TECHNOLOGY: A THEORETICAL BASE FOR INDUSTRIAL ARTS EDUCATION

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ABSTRACT

TECHNOLOGY: A THEORETICAL BASE FOR
INDUSTRIAL ARTS EDUCATION

By

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During the past two decades, "technology" has emerged as a major topic of discussion in virtually every field of scientific and philosophic inquiry. Moreover, some of our most respected universities have been serving as centers for projects, programs, seminars and conferences on "the impact of technology," and not a few of our most influential social critics have turned their attention to the problems that technology supposedly engenders.

The apparent import of these developments to Industrial Arts education had been noted in 1947, at which time a technology-centered "curriculum" was projected and formally proposed to the profession for acceptance. Since then, "technology" has come to occupy a dominant place in Industrial Arts discussions, and several modified versions of the original idea have been proposed.

In Chapter I it is argued that none of the several versions of the technology-centered concept had been established on sound theoretical grounds; and that the need for clarifying the meaning of technology had not been considered an essential prerequisite in establishing such grounds. It was further argued that on that meaning depend the conceptual framework for selecting and ordering the subject matter of instruction, as well as the rationale for including the selected subject matter in the curriculum.

Assuming then that Industrial Arts ought to center on the study of technology, the purpose here was to inquire into the meaning and scope of technology with a view toward framing a theoretical base for a technology-centered curriculum.

With that end in view, Chapter II inquires into the origin of the word 'technology' and its meaning in an historical perspective; and Chapter III subjects a number of contemporary definitions of technology to a critical analysis. The preliminary inquiry reveals a discernible pattern of common referents which in Chapter IV provide a basis for clarifying the meaning of technology. There the concept of technology is located and defined in the context of human activity and is identified with science and technic as a form of human work. In the process, a conceptual scheme is devised for purposes of identifying and structuring the essential elements of technology in any given realm of work.

In Chapter V it is argued that if technology does in fact have a place in Industrial Arts education, then the subject matter of instruction ought to reflect the technology of a significant realm of work. On that basis it is shown that the logical source of subject matter is the realm of engineering. Given engineering as the source of subject matter (scientific and technological), and given the conceptual scheme for identifying and ordering that subject matter, it should be readily apparent that place for technology in Industrial Arts education has been substantiated.

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To the memory of my mother
Louise Sikora Kasprzyk
(1894-1969)

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CHAPTER I

THE STATUS OF INDUSTRIAL ARTS EDUCATION

In 1947, the President's Commission on Higher Education, charged with the task of reexamining the objectives, methods, and facilities of higher education, observed that:

> For many years they [the colleges] had been healthily dissatisfied with their own accomplishments, significant though these have been. Educational leaders were troubled by an uneasy sense of shortcoming. They felt that somehow the colleges had not kept pace with changing social conditions, that the programs of higher education would have to be repatterned if they were to prepare youth to live satisfyingly and effectively in contemporary society...in a world in which technology is acting as a solvent of cultures.[1]

This observation was an appropriate appraisal of the conditions within the realm of Industrial Arts teacher education. Industrial Arts educators who were aware of the shortcomings of traditional curricular patterns, and the need for restructuring their technical subject matter, had already been addressing themselves to the problem. The same year, in fact, that the Commission made its report to the President, a group of graduate students at The Ohio State University, under the leadership of William E. Warner, proposed a New Curriculum[2] for Industrial Arts education. Unlike the existing curricula of the time the proposal was

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[1] *Higher Education for American Democracy*: A Report of the President's *Commission on Higher Education*, Vol. 1 (Washington: The Commission, 1947) pp.1 and 15.

[2] William E. Warner, *et al.*, *The New Industrial Arts Curriculum* (Newark: American Industrial Arts Association, 1947).

patterned around a new focal point--technology.

Since then, and more notably during the past decade, technology has come to occupy a dominant place in Industrial Arts discussions--at national, state, and local conferences, symposiums, and conventions, generally, but particularly in professional meetings devoted to the resolution of curricular problems.[3] The apparently genuine interest in technology is indicative of the growing dissatisfaction with the status of Industrial Arts education. For example, those programs of instruction which have been in vogue since the turn of the century are now widely conceded to be educationally untenable; their effectiveness in an era of "scientific and technological revolution," so-called, is increasingly being challenged by the profession. Instead, there appears to be a growing trend toward some kind of technology-centered curriculum for Industrial Arts. But what is most significant, the trend acknowledges a need and intimates a desire on the part of the profession to change.

The Problem

Acknowledgment of the need to change, albeit an indispensable pre-requisite, is hardly sufficient to institute change; nor will the mere specter of a novel idea suffice to bring it about. As so often happens in the realm of education, there is a readiness to adopt novel ideas and attempt to put them to practice before they have been seriously

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[3]See, for example, Improving Industrial Arts Teaching: A Conference Report (Washington: Office of Education, HEW, 1962); Marshal Schmitt and Albert L. Pelley, Industrial Arts Education: A Survey of Programs, Teachers, Students, and Curriculum (Washington: Office of Education, HEW, 1966); and Howard S. Decker, "The Washington Symposium," The Journal of Industrial Arts Education, XXXVIII (November-December 1968) pp.14-16. See also, the AIAA Convention Proceedings, (Washington: American Industrial Arts Association) 1965 through 1972.

considered from a theoretical point of view. Premature adoption, regardless how pregnant the idea, usually results in arbitrary implementation which in turn impedes further development.

The presumed need for Industrial Arts to change to a technology-centered curriculum is the case in point. Of the several proposals which have been presented to the profession for acceptance since 1947, none furnishes the requisite guide lines for identifying the subject matter of instruction. Generally speaking, they attend to certain practical matters that pertain to classroom instruction, and disregard or give only cursory attention to the theoretical requirements of curriculum construction. More importantly, none of the proposals appears to give serious attention to the fundamental requirement of clarifying the meaning of technology. As a result, there are as many conceptions of technology as there are proposals, each suggesting a different structure for Industrial Arts content. To add to the confusion, many in the profession, eager to change to some kind of technology-oriented program of instruction, are devising Industrial Arts courses and curricular schemes based on their own conceptions (or misconceptions) of technology.

In view of the growing conviction that the Industrial Arts curriculum should "reflect technology,"[4] there is an urgent need to clarify the meaning of technology on sound theoretical grounds. Without theoretical guide lines, the process of delimiting the field of study, of determining and organizing subject matter, and selecting the tools and methods of instruction, cannot be anything but an arbitrary enterprise.

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[4]See, for example, Industrial Arts in Senior High Schools, Twenty-second Yearbook of the American Council on Industrial Arts Teacher Education, 1973; particularly the articles contributed by John Mitchell, Paul W. DeVore, Donald F. Hackett, Donald G. Lux and Willis E. Ray.

Hence the problem for which a solution will be sought in the present study is: Can the meaning of technology be sufficiently clarified so as to provide a theoretical base for a technology-centered Industrial Arts curriculum?

Importance of the Problem: Scholars in various fields of scientific and philosophic inquiry--sociology, psychology, economics, history of technology, philosophy of science and technology--are seriously addressing themselves to the manifold problematic dimensions of technology--e.g., the supposed "impact of technology" on polity, on work, on human values, on man and his institutions in general. Various agencies in government, commerce, and industry, are also concerned with technology, particularly with its supposed relation to matters of immediate practical significance--e.g., "technological unemployment," "technology transfer," "technology assessment." The point is, if technology has a place in the Industrial Arts curriculum, then the fund of knowledge that issues from these sources is relevant to that curriculum.

Aside from its generally acknowledged instrumental value in improving material standards of living, technology is said to be a disruptive social force with far-reaching psychic, political, and economic consequences. That being the case, its ambivalent character needs to be understood by man if he is to exert rational control over its direction. To provide for an understanding of that social force is a function of general education; and Industrial Arts in its general-education purpose shares the responsibility. It is to that end that the Industrial Arts curriculum must be relevant.

Its relevance, however, can be ascertained only in light of a clear and unequivocal meaning of technology. For on that meaning depend the conceptual framework for selecting and ordering the subject matter of instruction, and the rationale for including that subject matter in a curriculum geared to general education.

The purpose of the present study, then,is to inquire into the meaning and scope of technology with a view toward framing a theoretical base for a technology-centered Industrial Arts curriculum.

Limitations of the Study: The ensuing inquiry into the meaning and scope of technology will consider the concept in its broadest acceptation, i.e., its import in any and all realms of human activity--industrial, educational, agricultural, medical, political, domestic, economic, for example. It is assumed that the essential characteristics of technology in any one realm of human activity are, in principle, congruous with those in each and every other realm; the technology of education, for example, ought to have certain essential characteristics in common with, say, industrial technology. On that assumption, the inquiry will, for the most part, be limited to a consideration of those elements of meaning which are attributable to technology in general; the "technology of" this or that particular realm will not be considered, except by example.

By the same token, no attempt will be made to identify the actual subject matter of instruction. It is hoped, however, that the theoretical model of technology (to be developed in the ensuing discussion) will furnish the guide lines for delineating and structuring the subject matter. In view of this limitation, the present study should not be construed as another "curriculum proposal" for Industrial Arts.

Definition of Terms: The major part of the study is addressed to conceptual clarification. It need only be noted here that technology will be located and defined within a conceptual scheme which in its extended treatment is herein referred to as the theoretical model of technology. The theoretical model coupled with the rationale for justifying the place of technology in a curriculum geared to general education constitute the theoretical base for Industrial Arts education.

The term 'Industrial Arts' (capitalized) is herein used with reference to a branch of general education; whereas 'industrial arts' (not capitalized) refers to the various manipulative technics employed in industrial production.

Related Studies

Since 1947, when Warner and his associates proposed the New Curriculum for Industrial Arts education, several other "technology-centered" studies have been presented to the profession for acceptance. Some of them--e.g., Olson's Technology and Industrial Arts (1958), and DeVore's Technology: A Structure for Industrial Arts Content (1965)--have received a great deal of attention in the Industrial Arts literature, and at Industrial Arts conventions and conferences. Curiously, none of the proposals have, to date, been accepted by the profession at large; and it is even more curious that none appear to have been subjected to criticism--in the literature or at professional meetings--to determine why they have been tacitly rejected by the profession.

Assuming that the studies by Warner, Olson, and DeVore more or less bespeak the prevailing mood of the profession to orient Industrial Arts toward the study of technology, perhaps a critical review of them, in terms of their basic assumptions, principal concepts, sources of content, and content structures, will help to bring into perspective the problem

undertaken in the present study.

A Curriculum to Reflect Technology:[5] The main features of Warner's Curriculum, those which distinguish it from the then existing curriculum concepts in Industrial Arts, are: a) its allusion to "technology" (prior to that time no consideration had been given to that concept); b) its attention to "socio-economic trends," to "research," "experiment," and "laboratory" activity; and c) its "large divisions of subject matter resources."[6] With regard to the latter, Warner asserts that the

> Content in the new Industrial Arts curriculum is derived via a socio-economic analysis of the technology and not by trade analysis as of old from the commoner village trades such as those of the carpenter, the blacksmith, the cabinet maker. Now, the subject matter classifications are conceived of as including:
>
> a. Power: tidal, solar, atomic, electric, muscular, hydraulic, combustion, ...;
>
> b. Transportation: land, sea, and air;
>
> c. Manufacturing: includes the basic industrial methods of changing raw materials into finished products such as foods, textiles, ceramics, metals, woods, plastics, and leathers, similar but broader in concept and application than has been developed in the so-called "general" shop of the past forty years;
>
> d. Construction: simple fabrication, housing, public works, industrial, national defense, ...;
>
> e. Communication: graphic arts including drawing, letterpress, planography, intaglio, and the miscellaneous processes in addition to electricity, electronics, and other communications media; and
>
> f. Personnel Management: including Line and Staff as in business and industry, or labor as well as management.[7]

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[5]William E. Warner, et al., A Curriculum to Reflect Technology (Columbus, Ohio: The Ohio State University, 1953). A reprint of the New Curriculum.

[6]Ibid., p.3.

[7]Ibid., p.6 (The authors' own italics).

With the new classificatory scheme for organizing subject matter, the proposal signaled a radical departure from the prevailing Industrial Arts "subjects"--woodworking, metalworking, drafting, and the like. This feature, coupled with a seeming concern for laboratory activity to supplant the traditional "shop work", the allusion to research and experiment to supplement the narrowly conceived "project method", and the ostensible attention to socio-economic trends, constitute the principal innovations which were supposed to orient Industrial Arts toward the study of technology.

From a theoretical point of view, the proposal evidences certain inherent weaknesses, which may account for the fact that it had not, in its original form, found acceptance in practice: Warner and his associates either ignored or found it unnecessary to attend to the fundamental task of clarifying the meaning of technology. Instead, they assumed that Power, Transportation, Manufacturing, Construction, Communication, and Management constitute the principal elements of technology.[8] These "divisions" were supposed to have been "discovered" in their "examination" of the _Census of Manufactures_,[9] indicating that Warner and his associates had presupposed a semantic association between 'technology' and 'manufacture' (or 'industry'), a presupposition that is arbitrary and without apparent meaning. Moreover, the claim that the "content in the new Industrial Arts curriculum is derived via a socio-economic analysis" is neither clarified nor substantiated in the proposal.

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[8] _Ibid_.

[9] "We examined the census," says Warner, "to discover five or more large _divisions_ of subject matter resources..." _Ibid_., p.3. _The Census of Manufactures_ is discussed below.

Despite its superficial treatment and resultant weaknesses, the proposal did, nevertheless, signal a new direction for Industrial Arts education; and not a few in the profession (intrigued perhaps by the aura surrounding the concept of technology) ultimately embraced it in substance. Yet, it is not a little curious that during the quarter century since the Curriculum was proposed, and subsequently adopted as a model for restructuring existing curriculum patterns, only token de facto changes have actually been effected in educational practice.

Technology and Industrial Arts:[10] Olson's study is essentially an extension of Warner's ideas and assumptions. He holds to the notion that Industrial Arts "should reflect the technology,"[11] and like Warner, turns to the Census of Manufactures as the principal source of subject matter.[12]

From the Census and other industrial literature, Olson first obtains "eight categories of industries" which establish the basis for his study. The categories thus obtained, include Manufacturing, Construction, Power, Transportation, Electronics, Research, Services, and Management. These, he says, "are assumed to account for all of American industry as would be essential for a curriculum study in industrial arts."[13]

Additional elements for his classificatory scheme are drawn from the list of Manufacturing industries enumerated in the Census report. "with the aid of this information," Olson says,

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[10]Delmar W. Olson, Technology and Industrial Arts (Urbana, Ill.: University of Illinois, 1958).

[11]Ibid., p.3.

[12]Ibid., p.41.

[13]Ibid., pp.3 and 41.

the classification of the manufacturing industries for this study was relatively simple, and was done largely on the basis of materials categories: ceramics, chemicals, foods, leather, metals, paper, plastics, rubber, textiles and woods, plus graphic arts, and tools and machines. These categories were selected as being most analyzable.[14]

The two "category groups", as Olson refers to them, are then combined to give him the following classification of industries:

Ceramics industries	Graphic arts industries
Chemicals industries	Tools and machines industries
Foods industries	Construction industries
Leather industries	Power industries
Metals industries	Transportation industries
Paper industries	Electronics industries
Plastics industries	Industrial research
Rubber industries	or Research industries
Textiles industries	Industrial management
Woods industries	Services or Service industries[15]

The combined "categories of industries" constitute the proposed structure for Industrial Arts subject matter. Supposedly, by way of an "analysis of industries,"[16] and a consideration of what are supposed to be the "functions of Industrial Arts,"[17] Olson finally arrives at what he terms a 'Master List of Curricular Components as Categories of Subject Matter."[18] The list in its entirety includes the following:

Aesthetics	Equipment	Materials	Representations
Analysis	Exhibits	Mathematics	Reproduction
Application	Experiment	Mechanics	Research
Assembly	Evaluation	Mechanisms	Safety
Automation	Fastening	Mining	Salvage
Chemistry	Finishes	Molds	Selection
Circuits	Fixtures	Models	Services
Communications	Hobbies	Occupations	Solutions

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[14] Ibid., p.42.

[15] Ibid., pp.107-166.

[16] Ibid.

[17] Ibid., pp.77-106.

[18] Ibid., p.169.

Computers	Human Engineering	Operation	Specifications
Conservation	Inspection	Organization	Standards
Construction	Installation	Physics	Structures
Controls	Instruments	Planning	Study
Creating	Integration	Power	Supervision
Decorating	Interpretation	Presentations	Supplies
Design	Invention	Preserving	Surveys
Development	Investigation	Principles	Synthetics
Diagnosis	Jigs	Processes	Systems
Dies	Legislation	Problems	Techniques
Discovering	Library work	Production	Testing
Distribution	Lubrication	Products	Theories
Drawing	Machines	Records	Tools
Editing	Management	Recreation	Transportation
Engineering	Manufacturing	Regulation	Utilization

This list of "curricular components" is the sum and substance of Olson's study--in his words, "the final version of the body of industrial arts subject matter to reflect technology."[19]

Despite its extended and detailed treatment,[20] Olson's proposal evidences several inherent weaknesses which are central to the problem undertaken in the present study: a) The sporadic references to "technology" appear to be totally irrelevant to Olson's thesis. The concept itself is not clearly defined, nor is its relevance to the "curricular components" explained. b) The proposed categories of subject matter and the categories of industries from which they supposedly derive, appear to have been arbitrarily conceived. The former, Olson admits, "were found by trial to be most revealing and most logical for the respective groups of industries."[21] With regard to the latter, Olson says:

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[19] Ibid., p.244.

[20] Approximately half of Olson's 250-page study consists in protracted lists of industrial materials, processes, products, and occupations, "industrial arts functions", and "student experience units." See pp. 77-225.

[21] Ibid., p.107. (Italics mine)

> The categories were decided on after considerable study and search of industrial literature, and after numerous trial groupings, as the best, simple yet inclusive, classification this writer could arrange. The classification employed in the New Curriculum [Warner's proposal] was influential in the selection.[22]

c) In view of Olson's admissions, it is evident that the requisite theoretical grounds for selecting the categories and components have not been established; and as such, they cannot be accepted, much less defended, as the subject matter for Industrial Arts education.

The Census of Manufactures:[23] It should perhaps be noted that the Census, to which both Warner and Olson turn for Industrial Arts subject matter, is a survey report on various aspects of "the thousands of more or less distinct lines of manufacturing activity," compiled biennially by the Bureau of the Census.[24] The survey data pertaining to these activities are tabulated (all but a few pages of the Census consists of tables) according to processes and products, arbitrarily grouped for the convenience of reporting. As new industrial processes and products are introduced, the system for grouping them in the survey reports is changed, both in number and in designation. The Census for 1947 (the one referred to in Olson's study) classifies the "industry groups" in the following manner:

1. Food and kindred products
2. Tobacco manufactures
3. Textile-mill products
4. Apparel and related products
5. Lumber and products
6. Furniture and fixtures
7. Paper and allied products
8. Printing and publishing industries
9. Chemical and allied products
10. Petroleum and coal products

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[22] Ibid., p.41.

[23] The Census of Manufactures, Vol. I (Washington: Department of Commerce, Bureau of the Census, 1947).

[24] Ibid., p.2.

11. Rubber products
12. Leather and leather products
13. Stone, clay and glass products
14. Primary metal industries
15. Fabricated metal industries
16. Machinery (except electrical)
17. Electrical machinery
18. Transportation equipment
19. Instruments and related products
20. Miscellaneous manufactures
21. Ordinance and accessories[25]

As noted above, the _Census_ is primarily concerned with the manufacturing industries; but it does make an incidental reference to what are therein termed "the broader sectors of the Nation's economy," namely:

1. Manufacturing
2. Agriculture, forestry and fisheries
3. Mining
4. Contract construction
5. Wholesale and retail trade
6. Finance, insurance and real estate
7. Transportation
8. Communication and public utilities
9. Services
10. Government enterprises[26]

These "sectors" are mentioned in the _Census_ merely to point to the fact that manufacturing ranks first in terms of the gross national product.

Note that Warner includes sectors 1, 4, 7 and 8 in his "divisions of subject matter resources," whereas Olson includes sectors 1, 4, 7 and 9 in his "categories of industries." Note too, that all but three of the industries named in the preceding list (namely, items 2, 10 and 19) are in one way or another incorporated into Warner's and Olson's proposals: Items 3 and 4, for example, are combined under the name "textiles", or "textile industries"; the elements in item 13--stone, clay and glass products--are included in the "ceramics" category.

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[25] _Ibid._

[26] _Ibid._

That the Census provides a sound basis for identifying and structuring Industrial Arts subject matter, is open to question. In the first place, it furnishes specific economic data that is of questionable value in general education; moreover, that data pertains to manufacturing activities only. Secondly, inasmuch as the classification of these activities is altered from time to time, commensurate with changes in the manufacturing industries, that classification does not provide a stable structure for educational purposes. But more importantly, the broad sectors of the economy, which Warner and Olson consider pertinent to a technology-centered curriculum, are not dealt with in the Census. In fact, the word 'technology' is not even mentioned.

Technology: A Structure for Industrial Arts Content:[27] In his proposal for a new curriculum structure, DeVore calls for "an abandonment of many of the previous curricular approaches including trade and job analysis, occupational analysis, material oriented courses," and the like.[28] He argues that curriculum concepts such as those are narrowly conceived, and are inflexible to accommodate changes in content.[29] Because the Industrial Arts profession holds tenaciously to outdated, inflexible concepts, is reason why, DeVore asserts:

> the efforts of the profession have failed to establish this area of education as an intellectual discipline. Without this attainment, those engaged in industrial arts, both individually and collectively, continually dissipate their energies justifying their existence, formulating objectives and defining and redefining the field of study.[30]

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[27] Paul W. DeVore, Technology: A Structure for Industrial Arts Content (A paper presented at Eastern Michigan University, January 1965).

[28] Ibid., p.14.

[29] Ibid.

[30] Ibid., p.3.

As a corrective, DeVore advances Warner's thesis, that the Industrial Arts curriculum should "reflect the technology,"[31] Technology, he holds, is an intellectual discipline;[32] and as such, will provide "a strong central integrating purpose and foundation for a curriculum structure,"[33] a structure "with external stability and internal flexibility and adaptability to technological change."[34]

The curriculum structure DeVore proposes, is based on the assumption that technology is a human creation, identifiable with man's intellectual achievements which reach back to "the dawn of civilization."[35] On that assumption, he further assumes that "an analysis of history and present society can serve as a means to identify...certain major areas of technological endeavor which may serve as a common ground for a curriculum foundation" for Industrial Arts.[36]

The historical-social analysis, DeVore says, "identifies" man as a builder, man as a communicator, man as a producer, man as a developer, man as a transporter, man as an organizer and manager of work, and man as a craftsman.[37] Having identified these "technological endeavors," DeVore then associates them with correlative major industries which he considers to be the "significant components of man's technology;"[38] and these in turn constitute the "core areas" of study in the proposed structure for Industrial Arts content:

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[31] Ibid., p.15.

[32] Ibid., p.9.

[33] Ibid., p.17.

[34] Ibid., p.3.

[35] Ibid., p.4.

[36] Ibid., p.16.

[37] Ibid., p.17.

[38] Ibid.

The Major Areas of Technological Endeavor	The Core Areas of the Curriculum
Man the Builder	A Study of the Construction Industries
Man the Communicator	A Study of the Communication Industries
Man the Producer	A Study of the Manufacturing, Power and Energy Producing Industries
Man the Developer	A Study of the Research and Development Industries
Man the Transporter	A Study of the Transportation Industries
Man the Organizer	A Study of Work: Its Management and Organization in Industry
Man the Craftsman	A Study of the Craft and Service Industries[39]

DeVore asserts that the structure satisfies the criterion of external stability "since the areas identified for study have established themselves as being significant components of man's technology by virtue of their historical and social base;" and it satisfies the criterion of internal flexibility because "internal changes can be adapted as man's technology advances in a given area...without changing the terminology of a given area."[40]

That the Industrial Arts curriculum should center on man and his technological endeavors, that the subject matter for such a study can be obtained by way of an historical and social analysis, that the instruc-

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[39] Ibid., p.19. Note that DeVore's "components of man's technology synthesize Warner's "divisions of technology" and Olson's "categories of industries."

[40] Ibid., p.17.

tional content should rest upon an externally stable and an internally flexible structure, that Industrial Arts needs to be established as an intellectual discipline: all of these considerations in DeVore's proposal, doubtless are pertinent to a technology-centered program of studies. The degree to which they have in fact been considered, however, leaves certain equally pertinent questions unanswered: How, for example, does DeVore make the transition from "man's technological endeavors"--man the builder, man the communicator, etc.--to a study of the industries? Are industrial activities *ipso facto* technological? In that connection, what aspects of technology are characteristically intellectual? Can questions such as these be answered satisfactorily without first having clarified the meaning of technology? That that basic theoretical requirement has been met, is not evident in DeVore's proposal.

The above critical reviews reveal some striking similarities in basic assumptions, concepts, and curriculum structures, which seem to reflect the opinions and persuasions of a large segment of the Industrial Arts profession. But they also reveal some shortcomings, which may account for the fact that the proposed concepts and structures have not been implemented noticeably in educational practice. In their survey of Industrial Arts education, Schmitt and Pelley note that "the new curriculum suggests new structures which would reorganize the instructional content to reflect the technology;" but they emphatically add, that: "*The current industrial arts curriculum does not even measure up to the programs recommended by the profession 10 to 20 years ago*."[41]

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[41] *Op. cit.*, p.30. (their italics).

On the Concept of Technology

What has happened in Industrial Arts is indicative of what has taken place elsewhere. During the past quarter-century, technology has emerged as one of the major topics of discussion among teachers and administrators in other branches of education (in the social studies,[42] and in vocational education,[43] for example), and among scholars in virtually every field of scientific and philosophic inquiry. Unfortunately, as is often the case with vague and ambiguous words for which specific referents cannot readily be discerned or pointed to, the meaning of 'technology' is generally taken on its face to be self-evident. And as such, it has yielded to loose interpretation and indiscriminate usage which, in turn, has perverted an indispensable concept and generated confusion in the realm of education.

Sources of Confusion: Deliberate attention to its current usage in the literature reveals several likely sources of confusion. At this juncture, they need only be marked out and briefly described in order to bring the problem into perspective.

1. A clear-cut distinction is seldom made between the broad meaning of 'technology' and the more popular, narrow acceptation of it. Broadly used, its meaning is extended into various realms of human activity--economic, domestic, medical, political, educational, industrial, etc. In its narrow application, the meaning of technology is commonly

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[42]See, for example, Science and the Social Studies, Twenty-Seventh Yearbook of the National Council for the Social Studies, Edited by Howard H. Cummings (Washington: The Council, 1957).

[43]Vocational Education, The Sixty-Fourth Yearbook of the National Society for the Study of Education, Edited by Melvin L. Barlow (Chicago: The University of Chicago Press, 1965).

restricted to the realm of industry and for practical purposes remains synonymous with 'industrial technology'. Such usage does not get by without criticism; Perry, for example, states that,

> Technology may be drawn from natural knowledge, as when the judgments of chemistry mediate the interests of industry. The term 'technology' is sometimes used in a restricted sense to refer only to such naturalistic technology. But this restriction is arbitrary.[44]

The French writer, Jacques Ellul, who has devoted considerable attention to problems of technology makes the following observation:

> Whenever we see the word technology or technique, we automatically think of machines....It is a mistake to continue with this confusion of terms, the more so because it leads to the idea that, because the machine is at the origin and center of the technical problem, one is dealing with the whole problem when one deals with the machine. And that is a greater mistake still. Technique has now become almost completely independent of the machine, which has lagged far behind its offspring.
>
> It must be emphasized that, at present, technique is applied outside industrial life. The growth of its power today has no relation to the growing use of the machine.[45]

2. In the restricted sense, 'technology' is often used synonymously with 'technic' and 'technique', and sometimes with 'praxiology'. A certain amount of confusion in this regard stems from the loose translations into English of works by French, German, Slavic, and other foreign writers who use the terms die Technik, la technique, and technologie, and similar derivatives of the Greek technē. For example, Klemm's work, Technik: Eine Geschichte ihrer Probleme (Technik: On the History of its Problems), appears in the English translation under the title, A History of Western Technology;[46] Daumas' Histoire Generale des Techniques (General

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[44]Ralph Barton Perry, Realms of Value (Cambridge: Harvard University Press, 1954), p.182.

[45]Jacques Ellul, The Technological Society, translated from the French by John Wilkinson (New York: Alfred Knopf, 1956), pp.3-4.

[46]Friedrich Klemm, A History of Western Technology, translated by Dorothea Woley Singer (Cambridge, Mass.: The M.I.T. Press, 1964).

History of Techniques) was recently published under the English title, A History of Technology and Invention;[47] Karmarsch's Geschichte der Technologie is referred to as "The History of Technology."[48] Inasmuch as each writer uses two or more derivative forms of technē in the same work one cannot arbitrarily assume that the terms are synonymous, much less that they all mean the same thing as the English 'technology'. Ellul's La Technique ou l'enjeu du siecle (Technique or the Wager of the Century) appears in the English translation under the title, The Technological Society, yet Ellul himself emphatically states that "the term technique, as I use it, does not mean...technology."[49] And in their translation of Max Weber's The Theory of Social and Economic Organization,[50] to cite another example, Henderson and Parsons note that "the German word Technik which Weber uses covers both the meanings of the English words 'technique' and 'technology'," and that a "distinction is not explicitly made in Weber's terminology;"[51] they go on to say that the terms are introduced according to the context, yet they do not clarify the distinction, in neither the French nor the English. To show that the problem is not something new, Espinas called attention to it eighty years ago in "Les

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[47]Maurice Daumas, A History of Technology and Invention, translated by Eileen B. Hennessy (New York: Crown Publishers, 1969).

[48]R. Oldenbourg, "The History of Technology," The Practical Arts Magazine, III, No.1 (1874), pp.107-111; see footnote on p.107.

[49]The Technological Society, op. cit., p. xxv.

[50]Max Weber, The Theory of Social and Economic Organization, translated by A.M. Henderson and Talcott Parsons (London: The Free Press of Glencoe, 1947).

[51]Ibid., footnote on p.160.

origines de la technologie."[52] Therein he says that the term technique, technologie, and praxeologie "are badly misunderstood;" and after a lengthy discussion on their distinctive differences, he says that he will use the latter two terms "indiscriminately one or the other."[53] Other examples could very well be cited; let it suffice to add that the champions of "modern" English usage, though they recognize the problem, have not been very helpful in resolving it. Follett's Modern American Usage, for example, states that:

> The logos of a thing or activity, from which we derive our fast-multiplying ologies, is its reason or theory--the discourse about it. The very length and roll of the word thus formed tempts the heedless to use it whenever the thing or activity itself, and not its theory, is what they have in mind. The flagrant example is technology, which should mean the theory of our mechanized world, instead of the machinery itself. This confusion has led some modern writers to use technics, techniques, and technē (Greek for art or craft) to mark the forgotten difference and properly designate the machine civilization.[54]

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[52] Alfred Espinas, in Revue Philosophique (XV-XXX, 1890), pp.114-115. Espinas defines the terms as follows (translated and paraphrased by this writer): Technique is a complex of established rules. The term praxiologie signifies the science underlying technique comprehended in their entirety, i.e., the science of the most general forms and the highest principles of activity in the world of living beings. Technologie generale signifies the greater part of praxiologie that deals with 1) analytical description, classification and systematization of techniques ("des arts utiles the useful arts")The Greeks called them Τεχναι; 2) investigation of conditions and laws which indicate the effectiveness of human activities; and 3) tracing the origin and development of techniques, and their progress driven by the forces of tradition and invention.

A similar distinction is made in Tadeusz Kotarbinski, Traktat O Dobrej Robocie (Warsaw: Polska Akademia Nauk, 1965) Annex 4, pp.358-377. There the author appropriates the term Prakseologia for his "theory of efficient work."

[53] Espinas, Ibid., p.115 (mais il nous d'employer indiffermen t l'un ou l'autre).

[54] Wilson Follett, Modern American Usage (New York: Hill and Wang, 1966), under 'ology, ologies", p.238.

The emphasis on theory may be a point well taken, but the implication that all of the derivatives of the Greek techne should be restricted to the machine industry is an arbitrary interpretation. The further development of the present study will argue against that point of view.

3. Despite the recent claims that "the history of technology has begun to establish itself as a discipline,"[55] historians of technology are far from agreeing on the nature and extent of their subject matter. Forbes, for example, treats the subject as a history of "discovery, inventions and engineering;"[56] Derry and Williams treat it as a "connected account of the evolution of modern industry."[57] Bronowski treats it as "the detailed and orderly story of men and their machines," concentrating on "specific materials, particular techniques, and certain well-defined fields of technological endeavor;"[58] while Kranzberg and Purcell perceive the history of technology as "a branch of social history" encompassing the "intellectual, economic, political, art, military, and even religious history."[59] The Historians themselves are well aware that their field is ill-defined: Derry, for example, admits that "the choice of what to include in such a work and what to omit must necessarily be very

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[55]Robert A. Merrill, "The Study of Technology," International Encyclopedia of Social Sciences, Vol. 15 (New York: The Macmillan Co. and the Free Press, 1968), p.582.

[56]R.J.Forbes, Man the Maker: A History of Technology and Engineering (London: Abelard-Schuman Ltd., 1958).

[57]T.K.Derry and Trevor I. Williams, A Short History of Technology (New York: Oxford University Press, 1961), p.2.

[58]Jacob Bronowski (Ed.), Technology (Garden City, New York: Doubleday & Co., 1964), p. 7.

[59]Melvin Kranzberg and Carroll W. Pursell Jr., Technology in Western Civilization, Vol. I (Toronto: Oxford University Press, 1967), p. vi.

subjective."[60] Moreover, they are their own best critics. Whereas Singer, for example, defines the history of technology "as covering the field of how things are commonly done or made,"[61] Daniels argues that "'how things are done or made' is not, strictly speaking, a historian's question;"[62] Kranzberg asserts that "such a definition is so broad and loose that it encompasses many items that scarcely can be considered as technology;"[63] Woodbury agrees with these assertions, and adds that "the editors seem to have made no clear distinction between technology and the arts and crafts."[64] That such discrepencies generate confusion among writers and educators goes without saying. "We are entitled to look to the historian of technology for a better understanding of technology;" says Drucker, "but how can he give us such an understanding unless he himself has some concept of technology?"[65]

4. Many writers treat 'technology' and 'science' ('pure' and 'applied') as correlative or corresponding terms, suggesting that technology and science naturally, logically, or necessarily go together. The arguments, pro and con, that technology is dependent on science (and vice versa) are so prevalent in the literature that they need not be cited.

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[60] A Short History of Technology, op. cit., p.vii.

[61] Charles Singer, et. al., A History of Technology, Vol. I (London: Oxford University Press, 1954), p.vii.

[62] George H. Daniels, "The Big Question in the History of American Technology," Technology and Culture, II, No. 1 (January 1970), p.2.

[63] Technology in Western Civilization, op. cit., p.5.

[64] Robert S. Woodbury, "The Scholarly Future of the History of Technology," Technology and Culture, I, No. 4 (Fall 1960), p.348.

[65] Peter F. Drucker, "Work and Tools," Technology and Culture, I, No. 1 (Winter 1959), pp.36-37.

The confusion arises when these terms are used interchangeably. Snow, for example, states that he cannot "draw a clear line between pure science and technology;"[66] Singer, on the other hand, asserts that since the nineteenth century, technology acquired a scientific content and came "to be regarded as almost synonymous with applied science."[67]

5. Unlike the scientific fields of inquiry identified by nouns with the terminal ending 'ology', the word 'technology' is frequently used, even by important writers, in a plural sense, as 'technologies'. Consequently, the historians' reference to ancient, medieval, and modern technologies; the anthropologists' reference to hunting, herding, fishing, and gathering technologies;[68] the engineering profession's reference to mechanical, electrical, civil, and chemical technologies; and the Industrial Arts profession's reference to wood, metal, and ceramic technologies; all suggest somewhat different referents. Needless to say, such usage results in a diversity of interpretations, both within and between the various fields of inquiry and the professions.

On Defining Technology: Attempts to rectify the terminological problem have focused on definition of technology. Many scholars have given serious attention to the problem and numerous definitions have been formulated; but there is little evidence to indicate that they have succeeded in reaching any measure of agreement. As one philosopher of

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[66]C.P.Snow, The Two Cultures: and a Second Look, (New York: The New American Library, 1964), p.64, This writer's italics.

[67]Charles Singer, et. al., A History of Technology, (London: Oxford University Press, 1954), Vol. I, p.vii., This writer's italics.

[68]See, for example, Leslie White, "The Evolution of Culture," and Stanley H. Udy, Jr., "Preindustrial Forms of Organized Work," in Peter B. Hammond, Cultural and Social Anthropology, (New York: The Macmillan Company, 1964), pp.406-426 and pp.115-124, respectively.

technology sees the situation, "any definition is inevitably colored by the way in which it has been reached. This is the reason," he writes, "why there are so many definitions of technique and technology."[69] Or as Bernard puts it, "men of affairs everywhere are prone consciously or unconsciously to warp definitions in their own interest."[70]

Here again, lexicographers are of little help, and sometimes add to the confusion. Burns writes in the Dictionary of the Social Sciences that,

> Early uses of the term, at the very beginning of the 18th century, adhere closely to the sense of the original Greek: the first Oxford English Dictionary reference is to a book title (1706) "Technology, A Description of Arts, especially the Mechanical".[71]

The citation is in error on two counts: a) The original Greek word, technologia, from which 'technology' derives, had no connection with Mechanical arts. (This point will be clarified in the next chapter). b) The Oxford English Dictionary makes reference not to a book title but rather to a definition of 'technology' which appears (as quoted by Burns) in Kersey's Dictionary, published in 1706.[72]

Several dictionaries, including the Oxford, define 'technology' in one of its senses as "the scientific study of the practical or industrial arts." Despite its restriction to a kind of "arts", the abbreviated definition appears to be etymologically valid. It does not follow, however

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[69] Andrew G. Van Melsen, Science and Technology (Pittsburg, Pa.: Duquesne University Press, 1961), pp.247-248.

[70] L.L.Bernard, "Definition of Definition," Social Forces, Vol.19. No. 4, (May 1941), p.508.

[71] Tom Burns, "Technology," A Dictionary of the Social Sciences, Edited by Julius Gould and William L. Kolb (New York: The Free Press of Glencoe, 1964), p.716.

[72] John Kersey, Dictionarium Anglo-Britanicum or A General English Dictionary, (London: J. Phillips, 1706).

that Industrial Arts is ipso facto the scientific study of technology. This illogical transformation of terms is sometimes sued by educators as a basis for defining Industrial Arts education. Industrial Arts indeed can, and many educators agree that it should, center on the study of technology, but the basis for such a study would have to be established on firmer grounds. The transformed dictionary definition is at best a tautological statement which leaves both Industrial Arts and technology undefined, and as such, merely compounds the terminological problem.

Many, or perhaps most, definitions appear to be arbitrary statements about technology, or statements based on quasi theories about technology. The latter are of course no more genuine than the arbitrary statements inasmuch as any "theory" about technology already implies an antecedent meaning of technology. Needless to say, a "theory" about technology is no substitute for a theory of definition which determines the criteria, or the requirements, for a genuine definition. "There must be," according to Perry, "a control or set of criteria, by which the definition is justified or rejected."[73] Even a cursory acquaintance with some of the well known theories--the Aristotelian per genus et differentiam definition,[74] Bridgman's "operational" definition,[75] Ogden

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[73]Perry, op. cit., p.2.

[74]"There is nothing else in definition," says Aristotle, "but the primary genus and the differentia...But further we must also divide by the differentia of the differentia...the ultimate differentia will be the substance and definition of the thing." The Metaphysics, BOOK VII, xii-xiii, Trans. by Hugh Tredennick, (London: William Heinemann Ltd., 1933) pp.373-5.

[75]"...the proper definition of a concept is not in terms of its properties but in terms of actual operations...In general, we mean by any concept nothing more than a set of operations; the concept is synonymous with the corresponding set of operations." In P.W.Bridgman's, The Logic of Modern Physics, (New York: The Macmillan Company, 1951), pp.5-6.

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and Richard's "referential" definition[76]--supports the foregoing assertions. Granted, theorists disagree, sometimes polemically; Ogden and Richards, for example, argue (in 1923) that no theory of definition, particularly the Aristotelian, is "capable of practical application under normal circumstances;"[77] Korzybski, on the other hand, criticizes all theories, (in 1941), particularly those based on "referential" and "operational" methods, arguing that on such bases "most terms are 'over/under defined'."[78] Such disagreements among important theorists serve more to emphasize the indispensability of theory for resolving terminological problems than they do to discredit opposing theoretical views.

Disagreements notwithstanding, some theorists seem to agree that a definition should take into account the antecedent usage of a word. According to Perry's criteria, for example, a definition names, or fixes a verbal label which is "usually secondhand; that is, the name has an antecedent usage, which renders its present usage appropriate or inappropriate."[79] Its appropriateness, he states, "must be judged by its history and suggestiveness."[80] Peirce agrees, asserting that the history

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[76]"...the essential problem of how we define, or attain the substitute symbols required in any discussion...is, in all cases to find the referent." In C.K. Ogden and I.A. Richards, The Meaning of Meaning, (New York: Harcourt, Brace & World), p.113, 1946.

[77]Ibid., p.109.

[78]Most terms, according to Korzybski, are over-defined by intension, or belief in verbal definitions, and are hopelessly under-defined by extension i.e., verbal definitions do not correspond to the extensional facts of the objects defined. In Alfred Korzybski, Science and Sanity (Lakeville, Conn.: The International Non-Aristotelian Library Publishing Co., Fourth Edition, 1958), p.

[79]Op. cit., p.3.

[80]Ibid., p.4.

of words is "the key to their meanings."[81] Ogden and Richards suggest that "at the beginning of a serious examination of an ambiguous word we should collect as wide a range of uses as possible"[82] and look for common elements of meaning.

Inasmuch as the word 'technology' is "secondhand", an inquiry into its origin and history should provide the basis for an ensuing discussion on its meaning. Chapter II opens first with a study of the etymological roots of 'technology' and its related concepts, followed by a synoptic account of its history and the context in which it was used. Against this background, Chapter III critically examines and compares current definitions given to the word by important writers from various fields of scientific and philosophic inquiry. There the essential elements of definition are identified, and in Chapter IV they are structured into a theoretical model of technology. Finally, Chapter V shows how the model can be used to select and structure subject matter for Industrial Arts education.

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[81]Charles S. Peirce, Proceedings of the American Academy of Arts and Sciences, (Boston, VII, 1868), p.295.

[82]*Op. cit.*, p.128.

CHAPTER II

TECHNOLOGY IN HISTORICAL PERSPECTIVE

The word 'technology' derives from the ancient Greek τεχνολογια (technologia), the roots of which are τεχνη (technē) and λογος (logos). These commonly accepted facts which any etymological dictionary or lexicon readily substantiates are frequently introduced into discussions on the meaning of technology suggesting that the ancient Greek terms have something in common with their derivatives. The mere reference to them alone, however, sheds little if any light on the meaning of technology so that in themselves they are hardly worth noting. To be of epistemic value, other pertinent observations need to be brought into the discussions, e.g., the various connotations of technē and logos, as well as the original meaning of technologia. Moreover, the terms technologia, techne, and logos need to be perceived in historical perspective in conjunction with other related Greek terms (e.g., epistēmē, theōria, praxis) and their derivatives.

Assuming that an etymological and historical inquiry can help to clarify the meaning of technology, the object of the present chapter is to go beyond dictionaries and lexicons into primary sources to find out what specifically the ancient Greek writers meant when they used the terms in question; when and in what context they originated; how and in what context the word 'technology' evolved; how it came to be associated with science and the industrial arts; and what effects the evolving concept of technology has had on educational thought. A consideration of these points should, accordingly, bring into relief a distinction between the ancient concept of technology and the modern concept of "ancient technology."

The following discussion takes into account the history of the word 'technology' as well as the historical context in which it evolved; hence, it is neither exclusively etymological, nor is it definitively historical. It is presented, rather, in the form of a chronological sketch consisting only of pertinent observations as they apply to the present object of inquiry.

The Origin of Technē

Even before the great literary period of ancient Athens the terms technē and logos were already embodied in the Greek language. They are first met with in the epic poems of Homer and Hesiod, which,[1] though uncertain, are supposed by many scholars of classical literature to have been committed to writing in the sixth century B.C. during the time of Solon and the reign of Pisistratus, the "tyrant" of Athens.[2] The uncertainty of their origin notwithstanding, the fact that they are the earliest sources of reference to the ancient Greek language, the works of Homer and Hesiod furnish a useful vantage point from which to observe the origin and evolution of the concept of technology.

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[1]"The time of Hesiod and Homer," says Herodotus (c485-425 B.C.), "was not more than four hundred years before my own" (II. 53); which places the ancient poets in the ninth century B.C. or thereabouts. From Herodotus, translated by A.D.Godley, Volume I (London: William Heinemann Ltd., 1920), p.341.

[2]J.J.Eschenbung, Manual of Classical Literature, translated by N.W.Fishe (Philadelphia: Edward C. Biddle, 1844), p.450.

Technē and the Manual Crafts: We find in the epics sufficient evidence to indicate that numerous manual crafts must have flourished in Greece prior to the time of Homer. His vivid descriptions of them in terms of craft processes, tools, and crafted products, indicate that Homer's acquaintance with them was more than passing. In the Iliad and Odyssey he talks about the potter (κεραμευς), the worker in leather (σκυτοτομος), the carpenter and joiner (τεκτων), the smith or worker in metal (χαλκευς).[3] He alludes to the processes of working bronze, iron, gold, and silver; of fashioning armour and "sturdy shields"; of forging "much cunning handiwork, brooches, and spiral arm-bands, and rosettes and necklaces" (Il. 18.401-2); of forging rivets; of inlaying ivory; of boring holes; of hewing beams. He gives equal attention to craft tools and crafted objects; for example, he talks about the smith who

> came bearing in his hands his tools of bronze, the implements of his craft, anvil and hammer and well-made tongs wherewith he wrought the gold (Od. 3.432-5).

> First fashioned he a shield, great and sturdy, adorning it cunningly in every part, and round about it set a bright rim, threefold and glittering, and therefrom made fast a silver baldric. Five were the layers of the shield itself; and on it he wrought many curious devices with cunning skill (Il. 18.477-482).[4]

Homer's references to the crafts are, of course, incidental to the epics, often introduced merely as metaphors or literary embellishments. Nevertheless, the fact that they are accorded so much attention suggests

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[3]The term τεκτων is used to refer to a builder (Od. 17.384), a shipwright (Od. 9.126), a craftsman (Od. 19.56), in addition to a carpenter (Il. 15.411); see Homer, The Odyssey, translated by A.T.Murray, Vols. I and II (London: William Heinemann, 1919); Homer, The Iliad, translated by A.T.Murray, Vols. I and II (London: William Heinemann, 1923).

[4]Note: All of the references to the Iliad and Odyssey in this chapter are taken from the Murray translations.

that perhaps the crafts were recognized in Homer's time as worthy human activities (activities which the aristocratic Greeks of a later period were to consider unworthy, below human dignity). There was even a place in their mythology for Daedalus (Δαιδαλος), the "ideal craftsman" (Il. 18.592); and among their gods, the high-ranking god of fire and metal-working, "the famed craftsman", Hephaestus (Ηφαιστον Κλυτοτεχνην) (Il. 18.491). It is in this context that the modern mechanical-industrial concept of technē has its origin.

Technē and the Verbal Arts: At the time the epics appeared in writing there was not yet a direct connection between technē and logos. The meaning of technē was more or less restricted to "manual" craft or "cunning" skill;[5] and logos conveyed the unequivocal meaning of a word or words, in the sense of the spoken word.[6] With the subsequent growing interest in the literary arts, however, technē gradually acquired the connotation of skill in oratory; and in the same context, logos acquired the broader connotations of discourse or treatise. The "verbal" context in which they merged came about in consequence of a chain of circumstances in which the epics played a significant and decisive role.

The literary form of the epics provided the ancient Greeks a model for literary expression; the poet, the statesman, the critic, the

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[5]It is sometimes used in the "bad sense" of one being crafty, (Od. 4.455; 8.327; 8.332); Hesiod uses the term in this sense only; see Hesiod, "The Theogony", in The Homeric Hymns and Homerica, translated by Hugh G. Evelyn-White (London: William Heinemann, 1914), lines 160 and 770, pp.91 and 135 respectively.

[6]According to Liddell, "λογος never means a word in the grammatical sense, as the mere name of a thing or act, but rather a word as the thing referred to, the material, not the formal part"; in Henry G. Liddell and Robert Scott, A Greek-English Lexicon, Seventh Edition (London: Oxford University Press, 1884), p.901.

philosopher, all wrote in the poetic style of Homer and Hesiod. "Such indeed was the preference for metrical composition," Eschenburg observes, "that Parmenides taught his philosophy in verse, and Solon published his laws in the dress of poetry."[7] In content, the epics furnished the substance for a new way of life that was to have a profound effect and a lasting influence on every class of the people. From Hesiod, the common man--the shepherd, the husbandman, the merchant--drew his simple ethics for daily conduct and practical rules for industry.[8] From Homer, on the other hand, Pope writes that,

> the poets drew their inspiration, the critics their rules, and the philosophers a defence of their opinions; every author was fond to use his name, and every profession writ books upon him till they swelled the libraries. The warriors formed themselves upon his heroes, and the oracles delivered his verses for answers.[9]

Homer's portrayal of brave and gallant heroes and their military prowess infused in the people a spirit of national pride. This attitude, coupled with the spread of literacy and the Hesiodic precepts for industry, brought forth a renaissance in Greek art, commerce, science, and philosophy, and a movement toward popular forms of government. In Athens, Solon had already layed the foundation for a democracy.[10] When the transition came in the latter part of the sixth century, and the tyranny of Pisistratus gave way to a democratic form of government, oratory superseded epic poetry as an indispensable form of literary

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[7] Manual of Classical Literature, op. cit., p.483.

[8] Hesiod, "The Works and Days", in The Homeric Hymns and Homerica, op. cit.

[9] Alexander Pope, quoted in the Manual of Classical Literature, op. cit., p.450.

[10] Herodotus, (1.19), op. cit., p.33.

expression. One of the immediate consequences of the transition, Jebb observes, "was a mass of litigation on claims to property, urged by democratic exiles who had been dispossessed" by the tyrants, and the new "art" of oratory "was primarily intended to help the plain citizen who had to speak before a court of law."[11]

Oratory as a genuine form of artistic expression had not as yet been developed on the theoretical level; the principles, and the practical rules deduced therefrom, were yet to be systematized. Here again, the epics furnished the model; in the Iliad there is evidence, for example, of Achilles' practical skill of exhorting warriors into battle, and of Nestor's oratorical eloquence in proving a point, and Homer's description of Nestor as:

> the clear-voiced orator of the men of Pylos, he from whose tongue flowed speech sweeter than honey (Il. 1.247.9).

The beauty of style exemplified in the speeches of Homer's heroes doubtless suggested to the early Greek statesmen the advantage of careful attention to the language and manner of oratorical delivery. "From the time of Solon," writes Eschenburg,

> political eloquence was much practiced at Athens, and by emulation of great speakers was ere long advanced to high perfection. Rhetoric and oratory soon became objects of systematic study, and were indispensable in the education of such as wished to gain any public office, or any influence in the affairs of the state.[12]

The urgent demand for some method of teaching the <u>craft</u> of speech writing and the <u>skill</u> in public speaking was soon met in the publication of numerous treatises on the "art" of rhetoric. "As often happens,"

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[11]R.C.Jebb, "Rhetoric" <u>Encyclopedia Britannica</u>, Ninth Edition, Vol. XX, p.509.

[12]<u>Manual of Classical Literature</u>, <u>op. cit</u>.

Fogarty observes,

> conscious theory seemed to follow unconscious art. Corax of Syracuse, one of the many who must have seen this social need, worked out a theoretical way to prepare speeches in what was the first technē, or art of rhetoric.[13]

Now, techne was used synonymously with the art of rhetoric; and logos came to be associated with techne in the same context. What we know about Corax (fl. 5th century B.C.) and the other compilers of the "art" comes from Aristotle's accounts (c.330 B.C.) of its history in his own Τεχνης Ρητορικης ("Art" of Rhetoric).[14]

Aristotle: On Science and Art

Almost a century before Aristotle's appearance in the history of Athens, Greek culture in general had already passed its zenith of excellence. The cultural development launched in the sixth century culminated in the great Athenian Age of Pericles in the fifth century. The degree to which the arts and crafts had proliferated and learning had advanced is reflected in the works left to posterity by the Greek writers and artist-craftsmen of that age. In Athens flourished the poets Sophocles and Euripides, the philosophers Anaxagoras and Socrates, the astronomer Meton, the painter Polygnotus, the architect Ictinus, the sculptors Phidias and Polyclitus; and elsewhere, Herodotus, "the father of history"; Hippocrates, "the father of medicine"; and the philosopher Democritus, who with Leucippus, authored the first "atomic theory". This was the age in which the architectural techne of Ictinus erected the

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[13] Daniel Fogarty, S.J., Roots for a New Rhetoric. (New York: Columbia University, 1959), p.10.

[14] Aristotle, The "Art" of Rhetoric, translation by John Henry Freese, (London: William Heinemann, 1926). Note: all citations from the Rhetoric in this chapter are taken from the Freese translation.

Parthenon, and the sculptural *technē* of Phidias created the Athena. But this was also the age in which the "physical" philosophy of Anaxagoras gave way to the "ethical" philosophy of Socrates.

Before Socrates, philosophic speculation had been, in Tredennick's words, "almost entirely scientific and materialistic."[15] Beginning in the sixth century with Thales of Miletus, "the father of philosophy", to the time of Democritus of Thrace, a string of "physicists" and "atomists" sought to find a rational explanation (logos)[16] of the processes of nature. "But with the growth of rhetoric," observes Tredennick, "men began to think in more abstract terms."[17] They found their best spokesman in Plato, disciple of Socrates, who turned rational inquiry from cosmology to the foundations of knowledge and the criticism of value. Thenceforth, scientific-materialistic speculation expired, not to be revived, as we shall see, until the seventeenth century.

These conflicting world views were inherited by Aristotle when he appeared on the scene in the fourth century B.C. It was his endeavor to compromise the differences between these views and to systematize the existing philosophic and scientific knowledge.[18] Moreover, he was

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[15]Hugh Tredennick, in the Introduction to Aristotle's *Metaphysics* (London: William Heinemann, [1933] 1961), p.xx. Note: all citations from the *Metaphysics* in this chapter are taken from the Tredennick translation.

[16]For Heraclitus (fl, 500 B.C.), one of the most important presocratic philosophers (he wrote *On Nature*), the term λογος means, according to Tredennick: "explanation to account systematically for the variation in the perceptible world"; in the "Introduction" to Aristotle's *Metaphysics*, *op. cit.*, p.xi.

[17]*Op. cit.*

[18]See George Sarton, *A History of Science* (Cambridge, Mass.: Harvard University Press, 1952), p.496; also John A. Symonds, *Studies of the Greek Poets*. (London: A. and C. Black, 1920), p.19.

particularly concerned with "working toward a more precise terminology."[19] By the fourth century B.C. the Greek language had undergone considerable change, so much so that "much of Homer was as unintelligible to an Athenian," says Rutherford, "as Chaucer is to an ordinary Englishman of the present century."[20] Not only had words changed in form and meaning, but several terms were used to convey the same or similar meanings. Among the ambiguous terms, logos had acquired the connotations of (1) that which is said or spoken, and (2) the power of mind which manifests itself in speech; or as one lexicographer puts it, logos came to mean:[21]

> (A) the word or outward form by which the inward thought is expressed; and (B) the inward thought itself; so that the λογος comprehends the ratio [reason] and oratio [discourse].

At the same time several terms other than technē came to signify "skill", among them, σοφια (sophia)[22] and επιςτημη (epistēmē),[23] two important

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[19] Martin Ostwald, Aristotle: Nicomachean Ethics (New York: The Bobbs and Merrill Co., 1962), p.312. Note: all citations from the Ethics in this chapter are taken from Ostwald's translation.

[20] W. Gunion Rutherford, The New Phrynichus (Hildesheim: George Olms Verlagsbuchhandlung, 1881), p.1.

[21] Lidell and Scott's Lexicon, op. cit.

[22] Homer used the term in the Iliad to mean "skill in handicraft" (15. 412); Ostwald notes that "in popular usage, sophia first appears in Greek to describe the skill of a clever craftsman, and also of poets and artists, a concept which was then extended to other fields of endeavor, e.g., to the itinerant teachers of rhetoric...and finally to the 'wisdom' of the scientist and philosopher." Op. cit., in a footnote on pp.155-156.

[23] Homer used the term in several forms, e.g., επισταto "manifold skill in handiwork" (Il. 23.705), and επισταμενοι "skilled in fighting" (Od. 4.49). The term conveys, in addition to mere skill, the idea of intellectual understanding or knowledge of some particular activity, e.g., επιστaιτo "man who hath understanding" (Il. 14.92), and επιστασθαι "knowledge of handiwork (Od. 2.117).

concepts in Aristotelian philosophy. Aristotle reserved the term _sophia_ to signify the highest intellectual excellence of which the human mind is capable, namely, "theoretical wisdom;" and to _epistēmē_, (the key to the present terminological problem) he assigned the specific meaning of "scientific knowledge".

Aristotle's Definition of Scientific Knowledge: All of the Greek terms relevant to the present discussion are embodied in Aristotle's _per genus et differentiam_ definition of _epistēmē_. (See Figure 1). A synopsis of the definition should help to show their interrelationships, and will provide a useful frame of reference for the reaminder of the discussion.

Under the genus _epistēmē_ (scientific knowledge), Aristotle recognizes three general divisions: _theōrētikē_ (theoretical or pure, science), _praktikē_ (practical science) and _poiētikē_ (productive science). The differentia _theōrētikē_ subsumes three specific branches of science: metaphysics, physics, and mathematics; _praktikē_ includes ethics and politics; _poiētikē_ subsumes rhetoric and poetics. These branches of science, according to Aristotle, encompass all human knowledge which, governed by _logos_ (reason, the rational principle), constitute the bases for all rational human activity.

Theoretical activity is characterized by _theōria_ (contemplation) and _sophia_ (theoretical wisdom); its end is intellectual excellence, i.e., knowledge as an end in itself. Practical activity is characterized by _praxis_ (moral action) and _phronēsis_ (practical wisdom); its end is moral excellence. Productive activity is characterized by _poiēsis_ (production; literally, "making") and _technē_ ("wisdom" in the arts); its end is excellence in artistic accomplishment.

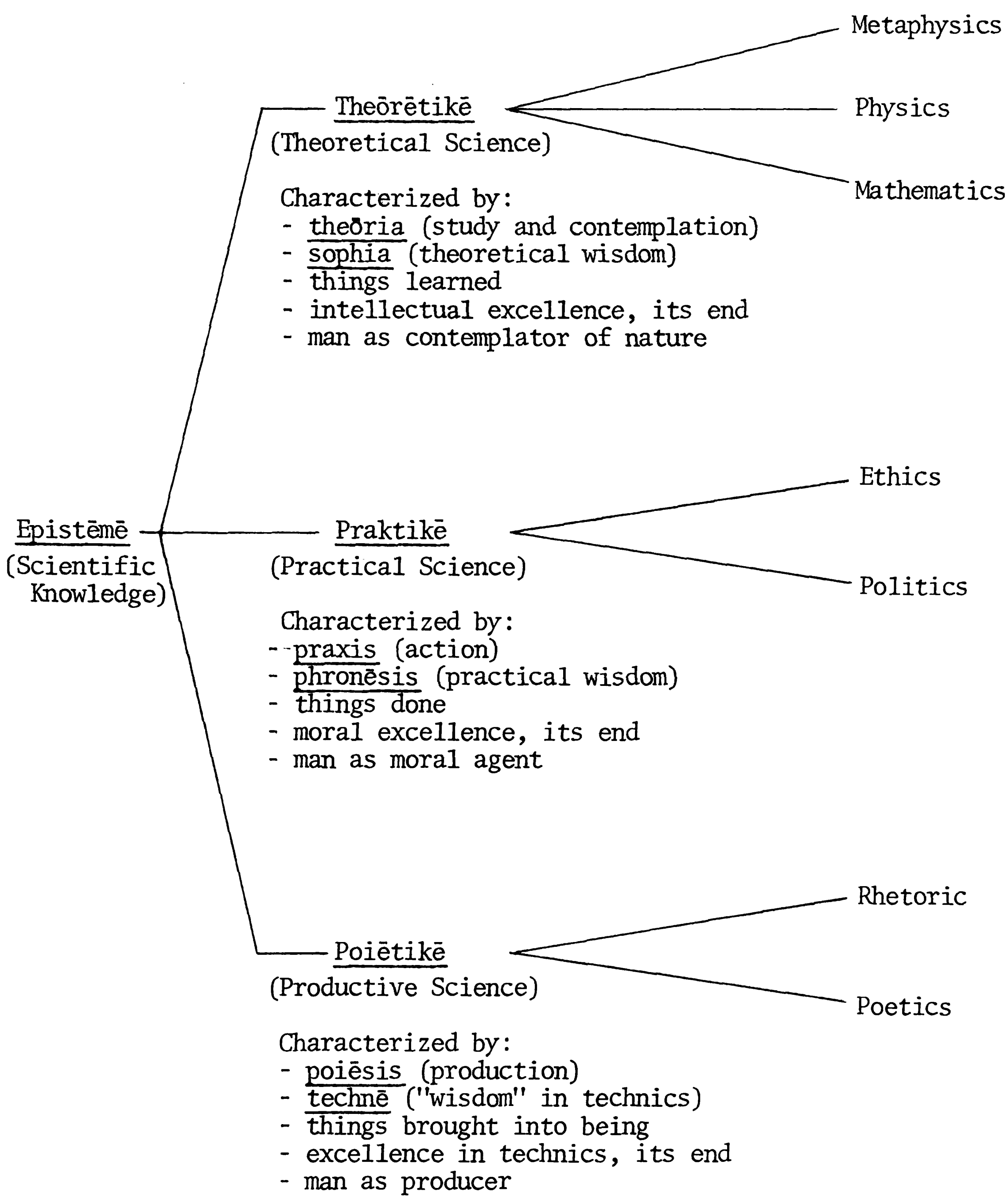

Figure 1. Aristotle's _per_ _genus_ _et_ _differentiam_ Definition of _Epistēmē_. (This writer's schematic interpretation.)

The foregoing adumbrated definition of science brings into perspective several conceptual relationships which are central to the problem under discussion. These relationships are of particular note in view of the general acceptance of Aristotelianism as the unquestionable foundation of philosophic and scientific thought and its subsequent authoritative influence in virtually every realm of human activity for more than two thousand years.[24] Coetaneously with the prevailing Aristotelian world view, Greek terminology remained fundamentally unchanged. "A very large part of our technical vocabulary, both in science and in philosophy," Morrow observes, "is but the translation into modern tongues of the terms used by Aristotle."[25]

Aristotle's Conception of Theoretical Science: It may be argued that Aristotle had no intention of assigning to "productive science" a special place in his classification of sciences;[26] on this point he himself is not consistently clear. In any event, what is more important to the present study is the fact that he draws a clear line between "pure" science and the other realms of scientific inquiry--between *theōrētikē* on the one hand, *praktikē* and *poietikē* on the other, i.e., between "knowing," "doing," and "making." Theoretical science centers on objects which exist of necessity, the "eternal", as Aristotle labels them; "for everything that exists of necessity in an unqualified sense is eternal,"

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[24]George Sarton, *A History of Science* (Cambridge, Mass.: Harvard University Press, 1952), p.496.

[25]Glenn R. Morrow, "Aristotelianism," in Dagobert D. Runes, *Dictionary of Philosophy* (New York: Philosophical Library, Inc., 1960), p.23.

[26]See for example, A.E.Taylor, *Aristotle* (New York: Dover Publications, Inc., 1955), pp.19-20.

he says, "and what is eternal is ungenerated and imperishable and hence cannot be otherwise;"[27] e.g., that the angles of a triangle equal two right angles. The practical and productive sciences, on the other hand, attend to "things which admit of being other than they are," namely "things made and things done."[28] In this respect, praxis (action) and poiēsis (production), though categorially consonant, are characteristically different forms of rational activity: praxis identifies with "what man does", e.g., good deeds, noble and just acts; whereas poiēsis identifies with "what man brings into being," e.g., the production of good health, of fine paintings, of useful objects. Of these forms of activity, Aristotle considers praxis worthier of higher esteem; "for production has an end other than itself, but action does not: good action is itself an end."[29] In like manner, he judges theōria (contemplation) to be intrinsically superior to both praxis and poiēsis; for "among the sciences," says Aristotle, "we consider that that science which is desirable in itself and for the sake of knowledge is more nearly Wisdom [Sophia] than that which is desirable for its results."[30] It is here that the modern dualisms of theory and practice, abstract knowledge and sensual experience, "pure" science and "applied" science, have their origin.

Aristotle's Conception of Art: Aside from clarifying the relationship of technē and logos to epistēmē, Aristotle's classificatory scheme shows technē and praxis to be categorially different concepts: praxis, a

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[27] Nicomachean Ethics, op. cit., p.150.

[28] Ibid., p.151.

[29] Ibid., p.153.

[30] Aristotle's Metaphysics, op. cit., p.11. (Italics added)

characteristic of practical science, is a human activity; whereas technē, a characteristic of productive science, is a human attribute, a kind of wisdom or disciplined faculty. "We attribute 'wisdom' in the arts," says Aristotle,

> to the most precise and perfect masters of their skills; we attribute it to Phidias as a sculptor in marble and to Polyclitus as a sculptor in bronze. In this sense we signify by 'wisdom' nothing but excellence of art or craftsmanship.[31]

The distinction between techne and praxis is stressed at this juncture because these terms, like their respective derivatives--e.g., 'technical' and 'technological', 'practical' and 'praxiological'--are, in current usage, commonly associated with, and often restricted to, the so-called "useful" or industrial arts.

In the first place, Aristotle's conception of techne does not differentiate between the production of "useful arts" and the production of "fine arts". "All art," he says,

> is concerned with the realm of coming-to-be, i.e., with contriving and studying how something which is capable both of being and of not being may come into existence, a thing whose starting point is in the producer and not in the thing produced.[32]

Moreover, since technē is a kind of wisdom, it follows that neither that which is produced nor its actual production constitute art; they are but outward manifestations of technē. Nor does it necessarily follow that every instance of excellent production reflects wisdom in the arts; for it is possible to attain excellence unconsciously, either by chance or by knack acquired through experience. A particular instance of producing something is a matter of experience; "art is produced when from many

[31] Nicomachean Ethics, op. cit., p.155.

[32] Ibid., p.152.

notions of experience a single universal judgment is formed with regard to like objects."[33] In short, experience is knowledge of particulars, whereas art is knowledge of universals, i.e., knowledge of the causes of excellent production. Hence it is not because of their greater success in producing things that we judge the master craftsmen as being superior in wisdom, says Aristotle, "but because they possess a theory and know the causes."[34]

The Origin of Technologia

The foregoing conception of art is exemplified in *The "Art" of Rhetoric*, which enters upon the subject with Aristotle's observation that,[35]

> all men in a manner have a share of both [rhetoric and dialectic]; for all, up to a certain point, endeavour to criticize or uphold an argument, to defend themselves or to accuse. Now, the majority of people do this either at random or with a familiarity arising from habit. But since both these ways are possible, it is clear that *matters can be reduced to a system*, for it is possible to examine the reason [*logos*] why some attain their end by familiarity and others by chance; and such an examination all would at once admit to be the function of an art [*technē*]...

In other words, to succeed in upholding a particular rhetorical argument by chance or habit is a matter of experience; but to inquire into, and come to know, the underlying causes and guiding principles of sound persuasive argument is a matter of art. The function of the "art" is not to persuade, says Aristotle, but "to find the existing means of persuasion."[36]

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[33] Aristotle's *Metaphysics*, op. cit., p.5.

[34] *Ibid.*, p.7.

[35] Aristotle's *Rhetoric*, op. cit., p.3.

[36] *Ibid.*, p.13.

It is in this context that technologia--the parasynthetic derivative of techné and logos--has its origin.

Technologia and the Verbal Arts: When Aristotle coined the term technologia (c.330 B.C.) its meaning was unequivocal, viz., "the systematic treatment of rhetoric."[37] Despite his assertion that the rational principle of reducing rhetoric to a system "holds good in respect to all other arts"[38] (and is in fact applied in Aristotle's Poetics), technologia is met with in no work other than The "Art" of Rhetoric. Nor does the term appear to have been used by any other ancient writer until the first century B.C. at which time it still conveyed the unambiguous Aristotelian meaning. We find it used in that sense, for example, in the Volumina Rhetorica, compiled around 60 B.C. by Philodemus, the Greek Epicurean philosopher.[39]

About the same time, attention was gradually shifting from rhetoric to the art of grammar. This is not to say that grammar had not theretofore been a subject of study among the Greeks; on the contrary, Plato had already assigned it a prominent place among the "liberal arts" in his Republic. Not until the first century B.C., however, had the art of

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[37]The term appears in the Rhetoric several times with various case endings (I. 1,9; I. 1,10; I.1,11; I.2,4; I.2,5). Lexicographers and scholars of the classics generally agree with Freese's etymological definition of the term; see for example, Liddell and Scott's Greek-English Lexicon, op. cit.

[38]Aristotle's Rhetoric, op. cit.

[39]Philodemi, Volumina Rhetorica, Edited by Siegfried Sudhaus (Lipsiae: B.G.Teubneri, 1892) (1.128s) p.128. The passage in which the term appears was translated for the writer by Dr. Charles A. Messner, Professor Emeritus of Foreign Language, State University College at Buffalo, New York.

grammar been subjected to systematic treatment. Perhaps the earliest evidence of it is the Τεχνη Γραμματικη, compiled around 60 B.C. by the Alexandrian grammarian, Dionysius Thrax.[40] Following the Roman conquest of Greece, Roman scholars had taken a more serious interest in Greek literature, necessitating a working knowledge of both languages; the study of grammar was an indispensable prerequisite. At that juncture in its history, technologia acquired a new connotation, to wit, "the systematic treatment of grammar." Plutarch, the Greek historian, uses the term in this sense in his Moralia;[41] and the Alexandrian grammarian, Appolonius Discolus, uses it in the same sense in De Conjunctione.[42]

In addition to its etymological association with the arts of rhetoric and grammar, technologia gradually acquired other connotations: the neo-Pythagorian philosopher, Nicomachus of Gerasa (1st century A.D.), uses the term with reference to the "systematic treatment of mathematics;"[43] the philosophical skeptic, Sextus Empiricus (fl. 200-250), uses it with reference to the "systematic treatment of definitions;"[44] the Athenian

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[40]E.A.Sophocles, Greek Lexicon of the Roman and Byzantine Periods (New York: Frederick Ungar Publishing Co., 1957), p.5. Also in Eschenburg, Manual of Classical Literature, op. cit., par. 135, p.497.

[41]Plutarch, Moralia, Vol. VI, Translated by W.C.Helmbold (London: William Heinemann Ltd., 1962) (514) pp.460-461.

[42]Appollonii Dyscoli, De Conjunctione, Liber XVI, in Grammatici Graeci, Pars. II, Vol. III, Edited by Richardus Schneider and Gustauus Uhlig (Lipsiae: B.G.Teubneri, 1910). In the Preface, p. v, reference is made to "Apollonii Dyscoli Technē Grammatikē." In the Index, p.271, reference is made to Technologia Grammatikē.

[43]Nicomachus, "Introduction to Arithmetic," Translated by Martin Luther D'Ooge, et al, in Great Books of the Western World, Vol. 11, Edited by Mortimer Adler (Chicago: Wm. Benton, Pub., 1952) (I.5,3) p.813.

[44]Sextus Empiricus, Outlines of Pyrrhonism, Vol. I, Translated by R.G.Bury (Cambridge, Mass.: Harvard University Press, 1961) (II.205) pp.284-285.

philosopher and rhetorician, Longinus (c. 213-273), uses it with reference to his "systematic treatise" on sublimity.[45] With the exception of Cicero's Letters to Atticus (c. 60 B.C.),[46] and Iamblichus' De Vita Pythagorica (c. 300 A.D.),[47] wherein technologia conveys the transliteral connotation (sic) "artificial discussion", the term appears to have retained the essence of its original etymological meaning, to wit, "systematic treatment of..."

Technologia and the Manual Arts:[48] Nowhere in the ancient Greek and Roman literature does the term technologia appear to have been associated with the manual or mechanical arts. Nor does there appear to be any evidence that the ancient writers addressed themselves to the task of systematizing such arts. "We must not imagine," observes Eschenberg,

> the first notions concerning the arts to have constituted any thing like a system reduced to a regular form and fixed principles. With regard to the theory, there were at first only disconnected observations and isolated maxims, the imperfect results of limited experience. As to the practice, there was little but a mechanical routine, some process marked out by chance or imperious necessity.[49]

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[45]Longinus, On the Sublime, Translated by A.O.Prickard (London: Oxford University Press, 1906) (I.1,7) p.1.

[46]Cicero, Letters to Atticus, Translated by E.D.Winstedt (London: Wm. Heinemann, Ltd., 1912) (IV.16,3) pp.314-315.

[47]Iamblichi, De Vita Pythagorica, Edited by Augustus Nauck (Amsterdam: Adolf M. Hakkert, 1965) (XXX.182) p.132; the English translation appears in Iamblichus' Life of Pythagoras, Translated by Thomas Taylor (London: John M. Watkins, 1818) p.96.

[48]Henceforth the terms "arts" and "crafts", and the terms "manual" and "mechanical", will be used interchangeably according to their usage by the authors cited, many of whom do not make a distinction between them. Generally speaking, lexicographers give the terms "art", "craft", and "skill" as English equivalents of the Greek technē. No attempt will be made in the present chapter to clarify their distinctive connotations.

[49]Manual of Classical Literature, op. cit., p.308.

The Greek philosophers embraced the Aristotelian predilection for the abstract, verbal arts. Considering the circumstances, their position, though in a way unfortunate, was quite understandable. Aristotle's breadth of knowledge in virtually all of the then acknowledged realms of philosophic and scientific inquiry, as evidenced in his imposing literary treatises, coupled with his seemingly incontrovertible syllogistic logic, established him as *the* philosopher among philosophers whom none would dare question. Even though he holds that all arts are in principle amenable to systematic treatment, he asserts that all of the arts pertaining to the necessities of life had already been invented and "fully developed."[50] Moreover, "art and science and the other kindred mental activities" are to be pursued "*for the sake of knowledge, and not for any practical utility*."[51] Is it any wonder then that the manual and mechanical arts had not become objects of systematic treatment? Those among the aristocratic class who had the intellectual ability, the literary skill, and the leisure to pursue contemplative study focused on the abstract, verbal arts. The working class, on the other hand, those who provided the necessities of life--the smith, the potter, the joiner, the builder--were for the most part slaves and alien craftsmen, skilled in their narrow pursuits but untutored in theoretical knowledge. Denied the rights of the citizen class, slaves and aliens were excluded from the privilege of "liberal" education. The privileged class, on the other hand, pursued a "universal curriculum" in which there was no place for the manual or mechanical subjects. As Taylor sums up the Aristotelian bias in education,

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[50] Aristotle's *Metaphysics*, *op. cit.*, p.9.

[51] *Ibid.*, 9, 13. (Italics added to emphasize the fact that for Aristotle, art, like science, was an intellectual pursuit.)

> care must be taken that only those "useful" studies (e.g., reading, and writing) which are also "liberal" should be taught; "illiberal" or "mechanical" subjects must not have any place in the curriculum. A "liberal" education means, as the name shows, one which will tend to make its recipient a "free man", and not a slave in body and soul. The mechanical crafts were felt by Aristotle to be illiberal because they leave a man no leisure to make the best of body and mind; practice of them sets a stamp on the body and narrows the mind's outlook. In principle, then, no study should form a subject of the universal curriculum if its only value is that it prepares a man for a profession followed as a means of making a living.[52]

Conditions in the expanding Roman Empire appear to have been more conducive to the proliferation of mechanical arts but were no more appreciative than they were in Greece. There too an unbridgeable gap existed between the theoretical and practical realms of human activity with the latter assuming controlling influence. The relationship between these divergent realms, however, was curiously paradoxical: although the Romans surpassed the Greeks in practical pursuits--e.g., the building of bridges, military roads, war engines, ships, and aquaducts, all of which were vital to the security and maintenance of the Empire--they exhibited a certain contempt for theoretical sciences which were supposed to possess the essential characteristics of things mechanical. The "practical Romans," writes Libby,

> eminent in war, in polite literature, and civil policy, showed at all times a remarkable indisposition to the pursuit of mathematical and physical science. Geometry and astronomy, so highly esteemed by the Greeks, were not merely disregarded by the Romans, but even considered beneath the attention of a man of good birth and liberal education; they were imagined to partake of a mechanical and therefore servile character.[53]

The tenuous relationship between theory and practice inherited from the Greeks prevailed in Roman thought; the theorist and the practical man

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[52]Taylor, Aristotle, op. cit., p.107.

[53]Walter Libby, An Introduction to the History of Science (Boston: Houghton Mifflin Company, 1917), p.41.

remained worlds apart. This dichotomous notion was bequeathed in turn to the medieval European civilizations which embraced and fostered the Aristotelian precepts and predispositions.[54]

Technologia in the Latin Literature: As early as the second century A.D. the Greek language "had deviated perceptibly from the ancient standard," Sophocles observes:

> Old words and expressions had disappeared, and new ones succeeded them. In addition to this, new meanings were put upon old words. The syntax, moreover, was undergoing some changes. Further, Latinisms and other foreign idioms were continually creeping into the language of common life. The purists of the day made an effort to check the tendency, but they were steadily opposed by usage...The grammarians...took it upon themselves to annihilate every word and phrase that had not the good fortune to be under the special protection of a Thucydides or a Plato.[55]

With the passing of Greek as the dominant language in the literary field *technologia* seems to have vanished from the literature.

Soon after the fall of Rome in the fifth century, Latin suffered a similar fate having been "most miserably torn in pieces by the Goths and other Barbarians" who invaded the Empire.[56] During the greater part of the medieval period that followed, learning in general had fallen to a very low ebb. Aside from the *doctores scholastici* who taught the liberal arts in the cloister and cathedral schools, a good secular scholar was a rare phenomenon until the close of the eleventh century.[57] Throughout the period, popularly referred to as the Dark Ages, such Latin works as may

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[54] Bertrand Russell, *A History of Western Philosophy* (New York: Simon and Schuster, 1945), p.234.

[55] Sophocles, *Greek Lexicon*, *op. cit.*, p.6.

[56] John Twells, *Grammatica Reformata, or A General Examination of the Art of Grammar* (London: Robert Clavell, 1683), pp.11-12.

[57] *Op. cit.*, p.10.

have made reference to technologia are very rare or nonexistent.

The situation in the literary field changed considerably around the twelfth century. Exposure of the European culture to that of the Middle East during the first Crusades sparked a revival of interest in the Greek scientific and philosophic literature. The ancient classics preserved for centuries by Arabic scholars began to appear in Latin translations. With their recovery there followed a corresponding interest in the verbal arts, particularly the art of grammar; and coincident with it the term technologia again came into prominent use in that context.[58] According to DuCange's Latin Glossarium of medieval literature (1688) the Latin technikoi and its Greek equivalent technologoi came to be used synonymously with "grammarian, or Doctores of the art of grammar."[59] DuCange notes that the term technologia appears "repeatedly" in treatises on grammar and elsewhere; he cites, for example, the works of Eustathius, a twelfth century Byzantine teacher of rhetoric and grammar, and the Technologia of Grammar, compiled by Lecapeni in the fourteenth century.[60]

It is not surprising that technologia should reappear restrictively

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[58] Op. cit.

[59] Carolo DuCange, "TEXNIKOI", Glossarium Ad Scriptures Mediae & Infimae Graecitates (Graz: Akademische Druck, V. Verlagsanstalt, 1958; printed in facimile from the 1688 edition). Excerpts from the Latin passage appear as follows: "TEXNIKOI, & Τεχνολγοι, Grammatici, seu Grammatica Artis Doctores, ur est apud Eustathium, Iliad, a. pag. 14.22 & alibi passim: apud Allatium in Syntagm, de Georgiis pag. 320, & ex quo Phavorinus Camers pleraque in sua cornocopia collegit. Laudatur in eodem syntagmata pag. 362, Georgii Lecapeni Τεχνολογια περι Γραμματικης. (Interpreted for this writer by Fr. J. Olszewski, SCA of Buffalo, New York.)

[60] Georgii Lecapeni, sometimes called Georgius Lecapenus "lived about the middle of the fourteenth century, and wrote on grammar and rhetoric;" in William Smith, Dictionary of Greek & Roman Biography and Mythology, (Boston: Little, Brown and Company, 1867), Vol.II, Art. 30, p.252.

in the context of the verbal arts. At the same time it seems inconceivable that the status of the natural sciences and the kindred crafts should not have made any appreciable progress during the Middle Ages, and that medieval scholars should have totally ignored these realms of human activity. Yet if one takes into consideration the medieval world view in its temporal context--the social and political instability of Western Europe following the barbaric invasion of the Roman Empire; the ensuing establishment of feudalism with its inherent class structure and its economic isolation; the concurrent spread of Christianity as an influential world-wide social and political force holding power over the minds of men--the prevailing attitude among medieval scholars is understandable.

A detailed account of the manifold implications of the medieval attitude toward practical concerns goes far beyond the limitations of the present discussion. Suffice it to say that neither feudalism nor the Christian movement furnished the desirable conditions for the advancement of natural science and practical activities. Under feudalism trade and industry were controlled for the most part by craft guilds which regulated prices, wages, work hours, standards of quality, and other economic factors. "The minute supervision of work and the innumerable regulations," Ferguson notes, "tended to check individual enterprise and to retard invention or progress of any kind."[61] Christianity, on the other hand, supported by the traditional philosophic systems of Plato and Aristotle, fixed medieval thought on a supernatural course. Divine revelation coupled with reason furnished the means to "real" knowledge the end of

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[61]Wallace D. Ferguson and Geoffrey Bruun, A Survey of European Civilization (Boston: Houghton Mifflin Company, 1969), p.239.

which was to come to "know" God and to have faith in His omnipotence. There was no place in intellectual pursuits for the secular sciences and the practical crafts. "It was natural," writes Guthrie,

> that religion, which played a paramount role in the culture of the middle ages, should bring influence to bear on the medieval, rational view of life. Revelation was held to be at once a norm and an aid to reason. Since the philosophers of the period were primarily scientific theologians, their rational interests were dominated by religious preoccupations. Hence, while in general they preserved the formal distinctions between reason and faith, and maintained the relatively autonomous character of philosophy, the choice of problems and the resources of science were controlled by theology.[62]

The prevailing medieval attitude toward the purely intellectual, as opposed to the mundane practical, concerns "profoundly influenced men's subsequent thinking and their ideas about education," says Dewey:

> Medieval philosophy continued and reenforced the ancient Greek tradition. To know reality meant to be in relation to the supreme reality, or God, and to enjoy the eternal bliss of that relation. Contemplation of supreme reality was the ultimate end of man to which action is subordinate. Experience had to do with mundane, profane, and secular affairs, practically necessary indeed, but of little import in comparison with supernatural objects of knowledge. When we add to this motive the force derived from the literary character of the Roman education and the Greek philosophic tradition, and conjoin to them the preference for studies which obviously demarcated the aristocratic class from the lower classes, we can readily understand the tremendous power exercised by the persistent preference of the 'intellectual' over the 'practical' not simply in educational philosophy but in the higher schools.[63]

Moreover, when one bears in mind the economic conditions in the feudal states "where such practical activities as could be successfully carried on were mostly of a routine and external sort and even servile in nature, one is not surprised," Dewey adds, "that educators turned their back

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[62]Hunter Guthrie, "Scholasticism" (in Dagobert D. Runes, Dictionary of Philosophy, New York: Philosophical Library, 1960), p.280.

[63]John Dewey, Democracy and Education (New York: The Macmillan Company, 1916), pp.310-311.

upon them as unfitted to cultivate intelligence."[64]

Natural Science and Naturalistic Technology

Cultural progress during the centuries that followed the close of the Middle Ages--the Renaissance in the fourteenth century, the invention of printing and the development of oceanic navigation in the fifteenth century, the rebirth of the scientific spirit in the sixteenth century, the establishment of academies of science in the seventeenth century, the Industrial Revolution in the eighteenth century--brought corresponding changes in the sciences and arts, in language and in terminology. New knowledge required new words, or "secondhand" ones, with new or extended meanings. The term 'technology' yielded to the latter; arts other than rhetoric and grammar begged systematic treatment, and 'technology' gradually acquired various connotations associated with objects of a manual or mechanical nature--the medical, the military, the agricultural, the industrial arts.

When the term first appeared in the English literature it conveyed the meaning of "a discourse or treatise" on some technical subject, or the "technical nomenclature" of a particular art or science. In 1615, for example, George Buck uses 'technologie' (perhaps the earliest writer known to have used the Anglicized derivative of technologia) with reference to his "Treatise of the foundations of all the colleges, ancient schooles of priviledge, and of houses of learning, and liberall arts" at the University of London, which systematically catalogues and describes

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[64] Ibid., p.321.

"all the arts and sciences" (among them the arts of rhetoric and grammar0 taught there at the time.[65] Several years later (1628) Thomas Venner used the term 'technology' with reference to a discourse on the techniques of bathing;[66] and in 1658, Thomas Browne used the term to denote the technical nomenclature in the mystical "science" of cabalism.[67]

It should perhaps be noted that as late as 1683, at least one scholar still adhered to the ancient concept of technology. In his General Examination of the Art of Grammar,[68] John Twells used the term to refer to grammatical "essays"; and he may well have been one of the last grammarians to have restricted its meaning to the verbal arts. But what is curious about his restricted usage is the fact that he seems to have been well aware of the trend in the manual arts and of the terms generally associated with "modern" science. He writes, for example:

> What could impede these two last Ages, Ages of Projects and Experiments, from exploding the old Hypothesis, and founding a New Grammar on truer Principles; For 'tis very obvious, that since Printing and Navigation have given a general Converse to Mankind; all Arts and Sciences have been exceedingly improved.[69]

Modern science had, in fact, already taken root more than a half-century earlier, and with it a new concept of art had begun to find

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[65]"And finally, the better to attayne to anie of these arts, sciences, and faculties, and to retaine their principles, and rules, in minde and remembrance," Buck writes, "I must not omit that the Art of Memorie is taught within this Universitie...which may also serve for an apt close of this general Technologie" Sir George Buck, "The Third Universitie of England," in John Stow, The Annales (London: Thomas Adams, 1615) pp.957 (in the text) and 988 (in the footnote).

[66]Thomas Venner, "The Baths of Bath" (1628), in The Harleian Miscellany, Vol. IV (London: R. Dutton, 1809) p.116.

[67]Sir Thomas Browne, "Garden of Cyrus" (1658), in Simon Wilkin, The Works of Thomas Browne, Vol. II (London: H.G.Bohn, 1852) p.558.

[68]John Twells, Grammatica Reformata, op. cit., p.17.

[69]Ibid., pp.20-21.

expression in the literary field. The period marks the transition from the traditional Aristotelian concept of the world to the new dynamic Baconian concept; from the abstract supernatural world view to a concrete natural one.

Natural Science: With the Renaissance and the Reformation man's thought and action turned from the mysteries of supernature over which he had no control, to the facts of nature and his potential power over the forces of nature. "Mechanics became the new religion," to quote Mumford, "and it gave to the world a new Messiah: the machine."[70] The hundred year period from 1550 to 1650 which produced the telescope and the compound microscope, the barometer and the thermometer, witnessed the inventions of the calculating machine, the knitting machine, the screw cutting machine, and the iron rolling machine, and spanned the productive years of Napier, Gilbert, Galileo, Kepler, Descartes, and Francis Bacon. They all played a major role in founding the new scientific movement; but Bacon deserves the distinction of having "had the most direct apprehension of the full extent of the intellectual revolution which was in progress."[71]

Unlike the Aristotelian concept of science based on a priori principles and deductive syllogistic logic, Bacon's concept centered on the observable facts of nature and "genuine induction". "The syllogism," Bacon writes,

> consists of propositions, propositions of words; words are the signs of notions. If, therefore, the notions (which form the basis of the whole) be confused and carelessly abstracted from

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[70]Lewis Mumford, Technics and Civilization (New York: Harcourt, Brace and World, 1962), p.45.

[71]Alfred North Whitehead, Science and the Modern World (New York: The New American Library, 1964), pp.44-45.

> things, there is no solidity in the superstructure. Our only hope is a genuine induction.[72]

In the new science (sometimes referred to as natural philosophy, or the philosophy of nature) direct observation superseded speculation as the means, and utility supplanted contemplation as the ultimate end, of scientific inquiry. Moreover, the proper goal of scientific knowledge was consummated in its usefulness in practice; for "it is safer to begin and raise the sciences from those foundations which have relation to practice," Bacon insists, "and to let the active part itself be as the seal which prints and determines the contemplative part."[73] These views, which are embodied in the famed "New Organon, or True Directions Concerning the Interpretation of Nature" (1620), along with Bacon's proposal for a "Natural and Experimental History for the Foundations of Philosophy" (1622),[74] catalyzed the new science and the manual arts, and layed the foundation for "naturalistic technology".

Naturalistic Technology: Although the term 'technology' does not appear in any of Bacon's published works, his outline for a natural history, particularly the history of "mechanical and illiberal arts," contains the germinal ideas which found literary expression in subsequent treatises so named--agricultural technology, industrial technology, and the like. An excerpt from Bacon's "preparative Towards a Natural and

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[72]Francis Bacon, "The Great Instauration," Part I, Aphorism XIV in Advancement of Learning and Novum Organum, Revised and Edited by Timothy Dwight, et al (New York: The Colonial Press, 1899), p.316.

[73]Francis Bacon, "The Great Instauration," Part II, Aphorism IV, in Essays, Advancement of Learning, New Atlantis and Other Pieces, Edited by Richard F. Jones (New York: The Odyssey Press, 1937), p.335.

[74]In "The Great Instauration," ibid.

Experimental History" should suffice at this juncture to convey his thoughts on the subject:

> History of Arts and of Nature as changed and altered by Man, or Experimental History, I divide into three. For it is drawn either from mechanical arts, or from the operative part of the liberal arts, or from a number of crafts and experiments which have not yet grown into an art properly so called, and which sometimes indeed turn up in the course of most ordinary experience, and do not stand at all in need of art...
>
> Among the parts of history which I have mentioned, the history of Arts is of most use, because it exhibits things in motion, and leads more directly to practice. Moreover it takes off the mask and veil from natural objects, which are commonly concealed and obscured under the variety of shapes and external appearance. Finally, the vexations of art are certainly as the bonds and handcuffs of Proteus, which betray the ultimate struggles and efforts of matter. For bodies will not be destroyed or annihilated; rather than that they will turn themselves into various forms. Upon this history therefore, mechanical and illiberal as it may seem, (all fineness and daintiness set aside) the greatest diligence must be bestowed.
>
> Again, among the particular arts those are to be preferred which exhibit, alter, and prepare natural bodies and materials of things, such as agriculture, cookery, chemistry, dyeing, the manufacture of glass, enamel, sugar, gunpowder, artificial fires, paper, and the like. Those which consist principally in the subtle motion of the hands or instruments are of less use, such as weaving, carpentry, architecture, manufacture of mills, clocks, and the like; although these too are by no means to be neglected, both because many things occur in them which relate to the alterations of natural bodies, and because they give accurate information concerning local motion, which is a thing of great importance in very many respects.
>
> But in the whole collection of this history of Arts, it is especially to be observed and constantly borne in mind that not only those experiments in each art which serve the purpose of the art itself are to be received, but likewise those which turn up anyhow by the way...For though this be an object which in many cases I do not despise, yet my meaning plainly is that all mechanical experiments should be as streams flowing from all sides into the sea of philosophy.[75]

Bacon's blueprint for a "History of Arts" aroused immediate interest in the utilitarian value of scientific knowledge--at first through private correspondence between the elite and the erudite adherents to the Baconian

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[75] <u>Ibid.</u>, pp.355-357.

concept, and subsequently through the publication of collected scholarly papers, scientific gazettes and journals which reached a wider audience.[76] But it took more than a century of literary activity before anything that even approached Bacon's idea of a comprehensive history had been published; and not until then did the derivatives of the Greek technologia come to be associated with the mechanical arts.

Beckmann's Conception of Technologie: The earliest reference to the term technologie in the context of the mechanical arts is found in the literary works of Johann Beckmann, professor of philosophy and economics at Gottigen University (1770-1881): viz., his Beitrage zur Okonomie, Technologie, Polizei und Kameral-wissenschaft (1777-1791), and Entwurf einer allgemeinen Technologie (1806).[77] Neither of these treatises had ever been translated into English; however, the latter is generally referred to as an "Introduction to Technology".[78]

Beckmann is best known among English and American historians through his Beitrage zur Geschichte der Erfindungen (1786-1805), two volumes of which were translated from the German in 1797 by William Johnson under the title: A History of Inventions and Discoveries.[79] This classic work, which ran into several editions (the fourth in 1846), traces the history, and describes the existing conditions, of the various sciences and arts

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[76]W.H.G. Armytage, The Rise of the Technocrats (London: Routledge and Kegan Paul, 1965), pp.28-40.

[77]Library of Congress Catalogue, Vol. 11, p.440.

[78]Lit., An Outline of General Technology.

[79]The fourth edition carries the title: A History of Inventions, Discoveries and Origins, revised by William Francis and J.W.Griffith (London: Henry G. Bohn, 1846).

employed in trade and domestic use. It treats in a quasi cyclopedic fashion a wide range of subjects--from alum to zinc, clocks to saw-mills; various machines, instruments, utensils, plants, foods and processes--that fill five volumes. The Contents of the first volume of the English edition will give the reader a synopsis of the extent of Beckmann's work:

Italian Book-keeping	Saw-mills
Odometer	Stamped Paper
Machine for noting down Music	Insurance
Refining Gold & Silver Ore by Quicksilver	Adulteration of Wine
	Artificial Pearls
Cold or Dry Gilding	Paving of Streets
Gold Varnish	Collections of Natural Curiosities
Tulips	Chimneys
Canary Bird	Humgary Water
Archil	Cork
Magnetic Cures	Apothecaries
Secret Poison	Clocks and Watches
Wooden Bellows	Quarantine
Coaches	Paper-hangings
Water-clocks, Clepsydras	Kermes. Cochineal
Tourmaline	Writing-pens
Speaking-trumpet	Wire-drawing
Ananas.--Pine-apple	Buck-wheat
Sympathetic Ink	Saddles
Diving-bell	Stirrups
Coloured Glass.--Artificial Gems	Horse-shoes
Sealing-wax	Floating of Wood
Corn-mills	Lace
Vedigris, or Spanish Green	Ultramarine
Saffron	Cobalt, Zaffer, Smalt
Alum	Turkeys
Falconry	Butter
Turf	Aurum Fulminans
Artichoke	Garden-flowers

Beckmann's History, according to one authoritative source, entitles him "to be regarded as the founder of scientific technology, a term which he was the first to use in 1772"[80] in connection with his lectures on agriculture, economics, mineralogy, manufacture, and related subjects.

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[80] "Beckmann, Johann," Encyclopedia Britanica, Vol. III, Eleventh edition (1911) p.610.

Other sources concur in the assertion.[81] More importantly, Johnston notes that Beckmann (1) "united an extensive knowledge of nature, with a decided turn for applying it to practical purposes;" and (2) it was his especial endeavor to bring all that is practical in human knowledge under "systematic rules, based upon fundamental principles."[82] These observations bespeak Beckmann's concurrence with Bacon's attitude toward the practical and utilitarian value of scientific knowledge; moreover, they support the contention that his use of the term technologie is essentially in accord with the ancient Greek concept of technologia.

Bigelow's Conception of Technology: In 1816, two decades after Beckmann's History of Inventions first appeared in the English translation, Jacob Bigelow, professor of materia medica, accepted the Count Rumford professorship at Harvard to deliver a course of lectures on the "Application of the Sciences to the Useful Arts." Bigelow reasoned that:

> A certain degree of acquaintance with the theory and scientific principles of the common arts, is found so generally important, that most educated men, in the course of an ordinary practical life, are obliged to obtain it from some source or to suffer inconvenience for the want of it.[83]

Directed toward that end, the lectures were continued for over a decade. And in 1829, they were edited and published under the title Elements of Technology--that being the first known use of the word

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[81]Armytage states that the word 'technology' "was coined by Johann Beckmann," op. cit., p.37; Webster's Biographical Dictionary refers to Beckmann as a "German Technologist" (Springfield, Mass.: G.& C.Merriam Co., 1966), p.123.

[82]Beckmann, A History of Inventions, Discoveries and Origins, op. cit., Vol. I, p.xx.

[83]Jacob Bigelow, Elements of Technology (Boston: Hilliard, Gray, and Wilkins, 1829) p.iv.

'technology' in American literature, with reference to mechanical-industrial arts.[84] More importantly, this work presents us with the first explicit definition of the term in that context. To quote Bigelow:

> I have adopted the general name Technology, a word sufficiently expressive, which is found in some older dictionaries, and is beginning to be revived in the literature of practical men at the present day. Under this title it is attempted to include an account as the limits of the volume permit of the principles, processes, and nomenclatures of the more conspicuous arts, particularly those which involve applications of science, and which may be considered useful, by promoting the benefit of society, together with the emolument of those who pursue them.[85]

Bigelow, like Beckman, was concerned with the practical ends of human knowledge; but unlike Beckman, who attempted to cover all of the sciences and arts, Bigelow limited his literary efforts to the mechanical arts and certain "fine" arts related to industrial production. Aside from being more discriminating, moreover, he is more systematic in organization. The whole of his work is treated under the following major headings:

I Of the Materials used in the Arts
II Of the Form, Condition, and Strength of Materials
III The Arts of Writing and Printing
IV Arts of Designing and Painting
V Arts of Engraving and Lithography
VI Of Sculpture, Modeling, and Casting
VII Of Architecture and Building
VIII Arts of Heating and Ventilation
IX Arts of Illumination

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[84]Ibid. According to the Encyclopedia Americana, Bigelow "is credited with inventing the term 'technology'" (see "Bigelow, Jacob," 1958 Edition, Vol. 3, p.659). According to Oliver, "the term 'technology' was revived from the classics and given a new meaning by applying it to the arts, industry, manufacture, and agriculture: John W. Oliver, History of American Technology (New York: The Ronald Press Co., 1956), p.146.

[85]Op. cit., pp.iv-v.

X Arts of Locomotion
XI Elements of Machinery
XII Of the Moving Forces used in the Arts
XIII Arts of Conveying Water
XIV Arts of Dividing and Uniting Solid Bodies
XV Arts of Combining Flexible Fibres
XVI Arts of Horology
XVII Arts of Metallurgy
XVIII Arts of Communicating and Modifying Color
XIX Arts of Vitrifaction
XX Arts of Induration of Heat
XXI On the Preservation of Organic Substances[86]

These divisions of Bigelow's treatise should not, of course, be construed as the elements of technology. In his definition, "the principles, processes, and nomenclatures" constitute the elements. And inasmuch as the emphasis is placed on the underlying principles, Bigelow's definition is in harmony with the Greek concept of technologia. By the same token, his concern for the "application of science" to "useful" arts coincides with the Baconian attitude toward the place of natural sciences in human affairs. At any rate, Bigelow's adoption of "the general name Technology" seems to satisfy the criterion of appropriateness. Its use in connection with "the more conspicuous arts" according to the definition does not imply a definite restriction, but rather a tentative one dictated by the "limits of the volume" and its intended purpose of serving as a basic text for "courses of elementary education."[87]

Its appropriateness notwithstanding, critical reviewers of Bigelow's work expressed some reservations regarding his choice of term. In Emerson's opinion, for example,

> the word Technology gives but an imperfect idea of the contents of this (Bigelow's) volume. The end of a name would have been better

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[86] Ibid., pp.ix-xx.

[87] Ibid., p.iv.

> answered by some title showing that it treated of the scientific and practical principles of many of the useful, curious, and elegant arts.[88]

At the same time (1830) a review by Treadwell was somewhat more sympathetic toward Bigelow's use of the term; he states that:

> the word 'technology' is not so familiar in our language as could be desired in order to convey, at once, a full idea of the subject here arranged under it. Some word of the kind, however, has become necessary, both for precision, and to avoid the use of an unwieldy phrase. This, as Dr. Bigelow observes, is sufficiently expressive, and has lately been revived; and, although not perfectly grateful to the ear, will probably come into general use.[89]

Dictionary Definitions of 'Technology': Despite its earlier use in English literature, the word 'technology' does not appear in any of the extant English dictionaries or encyclopedias published prior to 1676. Nor can it be found in any of those published between 1757 and 1832. Hence, Bigelow's reference to "older dictionaries" would have included only those which were published between 1676 and 1757.

'Technology' appears for the first time in Coles' 1676 edition of *An English Dictionary*,[90] and again in two later editions, 1658 and 1692; all three define the word as: "a treating of Arts or Workmanship." In 1708, the word appears in Kersey's *General English Dictionary* with the definition: "a Description of Arts, especially the Mechanical." The same definition appears in the 1727 edition of Bailey's *Universal Etymological English Dictionary*, and again in Scott's dictionary published in 1755

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[88]G.B.Emerson, "Elements of Technology," *North American Review*, Vol. XXX, No. LXVI (1830) p.338.

[89]D. Treadwell, "Elements of Technology," *Christian Examiner*, Vol. VII (Nov. 1830), p.187.

[90]See Appendix for complete descriptions of dictionaries cited here.

under the same title. Two other dictionaries published during the period, namely, Martin's New Universal English Dictionary (1754) and Buchanan's New English Dictionary (1757), both define 'technology' as: "a Description of the Arts, especially the Mathematical."

It is not unusual to find in the older dictionaries identical statements of definition; for it is safe to say, as Barnhart does, that "each succeeding dictionary maker borrowed liberally from his predecessor."[91] Yet it seems strange that the foregoing eighteenth century definitions of 'technology' should be identical except in point of emphasis on the "mechanical" or the "mathematical" arts. Considering, however, the great upsurge of scientific achievement during the eighteenth century and the collaboration between the practical minded mathematicians and the skilled craftsmen that brought it about, perhaps both dictionary connotations are appropriate. "These were the days before the age of specialization when", to quote Sadler,

> there were few divisions between the sciences, or between 'pure' and 'applied' science, or between theory and practice; it was in fact the great age of the Mathematical Practitioners, in the broadest and finest sense of the term. In spite of the obvious differences of rank, education, calling, methods or thought and expression, whether they were thinkers or doers, great or humble, they all had in common a practical attitude towards their problems, loosely associated with a mathematical approach.[92]

In any event, it is more important to note here that the dictionary definitions do not correspond with the actual usage of 'technology' in the

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[91]Clarence L. Barnhart, "Dictionary," The Encyclopedia Americana, 1958 Edition, Vol. 9, p.88.

[92]D.H.Sadler, in the "foreword" to E.G.R. Taylor, The Mathematical Practitioners (London: The Cambridge University Press, 1965), p.v.

literature of the eighteenth century.

The word does not appear again in the extant dictionaries until after the first edition of the Encyclopedia Americana in 1832 defined it as "the science which treats of the Arts, particularly the mechanical."[93] By contrast with Bigelow's earlier definition of 'technology' as "the application of science to the arts," the emphasis had shifted from the application of science to the science. This analytic distinction has an important bearing on the subsequent literary usage of the word and the terminological problem that ensued. In the short period of only three years between the publications of Bigelow's treatise and the first edition of the Americana, when the word had just begun to re-appear in the literature, its meaning had already undergone a degree of interpretive change. Compare Bigelow's definition with the further statement given in the Americana:

> Technology may be divided into two kinds, a higher and a lower, of which the latter treats of the various arts themselves, and their principles, their origin, history, improvement, etc.; the former, of the connexion of the arts and trades with the political conditions of a nation, and the important influence which they have exercised ever since the mechanical occupations have come to honor: i.e., since the growth of free cities in the middle ages.[94]

Wilson's Conception of Technology: Among the arts which Bigelow terms "useful", he includes the "fine arts" such as painting and sculpture; like Aristotle, he does not differentiate between them. In 1855, George Wilson, who occupied the then newly established chair of Technology at the University of Edinburgh, discussed this issue in his inaugural lecture

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[93] In Vol. XII under the article "Technology", p.163.

[94] Ibid.

titled "What is Technology?"[95] "It is by a quite conventional limitation," says Wilson,

> that the word Art, Τεχνης (technes), denoted by the first dissylable of Technology, is held to signify useful, utilitarian, economic, or industrial art...for no arts call for more skillful workmen than Painting, Sculpture, and Music, and none are more technical in their modes of procedure.[96]

These remarks, as far as they go, appear to be compatible with Bigelow's views, and in harmony with the Aristotelian concept of techně. But then he goes on to define 'technology' as "the Science of the Useful Arts"[97] and arbitrarily excludes certain arts which in his estimation are not useful. "It is not," Wilson asserts,

> because the utility of the Fine Arts is questioned that they are excluded from the domain of Technology. Neither is it because the feeling of their usefulness is lost in that of their delightfulness; but because they are not useful in the sense of being *indispensable*...Their defining characteristic is not that they deal with what is beautiful or unbeautiful, but with what is *essential* to man's physical existence.[98]

Wilson's assertions raise certain philosophical questions which strike at the roots of quasi theories about technology: e.g., Which arts are in fact "essential to man's physical existence"? What criteria determine "their defining characteristics"? On what grounds shall the criteria be established? Inasmuch as the process of defining *essential* arts is no less arbitrary than that of defining *useful* arts, Wilson's definition of technology might just as well have been worded, "the Science of the

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[95] George Wilson, "What is Technology?" *The Canadian Journal of Industry, Science, and Art*, Vol. 1 (1856), pp.53-58.

[96] *Ibid.*, pp.54 and 55.

[97] *Ibid.*

[98] *Ibid.*, pp.55-56. (Italics mine)

essential Arts." The substitution of terms would, according to his interpretation, have been more appropriate although it would not have rendered a definition any more genuine.

Technology and Education: By mid-nineteenth century, with the rapid expansion of the machine industries in America, 'technology' came to be associated almost exclusively with the "useful" or industrial arts. And in its restricted literary usage the term paradoxically ceased to symbolize an invariant reference.

The interim between Bigelow's lectures on technology at Harvard and Wilson's inaugural address on the subject at Edinburgh, a period of about twenty-five years, marks the genesis of the terminological problem. It coincides with the radical changes which were occurring in the traditional programs of higher education in consequence of the growing demands by the machine industries for trained engineers. To meet the demands new engineering programs were established at existing educational institutions under a variety of titles, several of which were adopted as names of new institutions: e.g., the Rensselaer Polytechnic Institute (1824), the Lawrence Scientific School at Harvard (1847), the Massachusetts Institute of Technology (1861), the Case School of Applied Science (1880), the Newark College of Engineering (1881). Unfortunately, all of the programs functioning under names such as these, irrespective of their curricular orientation, came to be commonly referred to as 'technical' or 'technological'.

A similar situation developed at the secondary-school level during the latter part of the nineteenth and the beginning of the present centuries with the introduction of various forms of manual-arts training (some

imported from abroad) into existing liberal-arts-oriented programs. The new concepts brought about radical changes in American education with consequent problems in terminology. Educational labels such as Manual Training, Manual Arts, Arts and Crafts, Practical Arts, Applied Arts, and Industrial Arts, among others, all came to be associated synonymously with the terms 'technical' and 'technological' by writers who would use these terms indiscriminately. The literature abounds in such indiscriminate usage. An appropriate example is herein singled out as an apt close to the present chapter: In an article from a century-old scientific journal, titled "Examinations in Technology," the writer states:

> No subject has been more talked about of late years than Technical Education. No term has been more vaguely or indefinitely used than this, even in education, that region of loose definitions; yet it cannot be doubted that at the present time no subject is of more vital importance to this country, to enable it to maintain its manufacturing position, than a general diffusion of sound technical knowledge--a knowledge, that is, which rests on a thorough apprehension of the scientific principles which lie at the root of the various arts and manufacturing processes.[99]

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[99]"Examinations in Technology," Nature, A Weekly Illustrated Journal of Science, Vol. VI (May 16, 1872) p.41. (Italics added for emphasis)

CHAPTER III

PREVALENT VIEWS ON TECHNOLOGY

For more than a century after it emerged as a naturalistic concept, technology rarely found literary expression in other than a mechanical-industrial context. Despite its prominent place in the "institutes of technology" where it first found its clerisy,[1] or perhaps because of its connection with mere "technical" matters, the concept received scant recognition in scholarly literature. Ironically, even the institutes soon lost sight of its significance,[2] whereupon the word 'technology' assumed little more than a nominal existence, at best as a fortuitous appendage to 'science' which itself had been slighted by important writers. "It is curious that science and technology have always occupied so small a place in literature," Huxley writes:

> This is all the more extraordinary when one considers that literature is supposed to hold the mirror up to life. In life people spend a great deal of time involved in the technology of the period in which they live. They work, and their jobs are connected with technology and the organizations technology engenders. Yet one sees little evidence of this in literature.[3]

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[1]Jacob Bigelow introduced the concept at Harvard University in his lectures (1816-1827) on "The Application of the Sciences to the Useful Arts". He published these lectures in 1829 under the title Elements of Technology (see supra., pp.60-3). Bigelow's pioneering work was instrumental in establishing the Lawrence Scientific School at Harvard in 1847, forerunner of the Massachusetts Institute of Technology, established in 1861.

[2]See "Trends Toward Vocational Training" in Report of the Committee on Educational Survey, (Cambridge: The Technology Press, 1949), pp.11-14.

[3]Aldous Huxley, "Achieving a Perspective on the Technological Order", in Carl Stover, The Technological Order, (Detroit: Wayne State University), 1963, p.257.

The Status of Technology Prior to World War II

The situation changed somewhat during the early 1900's. A few important writers began to call attention to the significance of technology in the expanding industrial economy, and the effects of industrial expansion on established cultural institutions.

Thorstein Veblen, best known perhaps for his vehement attacks upon big business and the profit system, prophetically noted that "science and technology combined had come to be the dominant force in modern life."[4] He observed (in 1906) that:

> Modern civilization is peculiarly matter-of-fact...This characteristic of western civilization comes to a head in modern science, and it finds its highest material expression in the technology of the machine industry...In the modern culture, industry, industrial processes, and industrial products have progressively gained upon humanity, until these creations of man's ingenuity have latterly come to take the dominant place in the cultural scheme: and it is not too much to say that they have become the chief force in shaping men's daily life, and therefore the chief factor in shaping men's habits of thought.[5]

In these premonitory prenouncements, Veblen stood conspicuously alone in the literary field for some twenty years, and was one of few writers who at the time made explicit reference to technology in that regard.[6]

4John W. Oliver, History of American Technology (New York: The Ronald Press Company, 1956), p.455.

5Thorstein Veblen, "The Place of Science in Modern Civilization," The American Journal of Sociology, XI, No. 5 (March, 1906), pp.585-609.

6See Veblen's, The Engineers and the Price System (New York: The Viking Press, 1921) Chapter II; and his Instinct of Workmanship (New York: The Macmillan Company, 1914) Chapters V and VII.

John Dewey presented (in 1915)[7] a comparable characterization of industry and the "changed social conditions"; but it was not until the 1930's that he explicitly referred to technology, noting that:

> The rise of scientific method and of technology based upon it is the genuinely active force in producing the vast complex of changes the world is now undergoing...If we lay hold upon the causal force exercised by this embodiment of intelligence we shall know where to turn for the means of directing further change.[8]

Elsewhere Dewey noted that "reference to science and technology is relevant because they are the forces of present life which are finally significant."[9]

Among the few social critics who wrote on technology long before that word came into popular use, one who still writes on its cultural significance, is Lewis Mumford.[10] Around 1930, he instituted an "Extension Course" on "The Machine Age" which, in his words, was "the first course of this kind, dealing with the cultural as well as the economic and practical aspects of technology, to be offered anywhere."[11] And in a recent edition of Technics and Civilization, the first draft of which was written in 1930, Mumford asserts that:

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[7]John Dewey, "The School and Social Progress," in The Child and the Curriculum and The School and Society, (Chicago: The University of Chicago Press, 1956), pp.8-9.

[8]John Dewey, Liberalism and Social Action (New York: G.P.Putnam, 1935), p.74. See also Dewey's "Science and Society," (1931) reprinted in Max H. Fische, Classic American Philosophers (New York: Appleton-Century-Crofts, 1951) pp.381-389.

[9]John Dewey, Individualism Old and New (New York: Milton, Black and Company, 1930) pp.98-99.

[10]See, for example, his recent work: The Myth of the Machine (New York: Harcourt, Brace Jovanovich, Inc., 1967).

[11]Lewis Mumford, Technics and Civilization (New York: Harcourt, Brace & World, Inc., 1934), in the "Introduction" to the 1963 Harbinger Books edition.

> The reader who, a generation ago, understood the second half of my book would not have been unprepared for the overwhelming scientific and technical achievements, nor for the perversions and paranoid compulsions, that have since taken place.[12]

The pertinent points to be emphasized at this juncture are these: a) reference to technology in the literature published during the latter half of the nineteenth and the first half of the twentieth centuries is at best sporadic;[13] b) the few writers who explicitly referred to technology during that period appear to have been primarily concerned with the cultural effects of _industrial_ technology; c) it should perhaps be noted that despite their common concerns they did not necessarily entertain the same philosophical points of view;[14] d) most writers either ignored or inadvertently underestimated the vast complex of changes the world was undergoing. The few who did were the harbingers of what was yet to come; and their pronouncements on the "impact of technology" so-called, have for the contemporary reader a familiar ring.

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[12] _Ibid._

[13] Note that _Poole's Index to Periodical Literature_ (1802-1906), documents only seven articles under the caption "Technology"; _The International Index to Periodicals_ documents only three articles under "Technology" for the twenty-year period, 1907-1927, and over 250 articles for the ten-year period, 1958-1968. It may be of interest to note also that the _Industrial Arts Index_, first published in 1913, was renamed _Applied Science and Technology Index_ in 1959, with no significant change either in format or in subjects indexed.

[14] See, for example, the series of polemic arguments between John Dewey and Lewis Mumford on the concepts of Pragmatism and Instrumentalism and their relations to Science and Technology, in _Pragmatism and American Culture_, Edited by Gail Kennedy (Boston: D.C.Heath and Company, 1950); viz., Mumford's "The Pragmatic Acquiescence" (1926) pp.36-49; Dewey's "The Pragmatic Acquiescence" (January 5, 1927) pp.49-53; Mumford's "The Pragmatic Acquiescence: A Reply" (January 19, 1927) pp.54-57. Dewey takes the position that science and technology conceived as instruments is central to understanding of these agencies and their dominant tendencies in human life. Mumford, argues that "the sum total of life has a much greater sphere than that which science, technology, or its philosophic counterpart, instrumentalism, habitually covers." ("A Reply," p.55)

The Status of Technology After the War

A significant change occurred in the literary field after World War II. Coincident with the release and subsequent control of atomic energy (1942-1945), "technology" re-emerged in a new scientific role that stirred the scientific and academic community of scholars. A far more noticeable change occurred in 1957, after the first artificial satellite was successfully launched into space. Henceforth, "technology" virtually dominated the literature.

The Government's Concern for Technology: "In 1957", Swain writes,

> the United States found itself suddenly jolted into an awareness that a new age had dawned. By orbiting the first earth satellite, the Soviet Union not only inaugurated the Space Age but shocked the American Government into a re-examination of its vast scientific program.[15]

Congress responded the same year by establishing the National Aeronautics and Space Administration (NASA), with the Division of Technology Utilization as part of its organizational structure. In 1959, the Federal Council for Science and Technology was established; and the same year, the President appointed James Killan of Massachusetts Institute of Technology to the newly created post of Special Assistant to the President for Science and Technology. When the existing organization was changed in 1962 to provide a channel of communication between the President and Congress, the Office of Science and Technology was established.[16] And in 1964, the President appointed a National Commission on Technology,

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[15]Donald C. Swain, "Organization of Military Research," in Melvin Kranzberg and Carroll W. Purcell, Jr., Technology in Western Civilization (Toronto: Oxford University Press, 1967), p.546.

[16]Federal Support of Basic Research in Institutions of Higher Learning (Washington: National Academy of Sciences, National Research Council, 1964) pp.53-55.

Automation and Economic Progress, which in its last report (1966), concluded that "if there is one predominant factor underlying current social change, it is surely the advancement of technology.[17]

With the growing concern for technology on the governmental scene vast amounts of "technical" knowledge accrued in the newly established agencies which had potential value in industry.[18] The resultant changes that occurred on the industrial scene, in turn, had a compelling effect in the literary field. "The intellectual ferment and curiosity inspired by technological advances in industry," writes Warner of Columbia, "led to the opening of vast areas for scholarly inquiry and research."[19]

Concern for Technology on the Academic Scene: Since World War II, the most significant scholarly work on technology and its attendant problems has taken place at, or in cooperation with, the universities via collective interdisciplinary effort. At this juncture, let it suffice to outline briefly several of the scholarly activities in order to identify the principal sources of literature relevant to the further development of the present study.

In 1945, the Yale University Technology Project got under way with Charles R. Walker as its director. In a pioneering joint effort, a group of social scientists undertook a series of field studies which focused on "the human impact of modern technology." Their investigations into

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[17]Technology in Western Civilization, op. cit., Vol. II, p.695.

[18]On the problems of channeling the new knowledge into industry and education, see Richard L. Lesher and George J. Howick, Assessing Technology Transfer (Washington, D.C.: Office of Technology Utilization, NASA, 1966).

[19]Aaron W. Warner, "Introduction," in Technology and Social Change, Edited by Eli Ginzberg (New York: Columbia University Press, 1964) p.1.

specific human problems covered the range from on-the-job assembly-line monotony to community effects of plant shut-downs. Many of the field notes were published in monograph form, others appeared in Walker's Technology, Industry, and Man.[20] All of the notes, including some which are classified, are catalogued at the Yale University Library.[21]

In 1947, the same year that Warner, of The Ohio State University, proposed for Industrial Arts education the Curriculum to Reflect Technology,[22] the Faculty of Massachusetts Institute of Technology appointed a Committee on Educational Survey,

> to re-examine the principles of education that had served as a guide to academic policy at M.I.T. for almost ninety years, and to determine whether they are applicable to the conditions of a new era emerging from social upheaval and the disasters of war.[23]

The Committee's findings, and its recommendations to broaden M.I.T.'s educational base in harmony with "technological trends," were published in 1949.[24]

In 1960, the Massachusetts Institute of Technology invited a group of distinguished scholars to its centenary celebration to present papers and discuss problems on the topic "Science and Technology in Contemporary Society." Seven of the papers appear under that title in the journal of

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[20]Charles R. Walker (McGraw-Hill, 1947); see also his Modern Technology and Civilization (McGraw-Hill, 1962).

[21]In this writer's conversation with Dr. Stanley H. Udy, Sociologist at Yale University, and present Director of the Technology Project (May 5, 1970).

[22]A Curriculum to Reflect Technology, supra., pp.1 and 6-8.

[23]Report of the Committee on Educational Survey (Cambridge: The Technology Press, 1949) p.3.

[24]Ibid., the entire report.

The American Academy of Sciences.[25]

In 1962, the Columbia University Seminar on Technology and Social Change was formed as a new addition to an existing program of seminars. According to Warner, of Columbia, it brings together "groups of experts" from various disciplines for "a continuing exploration of the frontiers of change in a world in which technology plays an increasing dominant role."[26] They meet monthly to present and discuss papers on topics related to predetermined annual themes, e.g., "Technology and Change", "The Impact of Science on Technology", "Technological Innovation and Society". The papers and discussion notes are edited and published in book form under their respective titles.[27]

In 1964, the Harvard University Program on Technology and Society began functioning under the direction of Emmanuel Mesthene of Yale, with the expressed purpose of inquiring into

> the effects of technological change on the economy, on public policies, and on the character of society, as well as into the reciprocal effects of social progress on the nature, dimension, and direction of scientific and technological developments.[28]

The Program organization[29] encompasses an active membership of well

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[25]Daedalus (Spring 1962).

[26]Dean Morse and Aaron W. Warner, Technological Innovation and Society, (New York: Columbia University Press, 1966) Preface.

[27]See Eli Ginzberg, Technology and Social Change, 1964; and Aaron W. Warner, Dean Morse, and Alfred S. Eichner, The Impact of Science on Technology, 1965. Both are published by the Columbia University Press.

[28]This statement appears on the inside cover of every Research Review, Reprint, and Annual Report published by the Program.

[29]For a more detailed description of the Program, see Emmanuel G. Mesthene, "On Understanding Change," Technology and Culture, VI, No.2 (Spring 1965) pp.222-235.

over a hundred, including a faculty committee, an advisory committee, a study group, a staff of associates and specialists, and research personnel representing various academic disciplines--business administration, economics, law, sociology, education, linguistics, mathematics, history, psychology, and the physical sciences. The Program publishes research reviews, monographs, selected reprints, and a yearbook which summarizes its annual activities. The breadth of the Program's studies is reflected in the titles of its Research Reviews:[30]

Implications of Biomedical Technology (Fall 1968)
Technology and Values (Spring 1969)
Technology and Work (Winter 1969)
Technology and the Polity (Summer 1969)
Technology and the City (In preparation)
Technology and the Individual (In preparation)

Significant Events in the Community of Scholars: 'Technology' was accorded especial recognition in the field of History with the 1954 publication of Singer's first volume of A History of Technology,[31] a collective work by scholars from various disciplines. This work appears to be the earliest history published in the English language under the rubric 'technology'.[32] Whether all, or any of the subject matter or its method of treatment is worthy of the title will not be debated at this

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[30]Harvard University Program on Technology and Society, Fifth Annual Report, 1968-1969 (Cambridge, Mass.: The Program, 1969) p.70. (Note: As of this writing, the Program has published its final report in 1972).

[31]Charles Singer, E.J. Holmyard, and A.R. Hall, Editors, A History of Technology (London: Oxford University Press) 1954.

[32]An earlier German work, Geschichte der Technologie seit der Mitte des achtzehnten Farhhunderts (The History of Technology from the Middle of the Eighteenth Century) by Karl Karmarsch, (Munich: 1872), was reviewed by R. Oldenbourg, in "The History of Technology," The Practical Arts Magazine, III, No. 1 (London: 1874) p.107.

point;[33] nor will the fact that most or perhaps all of the subjects have been treated in much the same manner under other titles,[34] for example:

1846 - Beckman: A History of Inventions and Discoveries
1895 - Mason: The Origins of Invention
1921 - Osgood: A History of Industry
1925 - Brocklehurst: A History of Engineering
1929 - Clark: History of Manufactures
1929 - Chase: Men and Machines
1929 - Usher: A History of Mechanical Inventions

What is of significance here is the fact that after 1954, "history of technology" was widely accepted as a genuine extension of History proper.[35] Thereafter, other historical treatises were published under similar titles,[36] among them:

1956 - Oliver: History of American Technology
1958 - Forbes: Man the Maker, A History of Technology and Engineering
1959 - Klemm: A History of Western Technology
1961 - Derry: A Short History of Technology
1964 - Hughes: The Development of Western Technology
1967 - Kranzberg: The Technology and Western Civilization
1969 - Daumas: A History of Technology and Invention

In 1958, a meeting of the Advisory Committee for Technology and Society at Case Institute of Technology led to the formation of the Society for the History of Technology. Its purpose, according to Kranzberg, is

> to promote the scholarly study of the history of technology, to show the relations between technology and other elements of culture, and to make these elements of knowledge available

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[33]See, for example, Robert S. Woodbury's criticism in "The Scholarly Future of the History of Technology," Technology and Culture, I, No.4 (Fall 1960) pp.345-348.

[34]A complete description of these works appears in the Bibliography.

[35]Robert S. Merrill, "Technology," International Encyclopedia of the Social Sciences, XV (New York: The Macmillan Company and The Free Press, 1968) p.582.

[36]See the Bibliography for full description.

> and comprehensive to the educated citizen...[37]

through the Society's quarterly journal, Technology and Culture.

In 1962, the publishers of the Encyclopedia Britannica called a "Conference on the Technological Order" in Santa Barbara, California. They invited scholars from this country and abroad to discuss "the nature of technology and its significance for human affairs."[38] Several papers focused on the meaning of technology and its relation to science, a concern which Carl Stover of the Britanica staff summarizes by stating that,

> the modern scientific-technology promises to be both the hope of man's future and the instrument of his enslavement or destruction. If we are to avoid the disasters it lays open to us and take advantage of the opportunities it presents, we must put it in the control of reason. To do so, we must understand what modern technology is, what it means...[39]

The papers and commentaries by the participants were edited by Stover, and published in 1962 by the Society for the History of Technology.[40]

In 1963, a panel of historians of technology convened at the University of Wisconsin to discuss the feasibility of developing a course in the history of technology for the Armed Forces Institute (USAFI). They examined the existing works on the history of technology and concluded that "no single available text stressed sufficiently the cultural,

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[37]Melvin Kranzberg, "At The Start," Technology and Culture, I, No. 1 (Winter 1959) p.9.

[38]Carl F. Stover, "Introduction," Technology and Culture, III, No.4 (Fall 1962) p.383; also in Carl F. Stover, The Technological Order (Detroit: Wayne State University, 1963).

[39]Technology and Culture, Ibid.

[40]Ibid.

economic, and social implications of technology and history."[41] The ensuing joint undertaking by some seventy scholars from various academic disciplines, the business field and government, culminated in a two volume anthology of related historical essays which were published in 1967 under the title, Technology in Western Civilization.[42]

In 1965, the Society for the History of Technology scheduled a session at its Conference to be devoted to a discussion on the philosophical dimensions of technology. Expressing the Society's concern, Kranzberg writes that, "despite the major role played by technology in human and social development, there has been little in the way of systematic philosophical investigation of technology."[43] Several scholars, from this country and abroad, presented papers addressed specifically to the problem of defining technology. These often quoted papers and related commentaries appear in the Summer 1966 issue of the Society's journal.[44]

The fact that some of our most respected universities are serving as centers for projects, programs, seminars, and conferences on technology, coupled with the fact that so many social critics have turned their attention to technology and the problems it supposedly engenders, leaves little doubt as to its omnipresence in human affairs. Aside from confirming the premonitory observations made by Veblen, Dewey, Mumford, and

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[41] Melvin Kranzberg and Carroll W. Pursell, Jr., Technology in Western Civilization, Volume I (Toronto: Oxford University Press, 1967) p.v.

[42] Ibid., Volumes I and II.

[43] Melvin Kranzberg, "Toward a Philosophy of Technology," Technology and Culture, VII, No. 3 (Summer 1966) p.301.

[44] Ibid., pp.301-390.

others during the early decades of the present century, the facts clearly indicate a need for continuing scholarly inquiry into the social implications of technology. Nor should there be any doubt as to its implications for general education. Warner and his colleagues at The Ohio State University sensed its significance more than two decades ago when they foresaw "the critical need for Industrial Arts to reflect the technology."[45]

Current Concise Definitions of Technology

In a paper read before the Britannica Conference on the Technological Order, Buchanan stated that:

> the current discussion of technology in books and journals, both learned and popular, can be heard as a desperate clamor for a definition of terms...There may be wisdom at the present stage in refusing to yield to the clamor...There perhaps is need at present of a more patient ruminating discussion that will identify and arrange the materials for a later definition.[46]

A decade has passed since Buchanan made that statement and we are no nearer to resolving the terminological problem than we were then. Judging from the papers presented at the above mentioned scholarly gatherings, the need for clarifying the meaning of technology is urgent. That was the primary purpose of the Britannica Conference.[47]

Admittedly, the task is a difficult one. "The phenomenon of technology has so many forms," says Skolimowski, "that there is no simple

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[45] A Curriculum to Reflect Technology, op. cit., p.3.

[46] Scott Buchanan, "Technology as a System of Exploitation," Technology and Culture, III, No. 4 (Fall 1962) p.535.

[47] Carl F. Stover, op. cit.

description of it. But define it we must."[48] The remainder of the present Chapter is directed to that end.

On Classifying Current Definitions: In a manner somewhat similar to Kroeber and Kluckhohn's treatment of a collection of definitions of 'culture',[49] forty definitions of 'technology' from the above scholarly sources are hereunder subjected to critical analysis in order to elicit common elements of meaning, as per Ogden and Richards' suggestion. All but three of the definitions come from literary works published since World War II; and of these, most have been formulated during the past decade. In a few instances, two characteristically different statements by the same writer are classified as separate definitions; others are but adumbrations of lengthier conceptions. The object of the present inquiry is to analyze only what appear to be concise definitions, without reference to any qualifying statements in the context of which the definitions are framed.

All definitions of technology, their apparent differences notwithstanding, evidence one, two, or three qualities or characteristics. More to the point, every definition is made up of one or more defining elements, each of which signifies: a) something that is characteristically human, i.e., something that is attributable only to individual human beings--like one's knowledge or one's skill; b) something that exists outside of and apart from an individual human being--like machines and instruments

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[48]Henryk Skolimowski, "On the Concept of Truth in Science and in Technology," Proceedings of the XIVth International Congress of Philosophy, II (Vienna: University of Vienna, 1968) p.553.

[49]A.L.Kroeber and Clyde Kluckhohn, Culture, A Critical Review of Concepts and Definitions (Cambridge, Mass.: Peabody Museum of American Archaeology and Ethnology, 1952).

(including other human beings); or c) something that mediates between a and b--like procedures or procedural systems. The first kind are herein referred to as an intrinsic elements; the second, as extrinsic elements, and the third, as transactional elements. To the extent that human beings invent systems and employ procedures, such things are in a sense human. But what sets them apart from intrinsic characteristics is that they stand as means to be utilized by any human being. They are not immanent human faculties per se.

Of the forty definitions to be subjected to analysis, three evidence intrinsic, extrinsic, and transactional elements; these definitions are hereunder assembled into Group I. Nine definitions evidence combinations of two kinds of elements; these constitute Group II. The remaining twenty-eight definitions evidence one of the three kinds of elements; these constitute Group III. Following each group, the specific elements of definition are excerpted and classified into intrinsic, extrinsic, and transactional categories. And in the last analysis, all of the elements will be categorially summarized.

Group I - Definitions Embodying Intrinsic, Extrinsic, and Transactional Elements: Each of the following definitions is preceded by the name and title of the definer, and the year that the definition appeared in print. A complete description of the source is given in the footnotes. The same procedure is followed for Group II and III definitions.

1. Schon, Industrial Psychologist (1967)

> 'Technology' will mean any tool or technique, any product or process, any physical equipment or method of doing or making, by which human capability is extended.[50]

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[50]Donald A. Schon, Technology and Change (New York: Delacorte Press, 1967) p.1.

2. Markovic, Philosopher (1966)

   Technology is the totality of all knowledge, material resources and practical procedures which are most suitable for achieving a certain given aim.[51]

3. Walker, Sociologist (1962)

   Technology includes both physical objects and the techniques associated with them...In such a definition, scientific management and other kinds of engineering rules which impinge on people are included under the term "technology".[52]

The elements of definition are excerpted and classified in Table 1, and are therein numbered to correspond with the numbered definitions.

Table 1. CLASSIFICATION OF THE ELEMENTS IN GROUP I DEFINITIONS

INTRINSIC ELEMENTS	TRANSACTIONAL ELEMENTS	EXTRINSIC ELEMENTS
1. any technique	any process; any method of doing or making	any tool; any physical equipment; any product
2. all knowledge	all practical procedures	all material resources
3. techniques	scientific management; engineering rules	physical objects

The element "technique" is herein taken to be an immanent, human faculty, something peculiar to an individual; as such, it fits the intrinsic category. The element "method", sometimes associated synonymously with "technique", is herein classified as a transactional element. Method is viewed here as a systematic procedure which can be adhered to by any individual regardless of his technique. For the same reason,

[51]Mihalo Markovic, "Man and Technology," Praxis, II, No. 3 (1966) p.346.

[52]Charles R. Walker, Modern Technology and Civilization (New York: McGraw-Hill Book Company, 1962) pp.2-3.

"procedures", "processes", "rules", etc. are classified as transactional.[53] Most definitions of technology include an appended purpose--to serve some human end, or words to that effect; these will be commented upon in the summarizing statement.

Group II - Definitions Embodying Combinations of Two Kinds of Elements:

4. Merril, Professor of Anthropology (1968)

> Technology in its broad meaning connotes the practical arts... Technologies are bodies of skills, knowledge, and procedures for making, using, and doing things. They are techniques, means of accomplishing recognized purposes.[54]

5. Melsen, Philosopher of Science and Technology (1961)

> Technology is the realization and consequently the embodiment of human ideas in matter.[55]

6. Hammond, Professor of Anthropology (1964)

> Technology refers to the tools and techniques used to modify natural resources to meet human needs.[56]

7. Derry, Professor of History (1961)

> Technology comprises all the bewildering varied body of knowledge and devices by which man progressively masters his natural environment.[57]

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[53] Inasmuch as the object here is to show that the elements of all of the definitions of technology submit to the trichotomic scheme, a more detailed analysis of the specific elements is deemed unnecessary at this stage of the present study. The point is that the elements do fit into the scheme; where they fit is a matter of interpretation.

[54] Robert S. Merril, International Encyclopedia of the Social Sciences, Ed. David L. Sills, Volume 15 (New York: The Macmillan Company & The Free Press, 1968) pp.576 and 585.

[55] Andrew G. van Melsen, Science and Technology (Pittsburgh, Pa.: Duquesne University Press, 1961) p.261.

[56] Peter B. Hammond, Cultural and Social Anthropology (New York: The Macmillan Company, 1964) p.95.

[57] T.K.Derry and Trevor I. Williams, A Short History of Technology (New York: Oxford University Press, 1961) p.3.

8. Feibleman, Professor of Philosophy (1961)

   Every undertaking has its special technology, its tools, and the skills to use them. Technology is the material side of an enterprise, the discipline which is equally necessary at every level. Thus both tools and skills are required for art, religion, and philosophy as much as for economics and politics.[58]

9. Schilling, Political Scientist (1968)

   Technology can be generally conceived of as encompassing man's methods and tools for manipulating material things and physical forces.[59]

10. Baranson, Economist (1966)

    Technology refers to characteristics of production systems including their scale and organization; factor combinations of labor, materials, and equipment; managerial aspects; and design characteristics of the products themselves.[60]

11. Childe, Professor of Prehistoric European Archaeology (1954)

    Technology should mean the study of those activities, directed to the satisfaction of human needs, which produce alterations in the material world. In the present work (_A History of Technology_) the meaning of the term is extended to include the results of those activities.[61]

12. Singer, Editor of _A History of Technology_ (1954)

    'Technology' should mean the systematic treatment of any thing or subject...The editors (of _A History of Technology_) have treated it as covering the field of how things are commonly done or made, extending it somewhat to describe what things are done or made.[62]

The principal elements from Group II definitions (numbers 4-12) are classified in Table 2.

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[58]James K. Feibleman, "Technology as Skills," in _Technology and Culture_, VII, No.3 (Summer 1966) pp.318-328.

[59]Warner Schilling,"Technology and International Relations" _International Encyclopedia of Social Sciences_, _op. cit._, p.589.

[60]Jack Baranson, "The Challenge of Underdevelopment" in _Technology and Western Civilization_, _op. cit._, p.517.

[61]V. Gordon Childe, "Early Forms of Society" in _A History of Technology_, _op. cit._, p.38.

[62]Charles Singer, in the Preface of _A History of Technology_, p.vii.

Table 2. CLASSIFICATION OF THE ELEMENTS IN GROUP II DEFINITIONS

	INTRINSIC ELEMENTS	TRANSACTIONAL ELEMENTS	EXTRINSIC ELEMENTS
4.	bodies of skills; knowledge; techniques	procedures for making; using, and doing things; means of accomplishing purposes	
5.	realization of ideas	embodiment of ideas in matter	
6.	techniques		tools
7.	body of knowledge		devices
8.	skills		tools
9.		methods	tools
10.		production systems, their scale and organization; managerial aspects	combinations of labor, materials and equipment; design characteristics of the products
11.		activities which produce alterations	results of activities
12.		systematic treatment of any thing; how things are done or made	things done or made

It should perhaps be noted that the classification of elements under a particular category depends on one's interpretation of a given term. Van Meslen's use of the term 'embodiment', for example, is here taken to mean "the act of embodying"; hence, it is classified as a transactional quality. And Baranson's use of the term 'design characteristics' might be taken to denote "a conception" or "idea", in which case it would logically fall into the intrinsic category. The term is interpreted here in an objective, after-the-fact sense, as accomplished, objectified forms. In any event, regardless of how one interprets a specific defining element, it can theoretically be subsumed under one of the three general categories.

Note that Feibleman views technology in the broad sense as an aspect of "every undertaking"--in art, religion, philosophy, as well as in economics and politics. Few writers, to reiterate a prior observation, conceptualize technology in other than a naturalistic, industrial sense.

Group III - Definitions Embodying One of Two Kinds of Elements: The following definitions are assembled into six sub-groups. Three of the definitions focus on "techniques", an intrinsic characteristic; five, on "knowledge", an intrinsic characteristic; six, on "application of knowledge", a transactional characteristic; five, on "application of science", a transactional characteristic; three, on "human work", a transactional characteristic; and the remaining six emphasize kinds of human activity, herein viewed as transactional characteristics.

Sub-group IIIa - Characteristically intrinsic with emphasis on "techniques":

13. Dewey, Philosopher-Educator (1930)

> 'Technology' signifies all the intelligent techniques by which the energies of nature and man are directed and used in satisfaction of human needs.[63]

14. Bronowski, Mathematician (1963)

> Technology is the sum total of all the different techniques by which man changes his environment.[64]

15. Lesher, Administrator for Technology Utilization, NASA (1969)

> Technology is basically a collection of techniques to perform functions to serve mankind.[65]

The three statements, except for slight differences in wording, convey similar conceptions of technology, to wit, techniques as means for attaining desired ends. Elsewhere, Dewey defines 'technique' as "intelligent means and methods for securing results."[66]

<u>Sub-group IIIb</u> - Characteristically intrinsic with emphasis on "knowledge":

16. Veblen, Economic and Political Theorist (1921)

> Technology--the state of the industrial arts--is in an eminent sense a joint stock of knowledge and experience held in common by the civilized peoples.[67]

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[63]John Dewey, "What I Believe," <u>Forum</u>, LXXXIII, No. 3 (March 1930) pp.176-182. <u>Quoted in Pragmatism and American Culture</u>, <u>op. cit.</u>, p.25.

[64]Jacob Bronowski, Editor, <u>Technology: Man Remakes His World</u> (New York: Doubleday & Company, 1964) p.8.

[65]Richard L. Lesher: in a personal letter, April 23, 1969.

[66]<u>Individualism Old and New</u>, <u>op. cit.</u>, p.29.

[67]Thorstein Veblen, <u>The Engineers and the Price System</u>, <u>op. cit.</u>, p.68.

17. Perry, Professor of Philosophy (1954)

    Technology is knowledge selected and processed for some ulterior use.[68]

18. Zvorikine, Historian, Philosopher (1961)

    Modern technology is the embodiment of the knowledge man has accumulated in his struggle to harness the forces of nature.[69]

19. Schmookler, Professor of Economics (1966)

    Technology is the social pool of knowledge of the industrial arts.[70]

20. Skolimowski, Philosopher of Technology (1966)

    Technology is a form of human knowledge.[71]

In the above sub-group, emphasis is placed on the one intrinsic element, "knowledge", with the exception of Veblen's definition which includes the element "experience". The latter term is herein interpreted in an imminent sense; thus, like knowledge, it fits the intrinsic category. Only Perry's definition stresses a particular kind of knowledge, otherwise the definitions are similar.

Sub-group IIIb - Characteristically transactional with emphasis on the "application of knowledge":

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[68]Ralph Barton Perry, Realms of Value (Cambridge: Harvard University Press, 1954) p.309.

[69]A. Zvorikine, "The History of Technology as a Science and as a Branch of Learning: A Soviet View," Technology and Culture, II, No. 1 (Winter 1961) p.1.

[70]Jacob Schmookler, Invention and Economic Growth (Cambridge: Harvard University Press, 1966) p.1.

[71]Henryk Skolimowski, "Technology and Philosophy," in Raymond Klibansky, Contemporary Philosophy II (Firenze: La Nuova Italia Editrice, 1968) pp.426-437, p.435.

21. Chandler, Professor of Economics (1947)

    Technology is but the application of knowledge, primarily scientific knowledge, to economic progress.[72]

22. Bronowski, Mathematician (1963)

    Technology is the application of scientific knowledge to human problems.[73]

23. Weisner, Dean, School of Science, MIT (1965)

    Technology is the application of organized knowledge to help solve problems in our society.[74]

24. Galbraith, Economist and Political Theorist (1967)

    Technology means the systematic application of scientific or other organized knowledge to practical tasks.[75]

25. Lesher, Asst. Administrator for Technology Utilization, NASA (1969)

    Technology is the application of new scientific knowledge, and in its broadest sense, includes the application of the products of the management sciences.[76]

26. Mesthene, Lecturer in Business Administration (1968)

    We define technology as the organization of knowledge for practical purposes.[77]

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[72] Lester V. Chandler, A Preface to Economics (New York: Harper & Brothers, 1947) p.39.

[73] Jacob Bronowski, Editor, Technology: Man Remakes His World, op. cit., p.9.

[74] Jerome B. Wiesner, "Technology and Innovation," in Technological Innovation and Society, op. cit., p.11.

[75] John Kenneth Galbraith, The New Industrial State (New York: The New American Library, 1967) p.24.

[76] Richard L. Lesher: in a personal letter, op. cit.

[77] Emmanuel G. Mesthene, "The Role of Technology in Society: Some General Implications of the Program's Research," Fourth Annual Report of the Harvard University Program on Technology and Society, 1967-1968 (Cambridge, Massachusetts: The Program, 1968) p.44.

Five of the six definitions, each by a writer from a different field, emphasize the "application of knowledge". In the definition by Mesthene the term "organization" is interpreted in a transactional sense, i.e., as the "process of organizing knowledge".

Sub-group IIIb - Characteristically transactional with emphasis on "applied science":

27. Jennings, Professor of History (1957)

> Technology is a word in large part synonymous with applied science...the process of transforming theoretical conceptions into practical, useful realities.[78]

28. Lachman, Professor of Psychology (1965)

> Technology = Applied Science. Field utilizing the findings of science to solve practical problems...application of the data, principles, and theories of one or more fields of science for the purpose of obtaining practical solutions to human problems.[79]

29. Bunge, Theoretical Physicist and Philosopher of Science (1967)

> The terms "technology" and "applied science" will be taken here as synonymous...the application of the scientific method and of scientific theories to the attainment of practical goals.[80]

30. Forbes, Professor of History and Ancient Science and Technology (1958)

> In our modern world both technology and engineering are branches of applied science; they follow very closely in the footsteps of scientific research as conducted in laboratories and universities.[81]

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[78] Manson Jennings, "Teacher Education," in Science and the Social Studies, Twenty-Seventh Yearbook of the National Council for the Social Studies (Washington, D.C.: the Society, 1957) p.217.

[79] Sheldon J. Lachman, The Foundations of Science (New York: Vantage Press, 1965) pp.15 and 109.

[80] Mario Bunge, "Technology as Applied Science," Technology and Culture, VII, No. 3 (Summer 1966) p.329.

[81] R.J.Forbes, Man the Maker: A History of Technology and Engineering, (New York: Abelard-Schuman Limited, 1958) p.3.

31. Levi, Professor of Philosophy (1959)

> The intrinsic meaning of technology is the application of the method of science to the productive problems of the industrial arts.[82]

Five of the definitions in this group equate 'technology' with 'applied science', and 'applied science' with the 'application of science'. In this respect they differ little from the previous definitions which emphasize 'application of knowledge'. Levi's definition differs from the others in two respects: a) it stresses the 'method of science' and b) restricts its application to industrial problems. The others could be interpreted in a broad sense to include other fields of human activity.

Sub-group IIIb - Characteristically transactional with emphasis on "work":

32. Drucker, Professor of Management (1959)

> We might define technology as human action on physical objects or as a set of physical objects characterized by serving human purposes. Either way the realm and subject matter of the study of technology would be human work.[83]

33. Zvorikine, Historian & Philosopher (1962)

> Technology may be defined as the means of work, the means of human activity developing within a system of social production and social life. The means of work become technology only within a system of social production.[84]

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[82]Albert William Levi, Philosophy and the Modern World (Bloomington: Indiana University Press, 1959) p.15.

[83]Peter F. Drucker, "Work and Tools," Technology and Culture, I, No. 1 (Winter 1959) p.30.

[84]A. Zvorikine, "Technology and the Laws of Its Development," Technology and Culture, III, No. 4 (Fall 1962) p.443.

34. Kranzberg, Professor of History (1967)

> In its simplest terms, technology is man's efforts to cope with his physical environment and his attempts to subdue or control that environment by means of his imagination and ingenuity in the use of available resources...
> It deals with human work, with man's attempt to satisfy his wants by human action on physical objects.[85]

Insofar as the three definitions focus on human work or human activity they are similar. In one respect Drucker's and Kranzberg's definitions are identical, to wit, "human action on physical objects." What sets Zvorikine's definition apart from the other two is its emphasis on "social production." In this respect Zvorikine, a Soviet professor of history, is influenced by Karl Marx's writings. "Technology," Marx writes, "discloses man's mode of dealing with Nature, the process of production by which he sustains his life, and thereby also lays bare the mode of formation of his social relations."[86] This conception of technology, Marx extends beyond human activity to plants and animals. He terms this activity, "Nature's Technology," and defines it as "the formation of the organs of plants and animals, which organs serve as instruments of production for sustaining life."[87]

Sub-group IIIb - Characteristically transactional with emphasis on human activity:

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[85] Technology and Western Civilization, op. cit., pp.5 and 6.

[86] Karl Marx, Capital, translated from the German by Samuel Moore and Edward Areling (New York: International Publishers, 1947) footnote on p.367. Also in Karl Marx, Das Kapital, Vol. I (German reprint of the original 1867, Werke. Berlin, Dietz Verlag, 1962) footnote on p. 393.

[87] Ibid.

35. Toynbee, Historian (1961)

Human activities are numerous and various. There is technology: the invention, manufacture, and use of tools.[88]

36. Daumas, Museum Curator (1969)

...a form of activity conventionally designated by the term "technology", as distinct from both simple applied techniques and the science of discovery.[89]

37. Watson-Watt, Physicist (1962)

Technology is the selective adaptation of one or more of the processes and materials identified and described by science, and their embodiment in devices designed to serve the needs of mankind in its progress from savagery toward advanced social evolution.[90]

38. White, Professor of History (1962)

Technology is defined as the systematic modification of the physical environment for human ends.[91]

39. McKay, Professor of Applied Physics (1967)

Technology is essentially a codified way of doing things, and much of this is based on systematic theoretical knowledge, which is science, but some simply on codified experience, which is what I mean by "art".[92]

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[88]Arnold J. Toynbee, A Study of History, XII (New York: Oxford University Press, 1961) p.658.

[89]Maurice Daumas, A History of Technology & Invention, Vol. II, (Translated from the French by Eileen B. Hennessy, New York: Crown Publishers, Inc., 1969) p.11.

[90]Sir Robert Watson-Watt, "Technology in the Modern World," The Technological Order, op. cit., p.1.

[91]Lynn White, Jr. "The Act of Invention: Causes, Contexts, Continuities and Consequences," The Technological Order, op. cit., p.114.

[92]Gordon McKay, "Applied Science and Technological Progress," Science, Vol. 156 (30 June 1967) p.1706.

40. Kockelmans, Philosopher of Science (1966)

> Technology should be conceived as a mode of bringing to light, of dis-covering...things which cannot dis-close themselves.[93]

Note that the twenty-eight definitions in Group III evidence only the intrinsic and transactional characteristics. The elements of definition for this group are classified in Table 3.

Summary: The foregoing analysis brings into relief distinct patterns of thought which warrant consideration in any discussion on the meaning of technology. In sum: a) There appears to be general agreement on the instrumental function of technology--"to extend human capability," "to serve human purposes," "to solve practical problems." b) The naturalistic, industrial connotation of technology is either implied or literally expressed in most of the definitions: For Merrill, technology connotes the "practical arts"; for Veblen and Levi, the "industrial arts"; for Zvorikine, "industrial production"; for Forbes, "engineering." c) Several writers include extrinsic elements in their definitions, but none define technology in those terms alone; there appears to be a general consensus that "technology is much more than tools and artifacts."[94] d) Most of the definitions evidence only one characteristic, predominantly the transactional; and all of the defining elements in the transactional category either name or imply some kind of human activity.

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[93] Joseph J. Kockelmans, Phenomenology and Physical Science (Pittsburgh, Pa.: Duquesne University Press, 1966) p.173.

[94] Kranzberg and Pursell, Technology in Western Civilization, Vol. 1, op. cit., p.6. See also, Markovic, Praxis, op. cit., p.343; Galbraith, The Industrial State, op. cit., p.24; Mesthene, Fourth Annual Report: Program Technology and Society, op. cit., p.44; Kockelmans, Phenomenology and Physical Science, op. cit., p.173; and Drucker, Technology and Culture, Vol. I, No. 1, op. cit., p.30.

Table 3. CLASSIFICATION OF THE ELEMENTS IN GROUP III DEFINITIONS

Intrinsic (Techniques)

13. all intelligent techniques
14. all the different techniques
15. collection of techniques

Intrinsic (Knowledge)

16. joint stock of knowledge and experience
17. knowledge selected and processed
18. embodiment of knowledge
19. social pool of knowledge
20. form of human knowledge

Transactional (Application of Knowledge)

21. application of knowledge, primarily scientific
22. application of scientific knowledge
23. application of organized knowledge
24. systematic application of scientific or other organized knowledge
25. application of new scientific knowledge, application of the products of the management sciences
26. organization of knowledge

Transactional (Applied Science)

27. applied science - process of transforming theoretical conceptions
28. applied science - application of the data, principles, and theories of science
29. applied science - application of scientific method and scientific theories
30. branch of applied science
31. application of the method of science

Transactional (Human Work and Human Activity)

32. human work; human action
33. means of work; human activity
34. human work; man's efforts to cope with physical environment
35. human activities: invention, manufacture, and use of tools
36. form of activity

Transactional (Human activity in other terms)

37. selective adaptation of processes and materials; their embodiment in devices
38. systematic modification of the physical environment
39. codified way of doing things
40. mode of bringing to light, of dis-covering

It can be argued, and rightly so, that a concise definition does not of itself convey a writer's total conception of 'technology', that it should be examined in the light of its supporting statements. The argument can, of course, be leveled at any dictionary-type definition. The fact is, writers do make such statements, presumably with the intent of conveying something. It is that something which was subjected to scrutiny, and only for the purpose of eliciting common elements of meaning. (The elements from Tables 1, 2, and 3 are summarized in Table 4.)

Two Extended Definitions of Technology

Allusion has already been made to the arbitrariness of most definitions of technology, and the urgent need to clarify its meaning on sound theoretical grounds. Before that task is undertaken (in Chapter IV), let us first examine briefly two theoretically conceived definitions, one by Ralph Barton Perry, the other by Charles Morris, each of whom locates technology in a different context, yet provides an equally plausible conception of it. Perry views technology as a form of knowledge, whereas Morris views it as a form of human activity.

Technology as Knowledge: Perry's definition of technology is an incidental outcome of his theory of value. It is framed in the context of what Perry conceives to be the dominant realms of value; and in that context technology plays an important role in the methodology for promoting cultural values. A synopsis of Perry's treatment of the realms of value should suffice to show how he arrives at his definition of technology.

1. Perry defines value in terms of interst; in his words, "any object, whatever it be, acquires value when any interest, whatever it be,

Table 4. A SUMMARY OF THE ELEMENTS OF DEFINITION FROM THE PRECEDING TABLES

INTRINSIC ELEMENTS
Knowledge; a form of human knowledge; selected and processed knowledge; scientific knowledge; all knowledge
Realization of ideas
Skills; bodies of skills
Techniques; any technique; all techniques; all intelligent techniques
TRANSACTIONAL ELEMENTS
Human activities; a form of activity; human action on physical objects; activities which produce alterations in the material world
Human work
Application of knowledge; application of organized knowledge; application of scientific knowledge
Application of scientific theories; application of the data, principles, and theories of science; application of the methods of science
Process of transforming theoretical conceptions; process of production; any process
Scientific management
Systematic modification of the physical environment; systematic treatment of any thing; systematic application of knowledge
Selective adaptation of processes and materials
Embodiment of ideas in matter
Embodiment of selected processes in devices
Mode of dealing with Nature
Mode of bringing to light
Mode of dis-covering
Invention, manufacture, and use of tools
Means of human activity; means of work; means of accomplishing purposes
Methods; any method of doing or making
Procedures for making, using, and doing things; all practical procedures
Codified way of doing things; how things are done or made
Engineering rules
Productive systems
EXTRINSIC ELEMENTS
Materials; all material resources
Tools; any tool
Machinery
Devices
Physical objects
Any physical equipment
Combination of labor, materials, and equipment
Any product; design characteristics of products
Things done or made
Results of activities

is taken in it."[95] So defined, the concept of value may be considered from the standpoint of individual interest or from that of group interest. When a group of individuals seeks to achieve a common object of interest, that object assumes the status of a value; and a group so organized defines an institution.[96] In so far as every individual within a group pursues various objects of interest, an institution comprises a complex of interests. Conversely the same individuals, each with a variety of interests, belong to a number of institutions. "If an institution is a specific way in which the members of a society organize for the promotion of common interests," says Perry, "there can be as many institutions, in the broad sense, as there are interests."[97] Certain institutions, however, are deemed more important than others because of the significant role they play in human life. According to Perry, there are those which are by general consent regarded as the major cultural institutions, namely, the institutions of conscience or custom, of polity, law, economy, science, art, education, and religion.[98] These, Perry holds, are the "institutions of which there always have been, always are, and always will be, eligible members."[99] The interests they claim are universal. When these universal interests are systematically described, and "the master concept of such a description is given the name 'value', then these major realms of human

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[95] Ralph Barton Perry, General Theory of Value (Cambridge: Harvard University Press, 1926) pp.115-116.

[96] Perry, Realms of Value, op. cit., pp.152 ff.

[97] Ibid, p.154.

[98] Ibid., p.156.

[99] Ibid., pp.14 and 155.

life are specifically described as realms of value."[100]

2. The pursuit of interests and their description implies knowledge. There is no institution, says Perry, without some degree of knowing; and insofar as institutionalized knowledge is generalized and systematized, it merits the name of 'science'. For "science is simply knowledge; or, in a more restricted sense, knowledge when this has reached a certain pitch of perfection."[101]

Hence, for every cultural institution there is a corresponding social or cultural science which mediates social action. Conscience has its science of conscience to promote collective approval or disapproval; polity has its political science to centralize the direction and control of human affairs; law has its jurisprudence to define and defend human rights; economy has its economics to produce and distribute material needs. Likewise, science has its science of science; art, its science of art; education, its science of education; and religion its science of religion.[102]

Perry draws a distinction between the cultural sciences (knowledge of the world which man has made for himself) and the natural sciences (knowledge of the world which man takes as he finds it).[103] But he argues that both divisions of science are concerned with facts (verifiable descriptions of their respective worlds) arrived at via one over-all method of knowing. "The method of the cultural sciences," Perry asserts,

> like that of all sciences, is descriptive. If knowledge consists in well-grounded expectations, then there is one over-all method

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[100] Ibid.

[101] Ibid., p.174.

[102] Ibid., pp.168-173.

[103] Ibid., p.169.

> of knowing, which is to form expectations and then look to see whether things are or are not as expected.[104]

That the cultural sciences focus on non-existent norms or ideals as their objects of interest does not nullify Perry's assertion. On the contrary, "the pursuit of them as standards of comparison do exist," he says, "and the ideals and norms are a part of their description."[105]

3. The methodology of cultural science distinguishes three "branches" of the descriptive method: explanatory, normative, and technological. The method most frequently employed by the cultural sciences is the explanatory method: It "takes the total fact of interested endeavor with its objects, and makes statements concerning its origins, constituents, conditions, and causal relations."[106] The normative method takes norms or standards as objects of interest, compares them with human achievements, and on that basis makes normative judgments. Given the norms, the technological method determines the most efficient means for achieving them.[107]

Hence, every cultural institution has its corresponding technology: Conscience or custom has its ethical technology; polity, its political technology; law, its legal technology; economy, its technology of economy; and so on. When normative approvals or disapprovals go unheeded, or polity fails to control, or law fails to direct and control human affairs, or economy fails to produce, technological judgments become the targets of criticism; technology has ceased to be effective.

"Technology," says Perry, "is knowledge selected and processed for

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[104] Ibid., pp.174-175.

[105] Ibid., p.176.

[106] Ibid.

[107] Ibid., pp.176-177.

some ulterior use."[108] Hence the test of technology is its efficiency in practice, in achieving desired ends or objects of interest. One who assumes the role of "a technologist" is, by virtue of his instrumental role, prepared to give advice on how one ought to go about pursuing his object of interest. His primary concern _qua_ technologist is not that of practice per se, but rather of the theory underlying practice. In that capacity he searches in the corpus of existing knowledge for what promises to be useful in practice; "but in knowledge, including knowledge of practice, it is theory which speaks the last word."[109]

4. Perry's use of the term 'science' has three distinct, though related, connotations: general, specific, and methodological. He uses it in a general sense with reference to a major cultural institution, namely, the institution of science (the community of "scientists" whose object of interest is verifiable knowledge). In the particular sense, the term is used with reference to a specific body of verifiable knowledge; the knowledge obtained and classified by each of the cultural institutions (including the "science of science"). In the methodological sense, the term 'science' is used with reference to the ways and means employed by each institution in the pursuit of its objects of interest. It is in the latter sense that technology joins with science in the service of institutionalized pursuits. Unlike science, technology is not an institution; it functions only in a methodological capacity, namely, to convert scientific knowledge into "how to" knowledge. Given the object of interest as an end to be pursued, technology provides the means to attain it: hence, the "technology of science."[110]

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[108] _Ibid._, pp.309-310.

[109] _Ibid._, p.182.

[110] _Ibid._, pp.296 ff.

Technology as Human Activity: Morris' conception of technology emerges from his discussion on "the major types of discourse" and their relations to "the dominant forms of human activity."[111] The discussion is grounded in what Morris terms "a behavioral theory of signs,"[112] certain aspects of which are essential to an understanding of his conception of technology.

1. The theory of signs distinguishes three dimensions of sign functioning: the semantical, syntactical, and pragmatical. The semantical function relates signs to the objects they signify; the syntactical relates signs to other signs; the pragmatical relates signs to interpreters. The three dimensions of sign functioning, in turn, correspond to three major types of discourse: scientific, aesthetic, and technological. As Morris explains it:

> scientific discourse brings into prominence the relations of signs to objects (the semantical dimension), aesthetic discourse accents in a distinctive way the sign structure itself (the syntactical dimension), technological discourse emphasizes the efficacy of signs in the practice of the users (the pragmatical dimension).[113]

2. The major types of discourse are the components and products of what Morris conceives to be the dominant forms of human activity, namely, science, art, and technology. It follows, then, that an analysis

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[111] Charles W. Morris, "Science, Art and Technology," The Kenyon Review, Vol. I (1939), p.420.

[112] Morris defines 'sign' as "something that directs behavior with respect to something that is not at the moment a stimulus." This "rough" definition appears in the glossary of his Signs, Language and Behavior (New York: Prentice-Hall, 1946) p.354. His emphasis on "behavior" links the theory of signs with human needs and activities. See also Charles S. Pierce, "Logic as Semiotic: The Theory of Signs," in Justus Buchler, Philosophical Writings of Peirce (New York: Dover Publications, 1955) pp.98-119.

[113] Footnote in "Science, Art and Technology," op. cit., p.411.

of the types of discourse in terms of their components and products can throw light on the nature of their corresponding forms of human activity and their interrelations; or as Morris puts it:

> The activities of the scientist, the artist, and the technologist are mutually supporting activities, and their differences and interrelations may be discerned in the differences and interrelations of scientific, aesthetic, and technological discourse.[114]

Scientific discourse is characterized by statements of fact which accurately describe space-time objects and phenomena, statements which empirical evidence confirms (or disconfirms), and on the basis of which accurate predictions can be made regarding the world of fact. The instrumentalities and the procedures by means of which such discourse is obtained, defines scientific activity.[115]

Aesthetic discourse, according to Morris, is "that specialized type of language which is the actual work of art (the poem, the painting, the music)."[116] Unlike scientific discourse whose signs are restricted to confirmable truths, aesthetic discourse communicates values which are embodied in the works of art. "In works of art," says Morris, "men and women have embodied their experience of value, and these experiences are communicable to those who perceive the molded medium."[117]

Technological discourse issues in prescriptive-informative statements, the purpose of which is "to induce a mode of action."[118] Such discourse is characterized by statements which suggest or inform how something ought, should, or must be done if a given end is to be attained. They are essentially "how to" statements, which aim at efficacy in practice.

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[114] Ibid., p.420.

[115] Ibid., pp.411-413.

[116] Ibid., p.414.

[117] Ibid., pp.415-416.

[118] Ibid., p.417.

Technological discourse, Morris writes,

> aims to give information concerning the techniques for attaining specific ends, whatever they may be. It is "how to" discourse: discourse informing one how to rivet, how to play the flute, how to cook a duck, how to speak Spanish. Since the goals may be anything whatever, there is technological discourse relevant to science, to morality, to religion, to mathematics, etc. Such technological discourse neither appraises the goal for which it is relevant nor aims to incite the actions it prescribes for reaching a goal; a manual on flute playing does not extol the significance of the flute nor tell the person that he ought to acquire flute-playing techniques: it merely tells how to play the flute. And the case is similar for technological treatises in engineering, medicine, agriculture, and the like. A goal is taken for granted; the treatises tell how to attain it.[119]

3. The important points to be gleaned from the foregoing brief analysis are these: a) Morris' conception of technology explicitly centers on human activity, and can be understood only in the context of his theory of discourse. b) Because it stems from a theory, the theory furnishes the grounds for its validity. c) On these grounds, technological activity can be distinguished from other forms of activity by its distinctively pragmatic function; and as a theoretical construct it has a wide range of applicability. d) In its pragmatic function, it agrees with the original Aristotelian meaning, to wit, a manual on flute playing does not differ in principle from a manual on rhetoric; each provides the means (in the form of systematized prescriptive-informative statements) for pursuing given ends. e) It is important to note that technological activity ceases with the provision of the means--the actual performance of a flute player, though it exhibits the efficacy of the means in practice, is not a technological activity. f) Technological discourse recognizes scientific facts as human values, and provides the most expedient means for their objectification in concrete or abstract ends.

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[119] Signs, Language and Behavior, op. cit., p.143.

Summary

The above discussion should suffice to substantiate the prior assertions that "technology" is an indispensable concept in contemporary thought, and that writers who deal with the subject entertain variegated conceptions of it. The inquiry centered first on a collection of dictionary-type statements of definition, selected from scholarly papers representing various fields of study. An analysis of the statements revealed significant patterns of defining elements, indicating that there is some semblance of meaning in their collectivity. A consideration of these elements is deemed essential to the ensuing discussion on the nature and scope of technology.

The inquiry then shifted to an analysis of two extended definitions, each framed in a totally different theoretical matrix. It was found that Perry locates "technology" in the context of the Theory of Value, and defines it as _a form of knowledge_; Morris, on the other hand, locates the concept in the Theory of Signs, and defines it as _a form of human activity_. In so far as their conceptions of technology emerge as incidental by-products of their more immediate objects of interest, their theoretical models are not sufficiently developed for purposes of identifying and ordering specific subject matter of instruction. They do, nevertheless, underline the urgent need of a sound theoretical approach to the problem of clarifying the concept. As Durcker puts it: "We desperately need a real understanding, and a real theory, a real model of technology."[120] The discussion to follow is directed toward that end.

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[120] Peter F. Drucker, "Work and Tools," _Technology and Culture_, _op. cit._, p.36.

CHAPTER IV

THE NATURE AND SCOPE OF TECHNOLOGY

The analysis in the preceding chapter more or less substantiates the previous claim that there is no one consensually received definition of 'technology'; that different scholars use the word to mean different things in different contexts. Notwithstanding their disparate individual points of view, however, the definitions they proffer, when taken collectively, do mark out a vaguely discernible field of common referents; i.e. they seem to convey a general notion of what the word is supposed to mean. But more importantly, the analysis reveals a pattern of interrelated elements which should prove useful in establishing a basis for working toward a meaningful synthesis.

Given the elements of definition most often attributed to, and the concepts usually associated with, 'technology'--taking into consideration the history of the word since its origin in Greek thought[1]--the object of the present chapter is to try to integrate certain essential characteristics into a conceptual model in the context of which a functional definition of 'technology' can be framed. Or what amounts to the same thing, to fix the meaning of an old word in order

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[1]This consideration is predicated on the assumption that "symbols, words, phrases, and expressions of any kind always possess a content due to previous employment;...there always remains a residue of the original content." Ernest H. Hutten, The Origins of Science (London: George Allen and Unwin Ltd., 1962) p.123.

to render it serviceable for effective communication in contemporary thought. "In fixing the meaning of words," Mill advises that,

> we ought to endeavour to render them significative of the most important distinctions which, without too glaring a violation of received usage, they can be made to express.
>
> We ought further, when we are restricted to the employment of old words, to endeavour as far as possible that it shall not be necessary to struggle against the old associations with those words.[2]

It may not be superfluous to recall that 'technology' originated in the context of the abstract-verbal technics; and that for two millenia its use had been limited (by convention) to "technology of rhetoric" and "technology of grammar." Only after its introduction into American literature[3] with reference to the principles and nomenclatures of the manual-mechanical technics did the word gradually come into wider use; acquiring different connotations in different contexts. Perhaps the most familiar terms in current literary usage are those which emerged in connection with things of a mechanical nature: terms such as agricultural technology, military technology, industrial technology; technology of manufacture, of transport, of construction, of communication, and the like. But countless other applications of the word have become common-place in scholarly discourse: e.g. those associated with human institutions, such as the technology of economy, of polity, of religion; those with a historical connotation, namely, prehistoric technology, ancient technology, medieval technology, modern technology; and various others, like general technology, scientific technology, craft technology; biomedical technology, behavioral technology, genetic technology,

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[2]John Stuart Mill, Essays on Some Unsettled Questions on Political Economy (London: Longmans, Green, Reader, and Dyer, 1874) p.80.

[3]Jacob Bigelow, Elements of Technology (Boston: Hilliard, Gray, Little and Wilkins, 1830).

psychotechnology, ad infinitum.

In order to satisfy the aforementioned requirements, 'technology' has to be given a precise, yet comprehensive, meaning: a meaning which at once fits all genuine acceptations of the word, and discriminately rules out all pseudo "technologies" (colloquialisms which have inadvertently crept into scholarly discourse).[4] It will be attempted here to ascertain the genuineness of the various uses to which the word 'technology' is commonly put, by identifying the principal characteristics that the so-called "technologies" hold in common: e.g., what does "technology of rhetoric" have in common with "technology of economy", or what does "industrial technology" have in common with "educational technology"; in short, what does technology mean?

Toward a Functional Definition of 'Technology'

A consideration of the question "What does technology mean?" is inevitably a study of the symbolic function of the word 'technology', as well as the propositional function of the statements in which it, among other words, is embodied as a constituent element. The first pertains to statements of definition, the second to assertions. The present discussion is concerned with definition; however, insofar as indirect reference to propositions cannot be avoided--not to mention the numerous semantic problems encountered in the process of defining words with words--perhaps a somewhat superficial treatment of a few relevant

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[4]The word 'technologies' is usually used colloquially as a synonym for 'techniques' or 'technics'. It is employed here in an ad hoc semantic sense with reference to the list of supposed branches of technology.

concepts may help with the task at hand.

1. The question "What does 'technology' mean?" is not the same as the question "What does writer X mean by 'technology'?" The first question implies that the word has a meaning, that 'technology' unequivocally signifies some definite object (thing, event, idea). The second suggests that its meaning is not fixed; it asks for an opinion or a special sense in which the word is to be understood. In answer to the question "What does technology mean?" one may inadvertently state that "technology means" such and such (a logical expression) when what he really intends is "'technology', as I use the term, means" such and such (a psychological expression).[5] Since both kinds of statements fall within the purview of "definition" the distinction is not of little import to the task of clarifying the meaning of technology.

2. The statement that "technology is the scientific study of the industrial arts"[6] is not the same as the statement that "technology is studied in Industrial Arts (or that "Industrial Arts centers on the study of technology").[7] The first statement is a definition (to be construed here as a hypothetical one) which purports to answer the question "What is technology?" The second statement, on the other hand, begs the question, for in order to know specifically what is studied in Industrial Arts depends on how 'technology' is defined. Hence the second statement

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[5]See Susan K. Langer's discussion on the logical and psychological aspects of meaning in Philosophy in a New Key (New York: A Mentor Book, The New American Library of World Literature, 1962) pp.54-55.

[6]The Oxford English Dictionary, Vol. XI, all editions.

[7]A notion widely subscribed to in the Industrial Arts profession. Cf. Chapter I.

is an assertion, the truth of which can be ascertained only in light of the definition. In other words, the assertion that "technology is studied in Industrial Arts" is true if, and only if, Industrial Arts education does in fact center on the "scientific study of the industrial arts." Whether the given hypothetical definition is "true" or not is of course another matter, irrelevant to the formal distinction between an assertion and a definition.

3. In common parlance it may suffice to say that a definition is an explanation of the meaning of a word, stated in other, more familiar, words. For purposes here, we need to qualify the statement by first noting that the meaning of a word (a word that is the name of a subject of discourse) has two aspects: a denotation or extension and a connotation or intension. In the first instance, the word 'teacher', for example, denotes "Socrates," "Pestalozzi," "Maria Montessori," "Anne M. Sullivan," "John Dewey," and many others; instances such as these constitute the extension of the word 'teacher'. In the second instance, 'teacher' connotes "skilled in the technics of instructing," "knowledgeable," "humanitarian," and the like; qualities such as these, which are attributed to, or predicated of, 'teacher' constitute its intension. The latter aspect is logically important; for it constitutes the definition of the word.[8]

With regard to definition, one further distinction needs yet to be noted: i.e., the distinction between a lexicographic definition and a

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[8]Morris R. Cohen and Ernest Nagel, An Introduction to Logic and Scientific Method (New York: Harcourt, Brace and Company, 1934) pp.31-32.

stipulative definition. A stipulative definition is one that is deliberately legislated in order to delimit vagueness and to eliminate ambiguity. Either a new word is invented to unequivocally signify one referent, or a new, precise definition is stipulated for an existing but heretofore vague or ambiguous word. Definitions of this kind are exemplified in dictionaries of science, medical dictionaries, mathematical treatises, legal documents, and the like. A lexicographic definition is one which has been established by custom or common usage. Such definitions are compiled in general, abridged and comprehensive dictionaries wherein succinct phrases, along with synonymous and analagous terms, are supposed to explain the various meanings commonly attributed to a word.

Needless to say, dictionaries are not the original sources of meanings; nor are dictionary makers the sole arbiters in instances of equivocation. Words originate with people who use them and give them meanings; dictionary makers, on the other hand, function as historians, in the capacity of which they systematically ferret out, and provide laconic accounts of, the various ways in which they find words used.[9] That being the case, their definitions of 'technology' merely reflect the most common acceptations of the word. In view of the critical analysis of such acceptations in the previous chapter, wherein they were deemed unacceptable, lexicographic definitions based upon them certainly cannot be honored.

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[9]Examples of definitions supported by historical references may be found in the Oxford English Dictionary. It may be of interest to note that the entry under "technology" in every edition of the OED (1928-1961) is a carbon copy of the original one which appears in its 1919 forerunner, _A New English Dictionary on Historical Principles_, wherein the latest historical reference to the term is dated 1882.

If 'technology' is to be retained as a useful word to symbolize an indispensable concept, obviously its meaning needs to be sharpened. As an alternative to the numerous unacceptable lexicographic definitions, it will be attempted here to give 'technology' a new connotation, to stipulate a definition.[10]

A Preliminary Generalization: From an etymological standpoint, technology may at once be viewed as a form of human activity and as a form of human knowledge, what man does and what man knows. Hence whatever else may be said of technology, it is first of all a human concern, something peculiar to man as actor-knower, and its meaning can be defined only in terms of the acting-knowing relationship.

This preliminary generalization narrows down somewhat the scope of the present inquiry, for it embraces the aggregate of elements identified in the previously analyzed definitions and at the same time rules out as inadequate those definitions which tend to restrict the meaning of technology to any one intrinsic, transactional, or extrinsic quality.[11] But as far as it goes the generalization reveals little if anything that is peculiar to technology alone. For science too may be generalized as a human concern--a form of human activity and a form of human knowledge. The same may likewise be said of art, of economy, of polity, or religion,

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[10]"It is a curious paradox, puzzling to the symbolic mind, that definitions, theoretically, are nothing but statements of symbolic abbreviations, irrelevant to the reasoning and inserted only for practical convenience, while yet, in the development of a subject, they always require a very large amount of thought, and often embody some of the greatest achievements of analysis." (Bertrand Russell quoted by Weitz in "Analysis and Real Definition", op. cit.)

[11]Supra, Chapter III.

etc., whether these human concerns are labeled "human activities"[12] or "human knowledge"[13] or "human institutions"[14] or "provinces of civilization."[15] Hence the task here is to invent a classificatory system which at once embraces all realms of human concern, and shows where technology logically fits into the scheme.

Technology as a Form of Human Activity

The concept of human activity blankets a broad range of things that man does which doubtless submit to no one tidy system of classification. They might, for example, be grouped according to conscious and unconscious activities, overt and covert activities, or mental and physical activities; or on the basis of theoretical and practical activities, work and play activities, or purposive and aimless activities. Although none of these dichotomous pairs is likely to provide an all-embracing system, the latter pair is presumed to be the most useful in establishing a basis for the discussion to follow.

Purposive and Aimless Human Activities: Purposive human activity presupposes aims in mind, or ends in view--the things that man does "on

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[12] Cf., Charles W. Morris, "Science, Art and Technology," The Kenyon Review, Volume I (New York: AMS Reprint Company, 1939) pp.409-423. Arnold J. Toynbee, A Study of History (London: Oxford University Press, 1961) pp.658-662. Ernst Cassirer, An Essay on Man (New Haven: Yale University Press, 1944) pp.72-221.

[13] Harold G. Cassidy, The Sciences and the Arts (New York: Harper and Brothers, 1962) pp.5-28. Philip H. Phenix, Realms of Meaning (New York: McGraw-Hill Company, 1964) pp.28-57.

[14] Ralph Barton Perry, Realms of Value (Cambridge, Mass.: Harvard University Press, 1954) pp.152-167.

[15] Paul Schrecker, Work and History (Gloucester, Mass.: Peter Smith, 1967) pp.12-18.

purpose". Such activity includes both mental and physical acts, covert as well as overt acts, acts which are consciously directed toward predetermined ends. (Granted, unconscious acts often enter into purposive endeavours; but such acts though they may serve predetermined ends are not in and of themselves done on purpose). Aimless human activity, on the other hand, includes mental or physical acts, overt or covert acts, conscious as well as unconscious acts, acts which collectively serve no particular predetermined end. Were we to match a list of descriptive adjectives, such as 'intentional', 'deliberate', 'reasoned','voluntary', 'planned', 'considered', and 'serious', against a second list, such as 'unintentional', 'precipitate', 'instinctive', 'automatic', 'accidental', 'casual', and 'frivolous', it would be safe to say that those of the first group characterize purposive activity, the latter group, aimless or random activity. Frivolous doodling during an academic lecture, for example, is an aimless activity, whereas serious copying of lecture notes is purposive; an accidental trip or stumble is an aimless act, whereas the intentional stumble, of say, a circus clown, is purposive. An ongoing human activity need but satisfy the condition of having a predetermined end in view (whether or not it does in fact proceed as planned, or whether that end is or is not ultimately realized) to qualify as a purposive human activity.

Work and Play as Purposive Activities: Every purposive activity involves an expenditure of effort or exertion directed toward the accomplishment of some predetermined end. The principle applies to both work and play.[16] The concept of work immediately suggests numerous determinate substantives generally associated with industry, e.g., 'labor', 'chore', 'toil', 'drudgery', 'grind', and the like, or the less determinate (and somewhat less pejorative) ones, like 'occupation', 'profession', 'employment', 'business', and so forth. The concept of play, on the other hand, is usually thought of as pastime activity commonly associated with 'sport', 'games', 'fun', 'frolic', and the like, terms which suggest the absence of any end except that of amusement, recreation, or pure enjoyment.

Play may be either deliberate or random; when play is deliberate, it fits the category of purposive activity, but when play is random, it is simply classified as an aimless activity. Take chess playing, for example: to play the game for the sheer joy of outwitting an opponent, defines deliberate playing; but to casually toy with captured pieces between moves defines random playing. The first activity is purposive, the second, aimless. Again with reference to chess: playing the game merely for the joy and satisfaction of outwitting the opponent is not the same as that in which the game is played to win a wager or a tournament trophy. Both activities are purposive by virtue of their having definite ends in view; both involve an expenditure of effort (mental and physical); the latter may be every bit as enjoyable as the former; and the involvement in one could lead to an involvement in the other. But the first, insofar as it is performed primarily for the sake of enjoyment,

[16] According to John Dewey, "both involve ends consciously entertained and the selection and adaptation of materials and processes designed to effect the desired ends;" in Democracy and Education (New York: The Macmillan Company, 1916) p.237. See also Paul Schrecker's concept of work in Work and History, op. ict., pp.17-18.

is play; the second, inasmuch as its purpose transcends mere enjoyment, is work.[17]

Human Work and Technology: On the basis of the foregoing chain of reasoning it may tentatively be concluded that technology is essentially human work, as opposed to play. Having logically arrived at that conclusion, it may not be superfluous at this juncture to take a closer look at some of the elements of definition identified with 'technology' in the preceding chapter. It was stated there that all definitions of the term exhibit certain qualities which readily submit to a classificatory system of intrinsic, extrinsic, and transactional elements. The latter, as summarized in Table 4,[18] appear as follows:

1. Human activities; a form of human activity; human action on physical objects; activities which produce alterations in the material world
2. Human work
3. Application of knowledge; application of organized knowledge; application of scientific knowledge
4. Application of scientific theories; application of the data, principles and theories of science; application of the methods of science
5. Process of transforming theoretical conceptions; process of production; any process
6. Systematic modification of the physical environment; systematic treatment of anything; systematic application of knowledge
7. Scientific management
8. Selective adaptation of processes and materials
9. Embodiment of selected processes in devices
10. Embodiment of ideas in matter
11. Mode of bringing to light
12. Mode of dis-covering

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[17]A similar distinction between work and play is afforded by Herbert Marcuse in Eros and Civilization (New York: Vintage Books, 1962) p.196.

[18]Supra, Chapter III.

13. Mode of dealing with Nature
14. Invention, manufacture, and use of tools
15. Means of human activity; means of work; means of accomplishing purposes
16. Methods; any method of doing or making
17. Procedures for making, using, and doing things; all practical procedures
18. Codified way of doing things; how things are done or made
19. Engineering rules
20. Productive systems

If there is one concept which embraces and integrates all of these elements, that concept is human work.[19] The first fifteen more or less describe kinds of work activities; the last five typify means of work. It is of particular interest to note that most of the elements have connotative significance in various realms of work. For example, the "embodiment of ideas in matter" can be attributed to artistic work; "productive systems", to economic work; "mode of bringing to light", to religious work. Even those elements which are usually associated with industrial work--e.g., the "use of tools", "practical procedures", "invention", "scientific management"--may be attributed to artistic, economic, political, and religious work; agricultural, military, medical, domestic and educational work. Although they may not be construed as unique attributes of technology they do nevertheless give a general idea of what technology is supposed to mean, and as such, they do provide a basis for defining the concept as a form of work.

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[19]They support Peter Drucker's assertion that "technology must be considered as a system, that is, a collection of interrelated and intercommunicating units and activities. We know that we can study and understand such a system only if we have a unifying focus...work might provide the focus..." Quoted from "Work and Tools", in Technology and Culture, Vol. I, No. 1 (Winter 1959) p.36. See also George H. Daniels, "The Big Question in the History of American Technology", Technology and Culture, Vol. II, No. 1 (January 1970) pp.1-21.

The Basic Forms of Human Work

The further consideration of technology as human work is predicated on the assumption that all human work is basically scientific, or technical, or technological in form. This assumption is central to the present dissertation. It means that the concept of technology is categorially consonant with the concepts of science and technic;[20] together they constitute the three basic forms of human work. In contradistinction, the concepts of art, economy, polity, religion, etc. constitute the various realms of human work, and as such are categorially of a different (albeit related) class of concepts. The two classes are in fact so indissolubly related and so open to misunderstanding that their differences must be noted if confusion is to be avoided. In the first place, the basic forms of work are implicit in every realm of work. Secondly, the things that man does, the multifarious kinds of work which distinguish one realm from another, can actually be scrutinized and theoretically classified according to the three basic forms of work.

At this stage of its development the conceptual model may be illustrated diagrammatically (Figure 2) to show at a glance where technological work fits within the framework of human activity.

Having reached the stage, then, where technology has been identified with the concepts of science and technic as basic forms of human work, it remains now to show how human work of every kind can in principle be classified according to the three basic forms. The seemingly

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[20] The term 'technic' is used here as a substantive to denote all of the so-called "fine arts" and "useful arts", and in the more general sense includes all sorts of technical tasks which man does "on purpose".

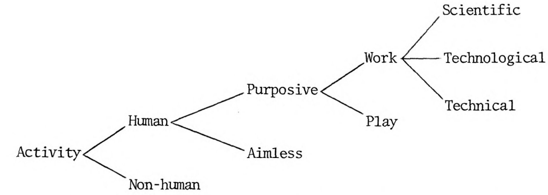

Figure 2. The Place of Technology in the Framework of Human Activity.

arduous task of providing a conceptual scheme for distinguishing their characteristic differences is facilitated somewhat in that the essential determinants have already been furnished in the foregoing preliminary considerations: 1. the concept of work by definition is purposive human activity (which, of course, rules out non-human, aimless, and play activities); 2. the concept of purposive human activity implies the presence of (a) man as the agent or *actor*, (b) with a tentative or fixed *aim* in mind (c) actively engaged (expending effort) in doing or producing something via certain *means* (tools, materials, methods, guides to action) (d) for the purpose of bringing about some desired result or *consequences*. This means that every conceivable kind of human work always involves an actor, some aim, certain means, and consequences; and it logically follows that if technology, science, and technic are the basic forms of human work which subsume every kind of human work, their distinguishing characteristics should become evident in the light of their respective aims, means, and consequences. A scheme for ordering the aims, means, and consequences of scientific, technological, and technical work may be diagrammed as shown in Figure 3.

	AIMS	MEANS Tools - Materials - Methods - Guides	CONSEQUENCES
Scientific Work			
Technological Work			
Technical Work			

Figure 3. Scheme for Ordering the Aims, Means, and Consequences of Scientific, Technological, and Technical Work.

The foregoing conception is a vast oversimplification of this, the second, stage of the profferred model. Although its specific elements deserve extended philosophical analysis, such a treatment would protract the present study beyond its intended limits. Let it suffice to show by example how the aims, means, and consequences of technical, technological, and scientific work can be scrutinized and differentiated according to the foregoing scheme.

Technical Work: The many kinds of work that man does in the various realms referred to--artistic, economic, political, religious; medical, military, industrial, domestic--may be viewed as simple or complex tasks. For example, laundering, sewing, cooking and baking, in the domestic realm of work, are complex tasks which involve many simple ones like: sorting laundry, threading a needle, dicing vegetables, or preheating an oven; these tasks, in turn, are composites of simpler ones like: striking a match, opening an oven door, turning up the gas, etc. Simple tasks may be viewed as the procedural stages in the process of performing complex tasks. In any event, the point to be made here is that every human task which involves the manipulation of things, along with the requisite skill to manipulate them, regardless of their simplicity or complexity, defines technical work.

The principle holds for every kind of work, in every realm of human concern. Tasks such as: turning a knob to activate a washing machine or turning a handwheel to adjust an astronomical telescope; sewing a torn garment or suturing a surgical incision; dicing a vegetable or cleaving a diamond; opening an over door or "cracking" a bank vault; tying a shoe lace or stamping leather blanks on a shoe factory assembly line; writing a letter or penning a novel; adding up domestic expenses or calculating the gross national product; they all exemplify human work that is basically technical in form. They all involve the manipulation of things--physical objects, words, or mathematical symbols; they all require an expenditure of effort--physical and mental; and they all may actually be done by anyone--neophite, master craftsman, or specialist in some profession--possessing the requisite technical skill and the means to execute them.

In the technics of laundering, sewing, cooking and baking, the average homemaker assumes the role of technician whose immediate aims are to wash linens clean, to sew or mend wearable garments, to cook or bake edible food. Whether or not her ends are successfully achieved depends, inter alia, on the effectiveness of her manipulative skills and the means she employs in the attainment of her desired ends. She may, for example, launder fabrics according to the manufacturers' instructions, sew a garment according to a commercial pattern, cook a meal according to a prescribed dietetic menu, bake a cake according to a Good Housekeeping recipe; or she may choose to do these things by rule of thumb or by trial and error. Similarly, a painter may create a landscape painting in accordance with the rules of perspective drawing; a building contractor may erect a house according to the Graphic Architectural Standards; a surgeon may remove a human appendix guided by deGraaf's anatomical models; a despot may govern a people according to Machiavelli's precepts; an advocate may defend a client guided by the rules prescribed in Aristotle's Technic of Rhetoric; or, like the homemaker, they may choose to perform their respective technics by other than prescribed guides. In any event, given the means--tools, materials, and guides to action (be they systematically ordered or randomly selected)--their role as technicians in their respective realms of work is to do or to produce things. Hence, in the hierarchy of the three basic forms of work, technic is the most basic, and is implicit in both technological and scientific work.

Scientific Work: The concept of science has been more than adequately treated in the literature by scholars in various fields of inquiry, particularly in the philosophy of science. However, something about the aims, means and consequences of science needs to be noted inasmuch as their distinguishing characteristics are essential to the further development of the present conceptual model.

To begin with, science, like technology, may at once be viewed as a form of human knowledge, and as a form of human work. Without scientific work there could be no scientific knowledge; man must exert a degree of effort toward its acquisition. But it does not follow that all men are able or willing to work toward its acquisition; nor does it follow

that all work directed toward its acquisition is scientific.

The aim of scientific work is to understand the nature of things, to come _to know_ with the highest possible degree of certainty their natural order and their underlying causes. That being the case, man _qua_ scientist desires _positive_ knowledge, knowledge that within the bounds of human powers meets the criteria of truth, proof, and certainty. By means of rigorous methods peculiar to scientific work, man _qua_ scientist employs his natural tools--the senses, natural talents, powers of reason--along with his artificial (man-made) tools--logic, mathematics, precise physical instruments--to systematically investigate and study the phenomena of nature (both human and non-human) with the intent of discovering new knowledge or to confirm or disconfirm prior discoveries. Scientific work ends with systematized positive knowledge: truths in the form of theories and laws, verified in proof through rigorous replication, shared through publication, classified and added to the joint stock of theoretical knowledge. The knowledge thus obtained leads to further scientific inquiry, and provides the groundwork for technological work.

It should perhaps be noted that theoretical knowledge in the broadest sense of the term is not peculiar to science alone. Nor is the theoretical knowledge of science the only source of guiding principles from which practice may proceed. On the contrary, many theories about the nature of things and their relations are supposedly derived by means other than science, e.g., revelation, intuition, common sense. Like science, they all lay claim to knowledge, and they all furnish principles which may be adopted as guides to action. Even the pseudo-sciences--astrology,

cabalism, palmistry, phrenology, and the like--entertain systems of theoretical "truths". The point is that even though such "truths" can in no way be substantiated, demonstrably or experimentally, they are nevertheless relied upon as guides to human action; and even though certain realms (or sub-realms) of human activity do not qualify as "sciences", they nevertheless do have (by virtue of their existence as realms of human activity) their technical and technological work.

Technological Work: In the domestic technics of laundering, sewing, cooking and baking, a homemaker is not immediately concerned with theoretical scientific knowledge, (e.g., the chemistry of laundry detergents, the comparative tensile strengths of synthetic yarns, the nature of enzymes, the concept of antivitamins, the physical properties of heat, and the like). Nor does she, in the role of technician, need to know how theoretical principles apply to her domestic technics. Such concerns transcend the bounds of technical work.

Baking a cake according to a recipe, for example, is not the same as working out a recipe according to chemical, physical, and mathematical principles. Both may in fact be done by one and the same homemaker; however, the two undertakings are quite different in form by virtue of their difference in aims, means, and consequences. The first fits the category of technical work; its aim is to bake an edible cake. The second fits the category of technological work; it aims to devise the most expedient how-to-do guides for producing an edible cake and ends with the recipe, which specifies the necessary tools and utensils to be employed, the requisite materials and their specific quantities, and the step-by-step procedures to be followed in measuring, mixing, blending and baking. In short, technological work ends with instrumental knowledge which furnishes the directive means for doing the technical work.

The means employed in the technological work differ in the kind and quality of physical tools (e.g., thermal and volumetric instruments used in precise measurement), the more exacting methods (e.g., in testing and quality control), and particularly, the prerequisite theoretical knowledge (chemical, biological, mathematical) upon which the technological work is based.

Generally speaking, the aim of technology as a form of human work is to systematize a given technic--<u>any technic</u>. The principle applies to every realm of human work--artistic, economic, political, religious; agricultural, domestic, medical, military, industrial; educational, literary, mathematical, rhetorical. All of their respective technics can in principle be reduced to a system. One who functions in the capacity of "a technologist" selects whatever theoretical knowledge he deems essential to a given technical problem and transforms that knowledge into a system of guiding principles and expedient rules for doing or producing something. In that capacity one must have a thorough understanding of the technics he aims to systematize, and must likewise be fully cognizant of the theoretical knowledge related thereto if the guides he prescribes are to prove effective in bringing about desired technical consequences.

<u>Technologist, Technician, and Scientist</u>: In the actual conduct of human affairs, individuals seldom assume any one role--technical, technological, or scientific--to the total exclusion of the others. Nor is it unusual to find the same individual occupationally engrossed in all three

forms of work. A classic example in the industrial realm of work is the Scottish physicist, engineer, and inventor, James Watt, who perfected the Newcomen steam engine. In the capacity of scientist, Watt studied the physical processes involved in the engine and carried out independent experiments which led to several thermodynamic discoveries; in the capacity of technologist he reasoned from the scientific data thus obtained, formulated principles which expressed the conditions for the efficient and economic working of a steam engine, and applied the principles to his inventions; in the capacity of technician he machined the parts and constructed the prototypes of his inventions.[21]

In view of the temporal shifting of occupational interests and the inevitable overlapping of technological, technical, and scientific functions in the actual conduct of human affairs one would be hard pressed to distinguish "a technologist", so-called, from "a technician" or "a scientist". These terms are in fact misleading when they are employed in a generic sense to label an individual according to his main line of work or on the basis of some occupational title. That "a botanist", for example, may be synonymously associated with "a scientist" merely follows from the generally accepted definition that botany is "a science"; the analogy likewise holds for "a cytologist", "a genetecist", "a plant pathologist", "a plant physiologist". Similarly, "a gardener" may be equated with "a technician" inasmuch as gradening by definition is "a technic"; the same may be said of "a crop picker", "a

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[21]Kerker writes that "The practical part of Watt's career came only after he was well launched upon the inventive part, when it became necessary to construct and to promote a commercial engine." Milton Kerker, "Science and the Steam Engine," in Thomas Parke Hughes, <u>Western Technology Since 1500</u> (New York: The Macmillan Company, 1964) p.72.

crop duster", "a tree pruner". But where in such a scheme of associations would one fit the numerous ill-defined occupational titles, such as "an agriculturist", "an agriologist", "an herbalist", "a horticulturist"? And more importnatly, which if any such occupations would one unequivocally associate with "a technologist"?

The point is that the terms in question have no fixed referents in the actual world of work, and any discussion which attempts to draw sharp lines between "a technologist", "a technician", and "a scientist" as distinct de facto entities is purely academic; but more importantly, to presume on such grounds, as some writers do, that a distinction cannot be made between technology, technic, and science is untenable.[22] The The terms in question ought instead to be understood as conditional, or ad hoc attributes; to put it simply: one is in fact "a scientist" if and when he is primarily engaged in scientific work; "a technician", if and when he is primarily engaged in technical work; "a technologist", if and when he is primarily engaged in technological work. But whether one is at any point in time actually engaged in scientific, technical, or technological work depends, inter alia, on his ends-in-view, the means he employs in their pursuit, and particularly the motivating interest that determines his sought-after ends. Thus when one is motivated by a cognitive or purely theoretical interest--to know for the sake of

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[22]"...to draw a clear line between pure science and technology," Snow writes, "is a line that once I tried to draw myself; but, though I can still see the reasons, I should'nt now. The more I have seen of technologists at work, the more untenable the distinction has come to look...The scientific process has two motives: one is to understand the natural world, the other is to control it. Either of these motives may be dominant in any individual scientist; fields of science may draw their original impulses from one or the other." C.P.Snow, The Two Cultures: and a Second Look (New York: The New American Library, 1964) p.64.

knowing--he functions in the capacity of a scientist; motivated by a practical or productive interest--to do in order to get something done--he functions in the capacity of a technician; motivated by a pragmatic or instrumental interest[23]--to know how something ought to be done if it is to be done efficiently and expediently--he functions in the capacity of a technologist. The consequences of scientific work cannot be converted into immediate rules of action; an "intermediary inventive mind must make the application."[24] Such is the role of "a technologist" who serves as liaison between "a technician" and "a scientist" at work. Hence it may be concluded that technology as a form of work, by whomever performed, in whatever realm of work, bridges the gap between science and technic, between "theoretical" knowing and "practical" doing.

Technology as a Form of Knowledge

Thus far in its development, the present study has layed open to view in its barest essentials the central thesis that technology is basically a form of human work. That technology may at the same time be viewed as a form of human knowledge (to reiterate a prior assertion) in

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[23]The foregoing conception of technology is in harmony with John Dewey's "pragmatic instrumentalism" the essence of which "is to conceive of both knowledge and practice as means of making goods--excellencies of all kinds--secure in experienced existence...Just as in science the question of the advance of knowledge is the question of what to do, what experiments to perform, what apparatus to invent and use, what calculations to engage in, what branches of mathematics to employ or to perfect, so the problem of practice is what we need to know, how shall we obtain that knowledge and how shall we apply it?" The Quest for Certainty (New York: Milton Balch & Co., 1929) p.37.

[24]William James, Talks to Teachers on Psychology (New York: Henry Holt and Company, 1929) p.8. See also John Dewey, The Sources of Science of Education (New York: Liveright Publishing Corp., 1929) p.19.

no way negates the central thesis. On the contrary, it merely focuses attention on but one aspect of technology; i.e., technological work ultimately ends in knowledge. But inasmuch as scientific work also ends with knowledge, it remains to show how technological and scientific knowledge differ in form.

Technological and Scientific Statements: "Human knowledge is by its very nature symbolic knowledge;"[25] and as such, can be expressed in verbal statements. Scientific knowledge finds expression in the form of descriptive and interpretive statements, statements of fact, the truth of which can be verified in proof; technological knowledge is expressed in the form of prescriptive and instructive statements, the efficacy of which can be ascertained in practice. Scientific statements explain the nature and the natural order of things, why things are as they are and why they behave as they do; such statements are referred to as hypotheses, theories, or laws, depending on the level of certainty. Technological statements on the other hand explain how things in nature can be obtained, changed, or altered for some ulterior use; such statements are herein referred to as rules.[26]

Rules and Laws: Technological rules may (but need not) be based on scientific laws;[27] i.e., law-statements may be knowingly accepted as

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[25]Ernst Cassirer, An Essay on Man (New Haven: Yale University Press, 1944) p.57.

[26]For an interesting distinction between scientific law and technological rule see Mario Bunge, "Technological Rule" in Studies in the Foundations, Methodology and Philosophy of Science, Volume 3, II (New York: Springer-Verlag New York Inc., 1967) pp.132-137.

[27]Supra, p.125.

the guiding principles in formulating systems of rule-statements. Take for example the following elementary laws, and some quasi rules deduced therefrom:

Laws: 1. At temperatures below 32° F. water passes from a liquid to a solid state.

2. When water passes from the liquid to the solid state it expands to the amount of 1-11th of its volume.

3. This expansion is sufficient to bring about a large quantity of mechanical work (e.g., it is sufficient to heave a concrete roadway).

Rules: 1. To prevent concrete roadways from heaving where the temperature drops below 32° F., a layer of coarse aggregate base must be provided to take care of water drainage; and culverts should be installed wherever there is subterranean seepage;

or 2. a) Install a heating system along the proposed roadway, and b) construct the concrete bed over the subterranean ducts which convey the heat.

3. If you want to destroy an existing concrete roadway, then a) plug up all drainage passages, and b) just before the temperature drops below 32° F. let water accumulate under the roadway.

Note that each of the three Laws is a statement of fact, the truth of which can be verified empirically. The Rules on the other hand have no truth value; they merely tell what to do in order to attain a desired end. Their positive value rests with their respective effectiveness in practice. Rule 1 is given in the form of an imperative-prescriptive (must-should) statement; Rule 2, in the form of a directive (do so and so) statement; Rule 3, in the form of a predictive (if-then) statement.

Where technical work adheres to a system of technological rules based on scientific laws (which are accepted as guiding principles), that work is principled. (Contrarily, work which proceeds by rule-of-thumb is unprincipled.) The rules, and the laws which govern them, furnish justifiable grounds for the ways and means (the method) by which technical work is performed. What is said here with regard to technical work applies likewise to scientific work. There is, at least in practice, agreement about the method used in scientific work. The rules of that method are laid down and unanimously accepted by men of science as <u>the</u> guides to scientific work. The special task of formulating rules for scientific work is of course a technological function--whence the concept "technology of science"; and these rules exemplify technological knowledge par excellence.

Summary and Concluding Statement

The foregoing all-too-brief consideration of technology as a form of knowledge should suffice to bring the profferred conceptual model to its final stage of development. At this stage the conceptual scheme for ordering the aims, means, and consequences of scientific, technological, and technical work can be used to illustrate synoptically some of their principal distinguishing characteristics. (See Figure 4)

The conceptual model, as illustrated, is of course vastly oversimplified. But then, the illustration is intended merely as a device to bring some of the aforetreated concepts into perspective; and more importantly, to show at a glance the interrelationship and interdependence of scientific, technological, and technical means and consequences.

The concept <u>means</u> should be understood here in the broadest sense as any and all intermediary agents and instruments (persons as well as things--things abstract as well as things concrete) through or by which scientific, technological, and technical work is or may be performed.

FORMS OF WORK	AIMS		MEANS		CONSEQUENCES
Scientific work	Motivated by a cognitive or theoretical interest	To know that...	Methods, tools, and skills characteristic of discovery	Guided by systematic rules of inquiry	Theoretical knowledge in the form of theories and laws
Technological work	Motivated by a pragmatic or instrumental interest	To know how...	Methods, tools, and skills characteristic of invention	Guided by theoretic knowledge and by effectual practice	Instrumental knowledge in the form of systematized rules
Technical work	Motivated by a practical or productive interest	To do or produce	Methods, tools, and skills characteristic of production	Guided by systems of prescribed rules, or by rule-of-thumb	Things done or produced

Figure 4. Schematic Illustration of the Principal Characteristics of Scientific, Technological, and Technical Work.

Needless to say, its scope comprehends mental as well as physical human resources--i.e., the mental and physical skills, tools, and methods incident generally in the acts of discovering, inventing, and producing things. Discovery and invention are to be understood primarily as mental activities: discovery, to denote the mental process of bringing to light existent but heretofore unknown nature and natural order of things; invention, to denote the mental process of designing effective systems for bringing artificial (man-made) things into existence. The point to be stressed here is that invention in the strict sense does not mean things per se; for things are but the objects or ends of invention. Given the systematic means, it is production that brings artificial things into existence. In the actual world of human work, discovery, invention, and production are of course so inextricably bound as to defy distinction. But practical inextricability notwithstanding, they are, from a theoretical point of view, discernibly different. These analytically discernible differences are of paramount importance to a clear conception of the foregoing science-technology-technic model wherein invention is perceived as a unique characteristic of technological work.

Keeping in mind the basic considerations just set forth, technology may be defined briefly as a form of human work concerned with selecting and systemizing knowledge for some ulterior use. So defined, 'technology' embraces the original (ancient Greek) meaning of the word as well as its modern, naturalistic acceptations. Thus it satisfies the criterion of appropriateness as judged by its history, and at the same time does not glaringly violate received usage--as per Mill's admonition.[28] "In so

[28] Supra, p.

defining it" (to borrow an appropriate statement from Herbert Spencer),

> we accept that which is common to the various conceptions of it current among both ancients and moderns--rejecting those elements in which these conceptions disagree or exceed the possible range of intelligence. In short, we are simply giving precision to that application of the word which is gradually establishing itself.[29]

Its de facto establishment in Industrial Arts education remains yet to be considered in the concluding Chapter.

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[29] Education--Intellectual, Moral and Physical (New York: A.L.Burt, Publishers, 1881) p.111.

CHAPTER V

THE PLACE OF TECHNOLOGY IN INDUSTRIAL ARTS EDUCATION

In Chapter I it was argued that the proposed technology-centered concept for Industrial Arts education had never been established on sound theoretical grounds, and that from its very inception the need for clarifying the meaning of technology had not been seriously considered an essential prerequisite in establishing such grounds. It was shown that Warner and his associates, who conceived the idea, apparently assumed they had defined the scope of technology when they declared Power, Transportation, Manufacture, Construction, and Communication "the principal elements of technology;"[1] and the proponents of subsequent versions of the idea appear to have entertained the same erroneous assumption: they merely differ in opinion as to which of the supposed "elements" ought to constitute the divisions of subject matter for Industrial Arts education.[2]

In view of the prevalent misconceptions regarding the meaning and scope of technology (not only in the Industrial Arts profession, but even among noted scholars who write on technology), the major part of the present study was addressed to the fundamental problem of conceptual clarification. Chapter II inquired into the origin of the word

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[1]William E. Warner, A Curriculum to Reflect Technology. op. cit. p.42.

[2]Supra. pp.6-17.

'technology' and its meaning in an historical perspective; and Chapter III critically analysed and compared a number of definitions of technology taken from recent scholarly literature on the subject. The preliminary investigation revealed a discernible pattern of common referents which in Chapter IV provided a basis for clarifying the meaning of technology in the broad sense of the term. There the concept of technology was located in the context of human activity and was identified with science and technic as a form of human work. In the process, a conceptual scheme was devised for the purpose of identifying and structuring the elements of technology in any given realm of work.

Assuming that technology does have a place in Industrial Arts education, and that the subject matter of instruction ought to center on the technology of a significant realm of human work, then given the realm of work and the foregoing conceptual scheme, it should be readily apparent that the place of technology in Industrial Arts education can be established. The object of the present Chapter is to suggest how it can be done.

Preliminary Considerations

A consideration of the place of technology in Industrial Arts education is inevitably a study of the basic forms of work--scientific, technical, and technological--implicit in that realm of work which determines the source of subject matter for Industrial Arts education. (It is essential in the following discussion to keep in mind the theoretical distinction made earlier between forms of work and realms of work.)

Education as a Dominant Realm of Work: Briefly, the concept of education comprehends the numerous and diverse kinds of things that human

beings do in all learning situations, informal and formal. The latter may be thought of as the institutions of learning--graded schools, technical, technological, and professional schools, colleges, and universities--institutions which are established for the expressed purpose of acquiring and disseminating positive knowledge. That knowledge--the things that man has come to know about himself and the world around him with a degree of certainty--is embodied in the academic disciplines, variously classified under "the humanities", "the arts", "the sciences", "the applied arts and sciences", or similar designations. The academic disciplines, and the procedures and instrumentalities which are used to promote them, define education as a dominant realm of human work.

Like any other realm of human work, education has its technical, its scientific, and its technological aspects. (a) To read a fairy tale to kindergarten children, or to demonstrate a scientific theory to college students; to do these things with the aid of a chalkboard, or to do them with sophisticated electronic teaching aids: such tasks exemplify educational work that is basically technical in form. (b) To conduct an experiment in order to find out how kindergarten or college students learn; to replicate experiments in order to confirm or disconfirm learning theories: these complex activities exemplify educational work that is scientific in form. (c) To devise systems for effective teaching and learning based on educational theories; to invent more expedient means for conducting educational experiments: such tasks exemplify educational work that is technological in form.

The theoretical knowledge derived from experimental work in education, and the educationally relevant theories drawn from "the sciences"--anthropology, biology, psychology, sociology--may, in their collectivity, be referred to as "educational science". Knowledge drawn from educational science, and systemized to expedite the teaching-learning process--e.g., the handbooks and manuals on how to study, how to teach, how to devise courses of study, how to program "teaching machines", and the numerous other instructional, supervisory, and administrative "know how" systems used in the technics of education--may be referred to as "educational technology".

Industrial Arts as a Branch of Educational Work: Inasmuch as Industrial Arts is considered to be a branch of education proper, then it too must have its science, its technics, and its technology. These aspects of educational work, however, Industrial Arts has in common with all other branches of education: the handbooks and manuals on how to study, how to teach, etc., are in principle applicable to all learning situations. What distinguishes one branch from another is the uniqueness of its subject matter--the disciplined knowledge, instrumentalities, and procedures, based upon that realm of work which it undertakes to study. It follows then, that Industrial Arts too must have its subject matter of instruction, based upon some realm of human work.

What is the Subject Matter of Industrial Arts Education? To reiterate a prior observation, the nature and source of subject matter for Industrial Arts education has yet to be made explicit and generally accepted by teachers and educators in the field. Because of the apparent dissatisfaction with the status quo, and the recent attempts toward establishing some kind of technology-centered curriculum without first having defined the meaning and scope of technology, the Industrial Arts profession is in a quandary as to the nature and source of its subject matter.

Ever since Warner and his associates introduced the concept of technology into Industrial Arts education the profession has taken one of two tentative positions on the question. Some say that Industrial Arts draws its content from "the technology", and they presume that Transportation, Manufacture, Construction, Communication, and the like constitute "the technology". Others hold to the long-standing notion that "the industries" furnish the subject matter for Industrial Arts education. From our previous discussion, it should be obvious that both positions are erroneous: (a) Transportation, Manufacture, etc., designate realms of human work (or branches of industrial work); as such, each has its technological aspects: hence,the technology of transportation, the technology of manufacture, and so on. But the same may likewise be said of Woodworking, Metalworking, and similar realms of work traditionally associated with Industrial Arts education. The former are merely broader in scope than the latter; and breadth alone by no means determines a technology-centered curriculum. (b) To say that "the industries" furnish the subject matter for Industrial Arts education is analagous to saying that hospitals or medical clinics furnish the subject matter for medical education. Needless to say, industries are established and maintained primarily for economic purposes--to produce consumable goods and render services at a profit. Moreover, they themselves turn to other sources for knowledge: they turn to the disciplines. Why then should the Industrial Arts profession attempt to structure its own subject matter, based on the hundreds of ill-defined and overlapping industries?[3] Why

[3] In his discussion of "The Scope and Organization of Industrial Arts", Bonser observed fifty years ago that: "By a rather general classification of the industries, there are over five hundred in the United States. But these may be divided into hundreds more. Specialization

should it not go directly to a primary source wherein knowledge is already disciplined and readily accessible for instructional purposes?

Engineering as a Source of Subject Matter

The logical source of subject matter for Industrial Arts education, and perhaps the most expedient, is engineering science and technology. The rationale of such a proposal can be discussed from several points of view. For our purposes, it will suffice to discuss in brief the relation of engineering science and technology to industrial production, and to note some of the implications of that relationship for Industrial Arts education.

Engineering as an Educational Discipline: In its long history as a dominant realm of human work, a history of human achievements which dates back to antiquity, an enormous amount of practical and theoretical knowledge has been amassed by ingenious men, appropriately called "engineers". Most of what now constitutes the body of engineering knowledge was acquired only since the nineteenth century, when human ingenuity and practical experience based on "rule-of-thumb" gave way to engineering based on natural philosophy, or what came to be known as "modern science" (from whence the term "modern technology"). By then, schools of engineering were being instituted to train potential engineers, and at the same time practicing engineers began to specialize, and to form themselves

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has gone so far that there are literally thousands of separate kinds of industrial production existing in our day and generation." Frederick G. Bonser and Lois Coffey Mossman, Industrial Arts for Elementary Schools. (New York: The Macmillan Company, 1923) p.19.

into engineering societies for purposes of promoting the acquisition of knowledge in their respective realms of engineering work. The first of these societies was formed (in 1818)

> for the general advancement of Mechanical Science, and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a Civil Engineer, being the art of directing the Great Sources of Power in Nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange, and in the construction of ports, harbours, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns.[4]

With the formation of engineering societies and the founding of engineering schools, engineering established itself both as a "profession" and as an educational "discipline". In order to do and profess all of the things that the Civil Engineers committed themselves to in the realms of construction, production, transportation, power generation, etc., their theoretical and instrumental knowledge had to be disciplined.

To meet the criteria of "a discipline", engineering had to have (a) a unique body of knowledge, consisting in clearly defined concepts, verifiable facts, and logically structured categories; (b) the instrumentalities--precise instruments, methods of research and development, and norms or standards--for acquiring, evaluating, systemizing, and disseminating theoretical and instrumental knowledge; and (c) unique purposive activities--the scientific, technological, and technical work that engineers actually engage in in all of the branches of engineering.

<u>The Branches of Engineering</u>: Engineering knowledge which a century and a half ago constituted the sole province of Civil Engineering has

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[4]Thomas Telford, <u>Charter of The Institution of Civil Engineers</u>, (London: The Institution, 1908) p.7.

since proliferated to the extent that numerous branches of engineering, and as many educational disciplines had to be created. The broader divisions, those on the basis of which engineering schools structure their curricula, and in the names of which practicing engineers have formed themselves into societies, include Civil Engineering, Mining and Agricultural Engineering, Metallurgical and Chemical Engineering, Mechanical and Electrical Engineering. These divisions in turn subsume the specific branches of engineering work--e.g., Automotive Engineering, Ceramic Engineering, Electronic Engineering, Nuclear Engineering--some of which have in recent years developed a highly sophisticated body of scientific and technological knowledge.

A scheme for classifying the numerous branches of engineering is afforded in the accompanying diagram (Figure 6).[5] There too, the divisions of engineering are shown in relation to the processes of industrial production: viz., the relation of Civil Engineering to Construction (of buildings, highways; atomic plants, missile launching pads); Mining and Agricultural Engineering to Production of Raw Materials (of metals, minerals, fuels; of lumber, textile materials, food materials); Metallurgical and Chemical Engineering to Processing of Raw Materials (of metals, alloys; of plastics, textiles, foods); Mechanical and Electrical Engineering to Communication (mechanical, electrical, electronic), to Transportation (terrestrial, nautical, aeronautical), to Manufacture (of food, clothing, luxuries; of instruments, weapons, machines), to Power

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[5]Harold T. Larsen, "Engineering," The Encyclopedia Americana, Vol. 10, (1971 Edition) pp.341-345; the diagram as suggested by Arthur B. Parsons appears on p.344. Note, that Parsons conception of engineering is perhaps one of many, and is used here merely as a matter of convenience to show the relation of industry to engineering.

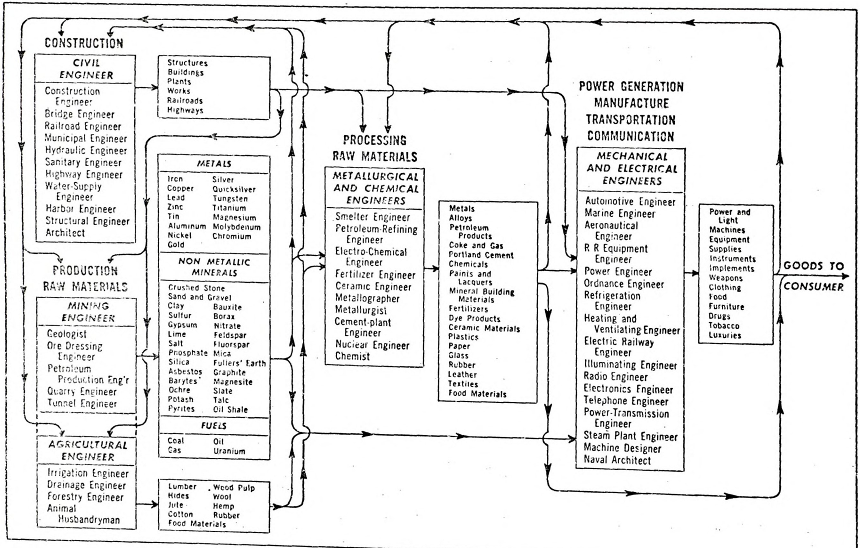

Figure 5. Processes of Production and Related Functions of Engineers. (From The Encyclopedia Americana, 1971 Edition, Volume X, p. 344. Used by permission with Grolier Inc., Encyclopedia Americana Corporation.)

Generation (for light, heat; for manufacture, transportation, communication).

The intimate connection between engineering work and industrial production is of particular significance to the foregoing proposal which opts for engineering science and technology as the logical source of subject matter for Industrial Arts education.

Implications for Industrial Arts Education: As realms of human work, engineering and industry have one thing in common: generally speaking, both are concerned with the production and transformation of natural resources into economic goods or commodities. In their common concern, however, the two realms of work are essentially and characteristically different. Stated briefly, engineering deals with the properties of matter and energy given in nature (work that is basically scientific in form), and through research and development (work that is essentially technological in form) determines how these natural resources can be directed toward "the use and convenience of man, as the *means* of production."[6] Industry, on the other hand, utilizes the technological means in the actual processes of producing natural resources and in transforming them into economic goods (work that is, for the most part, technical in form). In short, industry depends on engineering; or what amounts to the same, engineering science and technology is essential to the technics of industrial production.

By the same token, the study of engineering science and technology is, from a pedagogical point of view, essential to an understanding of industry and the technics of industrial production. Or more to the

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[6] Telford, *op. cit.*

point: if the purpose of Industrial Arts education is to advance an understanding of the technics of Construction, Power Generation, Manufacture, Transportation, Communication, and the like, the source of its subject matter is the science and technology of Civil, Mining, Agricultural, Metallurgical, Chemical, Mechanical, and Electrical Engineering.

It may be noted that most of the things that Industrial Arts teachers and educators claim (in word, if not in deed) to be unique to their realm of educational work--laboratory activity, research and development, problem solving, product designing, production planning--are inherent in engineering. Hence, as a matter of pure expediency, the profession need but turn to engineering science and technology for its subject matter, if only to justify its claims.

Given the realm of engineering as the source of subject matter, and given too, the conceptual scheme[7] by means of which the technical, scientific, and technological elements of engineering (in any or all of its branches) can be identified and structured for instructional purposes, a curriculum may be oriented toward the technics of engineering (for a technic-centered program of studies), toward the science of engineering (for a science-centered program of studies), or toward the technology of engineering (for a technology-centered program of studies). For that matter, a curriculum may be devised to encompass all three forms of engineering work for a general education program. And it matters little whether one holds to the notion that Industrial Arts ought to be concerned with "the industries", or that it ought to "reflect the technology": either way, engineering can furnish the subject matter of instruction, as well as the categories for structuring an "externally stable"

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[7] Supra, p.134.

and an "internally flexible" curriculum.

Concluding Statement

When Charles R. Richards introduced the concept of "industrial art" into education at the turn of the present century, he asserted that "such a term clearly indicates a specific body of knowledge as the subject-matter of instruction and at once establishes criteria as to (its) selection and organization".[8] Arguing against the narrowly conceived, trade-oriented, "manual training" concept then prevalent in "the common-school curriculum," Richards held that:

> The common school cannot teach trades, but it can give an insight into the basic operations of a great number of trades and occupations; it can give a wide variety of experiences in the manipulation of tools and materials, and a considerable knowledge of typical methods and principles of construction. It can go farther, and trace the course of invention in the primary arts; it can bring out the intimate dependence of industry upon science; it can develop an insight into the economic relations of industry to social life and give some idea of the laws governing those relations; in short, it can do much to advance an understanding of, and interest in, the facts and forces fundamental to all human art and industry, and to define the place of these activities in the life of to-day.[9]

Richards' concise statement aptly sums up the general-education purposes of Industrial Arts education, and implicitly supports the proposition that engineering science and technology is central to an understanding of industry and of the problems of life related thereto.

That the Industrial Arts profession had never openly adopted engineering as its primary source of subject matter is indeed curious.

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[8]Charles R. Richards, "Is Manual Training a Subject or a Method of Instruction," Educational Review, Vol. 27 (April 1904) p.373.

[9]Ibid., p.372.

Although Richards did not elaborate on the "specific body of knowledge," he states that the term 'industrial art' "places the subject in company with such intelligible titles as architecture, engineering, and domestic science."[10] Perhaps the term 'industrial art' is in itself too narrow to comprehend Richards' conception of the subject.

In any event, Richards' observations are as significant today as they were during his time, perhaps more so. The progressive growth of industrial production, and its attendant socio-economic problems, coupled with the growing disenchantment with science and technology, ironically presumed even by important writers to be at the root of those problems, attests to the significance of Richards' observations. The need "to advance an understanding of, and interest in, the facts and forces fundamental to all human art and industry," needless to say, is critical; and to reiterate a prior assertion, engineering science and technology is central to an understanding of human industry. In view of its social significance as a dominant realm of human work, one which centers on man and his achievements in all of what is sometimes dubbed the "man-made-world", engineering deserves a place of its own in general education (a place yet to be accorded to it) alongside the established disciplines. Perhaps the time is right for what is now called 'Industrial Arts' to be repatterned and reoriented toward filling the void under the name 'Engineering'. "We have surely reached the point," to quote Richards, "where we can afford to call things by their right names."[11]

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[10] Ibid., p.373.

[11] Ibid., p.374.

APPENDIX

APPENDIX

Bibliography of Extant English Dictionaires and Cyclopedias 16th-19th Centuries

1538 - Thomas Elyot, The Dictionary of syr Thomas Elyot knyght. London: 1538. (Microfilm - Pollard and Redgrave STC 7659)

"The first complete Latin-English dictionary,"[1] This work was published about sicty years after Caxton introduced printing into England.

The word 'technology' does not appear in this early work.

1547 - William Salisbury, A Dictionary of English and Welshe. London: 1547.

The word 'technology' does not appear, nor does its Welsh equivalent 'celfyddiaeth'.

1548 - Sir Thomas Elyot, Bibliotheca Eliotae, (Edited and Enlarged by Thomas Cooper). London: 1548. (Pollard STC 21616)

"This Dictionarie now newly imprinted, Anno Domini, M.D. XLVIII, is augmented and inriched with above, xxiij, thousande wordes and phrases."

The word 'technology' does not appear.

1604 - Robert Cawdrey, A Table Alphabeticall of English Words London: Edmund Weaver, 1604. (Pollard STC 4884)

"The first English dictionary,"[2]

The word 'technology' does not appear.

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[1]"Elyot, Sir Thomas," Americana. 1958 Edition, Vol.10, p.269.

[2]Clarence L. Barnhart, "Dictionary" Americana, 1958 Edition, Volume 9, p.88.

1611 - John Florio, Queen Anna's New World of Words, or Dictionarie. London: Edw. Blount, 1611. (Pollard STC 11099)

The word 'technology' does not appear.

1611 - Randle Cotgrave, A Dictionarie of French and English Tongues. London: Adam Islip, 1611. (Pollard STC 5830)

The word 'technology' does not appear.

1616 - John Bullokar, An English Expositor. London: John Legatt, 1616. (Pollard STC 4083)

The word 'technology' does not appear.

1623 - Henry Cockeram, The English Dictionarie. London: Nathaniel Butler, 1623. (Pollard STC 5461)

The word 'technology' does not appear.

1656 - Thomas Blount, Glossographia: or a Dictionary. London: Tho. Newcomb, 1656. (Wing STC B3334)

The word 'technology' does not appear.

1658 - Edward Phillips, The New World of English Words: Or a General Dictionary. London: Nath. Brooke, 1658.

The word 'technology' does not appear in this, the first, nor in the later (1663 and 1678) editions.

1670 - H.C. Gent, The English Dictionary, or An Expositor of Hard English Words. London: W. Miller, 1670.

The word 'technology' does not appear.

1676 - Elisha Coles, An English Dictionary. London: Printed for Samuel Crouch, 1676.

In this, the first edition, and in two later editions (1685 and 1692) of Coles' Dictionary the word 'technology' is defined as: "a treating of Arts or Workmanship."

This represents the first appearance of the word in an English dictionary, despite the fact that it had been used in English literature as early as 1615.

1704 - John Harris, Lexicon Technicum or An Universal English Dictionary of Arts and Sciences. London: Printed for Don Brown and others, 1704.

The word 'technology' does not appear.

1708 - John Kersey, Dictionarium Anglo-Britanicum or A General English Dictionary. London: J. Phillips, 1708.

'Technology' is defined as: "a Description of Arts, especially the Mechanical."

1727 - Nathan Bailey, The Universal Etymological English Dictionary, Vol. II. London: T. Cox, 1727.

'Technology' is defined as: "a Description of Arts, especially the mechanical Ones."

1734 - Peter (Pierre) Boyle, The Dictionary Historical and Critical (5 volumes) translated from French (Dictionnaire historique et critique. Rotterdam: 1696) London: printed for J.J. and P. Knapton, 1734-38.

Carefully collated with the several editions of the original.

The word 'technology' does not appear.

1754 - Benj. Martin, Lingua Britannica Reformata: or, A New Universal English Dictionary. London: Printed for C. Hitch and others, 1754.

'Technology' is defined as: "a description of arts, especially mathematical ones."

1755 - Samuel Johnson, A Dictionary of the English Language, Vol.2. London: W. Strahan, 1755.

The word 'technology' does not appear.

1755 - Joseph Nicol Scott, A New Universal Etymological English Dictionary. London: Printed for T. Osborne and others, 1755.

This work is a revision and enlargement of Nathan Bailey's Dictionary.

'Technology' is defined as: "a description of arts, especially mechanical ones."

1757 - James Buchanan, New English Dictionary. London: A. Miller, 1757.

'Technology' is defined as: "a description of arts, especially mathematical ones."

1773 - William Denrick, A New Dictionary of the English Language. London: John and Francis Rivington, and others, 1773.

The word 'technology' does not appear.

1780 - Charles Marriott, The New Royal English Dictionary. London: J. Wenman, 1780.

This work claims to be a "complete library of grammatical knowledge. Containing a full and copious explanation of all the words in the English language."

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The word 'technology' does not appear.

1787 - Ephraim Chambers, Cyclopedia: or, An Universal Dictionary of Arts and Sciences. London: J.F.Rivington, 1787.

The word 'technology' does not appear.

1788 - Perry's Royal Standard English Dictionary. Worcester, Mass.: Isaiah Thomas, 1788.

According to the title page of the Dictionary it is "the First work of the kind printed in America;" and is dedicated to The American Academy of Arts and Sciences.

The word 'technology' does not appear.

1791 - John Walker, A Critical Pronouncing Dictionary and Expositor of the English Language. London: Printed for G.G.J. and J. Robinson, 1891.

The word 'technology' does not appear.

1806 - Noah Webster, A Compendious Dictionary of the English Language. New Haven, Conn.: Hudson & Goodwin, 1806.

The word 'technology' does not appear in this, the first edition of Webster's Dictionary.

1832 - Encyclopedia Americana, First Edition, Vol. XII, 1832.

'Technology' is defined as: "the science which treats of the Arts, particularly the mechanical. Technology may be divided into two kinds, a higher and a lower, of which the latter treats of the various arts themselves, and their principles, their origin, history, improvement, etc.; the former, of the connexion of the arts and trades with the political conditions of a nation, and the important influence which they have exercised ever since the mechanical occupations have come to honor; i.e. since the growth of free cities in the middle ages."

1839 - Charles Richardson, A New Dictionary of the English Language. London: William Pickering, 1839.

Richardson "was the first English dictionary maker to use the historical method."[3]

The word 'technology' does not appear; the word 'technological' appears as an equivalent of 'technical' with the definition: "That can or may make; by usage,--of or pertaining to art, to the arts, to any peculiar art."

1845 - W.T.Brande, A Dictionary of Science, Literature, and Art. New York: Harper & Brothers, 1845.

'Technology': "A term invented to express a treatise on art or the arts.

1888 - Robert Hunter, The Encyclopaedic Dictionary, Vol. VII, Part I. London: Cassell & Company, Ltd., 1888.

'Technology' is defined as: "that branch of knowledge which deals with the various industrial arts; the science or systematic knowledge of the industrial arts, as of weaving, spinning, metalurgy, or the like."

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[3]Ibid., p.90

1892 - Alden's Manifold Cyclopedia. New York: J.B.Alden, Pub., 1887-1892.

'Technology' is defined as: "science or systematic knowledge of the industrial arts. In its widest sense it would embrace the whole field of industry, but it is generally restricted to the more important manufactures. Technology is not an independent science with a set of doctrine of its own, but consists of applications of principles established in the various physical sciences (chemistry, mechanics, mineralogy, etc.) to manufacturing processes."

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