SOME PRELIMINARY CONSIDERATIONS REGARDING THE ANALYSIS OF TECHNOLOGIES [1]

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The present remarks deal with part of a larger problem, that of describing whole-culture systems using categories universally applicable and comparable, and, preferably, with units which permit measurement. The assumptions here are: (a) that total-culture systems exist and have wholistic characteristics independent of the parts; (b) that parts, to be intelligible must be understood in relation to wholes; (c) that comparisons can genuinely be made only among complete morphological units, that is total-culture systems, and with a uniform terminology; and (d) that the dynamics of culture change can only be understood fully when examined in the context of the total systems. These assumptions are by no means new, as many writers have presented them in one form or another before. However, the ability to work with these assumptions rests on our capacity to specify or describe whole-culture systems in some universalistic or generalizing terminology, i.e. one that is not culture-specific, and also to treat the entire range of the culture content at one time.

Heretofore, the existence of total-culture structures has remained mainly intuitive, not even really achieving the status of a working hypothesis. Although relationships between this and that part of culture are asserted to exist or even demonstrated, few attempts have been made at systemic whole-culture descriptions other than in the seriate particularizations characteristic of the standard monographic report. Put another way, few, if any, have attempted to present the total order of a culture in a terminology, or with a set of categories, which is not uniquely conditioned by the culture content to be described. That is, monographs describing total cultures tend essentially to be <u>listings</u> of the entire culture content rather than formal descriptions, in a universal terminology, of the relationships among the parts entering into the total structure of the culture. Much less have monographs tried to describe the causal relations among these parts. Only within social organization has such a treatment been elaborated with a degree of success, while descriptions of systems of technology and of ideology remain quite undeveloped, and their formal and causal relations to all intents untreated.

The fact is, we have no categories or dimensions, such as length, weight, mass, density, hardness, and so on, as in physics, with which to describe the formal attributes of any total culture, or even of its significant parts, regardless of its unique cultural constellation of specific characteristics or measurements. The parallel situation in physics would occur if we were to specify the formal properties of, say, the solar system without reference to density, mass, or temperature.

A number of reasons may be given for the impelling necessity to develop, at the present time, some set of units, categories, or dimensions for analyzing whole cultures or at least those parts of cultures which have still largely been slighted by anthropologists.

First, there has been a renewed interest in what might be termed macro-evolution, as in the work of Steward, Childe, White, Sahlins and Service, and others, which deals, explicitly or implicitly with achieved stages of development of whole-culture systems (Childe 1936, 1942, 1951; Steward 1955; White 1948, 1959b; Sahlins and Service 1960). Essential to such macro-evolutionary interests, whether comparing genetically related or independent systems (see Leeds 1961b), is taxonomy, or the formal description and comparison of systems. Only with formal units, categories, and dimensions, applicable to the entire class of systems under consideration, can one make descriptions of cultures truly adequate for formal comparisons. This is an accepted principle in other taxonomic disciplines such as systematic biology or astronomy.

Second, there has appeared a new interest in what we may call micro-evolution (Levins 1960; cf. also Sahlins and Service 1960 on "special evolution"; Leeds 1962), the immediate processes which bring about motion from one cultural state of being to another. In order properly to describe such motion, one must be able to specify formally the beginning state in terms comparable to those used to describe the end state. Since, over time, it is the entire system which changes, one must be able to describe the total culture which is changing.

Third, a new interest in applying the concept of equilibrium to the analysis of culture systems (cf. Birdsell 1958; Collins 1964; Leeds 1961a, 1965; Suttles 1960a, 1960b; Vayda 1960, 1961; Vayda, Leeds, Smith 1961) also necessitates our being able to deal with total-culture systems. Equilibrium analysis assumes that cultures are systems with self-regulatory or feed-back mechanisms tending to maintain the system-as-a-whole in a given state.

Fourth, recent theorizing on acculturation, such as that of the Summer Seminar on Acculturation (Social Science Research Council 1954) also assumes that the cultures entering into acculturation are total systems. Fully adequate descriptions of acculturation processes appear to me dependent on means of describing the total systems in contact.

Fifth, the continuing and ever-refining interest in functional systems has always implied a total-culture description. Views of culture of a functional sort--whether of the British, American, or French varieties--at least implicitly involve the relationships of all parts of a culture, or of cultures, to each other in a system which every field-working anthropologist has had to cope with certainly at an emotional, experiential level. However, the functional relations between technology or ideology and the social order have, for the most part, not been teased out and the functional wholeness of cultures has, in description, remained largely at the level of intuition, resting, as I said above, on the subjective experience of the observing anthropologists. However, much of our explicit theorizing about culture asserts that cultures including the technological, social, and ideological orders are, in fact, whole functional systems. Theorists may even make assertions about a hierarchy of functional importance such as are contained in Steward's distinction between "core culture"--the more fundamental "parts"--and "secondary features" (Steward 1955:37ff; Driver and Massey 1957, especially the final sections of the book).

That cultures are in fact total, functional systems still await demonstration in an objective scientific manner, accessible to non-anthropologists as well as anthropologists. This sort of demonstration would render unnecessary such exchanges of opinion as the recent article by Morgenbesser and the answering letters by Bohannan and Bateson (Morgenbesser 1958; Bohannon 1959; Bateson 1959).

An objective demonstration of what most of us have experientially felt to be the case requires, on one hand, the isolation of relevant units, categories, and dimensions, and, on the other, treatment of neglected parts of culture in a systematic, theoretically-oriented way.

In what follows, I shall try to indicate some categories of technology which appear to me to be suggestive. I would like to invite full discussion of these points.

First, some definitions are needed. "Technology" refers to all behaviors and things utilized directly or indirectly in the creation or maintenance of the material conditions of life. This definition excludes all material culture, such as houses, scepters, paintings, censers, and the like, which are products of the objects and behaviors used to create material bases of life, but which, as such, are not themselves such objects.

Technology may usefully be divided into at least five categories: "tools," "resources," "activities," "tasks," and "techniques." The category of techniques is itself usefully divided into two sub-categories, the "manufacturing" and "utilization" of objects.

"Tools" may be defined as referring to objects used to make other objects or used to operate on resources in processing them for consumption.

"Resources," a second class of objects entering into the technology by cultural definition only, may be defined as all substances existing in the natural environment or available from other cultures which are designated as relevant for utilization by any given socio-cultural unit before being processed for final consumption uses. Any substance not so defined culturally has no relevance to the culture under discussion, should not be discussed in connection with it, and is not a resource. It will be noted regarding this definition of resources that no statement is included about the location of resources in the natural environment, nor about natural conditions affecting the resources. These conjunctly we may term "habitat." Thus the resources, as culturally defined objects of value, are parts of the culture but as physical objects in space comprise a sub-class of things of the total environment which may be designated as "habitat."

Technological behavior may be classified into a hierarchy of three categories. The first category of technological behaviors comprise "techniques" which refer to characteristic ways of using tools, including parts of the body such as the feet, hands, or teeth.

The second category of processes consists of "tasks." "Task" refers to a mediating technological end, which, with other such mediating ends, contributes to the larger, inclusive aim of the production of some object of

cultural value. Thus, to build a pyramid, the final aim or object of cultural value, whose construction is an "activity," it is necessary to perform a number of tasks such as moving great blocks of stone, hewing logs for rollers and levers, building ramps, cutting the blocks, and so on. None of these tasks is an independent end in itself, although, especially in simpler societies, a task and an activity may be coterminous.

Third, a "technological activity" may be defined as any given behavioral complex which is entailed by the regular use of a specified set of tools, resources, techniques, and tasks in order to produce some object of cultural value. Making a garden, building a pyramid or a skyscraper, making manioc flour, assembling tractors are all activities. The description of such activity involves the specification of the aims to be achieved, the tools used, the techniques employed, the resources worked on, the tasks which need to be performed, and the spatial and temporal order of tool and technique utilization and of the tasks carried out.

Three points should be noted. First, formally, as a category, neither the technological activity nor the task entails or specifies any particular tools or techniques, and even the resources may vary widely. Great blocks of stones may be moved by manpower pulling them along the ground, by the use of draft animals with sledges or rollers, by the use of simple machines and hoists, or by the use of power machines. House building may involve different resources. These are questions of culture content, not relevant to my present discussion.

Furthermore, many techniques, especially simpler ones like hammering, may not entail the use of particular tools, although the use of particular tools, especially more complex ones, generally determine the techniques. In general, the several categories of technology appear to be partially independent of one another; it is often even the case that one kind of activity can be accomplished with two different organizations of tasks, or that two different activities can be comprised of at least a number of like tasks. Despite this partial independence, technologies-as-wholes represent fairly coherent systems as I shall try to suggest below.

Second, it is to be noted that none of the categories, as defined, includes any reference to the social organization of work. One aim of this paper is to argue that a technological system entails consequences in social organization, and hence that the specification of major characteristics of the technology also permits the specification of significant characteristics of the social order. I turn briefly to a discussion of the relationship of some aspects of technology, as defined above, to other "parts" of cultures.

The structure of tools themselves implies, both for their entailed utilization and manufacturing techniques, a certain logic or organization of the human users. A compressed air riveting machine can do only one task--riveting. This task must necessarily be connected with a long row of other tasks in some activity of creating a product. The machine operates on some object which has, by another series of tasks, been prepared for the riveting. The riveting machine itself is an end product of a lengthy series or set of series of tasks. The logic of utilization of a riveting machine is such as to require several networks of other tools, each with their own specific

techniques, and two major activities--the production of the riveting machine and the production of the object with respect to which riveting is a single task.

Such a situation necessarily involves a network of human organization in which humans behave regularly in certain temporal and spatial sequences. The units of organization must necessarily be extremely large, must be widespread in space, and entail complicated systems of decision making and communication of a supra-local character. One would therefore expect to find dense centers of information gathering and dispersion, accompanied by appropriate personnel to carry out the tasks of transferring information. In short, one would expect dense concentrations of population or cities.

One may carry on this sort of logical deduction indefinitely, discovering that one can logically reconstruct the major organizational features of any society with our type of technology. One might say, on logical grounds, that one would, deductively, expect a number of identical major organizational features in the United States, the Soviet Union, Great Britain, Germany, Japan, and so on. No one will deny that this deduction is confirmed, in a general way, by the empirical data.

By contrast, we may speak of a hand ax. A hand ax can be used only by one person at a time and entails no other user of tools to work in coordination with the user. The manufacture of the hand ax is probably best done by a single individual, though not necessarily so done. The tool can be used for a number of tasks, in fact, possibly the major part of the inventory of tasks entailed by the resource uses and activities of those cultures having the hand ax as their chief tool. The only human-organizational feature which is necessarily entailed by the hand ax is a minimal group capable of carrying on the tool-making tradition; that is, minimally a nuclear family which itself probably entails a certain minimum of other human individuals or nuclear families in permanent and more or less continual relationship with one another.

The foregoing examples suggest some significant dimensions of technologies for which appropriate scaling or other quantitative treatments might be found. First, we may speak of the generality or specialization of tool function; tools of all sorts may be ranged on a continuum falling between the maximum generality of all-purpose tools, on one hand, and extremely specialized tools, on the other. I think this dimension can probably be usefully applied to the entire technology, including techniques, tasks, and activities, rather than to tools alone. Thus, when the activity of bread-making was still a home industry, the specialization of tasks involved in making bread was less developed than today when it has become a factory industry. Furthermore, the resource-getting and tool manufacturing activities to create the miller's grinding tools were also less specialized than today; therefore, considerably less intricate networks of human organization were entailed, with a much greater degree of localization of the networks. I think these expectations are easily confirmed by an examination of, say, eighteenth century technology and society (see, for example, Gillispie 1959).

A simple numerical aspect seems significant of this first dimension. One may count the number of categories of tools, resources, activities, and

so on, and also count the varieties within each category. For example, in Tahiti, one may point to the activities of irrigation horticulture, arboriculture, pisciculture, fishing, house building, canoe building, and so on. For the fishing and pisciculture tool inventory, one may mention the tasks of pool construction, fish trap making, stone fish trap construction, seine and net making, raft making, canoe making, hook making, line making, sweep making, torch preparation, and so on. Within the tool category of nets, one may number the dip nets, throw nets, circular nets, long seines, basket nets, storage nets, etc., each with varying sizes of mesh and varying materials for different kinds of fish. Techniques of fishing are also numerous. One may contrast this situation with that of the technology of the Yaruro of Venezuela in which the activity of fishing, insofar as tools are concerned, involves only the tasks of making hooks and lines and merely one type of arrow for fishing along with the independent activity of canoe construction. The numerical dimension may serve as a gross index of population size, of complexity of social interaction, though not necessarily of form of organization, of specialization, and of degree of coordination required.

A second dimension is the nonrepeatability or repeatability of a task. Catching an alligator is essentially nonrepeatable--each catch is unique, involving different conditions, locations, and so on. In contrast, the task of riveting with a compressed air riveter is one which is endlessly repeatable. The greater the repeatability of the task, the narrower the range of behaviors expected of the worker, and therefore the less complex are his individual relations to other tasks, also repeatable, being carried out by other workers. Consequently, the greater the repeatability, the greater must be the degree of coordination of the repeatable tasks. In short, as repeatability increases, so do managerial functions, probably hierarchically arranged.

A third dimension has already been hinted at above. This is the continuum ranging from the independence of any given tool, technique, or activity to its inclusion in a complex hierarchy of sub- and superordination. Among the Greenland Eskimo, gathering is a significant technical activity. One gathering task is berrying. In general, berrying is technically of such a nature that only one person can pick berries at the same time and place, even though he may be surrounded by other berry pickers. Berrying is intrinsically a task and set of techniques which we may term "independent." However, the activity of building a bridge with its multiplicity of subsidiary tasks, distributed both spatially and temporally, each with its own specialized sets of techniques and tools, is inherently a hierarchical arrangement requiring not only coordination but also centralization of tasks. That is, such an activity, as also assembling a car or in fact <u>any</u> contemporary industrial activity, entails managerial hierarchies. The greater the number of tasks which must be coordinated, the more elaborate and structured must be the managerial hierarchy. One may even speak of hierarchies of activities. For example, in the production of an automobile there are the activities of part manufacture, assembly, and transport, as well as those of resource collection and sales. The five activities each entail managerial hierarchies of their own, while the five managerial hierarchies, together, must also be managerially coordinated. One would expect, as one indeed finds, strata or, actually, mutually exclusive classes of managerial functionaries--the distinction loosely corresponding to managers as against executives.

As a final dimension, for the present, we may mention the dispersiveness or concentrativeness entailed in the relationship of tasks and activities to resources. Greenland Eskimo activities include fishing, hunting, and gathering, with a number of subsidiary tasks. The resource areas, object of these tasks, are variously distributed inland and oceanward at any given time, except for one season during which the subsistence activities are more or less spatially concentrated. Where widely distributed--given generalized tool technique systems--a dispersed communal pattern of organization is entailed logically; where concentrated, a concentrated community pattern is to be expected. Both patterns occur among the Greenland Eskimo, depending on the change of seasons. With highly specialized tool technique systems, dispersed resource areas would entail expansive urbanism and even nationalism, and a series of institutions directed at encompassing the resource areas, e.g. trade, warfare.

In conclusion, I should like to suggest that this approach to the analysis of technologies and of the relationship of technologies to the social order has applicability in predicting culture change. Where innovations or introductions of technological culture traits occur, by whatever process, it should be possible to develop logically a model of the results that the new technological culture element will have on the social and, possibly, the ideological order. I would suspect that we are really already in a position to make fairly accurate predictions as to the specific forms of organization entailed by the introduction of automation or of atomic energy.

Second, the approach suggested here should be useful retrospectively in deducing better hypotheses concerning the social structure of cultures known only archeologically from their tool assemblages and possibly from their technological activities and tasks. The approach seems to me useful in the analysis of functional systems as well. Further, by extending the logical analysis to archeologically sequential orders of tools and techniques and perhaps also of activities and tasks, the approach permits a closer analysis of stages of evolutionary development. Last, I should like to suggest that techno-social organization may probably be shown to entail certain types of ideological formulations, exclusively and formally, but this task must remain for a later date.

NOTE

[1]This paper, read at the VI International Congress of Anthropological and Ethnological Sciences, Paris, 1960, by the editors' error was published in its proceedings (Vol. II [1]:557) only in abstract, whereas another paper which was not to have been published, was published instead.

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