which was itself a critique of physicalism.

Mannheim (1953:45) uses the term "natural" approach to the world to describe the same world view:

An attitude directed at the objects as such. To such a mind the universe would present itself as a uniquely determined context where everything has its proper place -- it would then be literally inconceivable that anything might perhaps be different.

12. William F. Ogburn (Becker, 1971:28) expresses a similar sentiment in his presidential address before the American Sociological Association.

13. The World 3 model assumes that all world resources are a single entity and therefore can be represented by one model level. This aggregate total is graphed as declining at the rate of 2% per year. Aggregate resource depletion is predicted on the

basis of the fact that world reserve indexes on most strategic items would indicate depletion in the next 50 to 100 years. (Meadows et al., 1972). The counter-argument of Boyd (1972), Cole et al. (1973), and Oerlemans et al. (1972), is that resources are never discovered too far in the future because exploration costs for resources of long term future use could not be economically justified.

Bell (1973:464) states the case as follows:

The ecological models take the physical finiteness of the earth as the ultimate bound, but this is fundamentally misleading. Resources are properly measured in economic, not physical terms. (Cf. Barnett and Morse, 1963).

14. Gouldner (1970:141) gives a brief historical account of Parsons' theoretical position against the background of the depression of the 1930's. Parsons' position was a response to the failure of utilitarian liberalism to establish world order out of laissez faire economic competition.

15. Parsons has not commented publicly on Limits to Growth or the Forrester-Meadows models. There is no way to know what his position would be on the issue as a substantive issue. The argument presented herein is that technologists and social theorists have used a notion of "manifest destiny" to support their positions. Whether these ideas were transmitted directly from Parsons or not is immaterial. World views are communicated in a multitude of ways and forms.

Parsons (1966:21) sets out a paradigm of evolutionary change that apparently is valid for all societies. Societies according to this paradigm strive for the "enhancement of adaptive capacity" by continually changing social structure in the direction of from less to more adaptive. This social change is accomplished by two basic processes, differentiation and diffusion. Differentiation (Parsons, 1966:22) moves social structure from simpler to more complex forms, while at the same time increasing its adaptive capacity to perform the primary function for which the particular structure was intended. Diffusion (1966:26) is a cultural phenomenon which accompanies differentiation. The knowledge necessary to direct the system differentiation tends to move from the more specific to the more general. Knowledge transmission likewise moves from direct lines of communication to "broadcasting." Both this content and transmission factor work together to increase the "quantity" of knowledge within the total society. This increasing reservoir of knowledge, according to Parsonian theory,

is not independent of social system evolution, but rather is the foundation of such evolution.

Parsons and Platt (1973:305) pursue further the parallel structure of knowledge increase and money and credit increase in a total societal system. Such an evolutionary paradigm with knowledge (increasing rationality) and money and credit (increasing capital) leads one to infer the kind of deterministic evolutionary structure which we call "manifest destiny".

16. Although behaviorist assumptions may indeed lay the foundations for contemporary legitimations of the growth ethic, Neurath (1959:315) as a social critic viewed unending economic progress as naive and untenable.

17. Mannheim in his doctoral thesis (1953:48) first posed the problem of dominance between competing "theories of knowledge" as he called them. Mannheim compared three theories of knowledge, that of psychologism, logic and ontology. He considered each to be in historical competition at the time of his dissertation (about 1922). Psychologism and physicalism were much the same by his definition. Both stress knowledge or truth as an outcome of observation of the spatial temporal world. Both avoid judgments based on other than empirical data. Such a knowledge objectifies the measurement of social values. (Mannheim, 1953: 52).

Friedrichs (1970:1-10) gives a synopsis of the process of a revolution in social theories. His review condenses Kuhn's more detailed account of that process.

18. Berger and Luckman (1966:109) discuss the social link between the confrontation of ideologies as a theoretical problem and a problem of power.

19. Heilbroner (1972:150) apparently agrees with the Limits to Growth thesis that zero population growth and zero economic growth would be desirable world goals. He concludes however: "... that the imposition of such a program is far beyond our existing social and political capabilities."

EPILOGUE

In Chapter I the basic hypothesis of sociology of knowledge as it applies to this work was stated as follows:

Cognatively rational theories about how social systems work are inevitably founded on presuppositions which are value judgments of the theorist as advocate of a social group with whose destiny he identifies and whose ongoing experiences he shares.

Thus, world models are legitimations of world views or belief structures of the modeller. The Forrester-Meadows models are no exception. Such models assert the value of economic equilibrium as a means of achieving long term world society adaptation to changing environmental realities. Values must eventually relate to concrete people, not merely abstractions. Therefore, what the Forrester-Meadows models are saying is that the long term interests of the great masses of people living in the twenty-first century and beyond are best served by a policy that would end economic growth and further capital accumulation as dominant societal values and substitute instead, societal goals which emphasize a balance between carrying capacity of the physical world and the needs of the populations that must be supported by this carrying capacity.

Such a reduction of the Forrester-Meadows models sounds

somehow like a debunking or unmasking of what was originally a scientific enterprise and an exposure of hidden overriding value judgments that drive the modeller to foreordained conclusions.

An unmasking critique of Limits to Growth is not intended. A careful reading of Limits to Growth itself should convince the reviewer that the group believes all concretely existing social systems are built around a nucleus of values reflecting the world views of existing society. Forrester calls this nucleus of values the mental models of policymakers.

Policymakers imbued with the ideology of growth think and perceive in pragmatic paradigms. Justification of planning is confirmed by results of those plans. Such an ideology is future oriented, but the overall societal goal is irrevocably locked on exponential economic growth. Because this goal is beyond rational criticism, one can only agree or disagree. Any social system modelled around this goal is in actuality a closed deterministic system.

The ideology of growth allows a vision of industrial expansion in parallel with a rise in material standard of living of the general population. Those individuals whose futures are tied to industrial expansion, be they corporation presidents or stockholders intent on exponential growth of profits in a private capital society or communist planners intent on expanding the power base of their centralized economy, can expect a future of "more". These are representa-

tives of the conservative phalanx of the ideology of growth.

On the other hand, the liberal elements of the ideology of growth focus on expansion of material standards of living of both the producers and the so-called socially dependent. Economic growth is the cement of social cohesion that binds conservative and liberal perspectives together.

The scientific and technological community is cast in the role of technology producer, the architect and engineer of future expansion subject to the superordinate authority of political and economic policymakers.

The ideology of growth postulates for a utopian scenario consisting of a unified world economic system in which political entities are so interdependent that economic reality dictates a kind of forced cooperation. Such a planned future is not in itself evil. The problem is that persons holding these singleminded values overlook realities that do not show up in their particular field of vision.

The process of economic development literally and physically projects its social institutions on to and into the "real" world. Thus, the world economic system becomes reified and deified until it achieves the perceptive stature of physical law. Those perceiving this law lose consciousness of the historical origin of its social construction. The world economic system becomes the reality of the everyday world. At this later state of objectification of this

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socially derived law one need not internalize the norms of the ideology of growth to lead a life in accordance with its precepts.

An actor may be disenchanted or estranged from notions of progress and technological achievement. Feelings of anomie are more often found among technological elites rather than among worker producers or the economically dependent, yet the actions of the uncommitted become entrained to the objectification of the economic process in much the same manner as "true believers" in the ideology of growth.

Since those that are the "true believers" in the ideology of growth form a coalition of both conservatives and liberals, each wing has its own distinct perception of his adversaries on the issue of economic development. Conservatives in the so-called "developed, free world countries" often perceive their adversaries as radicals from the left who have lost faith in free enterprise.

Liberal elements of the ideology of growth, for example the Sussex group that critique Limits to Growth in Models of Doom, perceive the equilibrium utopians as right wing technologists ready to shut down the hard-won material gains of the masses and cut off their chances for future progress. There is much in Forrester's writings to document a case supporting the Sussex group's argument, particularly in Forrester's urban model and in his article "Churches at the Transition between Growth and World Equilibrium" (1972).

Members of the M.I. T. systems dynamics group believe that a world equilibrium economy is closely associated with humanitarian and egalitarian values. Sen (1969), Shaw (1970), Critchfield (1971), and Randers and Donnella Meadows (1973:334) have all studied the "green revolution" and third world peasant farmers. In Chapter V, we noted that this facet of the industrialization process has been, according to Moore (1966), the leading edge of the industrial revolution for the past three hundred years. Mechanization of agriculture results in the eventual "crowding out" or pushing off the land of the traditional peasant farmer whose methods and prices cannot compete with the new technology. Migration of the rural poor to urban centers has been a world phenomena. For instance, in the United States thirteen million persons migrated from farms to cities between 1950 and 1970 (Ford Foundation, 1974:93). In this country and in most developed countries the migration process itself is in the advanced stages, if it has not already been completed. In the third world countries the process has just begun.

The most ominous implication of the Limits to Growth thesis is precisely this world population shift from rural to urban occupations under the pressure of the green revolution as world technological society reaches the end of its growth-of-employment phase. What worked during the period of the eighteenth to the twentieth centuries in the developed countries may very well not work in the

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underdeveloped countries in the late twentieth and the twenty-first centuries. These migrants will be caught in the double bind of advancing agricultural technology on the one hand and automating industrial technology on the other, and will be "crowded out" of twenty-first century world technological society (cf. Goulet, 1971).

Wiener, writing in the 1940's foresaw this end result of the second industrial revolution, but leading to the American urban poor and middle-management people being declared surplus to the needs of automated society. So far, most advanced, industrialized countries have managed to counteract economic pressure of a shrinking industrial work force with expanding services and social programs funded to a large extent by state subsidies. As resources become more scarce capital demands for new resources development intensify. There is a "crowding out" of services capital, if one wishes to use money as the unit of analysis of the social system, and there is a "crowding out" of people for those who are concerned with people (Ford Foundation Report, 1974:85).

One way of visualizing this "crowding out" effect is to conceptualize world population as divided into two groups. Assume arbitrarily that eight-tenths of the world population consists of an ideal type called the biologic person. This group is representative of rural-traditional and marginal-farmer populations, unskilled urban populations, and the economic dependents of all types who are

isolated from institutional ties with producing society. This category of persons is an economic liability insofar as the efficiency and smooth operation of world technological society is concerned. The second type, the technological person, consists of necessary producers for world technological society. This class also includes dependents of the producer linked to him by family ties or other institutional mechanisms. Such a dichotomy consists of groupings by work requirements of world society.

Assume, further, that the biologic person expands at a 2% growth rate, reflecting the measure of biological reproduction at present historical growth rates. In contrast, the technological person expands at 6%, reflecting an aggregate historical growth rate of capital expansion and thus population consumption patterns of populations tied into technological development. Graph II indicates that by the 35th year from the base year the annual consumption needs of the technological person would surpass those of the biologic person in a finite world of resources.

This graph suggests that the only option open to the world technological person, given the fact that it is still committed to the ideology of growth, is to maintain its historic growth rate by forcing a concomittant negative growth rate on the biologic person. This becomes the final solution in the twilight of the life cycle of a growth-oriented world technological society.

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10⁰
8⁰
7⁰

GRAPH II

RELATIVE RESOURCE
CONSUMPTION OF TECHNOLOGICAL
PERSON AND BIOLOGIC PERSON5⁰4⁰3⁰2⁰1⁰

.9

.8

.7

.6

.5

.4

.3

.2

RESOURCE CONSUMPTION

BIOLOGIC

TECHNICOLOGICAL PERSON

6% GROWTH RATE

PERSON 2% GROWTH RATE

SEMI-LOG GRAPH

0

20

40

60

80

TIME IN YEARS

The utopians of equilibrium either see this kind of conflict as inevitable or do not wish to take the risk of its occurrence. They share an egalitarian and humanistic idealism that points to the end of economic growth now and implies some kind of redistribution of world resources in the future.

The following from Meadows et al. (1972:178) summarizes this perspective:

One of the most commonly accepted myths in our present society is the promise that a continuation of our present patterns of growth will lead to human equality. We have demonstrated in various parts of this book that present patterns of population and capital growth are actually increasing the gap between the rich and the poor on a world-wide basis, and that the ultimate result of a continued attempt to grow according to the present pattern will be a disastrous collapse.

Some final remarks about the world model are in order. The model itself is not, nor can it ever be, a model of total societal reality. The model is a response to a question asked by the modeler. The question is, what is the relationship of world technological society to its physical environment? The model as a social system becomes a global environmental impact statement.

Because the model asks a different question about the real world than the mental models of global growth-oriented society asks, it presents a totally different and disjointed social reality. Those whose interpretation of world reality is limited to an economic development model find the Limits to Growth perception unreal and incom-

prehensible. Those who insist that social systems models must copy the real world find the Forrester-Meadows model simplistic. To circumvent the one world model format Mesarovic and Pestel (1974) have disaggregated the model into ten discrete geographic regions. This gives their model an element of geographic realism lacking in the more abstract Forrester-Meadows models. Such disaggregation does not necessarily make the model "better" or "more exact". The model does answer different questions, perhaps questions some critics searched for in the Forrester-Meadows models but did not find.

Those who believe that eventually some world model can be developed to approximate the real world will clamor for new generations of models, each more elaborate and sophisticated than the last -- and more incomprehensible. This is the way a technology is supposed to grow, even a technology of world modelling.

The law of parsimony is a more valid norm of science. The real world itself is divided into a multiplicity of disparate realities. The problem of integration is not one of modelling technique but of community consensus and conflict.

Finally, the greatest deficiency in the total Limits to Growth thesis considered as a theory of social change, is its lack of understanding of the strategy of accomplishing real world institutional changes. The M. I. T. systems dynamics group either avoids the

mundane problems of political strategies or thinks of social change in terms of "enlightenment" of the scientific community and present rational planners. As the analysis of epistemology in Chapter V disclosed, the M.I.T. systems dynamics group shows a distinct tendency in their model explanations to consider resolutions of problems as rational solutions to objective social system structure design rather than as value solutions to problems in the world of belief systems, a distinctly different cultural reality. This criticism is a valid one of Limits to Growth and Forrester's Urban Dynamics and World Dynamics. On the other hand one of Forrester's recent statements¹ suggests an increased awareness of the ultimate importance of values in the decision making process. He asserts that world policymakers could probably successfully find technological solutions which allow survival of world society based on the overriding value of exponential capital formation. The questions Forrester now asks are, would this be wise? Is this the kind of society that future generations of human beings would want to live in?

Mesarovic and Pestel (1974:11) argue that past major world crises had:

negative origins: they were caused by evil intentions of aggressive rulers or governments, or by national disasters regarded as evil according to human values -- plagues, floods, earthquakes, and so on.

This crisis, the crisis of undifferentiated world growth as they call it, they claim stems from man's best intentions, his desire to reduce labor by exploiting non-human energy sources, to have children, to conquer disease, to construct large projects for man's benefit. It is the "imposition of man's design on the natural environment for man's own good -- . . . man's way of 'taming' Nature; . . . " that leads to his downfall.

To many, the "progress" of advancing world technological society has always carried with it the seeds of its own destruction. A roll call of the critics would be endless, but would start with such names as J. J. Rousseau and Karl Marx and would continue through Wilhelm Dilthey, the German historicists, and Heinrich Rickert, the neo-Kantian. The maverick thinker, Oswald Spengler, predicted the eventual demise of materialist world society. The phenomenologists Edmund Husserl and Max Scheler and the latter day existentialists Camus, Heidegger and Sartre differed with generally held contemporary world views. In terms of sociology such writers as Ferdinand Tönnies, Max Weber, Karl Mannheim, Albion Small, Jacques Ellul, David Riesman, Georges Gurvitch and Alvin Gouldner represent only a few of the many critics of what has been variously called *gesellschaft*, urbanization, mass society, and technological society. Such popular contemporary writers as Fritz Perls, Paul Goodwin, Charles Reich or Walter Dill Scott may be included on the list.

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The environmentalists Rachael Carson, Paul Erlich, and Barry Commoner also bear mention. Each one of these and still others have developed disenchantment with the historical thrust of world society. At first glance perhaps the only quality that persons on such a disparate list have in common is their dissent.

Wiener, Forrester, Meadows and the M.I.T. systems dynamics group can be distinguished from other dissenters in that they are technological insiders. They are simultaneously technology developers and critics. This capacity to alternate in each role signals a certain change in thought process seldom found in historical periods, although Georges Sorel, the nineteenth century French syndicalist, seems to fit the pattern. Before becoming a revolutionary theorist, he was director of the French national railroad system at a time when this position was the most prestigious in France for a member of the engineering profession.

On closer examination, there are more specific ties that bind these dissidents together. Somewhere, in each of these critics, there is a common theme of the evil of the unholy union of science, technology and economics, the dominant social institutions of the contemporary world society.

Ernest Becker (1971), discussing the life of Albion Small, one of the founders of American sociology, asks and answers the question that leads to the common thread in much of the criticism

of present society. He asks, how economics in America became a science. He answers that it occurred because economists presupposed an abstraction, "economic man", acquisitive, searching for ever increasing material wealth, manipulating his environment with new technologies in order to achieve that wealth. Further they postulated a social system based on the goals of "economic man". Economics then became a science of the techniques required to make this social system work efficiently.

In contrast, Small proposed sociology as a science which began by asking the question: what is man as a living human being? Small replied: let us find out what and who man is; then we, as sociologists, will devise social systems to best serve his concrete needs.

Becker (1971:8) argues that with this notion, sociology has become "the lost science of man." It was a failure because there was no "living man" with needs of his own. Instead man has proven to be all too malleable, a servant of the system rather than its master.

The thesis of the M. I. T. systems dynamics group and the environmental movement as a whole for that matter, is one which picks up from a failing humanistic sociology. Concrete, humanistic man did not have the power to dethrone abstract "economic man", but the environment does. Their thesis is that physical law will in

the end triumph over economic law. But will it? The question is, at the end of economic overgrowth and collapse, who will survive? It may yet be economic man, existing in an ever-shrinking physical wealth, but still in control.

Marx, in his strategy of social change, called for elevating the consciousness of those that in his time had the potential to seize control of the means of production, the workers. In contemporary, automated society, production workers have become a part of the dominant productive class. Their everyday experience is not one of deprivation. Scientists and technologists may indeed control the only institutions that place them in positions of power and at once put them at arm's length from the ideology of that power structure. Their paradigms allow them to perceive dynamic objects, long range technological change over time. Much of the struggle going on between the growth orientation and the equilibrium orientation is within the community of science and technology.

If there is a special insight to be gained from this paper on how members of scientific epistemic communities concomitantly develop and theorize about social systems that affect their personal lives, and their group fate, it is just that. It is not their rational theories that hold them together but rather their common set of values and their particular way of perceiving the world through their paradigms. Those ignorant of the communal nature of science fall

into the technological trap of searching for ever-increasing sophistication of theoretical position. The competition of such a search fragments the scientific community and makes it easy prey to those who exploit science and technology to play the role of servant to technological society.

Martindale (1960:541) has observed that social theorists usually approach theory

. . . in terms of the distinctive features of the theory rather than from the standpoint of the humble platform of basic agreement.

The scientific community itself should and must think in terms of imperative sentences as well as descriptive ones. This mode of expression has its own truth value. Following Mesarovic and Pestel, the goal of functional interdependence and organic growth as opposed to undifferentiated growth might best and first apply to the community of science and technology itself.

EPILOGUE ENDNOTES

¹Forrester's statement made at the June 3, 1975, World Future Society Plenary session.

KEY TO BIBLIOGRAPHY

The bibliography is divided into six sections to indicate how the reference material was used in preparing this paper.

Section

1. Theoretical and Methodological Foundations
2. Supporting Theoretical and Methodological Foundations or Used as a Definition Reference Only
3. Works of the M.I.T. Systems Dynamics Group including Wiener's Writings on Cybernetics
4. Review of Limits to Growth or Systems Dynamics Used in Citations
5. Articles in Technical Journals on Systems Dynamics Modelling
6. Other Relevant Works

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