

SCIENCE, TECHNOLOGY  
AND  
SOCIETY  
(A System Study)

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## INTRODUCTION

The impact of science and technology of modern human society is undeniable. The advances of empirical knowledge and its social applications have changed dramatically mankind's way of life. This change has brought about great benefits for people, but at the same time has created grave problems, both for individuals and collectives.

Whether they are looked upon as positive or negative forces, science and technology cannot be ignored as agents of social change. The relationship between these forces and human life has therefore become the critical link in understanding how contemporary society works. With such understanding, we are better able to adjust and control the complex mechanism we have created.

This study is a preliminary step in this direction. It tries to look upon the whole picture resulting from the interplay of science, technology, society and humanity. As such, of course it sacrifices detail to generality on the grounds that depth can always be provided after the broad lines have been drawn. For this reason, we have chosen to outline the overall characteristics and behaviour of modern society, and leave their specific applications in particular cases to other studies.

The presentation which follows sketches the most significant elements concerning the intricate relations and interactions among various factors. In order to clarify this highly complex content, we are going to utilize the systems theory-method, which we find the best for such purpose. As will become evident presently, each chapter of this essay analyses one aspect of the social system until the end when a synthesis and evaluation concludes the whole study.

SYSTEM

We begin this study with a brief outline of the systems method, which should give an overall picture of how we plan to treat the subject matter.

As is well known, systems theory looks at reality as a complex of interdependent parts. In order to study any aspect of reality, the systems theorist must distinguish those parts which are central to his concensus, those which are of peripheral interest and finally the rest of reality which cannot be taken into account at all.

Evidently, the central themes of the study form the system and the peripheral elements the environment. This basic dichotomy determines the focus of the research and delineates its parameters. As a first approximation, the "system" may be defined to be a number of inter-related elements. If the system is "dynamic", its elements interact and if it is "open", it also interacts with elements of its surrounding environment, thus having "inputs" and "outputs".

Accordingly the minimal requirements for a system are:- 1) at least two elements and 2) one connection between them. These two requirements form the structure of the system, i.e. its persisting characteristics. Beyond that, some systems also exhibit a degree of activity, i.e. behavioral characteristics. Thus in addition to the relatively static structure, they manifest dynamic action and useful function. In that case, they perform an operation which converts inputs into outputs, thus playing the role of a transformer.

The kind of system that we are dealing with here shows all these characteristics. Seen as a system, society is composed of many and disparate elements, surrounded by the natural environment. The structural elements of the social system are the people and their institutions.

It is they who determine the functioning of the system within the natural constraints imposed upon it from the outside.

The structural and functional categories of the system are clearly differentiated in the matrix below. This dichotomous differentiation serves as the first criterion to distinguish between social actors and their actions, or between the relatively constant and variable factors of the system.

The other dichotomy of the matrix serves as the criterion of salience which identifies the focus or locus of social activity. The former are the centres of high energy, whereas the latter are the channels that transmit this energy among the various centres. The nodes of social activity coincide with the concentration of institutions and the roles which they play in the system, whereas the ties connecting these nodes set the interrelations and guide the interactions between them.

Cross-cutting each other, the above two criteria form the vertical and horizontal dimensions of our matrix, producing four (2x2) mixed types of elements: actors, actions, relations, and interactions. The bulk of this paper will be devoted to elucidating these four concepts. The four chapters following will, therefore treat each one in turn.

SYSTEM MATRIX

SALIENCE ELEMENT	<u>FOCUS</u>	<u>LOCUS</u>
	CENTERS	CHANNELS
<u>STRUCTURE</u> STATICS	ACTORS (UNITS)	RELATIONS (TIES)
<u>FUNCTION</u> DYNAMICS	ACTIONS (ROLES)	INTERACTIONS (FLOWS)

PRINCIPAL COMPONENTS

~~A~~  
II '84

## ACTIONS

As an open, dynamic and functional system, society must have certain inputs, outputs and feedback. The inputs provide the system with the necessary materials and energy to maintain its structure and carry out its functions. The outputs are the surplus products, by-products and refuse which society exports to other systems or rejects into the environment. Finally the feedback is the information or reaction which comes back into the system as a result of its own actions

In order to perform these three indispensable functions, the social system has developed the structures which will be mentioned in the next chapter. To begin with, there are the economic functions which extract from nature or import from other systems, material and energy resources to fulfill the needs of society. Insofar as it is able to do so, the economy transforms raw materials into goods and energy into services, which it then exchanges and distributes to the system.

Most of the products of the economy are consumed by the cultural sub-system of society. That is to say, they serve to feed, house, clothe and move people. By fulfilling these basic human needs, the economy provides the culture with the infrastructure upon which human desires can be manifested and implemented. By consuming the products of the economy, the system's cultural sector can help people communicate, create, play and develop their potential.

In addition to the production and consumption function of society, a third requisite of the system is regulation. Feedback systems are self-regulating because they can adjust their behaviour to optimize their functions. To do so, they must have a cybernetic mechanism which can govern their inputs and outputs. This mechanism is in effect the political sub-system of society.

Governing a complex social system is not an easy matter, so it is done with various degrees of efficiency and efficacy. Collective decision-making and conflict-resolution takes a lot of time and energy, thus the political process absorbs an increasing amount of social resources. The development of science and technology has contributed to the problems of government by making society a much more sophisticated and delicate system.

The scientific revolution and its dramatic applications in everyday life even within the present generation has changed the face of society and affected all aspects of human behavior. More specifically, science and technology has transformed both the economic and cultural sub-systems by increasing the quality and quantity of production and consumption in society. As a result, these social changes have created both problems and opportunities for the political sub-system which is trying to maintain control over the changes according to some rational policy.



## ACTORS

The component units of the social system are its people. The people, who are members of society, act either individually or collectively to promote their interests. In complex, large social systems, collective action is more effective than individual, so interest groups become powerful institutions of ubiquitous presence.

Social groups are formed and maintained whenever there is enough common interest shared among a distinct number of people. Such groups may be found for every special and particular interest in society. In any case however, these interests can be divided into either economic or cultural.

In the former sector are found those groups which primarily share production or exchange interests. Thus, industrial, agricultural, financial and commercial institutions belong to this type. In the latter sector are found those sharing consumption or expression interests, such as families, clubs, schools, studios and churches.

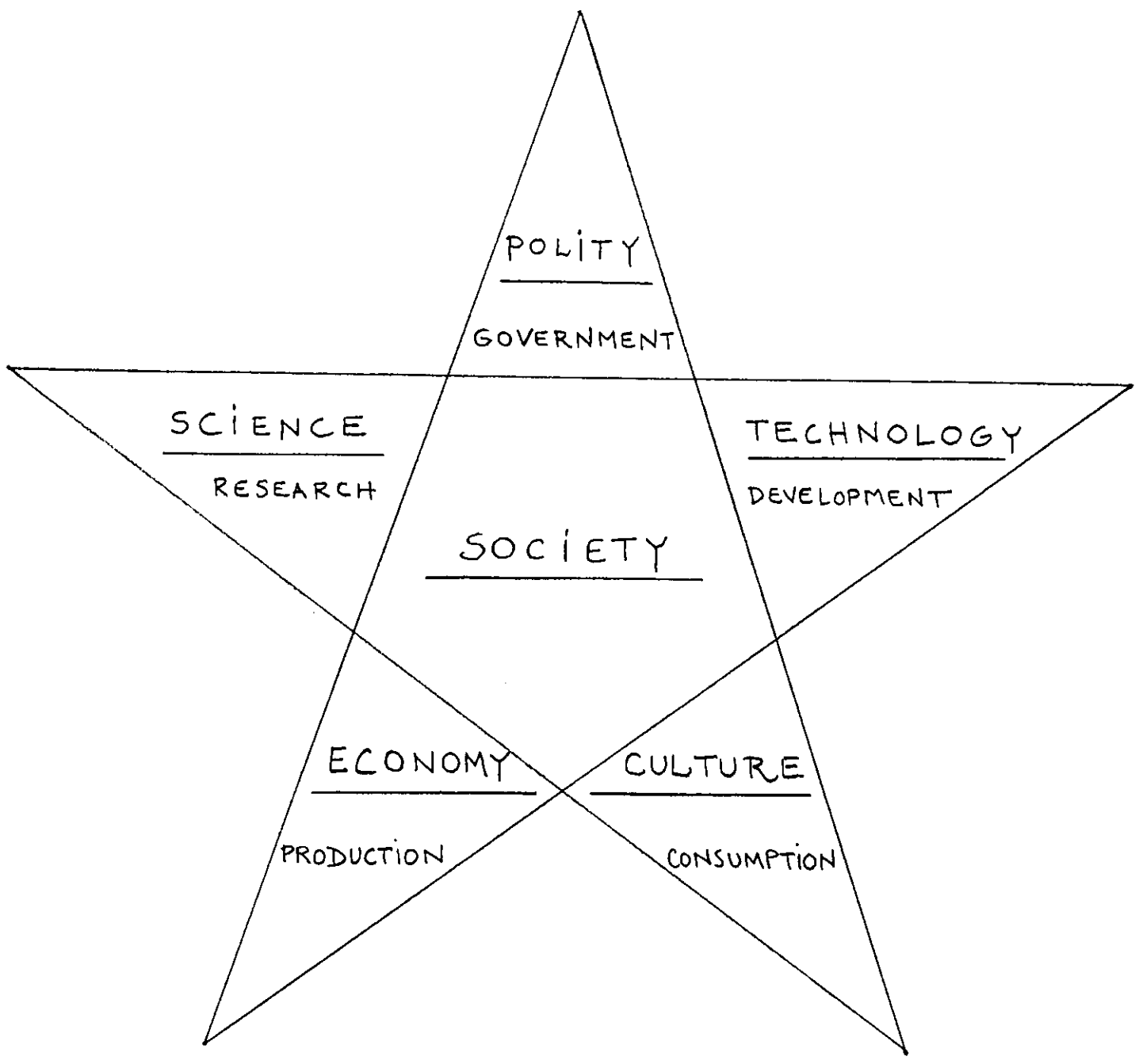
Since this study is particularly interested in science and technology, we must distinguish those groups which are concerned with these aspects of social life. Although such groups could sometimes fall under the economic or cultural category, we should here make a clear differentiation between them.

In the scientific sector are those groups which create or discover information or knowledge. The main examples of this type are research institutes and experimentation laboratories as well as societies for the advancement of science. In the technological sector are the groups which develop and adapt the scientific discoveries to practical applications. The institutions in this sector are engineering companies and innovation firms, as well as associations of inventors and technical experts.

So far, we have identified two dyadic types of collective actors making up our social system. On the one hand, there are the economic and cultural groups and on the other, the scientific and technological ones. These four kinds of actors, however, are supplemented by a fifth one, which stands apart from them in a class by itself.

This actor is the "state" or political sub-system of society. The institutions of this sector are the official agencies of the government, as well as the legislative, executive and judiciary bodies of the social system. It is only by specifically including them, that we complete the list of the five protagonists of modern society. As far as we are concerned, these five groups are the necessary and sufficient components of the social system we are trying to describe. To illustrate what we have said so far about the structures and functions of the five principal elements of our social system, we present the drawing in the next page. The five legs of the asterisk represent the Scientific, Political, Economic, Cultural and Technological components of society. We have thus named this stylized representation the S/P/E/C/T/ Model.

SPECT. MODEL



SOCIAL SYSTEM  
STRUCTURES & FUNCTIONS

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IV '94

## RELATIONS

According to the SPECT Model diagram, society is composed of five sub-systems which are structurally interrelated. Now that we have described the nature and function of each of these sub-systems, we shall investigate the relationships which tie them together in an all-inclusive social system.

Firstly, we should recall that open systems have two kinds of spatial relationships: domestic or intramural and foreign or extramural. The internal relations connect the parts of the system to each other, whereas the external relations tie the system to its environment. In this chapter, we shall look at both kinds.

It is well-known that as units increase arithmetically, their interrelations increase geometrically, therefore the more members a system has the much more will be relations among them. Beyond a certain number of units, their combinations or permutations become astronomical, according to the factorial formula.

Fortunately, we have aggregated the members of our system into five groups, so that we need only worry about a relatively small number of relations. Moreover, we shall consider only bilateral relationships which run in both directions between them. With this simplification we remain with twenty relationships (5 sectors x 2 directions x 2 couples). These twenty internal dyads, connecting each of the five sub-systems to the others, form our total social network.

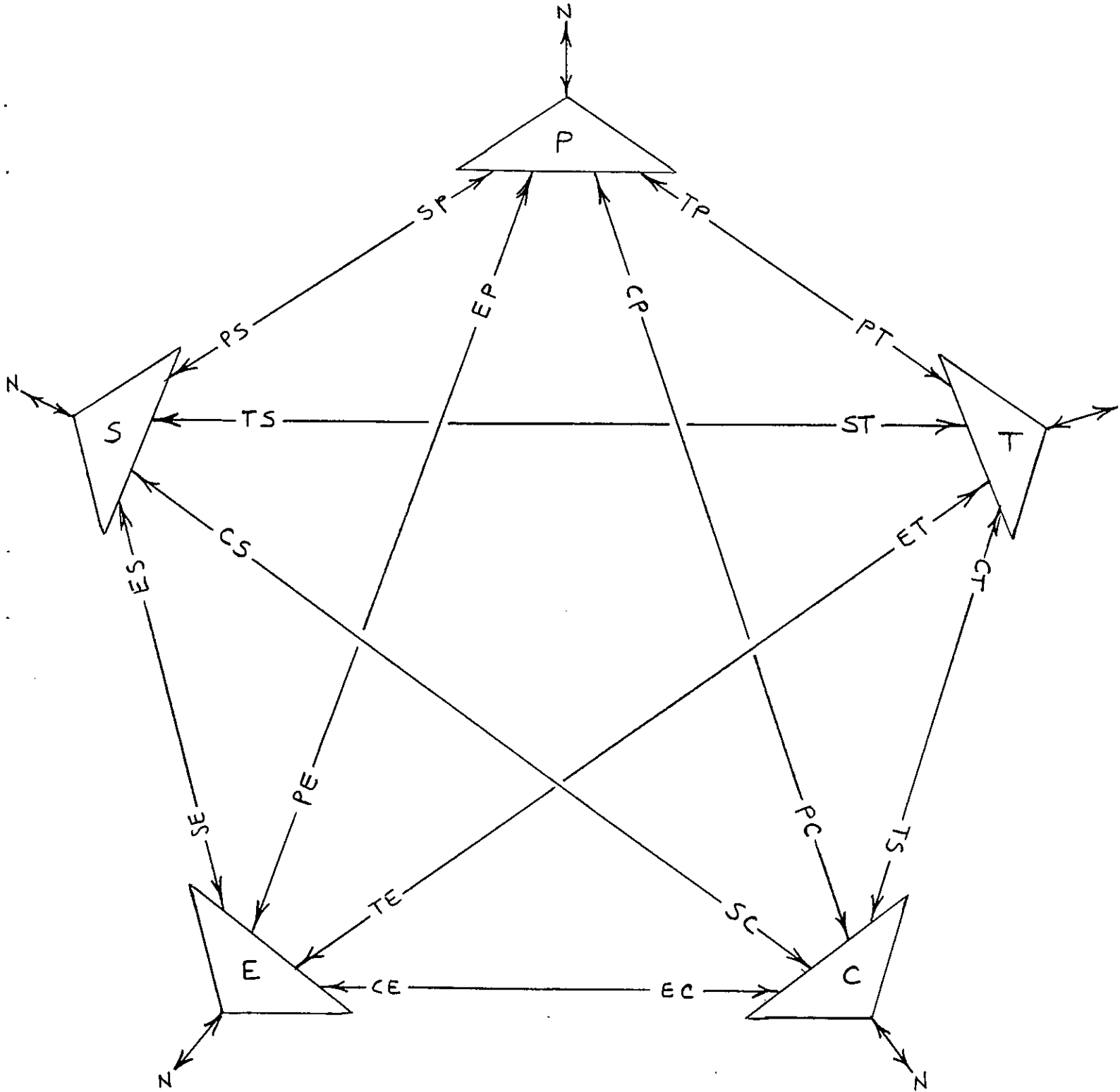
In order to illustrate this network, we have revised the SPECT Model as shown in the next page. From that, one can easily see the twenty interrelations within the system. In this way, each of the five sectors is related to the other four by a double connection. For example the political sector relates to the economic (PE) x vice versa (EP), to the cultural (PC x CP), to science (PS x SP) x technology (PT x TP) thus totaling eight relationships.

Every other sector is similarly interconnected in eight ways; but since some of these connections are duplicated the total is only twenty.

In addition to the internal relations, we must also consider the external ones. In this area, we shall take into account only a two-way channel between each sub-system and the environment.

For instance, the political sector has an input (NP) and an output (PN) with nature. So does each of the other four, for a total of ten relationships, as shown in the next page.

This network of thirty relationships, along with the nodal points where they cross-cut each other, describes all the significant characteristics of the social system. Of course, not all relations are equally significant, some are critically important for our purpose, while others are almost non-existent. This distinction will become clear in the next chapter, where we shall look into the substance of these relationships.



STRUCTURAL CHANNELS  
OF  
SOCIAL RELATIONS

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IV '84.

## INTERACTIONS

On the basis of the structural relations worked out in the previous chapter, we can now superimpose the interactive flows which animate the system. These flows provide the content that fills the channels connecting the five centers of activity in society.

Theoretically, there are three types of activity and content running along the arrows of the social network model: Transportation of Matter (inanimate and animate, including people); Transmission of Energy (natural and human, including labor); Communication of Information (facts and values, including money).

These three interacting aspects of reality are convertible to each other, so that exchanges are possible between them. Since the social system may be regarded as a transformer, it continuously converts one form of reality into another. As we saw, each of the five sub-systems of society specializes in a particular kind of conversion which changes its inputs into outputs. Thus combining matter, energy and information, the principal product of science is knowledge, of government is policy, of economy is goods, of culture is values, and of technology is tools. The natural environment, of course, provides the resources for all these social outputs and receives the discarded left-overs in return.

It should be noted that the distinctions we are making here are of emphasis other than exclusivity. Social functions cannot be precisely separated along institutional lines. So that when we say that the principal function of science is research to increase knowledge, we do not mean that it is its only function. Social activities are multifunctional as well as multicausal thus their inputs, conversions and outputs are many, including several factors, syndromes and by-products, intended or unintended.

Nevertheless, for purposes of analysis, we can distinguish a formal activity for each institution and relation. In order to illustrate all these interactions taking place along the inter-relation channels, we have constructed the matrix in the following page. As is easy to see, the matrix forms an input - output table shown the twenty internal and ten external flows to and from each sub-system (Nature is here treated as the sixth sub-system).

The labels in each box are only examples of a central interaction and not necessarily the dominant one. So that an important flow along CE is consumer demand upon economy and conversely the flow along EC is the supply of economic products to the consumer. The upper left to lower right diagonal of six boxes represents the activities within each sub-system (SS,PP,EE,CC,TT,NN) and therefore are not properly speaking interactions, which only total thirty (  $6 \times 6 - 6$  ). Some of the boxes are empty because no significant flow could be discerned between its two components. All in all, the table should give a synoptic picture of the kind of flows running along the arrows shown in the social network.



SOCIAL INTERACTIONS  
MATRIX

OUTPUTS FROM INPUTS TO	S KNOWLEDGE	P POLICY	E GOODS	C VALUES	T TOOLS	N RESOURCES
S	<u>RESEARCH</u>	GRANTS	CAPITAL	PARADIGM	APPARATUS	DATA
P	INTELLIGENCE	<u>GOVERNMENT</u>	TAXES	LOYALTY	WEAPONS	
E	SERVICES	CONTROLS	<u>PRODUCTION</u>	DEMANDS	INVENTIONS	MATERIALS
C	EDUCATION	SECURITY	SUPPLIES	<u>CONSUMPTION</u>	KNOWHOW	PEOPLE
T	DISCOVERIES	RULES	FUNDS	NEEDS	<u>DEVELOPMENT</u>	
N		MANAGEMENT	WASTE	POLLUTION		<u>CONTEXT</u>

INPUT-OUTPUT

TABLE

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12/84

## PROCESS

Going through the four previous chapters, we have completed the presentation of the structural - functional aspects of the SPECT Model. By doing so, we have now discribed the activity centers as well as the flow channels of the social system.

What remains to be done before the conclusion is to give an indication of how the system operates under certain conditions. To do so, we introduce the time element, which was so far held constant. This means that we shall now follow the chronological sequence of the flow of events among the various sectors in society.

In order to illustrate this sequence of events, we have prepared the flow chart on the next page. The vertical dimension shows the SPECT sectors, while the horizontal shows eight time steps in chronological order. These steps indicate the phases which a typical relevant activity might follow in one cycle of its process.

Since our interest here is the interaction between Science-Technology on the one hand and Economy - Culture on the other, with the polity in the middle; the process we want to follow oscilates between each of these sectors in a particular sequence. The particularity, of course depends on the specifics of the case in question and is not always uniform.

Nevertheless, what we have chosen to illustrate is general enough to serve as a typical case study. In such case, science begins the cycle by some discovery of a "secret" of nature. This new knowledge is diffused throughout society and thereby affects the mental or spiritual culture by distroying old beliefs and creating new expectations.

The political arena here comes into play by debating the pros and cons of the discovery and trying to anticipate its social impact. As a result, it can promote or discourage its further development by regulating its application from theory into practice. If there is enough support, technology takes over to develop some functional implement, useful to the system.

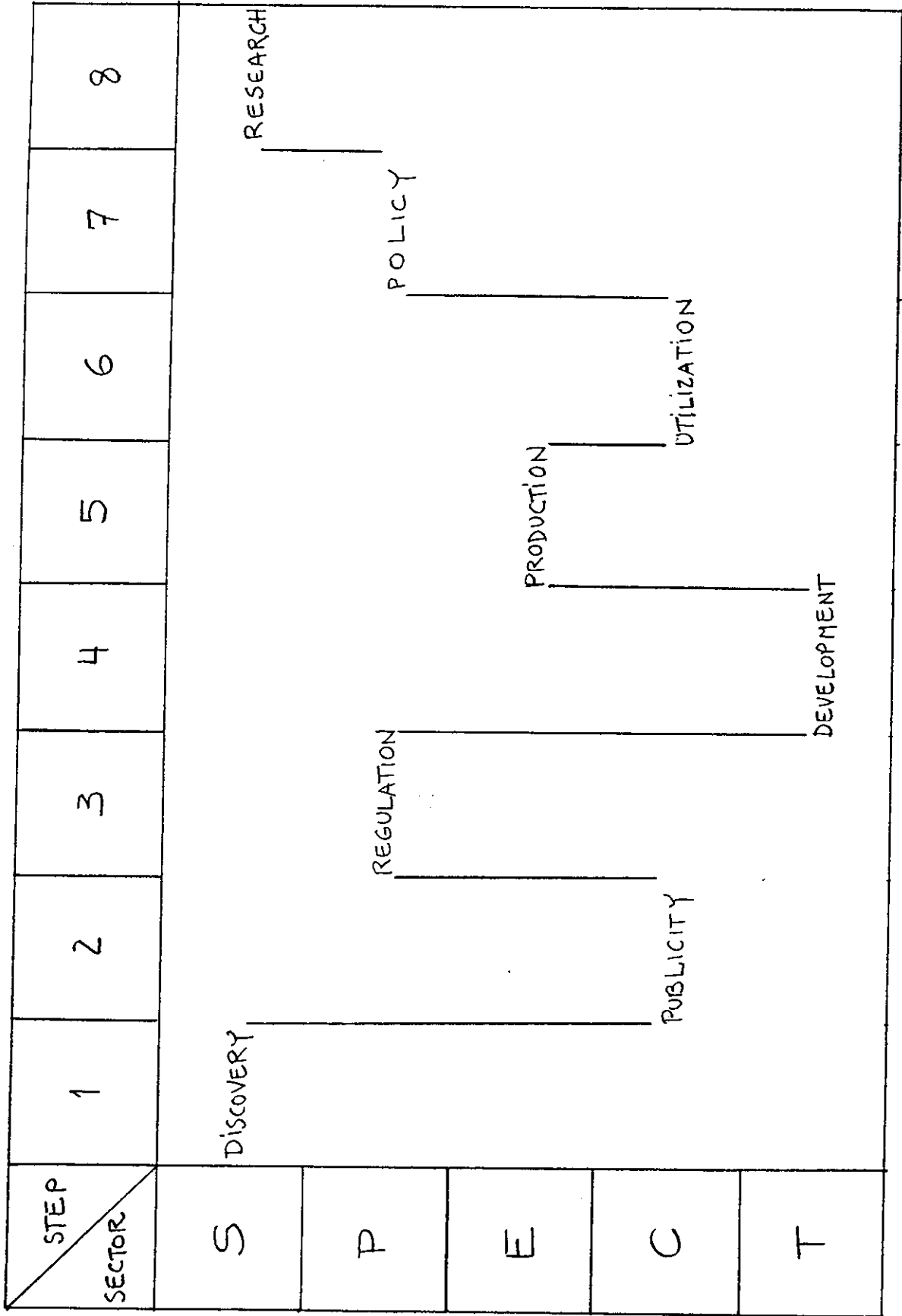
The economic sector takes over next, by mass producing the prototype for popular consumption. If the market succeeds in selling the new product to the people, another step in the process of cultural change has been effected. Whether such change is a gradual evolution or a quantum jump, there comes another public debate evaluating the social impacts of the new technology.

As a result, the governing institutions of society will most likely formulate a public policy controlling the usage of the new product or directing new research into its improvement, thus starting another cycle of this ongoing process.

Of course, all cases do not follow this scenario in exactly the same steps. Often, certain phases may be skipped altogether and others prolonged. Moreover, the process may be short-circuited and return to its origin before it completes the entire cycle. It all depends on the particular factors shaping the progress of each case.

Having said that, however, we still think that the model we have presented is generally valid. Therefore, it could be useful in noting how particular cases fare according to it, either as forecasts or history.

OPERATION CHRONOLOGY



~~4/11/84~~

## CONCLUSION

As we promised to do in the introduction, we have investigated and analysed some important aspects of society. We have done so by relying on systems theory to understand the structure and functions, relations and interactions, as well as the content and process of the social system.

More specifically , we focused on the connections of science & technology to economic, political and cultural affairs. Looking at the interdependence of these five areas, we were able to discern the potential impact that one can have on the others. Finally, we saw how the system operates in a cyclical process involving a typical sequence of events.

Since this study has been described in a very succinct manner, no further summary is necessary. What we can do in closing is emphasize the research agenda-setting purpose of this essay. It is evident that every relation and activity we have described can be the subject of a separate study. As the bibliography at the end indicates, many such studies have already been done and others are on the way.

Yet, seen in isolation, specialized research loses the forest for the trees, so it was to correct this problem that the present synoptic study was undertaken. Perhaps, it went too far in the generalized direction, but this was to compensate for the opposite tendency which tends to dominate contemporary research.

As a result of this overview, we shall be better able to understand where the various pieces of the social system fit in the total picture. At the same time we should be able to see the areas where more work has to be done to tie together the loose ends. This, however, is the topic of another study which should be undertaken next.

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